

# **Strengthening the resilience of ecosystems and populations in four regional hubs in northern Mauritania**

## **ANNEX 2**

### ***FEASIBILITY STUDY***



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## Acronyms and abbreviations

AF	Adaptation Fund
AFDB	French Agency for Development
AfDB	African Development Bank
AGLC	Association for Natural Resources
AGPO	<i>Association de gestion participative des oasis</i> (Participatory oasis management association)
CAP	Climate Action Plan
CBO	Community-based organisation
CCPNCC	<i>Cellule de Coordination du Programme National sur le Changement Climatique</i> (Coordination Cell for the National Climate Change Programme)
CDD	Consecutive dry day
CDP	Communal Development Plan
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women
CTC	Commune-level technical committees
CNRE	<i>Centre National des Ressources en Eau</i> (National Water Resources Centre)
COSOP	Country Strategic Opportunities Programme
CREDD	<i>Conseil Régional Environnement et Développement Durable</i> (Regional Councils for Environment and Sustainable Development)
CRPD	Convention on the Rights of Persons with Disabilities
CSA	Climate-smart agriculture
CSLP III	<i>Cadre Stratégique de Lutte contre la Pauvreté III</i> (Strategy Framework Against Poverty III)
DAR	<i>Direction de l'Aménagement Rural</i> (Directorate for Rural Planning)
DREDD	<i>Délégation Régionale de l'Environnement et du Développement Durable</i> (Regional Delegation for Environment and Sustainable Development)
DSSI	Debt Service Suspension Initiative
EbA	Ecosystem-based adaptation
EDP	Emergency Development Programme
ESS	Ecosystem service
ETF	Enhanced Transparency Framework
ETP	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organisation
FMNR	Farmer-managed natural regeneration
GAP	Gender action plan
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GER	Gross enrolment ratio
GGGI	Global Gender Gap Index
GGW	Great Green Wall
GHG	Greenhouse gas
GII	Gender Inequality Index
GNI	Gross national income
GoM	Government of Mauritania
GTA	Grand Tortue Ahmeyim
HCI	Human Capital Index
HDI	Human Development Index
IFAD	International Fund for Agricultural Development
IGA	Income-generating activity
IMF	International Monetary Fund
IMPADRA	Integrated Management of Protected Areas in the Arid Regions of Mauritania
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
KM	Knowledge management

LDC	Least-developed country
LDCF	Least Developed Countries Fund
LMIC	Lower-middle-income country
MAED	<i>Ministère des Affaires Economiques et du Developpement</i> (Ministry of Economic Affairs and Development)
MCM	Million cubic meters
ME	<i>Ministère d'Élevage</i> (Ministry of Livestock)
MEA	Multilateral Environmental Agreement
MENA	Middle East and North Africa
MEDD	<i>Ministère de l'Environnement et du Développement Durable</i> (Ministry of Environment and Sustainable Development)
MHA	<i>Ministère de l'Hydraulique et de l'Assainissement</i> (Ministry of Water and Sanitation)
NAP	National Adaptation Plan
NAPA-Rim	National Adaptation Programme of Action to Climate Change
ND-GAIN	Notre Dame Global Adaptation Initiative
NDC	Nationally Determined Contribution
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
OMVS	<i>Organisation pour la mise en valeur du fleuve Sénégal</i> (Senegal River Basin Development Authority)
ONM	<i>Office National de la Météorologie</i> (National Meteorological Office)
ONSER	<i>Office National des Services d'Eau en Milieu Rural</i> (National Office for Rural Water Services)
P-SAH	Payments for hydrological environmental services
PAN-LCD	<i>Programme d'Action National de Lutte Contre la Desertification en Mauritanie</i> (National Plan Against Desertification in Mauritania)
PANE II	<i>Plan d'Action Nationale pour l'Environnement</i> (National Environmental Action Plan)
PANEDD	Plan of Action for the Environment and Sustainable Development
PARSACC	Enhancing Resilience of Communities to the Adverse Effects of Climate Change on Food Security in Mauritania
PDDO	<i>Programme de développement durable des oasis</i> (Oasis Sustainable Development Programme)
PES	Payment for ecosystem services
PROGRES	Sustainable Management of Natural Resources, Communal Equipment and the Organization of Rural Producers Project
PSEA	Sectoral Water and Sanitation Project
PSC	Personal Status Code
RCP	Representative Concentration Pathway
RWH	Rainwater harvesting
SAWAP	Sahel and West Africa Programme
SCAPP II	<i>Stratégie Nationale de Croissance Accélérée et de Prospérité Partagée II</i> (National Accelerated Growth and Shared Prosperity Strategy II)
SDG	Sustainable Development Goal
SDS	Sand and dust storms
SDSR	<i>Stratégie de Développement du Secteur Rural</i> (Development Strategy for the Rural Sector)
SLM	Sustainable landscape management
SNADEA	<i>Stratégie Nationale pour un Accès Durable à l'Eau et l'Assainissement</i> (National Water and Sanitation Strategy and Policy)
SNEDD	<i>Stratégie Nationale de l'Environnement et du Développement Durable</i> (National Strategy for Sustainable Development)
SNFP	<i>Société Nationale des Forages et Puits</i> (National Company of Boreholes and Wells)
SNRM	Sustainable natural resources management
SPEI	Standardised Precipitation-Evapotranspiration Index
SSP	Shared Socio-economic Pathway
UAA	Utilised agricultural area

UNCT	United Nations Country Team
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
WAM	West African Monsoon
WBL	Women, Business and the Law
WB	World Bank
WFP	World Food Programme
WHO	World Health Organisation
WSDI	Warm spell duration index
WUG	Water user group

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## Executive summary

### *Geographic and socio-economic context*

The Islamic Republic of Mauritania is an arid country located along the Atlantic coast of Northwest Africa. Much of the country encompasses part of the Sahara Desert and is divided into 12 major administrative *wilayahs*<sup>1</sup>, which are then further split into 126 communes. Although primarily a desert state, the country supports a range of additional vegetation zones, including grassland, savanna, and shrubland. The distribution of these zones depends on the degree of aridity, which increases from south to north. Notably, these arid ecosystems provide important ecosystem services to local communities to support their livelihoods, including, *inter alia*, hydrological regulation, fodder generation, and fuel and food resources.

Until the 1970s, a large proportion of Mauritania's population was nomadic. However, droughts, desertification, and land degradation have all contributed to a mass exodus of nomadic and rural peoples into urban zones. By 2021, ~57% of the population had moved to urban areas. In addition, although the country is one of the least densely populated countries in the world, its population growth rate (2.7%) far exceeds that of the global average (0.8%)<sup>2</sup>. The current population of 4.8 million people is expected to increase to ~9 million by 2050<sup>3</sup>.

Despite recent progress toward poverty reduction, Mauritania is considered a least developed country with a Gross Domestic Product (GDP) of US\$7.9 billion and a gross national income (GNI) of US\$1,670. Many households show deficits in human capital accumulation and have limited access to basic infrastructure; daily consumption has been recorded as less than US\$1.90 per person<sup>4</sup>. Approximately 46% of the population is considered multidimensionally poor, which is reflective of low consumption levels, limited access to education, and gaps in access to basic services, such as drinking water, sanitation, and electricity<sup>5</sup>. These factors, as well as the country's relatively low life expectancy, contribute to Mauritania's Human Development Index (HDI) value of 0.556 — which puts the country in the Medium human development category. Gender inequality is also prevalent across the country, with Mauritania's Gender Inequality Index (GII) of 0.634, ranking 151<sup>st</sup> out of 162 globally, and a Global Gender Gap Index (GGGI) of 0.606, ranking 146<sup>th</sup> out of 156 countries.

The largest contributors to Mauritania's economy include services, industry, and agriculture, at ~45%, ~25%, and ~21%, respectively<sup>6</sup>. Of these, the country's rural populations — including the four target hubs of Aoujeft, Rachid, Tamcheket and Nema — contribute considerably to agriculture, with animal husbandry and oasis agriculture comprising the foundation of these communities' livelihoods. Traditionally, animal husbandry<sup>7</sup> management has made use of nomadic techniques; however, sedentary methods are becoming more prevalent in line with the declining number of nomadic pastoralists. Oasis and rainfed crop production have also become more sedentary, and include date palms, cereals and market gardens. However, the increasing concentration of pastoralism and crop production around settlements has degraded Mauritania's fragile ecosystems. In particular, agricultural land expansion, overgrazing, and unsustainable water extraction have increased the risk of desertification and sand inundation along the border between the Sahel and Saharan desert, consequently increasing the water and food insecurity of rural and peri-urban communities in these

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<sup>1</sup> Usually translated as a 'state' or 'province'.

<sup>2</sup> Macrotrends: World population growth rate 1950-2022. Available at: <https://www.macrotrends.net/countries/WLD/world/population-growth-rate>

<sup>3</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>4</sup> Poverty and Equity Brief, Mauritania: October 2020. Available at: [https://databankfiles.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databankfiles.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf)

<sup>5</sup> Poverty and Equity Brief, Mauritania: October 2020. Available at: [https://databankfiles.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databankfiles.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf)

<sup>6</sup> WB. 2020. Country Profile – Mauritania. Available at: [https://databank.worldbank.org/views/reports/reportwidget.aspx?Report\\_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT](https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT)

<sup>7</sup> Animal husbandry usually involves camels, goats, and cattle.

areas. Water scarcity is further aggravated by international water conflicts, population growth and increasing demand, insufficient water infrastructure and social inequalities regarding water access.

#### *Climate change and impacts*

Mauritania's average temperature is 28°C with an average minimum and maximum temperature of 21°C and 36°C, respectively<sup>8</sup>. The country's seasonal rainfall averages 98 mm per year, which is highest in the wet season from June to October. Many regions of the country also experience high wind conditions, which predominately originate from the Saharan Desert to the east. The country's high temperatures, low and variable rainfall, and high winds contribute to several climatic hazards, including: i) heatwaves; ii) sand and dust storms (SDS); iii) droughts; iv) bushfires; and v) floods. These hazards impact cause health complications, reduce water availability, damage infrastructure and lead to considerable agricultural losses, all of which negatively impact livelihood stability.

Since the 1950s, climate change has resulted in rising temperatures of ~0.3°C per decade, reductions in annual precipitation, increases in the frequency of extreme rainfall events and increases in the rate of evapotranspiration. These trends are predicted to continue in the future under projected climate change conditions. Temperature is expected to increase by 1–3°C by 2050 and 3–6°C by 2100, while precipitation is expected to decrease by 6–11 mm by 2080. These are expected to influence the rate of evapotranspiration, which is projected to increase by ~4% by 2050 and ~6% by 2080.

The climatic changes discussed above will influence climatic hazards in the future, including heatwaves and droughts. The number of days with a heat index above 35°C will increase by 89–99 days by 2040 and 93–192 days by 2100. With regards to droughts, the number of consecutive dry days will increase by 219–230 days by 2040 and 225–236 days by 2100 compared with historical values. These future climate change projections are expected to increasingly impact vulnerable communities and ecosystems by: i) reducing water availability, particularly for agricultural use; ii) increasing water demand through higher temperatures and elevated potential evapotranspiration; iii) decreasing fodder availability; iv) reducing livestock and crop productivity; v) increased degradation of ecosystems, which exposes communities to sand inundation and sedimentation of existing water sources and infrastructure; and vi) reducing health of communities through water and food insecurity as well as more prevalent respiratory and water-borne illnesses.

#### *Institutional and strategic framework*

The Islamic Republic of Mauritania has been a sovereign state since its independence in 1960. Numerous governmental institutions are relevant to the proposed project, including the:

- Ministry of Environment and Sustainable Development;
- Ministry of Water and Sanitation;
- Ministry of Agriculture and Rural Development;
- Ministry of Livestock;
- Ministry of Social Affairs, Children and Family;
- Ministry of Economic Affairs and Development;
- Ministry of Housing, Urbanism and Regional Planning;
- and the Ministry of Interior and Decentralisation.

In addition to these national governmental institutions, several non-governmental organisations have played an active role in addressing climate change and natural resource management-related challenges, including the American-Mauritanian Association for Social and Economic Development, *Actions pour le Développement Durable en Mauritanie*, *Association Internationale des Femmes Francophone*, Organisation Mauritanienne pour l'Encadrement et le Développement and the UK-based Rainbow Development in Africa. A number of policies and frameworks also exist to guide the

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<sup>8</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-historical>.

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country's approach to addressing climate change vulnerability and desertification. These include inter alia the National Adaptation Programme of Action to Climate Change, National Adaptation Plan, National Communication on Climate Change IV, and Nationally Determined Contributions.

#### *Best practices and lessons learned*

Several recent and ongoing initiatives to address the challenges of climate change and natural resource management in Mauritania offer best practices and lessons learned for the proposed project to draw on. Specifically, the project will focus on elements relating to: i) the establishment of an enabling environment for climate change adaptation; ii) knowledge management and monitoring systems; iii) payment for ecosystem services and sustainable natural resource-based livelihood options; iv) dune fixation and the control of sand encroachment; v) the adoption of sustainable agricultural and livestock management practices; and v) water resources and demand management.

#### *Strategic recommendations*

A long-term increase in the climate resilience of rural communities of the arid landscapes of Mauritania can be achieved through transformational change via the creation of an enabling environment for climate change adaptation within the institutional and legal framework. This Feasibility Study (FS) presents the first step in creating that enabling environment and recommends a strong focus on building the coordinating and executing capacities of government staff and local communities to achieve that outcome. Enhanced knowledge management platforms will also be necessary to design and implement awareness-raising campaigns on climate change adaptation and assess the vulnerabilities of the rural communities in Mauritania. In addition to an enabling environment, the FS recommends an approach that simultaneously increases the resilience of vulnerable communities that rely on natural resources for their livelihoods. This approach should include the application of EbA interventions to rehabilitate and conserve degraded ecosystems to restore ecosystem services related to water infiltration and protection against sand inundation. The approach should also include the development of livelihoods that do not depend on agriculture or other climate-sensitive sectors.

## 1 Context and baseline

### 1.1 Physical and geographical context (focus on oases and urban hubs)

The Islamic Republic of Mauritania (hereafter referred to as Mauritania) is situated in north-western Africa. The Atlantic Ocean borders the country to the west, Morocco to the north-west, Algeria to the north-east, Mali to the east and south-east, and Senegal to the south-west. At 1,030,700 km<sup>2</sup>, Mauritania is the 11<sup>th</sup> largest country in Africa<sup>9</sup>. It comprises 12 major administrative divisions known as regions or wilayah (Figure 1), with the wilayah further sub-divided into 44 departments, or *moughataa*, which are, in turn, divided into 216 communes.



**Figure 1.** Map of Mauritania showing the 12 major regions or wilayahs<sup>10</sup>.

#### 1.1.1 Geography

Mauritania is divided into three distinct geographical regions, namely: i) the Saharan zone, which covers the northern two-thirds of the country and comprises dunes, rock outcroppings and mountain plateaus; ii) the Riverine zone, comprising a narrow belt of nutrient-rich alluvial soil found along the Senegal River valley; and iii) the Sahel zone, which is a broad east-west band that separates the other two zones and is characterised by sand plains and dunes fixed by vegetation (Figure 2)<sup>11</sup>. Within these three regions there are areas of differing topography. One of these topographical areas is the coastal plains. The plains are generally flat and lower than 45 meters above sea level (masl), with the lowest point reaching 5 m below sea level. The higher plains in the country's interior vary from 180–230 masl and appear as a plateau that forms tablelands connected by long, gentle slopes<sup>12</sup>. This

<sup>9</sup> World Population Review. 2021. Largest Countries in Africa 2021. Available at: <https://worldpopulationreview.com/country-rankings/largest-countries-in-africa>.

<sup>10</sup> World Atlas. 2021. Maps of Mauritania. Available at: <https://www.worldatlas.com/maps/mauritania>.

<sup>11</sup> Country Reports. 2021. Mauritania Geography. Available at: <https://www.countryreports.org/country/Mauritania/geography.htm>.

<sup>12</sup> Britannica. 2021. Mauritania. Available at: <https://www.britannica.com/place/Mauritania/Plant-and-animal-life>.



terrain is broken up by vestiges of homoclinic ridges (*cuestas*<sup>13</sup>) or inselbergs<sup>14</sup>, the highest of which is Mount Ijill which reaches 915 masl<sup>15</sup>. The topography contributes to the aridity that characterises most of the country's expanse and shapes the vegetation in these areas (Section 1.5).



**Figure 2.** Geographical zones within Mauritania<sup>16</sup>.

### 1.1.2 Geography of the project target hubs

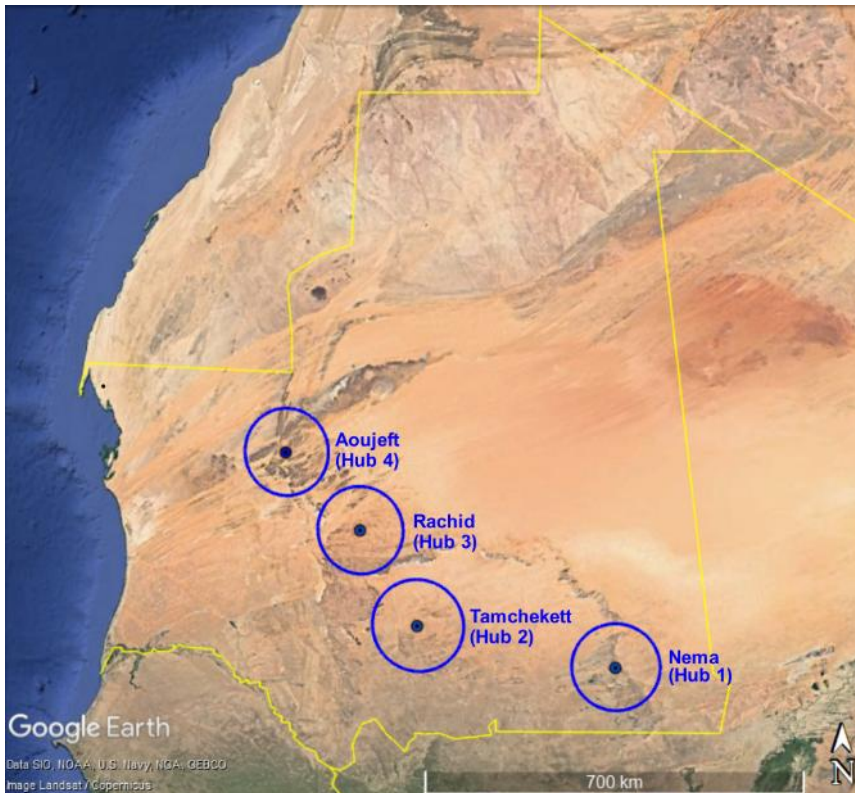
The proposed project will focus on four hubs within the central and eastern wilayahs of Adrar (Aoujeft hub), Tagant (Rachid hub), Hodh El Gharbi (Tamcheket hub) and Hodh Chargui (Néma hub) (Figure 3). Each hub covers an area of 80–85 km<sup>2</sup>, spanning several communes. The Néma hub covers ten communes, while there are six, five and three communes within Aoujeft, Tamcheket and Rachid, respectively. The sections below describe the geography of each of the four hubs.

<sup>13</sup> Homoclinic ridges or *cuestas* (Spanish for 'slope') are features with a steep cliff or escarpment on one side and a gentle back slope on the other.

<sup>14</sup> Inselbergs (German for 'island mountains') are isolated hills or mountains that stand prominently above a flat plain.

<sup>15</sup> World Atlas. 2021. Maps of Mauritania. Available at: <https://www.worldatlas.com/maps/mauritania>.

<sup>16</sup> Lekweiry KM, Salem MSOA, Basco LK, Briolant S, Hafid J & Boukhary AOMS. 2015. Malaria in Mauritania: retrospective and prospective overview. *Malaria Journal*, 14: 100.



**Figure 3.** Satellite imagery of Mauritania showing the locations of the four project hubs. The central point for each hub indicates the primary towns of Néma, Tamchekett, Rachid and Aoujeft, while the larger surrounding circles indicate the extent of each hub with a radius of 80–85 km<sup>17</sup>.

### Néma

The Néma hub is found in the Sahel zone, specifically in the Dhar Néma mountain range, at ~270 masl (N16.61363°; W7.26064°). The land cover in Néma predominantly includes flat Sahelian grasslands, rocky outcrops and flat areas with sparse vegetation cover, such as *hamada* (flat stony areas), floodplains and consolidated sand<sup>18</sup>.

### Tamchekett

The Tamchekett hub is located on the northern edge of the Sahel zone and north of the Afolle mountain range at an elevation of ~175 masl (N17.24526°; W10.66968°). The area surrounding Tamchekett includes fixed and mobile sand dunes, as well as consolidated soils<sup>19</sup>.

### Rachid

Rachid and its hub are found in the Saharan zone on the northern edge of the Tagant mountain range at an elevation of 270 masl (N18.79002°; W11.68750°). The land cover in Rachid is predominantly sand dunes, flat areas of consolidated sands and rocky outcrops<sup>20</sup>.

### Aoujeft

The town of Aoujeft is located in the Saharan zone, specifically in the Adrar Atar mountain range, at an elevation of ~250 masl (N20.02386°; W13.05565°). The area surrounding Aoujeft consists of rocky outcrops, sandy floodplains, fixed and mobile sand dunes, flat areas of consolidated sandy soils and cropland<sup>21</sup>.

<sup>17</sup> Mazar Technologies. 2021. Google Earth Pro.

<sup>18</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Biodeserts Report EN-02.

<sup>19</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Biodeserts Report EN-02.

<sup>20</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Biodeserts Report EN-02.

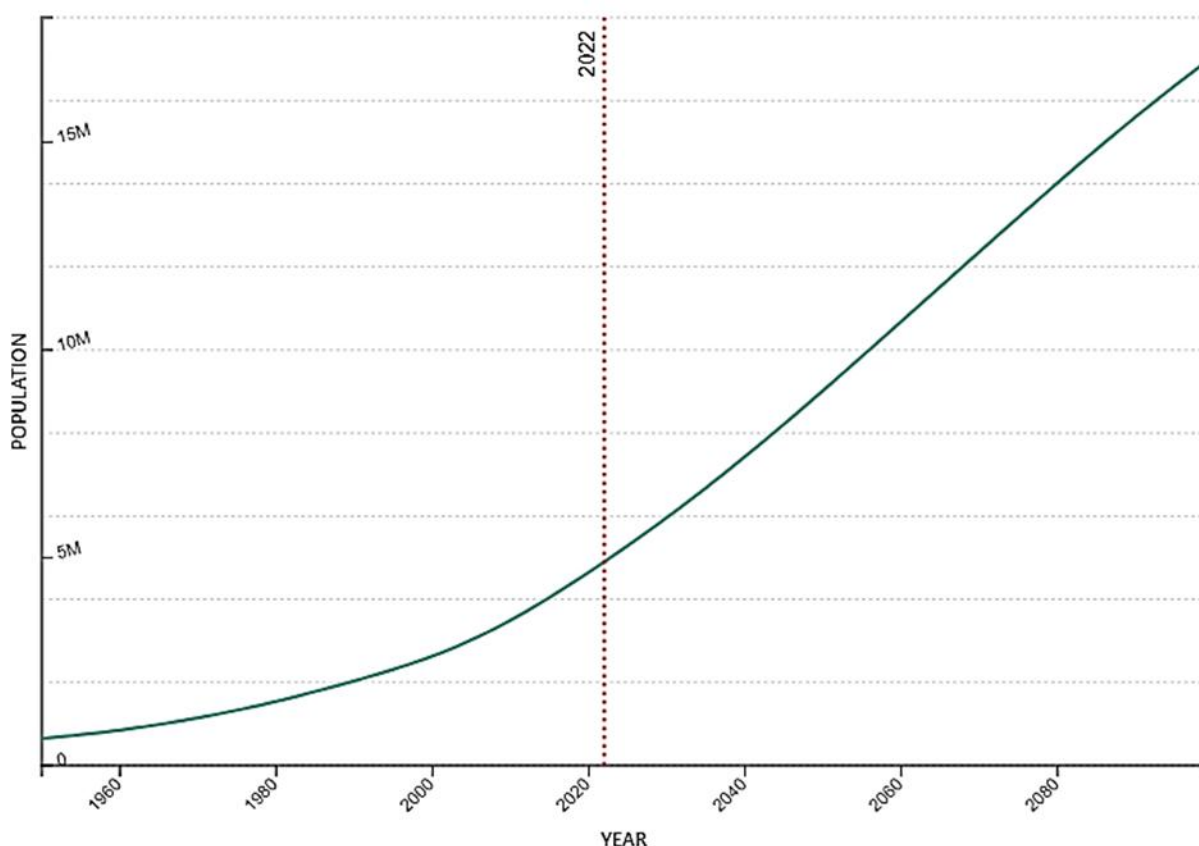
<sup>21</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Biodeserts Report EN-02.

## 1.2 Socio-economic context

### 1.2.1 Socio-economic development overview

#### Demographics

Mauritania has a total population size of ~4.8 million people and an annual population growth rate of 2.7%<sup>22</sup>. Population growth is almost exclusively because of the country's high birth rate — ~33 births/1,000 people — with the net migration rate of -0.72% indicating that more people emigrate from Mauritania as opposed to settling there<sup>23</sup>. With a fertility rate of ~4 children per woman and ~57% of the population below the age of 25 (still at or below child-bearing age), Mauritania's population is projected to reach ~9 million by 2050 and ~14 million by 2080 (Figure 4).



**Figure 4.** Historical and projected population growth for Mauritania (1960–2100)<sup>24</sup>.

Mauritania's population comprises three main ethnic groups: i) the Arabic-speaking Haratins<sup>25</sup> ('Black Moors'); ii) the Arabic-speaking Bidhans<sup>26</sup> ('White Moors'); and iii) the non-Arabic-speaking sub-Saharan Mauritians<sup>27</sup>. Haratins account for ~40% of the population, while Bidhans and sub-

<sup>22</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>23</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>24</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>25</sup> Descendants of former sub-Saharan slaves and the original inhabitants of the Sahara

<sup>26</sup> Individuals of Arab and Amazigh (Berber) descent

<sup>27</sup> Gerteiny AG, Stewart CC, Deschamps HJ & Toupet CH. 2022. Mauritania. Encyclopaedia Britannica. Available at: <https://www.britannica.com/place/Mauritania>.

Saharan Mauritians each comprise ~30%<sup>28</sup>. The Haratins and Bidhans were historically transhumant communities, but they now reside predominantly in the northern and western parts of the country, while sub-Saharan Mauritians — including, *inter alia*, the Tukolor, Halpulaar, Fulani, Soninke, Wolof and Bambara ethnic minorities — reside primarily in the Senegal River valley and surrounding regions<sup>29</sup>. Under the Constitution, Islam is recognised as the sole religion in Mauritania; most of the population adheres to the Sunni denomination. Although the country's official language is Arabic, Fula, Soninke and Wolof are recognised as national languages, and French is widely used in official documents and the media<sup>30</sup>.

Mauritania is the 29<sup>th</sup> largest country in the world<sup>31</sup>; however, ~75% of its land area falls within the Sahara Desert and is largely inhospitable<sup>32</sup>. As a result, the country has a population density of only ~5 inhabitants/km<sup>2</sup>, making it the fourth-least densely populated country in Africa<sup>33</sup>. Although Mauritania's population has historically been dominated by nomadic pastoralists, the country has undergone rapid urbanisation since the 1970s. Of the total population, ~57% now reside in urban areas — compared with ~15% in 1970<sup>34</sup> — and the current rate of urbanisation is ~3.8% (2022)<sup>35</sup>. This rural exodus is largely the result of drought, desertification and land degradation, which drive rural communities into urban areas in search of greater food, water and livelihood security<sup>36</sup>.

Mauritania's largest urban centre and capital city, Nouakchott, accounts for ~30% of the population — ~1.4 million people<sup>37,38</sup>. Nouadhibou is the next-largest city with ~120,000 people, and Néma, a city in one of the project's target hubs, is the third-largest city with ~87,000 people<sup>39</sup>. The distribution of Mauritania's population across major urban centres is shown in Figure 5. Additionally, Table 1 provides population estimates for the four wilayahs in which the project's focal hubs are located (Aoujeft, Rachid, Tamcheket and Nema)<sup>40</sup>.

<sup>28</sup> Misachi J. 2019. What is the ethnic composition of Mauritania? Available at: <https://www.worldatlas.com/articles/what-is-the-ethnic-composition-of-mauritania.html>.

<sup>29</sup> CIA World Factbook. 2022. Mauritania — people and society. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#people-and-society>.

<sup>30</sup> Misachi J. 2019. What is the ethnic composition of Mauritania? Available at: <https://www.worldatlas.com/articles/what-is-the-ethnic-composition-of-mauritania.html>.

<sup>31</sup> World Population Review. 2021. Largest countries in Africa 2021. Available at: <https://worldpopulationreview.com/country-rankings/largest-countries-in-africa>.

<sup>32</sup> World Bank (WB) Group. 2022. Climate change knowledge portal — Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania>.

<sup>33</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>34</sup> WB Group. 2022. Urban population (% of total population) — Mauritania. Available at: <https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=MR>.

<sup>35</sup> CIA World Factbook. 2022. Mauritania — people and society. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#people-and-society>.

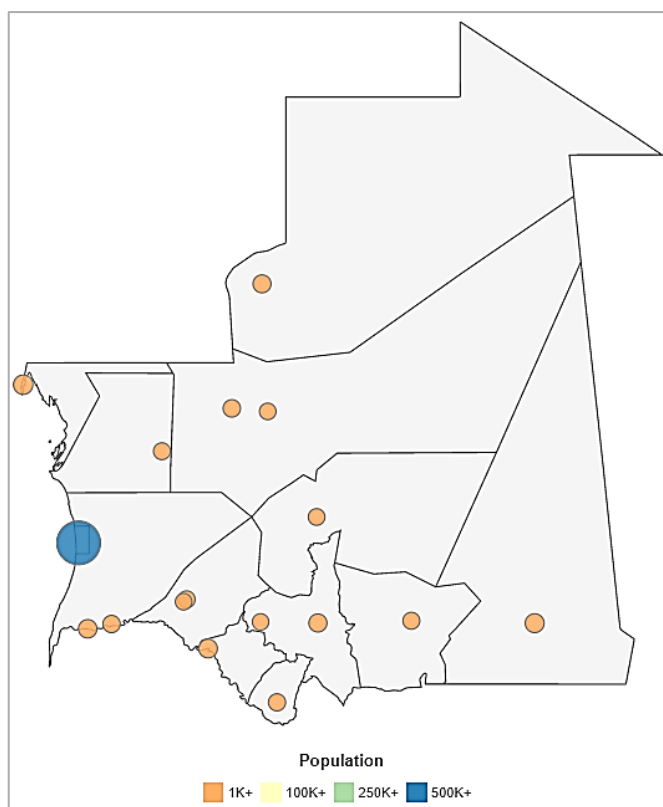
<sup>36</sup> Hennings A. 2021. Mauritania — context and land governance. Available at: <https://d9.landportal.org/book/narratives/2021/mauritania>.

<sup>37</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>38</sup> CIA World Factbook. 2022. Mauritania — people and society. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#people-and-society>.

<sup>39</sup> Ministry of Economic Affairs and Development (Mauritania), National Office of Statistics (Mauritania). Mauritania population and housing census 2013.

<sup>40</sup> Ministry of Economic Affairs and Development (Mauritania), National Office of Statistics (Mauritania). Mauritania population and housing census 2013.



**Figure 5.** Map indicating the location and population size of Mauritania's major urban centres<sup>41</sup>.

**Table 1.** Population statistics for the four wilayahs in which the project's target hubs are located<sup>42</sup>.

Wilayah	Target hub	Population size	Percentage of total population (%)	Population density (inhabitants/km <sup>2</sup> )
Adrar	Aoujeft	62,658	1.77	0.3
Tagant	Rachid	80,962	2.3	0.9
Hodh El Gharbi	Tamcheket	294,109	8.3	5.5
Hodh Chargui	Nema	490,367	13.8	2.4

<sup>41</sup> World Population Review. 2022. Mauritania population 2022 (live). Available at: <https://worldpopulationreview.com/countries/mauritania-population>.

<sup>42</sup> Appendix 1

## Development

Between 1990–2019, Mauritania's Human Development Index (HDI)<sup>43</sup> value — which summarises long-term progress in three basic dimensions of socio-economic development (life expectancy, education and income) — increased from 0.397 to 0.546<sup>44</sup>. Over the same period, the average life expectancy at birth in Mauritania increased by 5.2 years, the mean years of schooling<sup>45</sup> increased by 2.5 years, the expected years of schooling<sup>46</sup> increased by 4.8 years and the country's gross national income (GNI) per capita increased by 14.8%<sup>47</sup>. Despite progress made over the past three decades, however, Mauritania's HDI value is still ranked 157<sup>th</sup> out of 189 countries globally (2019), placing the country in the 'low human development' category<sup>48</sup>.

In line with this, Mauritania was ranked 150<sup>th</sup> out of 157 countries on the 2018 Human Capital Index (HCI), which measures the amount of human capital<sup>49</sup> a child born in Mauritania can expect to attain by the age of 18. In 2020, Mauritania had an HCI score of 38, which suggests that on average, children born in Mauritania attain only ~38% of the total productivity they could achieve in adulthood if complete health and education were acquired<sup>50</sup>.

## Health

Current health expenditure in Mauritania amounts to ~3.3% of the gross domestic product (GDP), or ~USD60 per capita (2021)<sup>51</sup>, well below the global averages of ~9.8% of GDP<sup>52</sup> and ~USD1,120 per capita<sup>53</sup>. Total health expenditure comprises: i) private health spending (~51%), including out-of-pocket spending; ii) public health expenditure by the Government of Mauritania (GoM) (~37%); and iii) external health expenditure<sup>54</sup> (~12%)<sup>55</sup>. As a result of limited health sector investment, Mauritania's healthcare system is characterised by a shortage of both doctors and treatment facilities (Section 0), particularly in isolated rural areas.

The average life expectancy at birth in Mauritania is ~65 years — ~63 years for men; ~67 years for women<sup>56</sup> — which falls below the global average of ~73 years. This relatively low life expectancy is reflective of high infant and child mortality rates and a high disease burden<sup>57</sup>. The infant mortality rate in Mauritania is ~5.2% (~52 per 1,000 live births) and the under-five mortality rate is ~7.6% (~76 per 1,000 live births)<sup>58</sup>. The share of deaths caused by communicable diseases — including maternal,

<sup>43</sup> The Human Development Index (HDI) summarises a country's long-term progress in three basic dimensions of socio-economic development: i) a long and healthy life (health); ii) access to knowledge (education); and iii) a decent standard of living (income).

<sup>44</sup> United Nations Development Programme (UNDP). 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>45</sup> The average number of years of schooling received in a lifetime by people aged 25 years and older

<sup>46</sup> The total number of years of schooling a child of school-entry age can expect to receive if prevailing patterns of age-specific enrolment rates stay the same throughout the child's life

<sup>47</sup> UNDP. 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>48</sup> UNDP. 2020. Human development reports — Mauritania. Available at: <https://hdr.undp.org/en/countries/profiles/MRT#>.

<sup>49</sup> The skills, knowledge, and experience possessed by an individual or population, viewed in terms of their value or cost to an organisation or country

<sup>50</sup> WB Group. 2020. Human Capital Index 2020 — Mauritania. Available at: [https://databank.worldbank.org/data/download/hci/HCI\\_2pager\\_MRT.pdf](https://databank.worldbank.org/data/download/hci/HCI_2pager_MRT.pdf).

<sup>51</sup> WorldData.info. 2022. Healthcare in Mauritania. Available at: <https://www.worlddata.info/africa/mauritania/health.php>.

<sup>52</sup> WB Group. 2019. Current health expenditure (% of GDP). Available at: <https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS>.

<sup>53</sup> WorldData.info. 2022. Healthcare in Mauritania. Available at: <https://www.worlddata.info/africa/mauritania/health.php>.

<sup>54</sup> Share of current health expenditures funded from external sources, including direct foreign transfers and foreign transfers distributed by the government.

<sup>55</sup> World Health Organisation (WHO). 2016. Country cooperation strategy at a glance — Mauritania. Available at: [http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief\\_mrt\\_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1](http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief_mrt_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1).

<sup>56</sup> UNDP. 2020. Human development reports — Mauritania. Available at: <https://hdr.undp.org/en/countries/profiles/MRT#>.

<sup>57</sup> This term is used to describe the impact of a health problem on a given population. Disease burden can be measured using a variety of indicators, including mortality, morbidity and financial cost. It is often quantified in terms of quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs).

<sup>58</sup> WHO. 2016. Country cooperation strategy at a glance — Mauritania. Available at: [http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief\\_mrt\\_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1](http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief_mrt_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1).

prenatal and nutritional conditions — is ~53%<sup>59</sup> and the share of deaths caused by non-communicable diseases is ~37%<sup>60</sup>. The national epidemiological profile is dominated by diseases of infectious and parasitic origin<sup>61</sup> — including malaria, and waterborne diseases such as diarrhoea and cholera — which are closely linked to extreme weather events, such as flooding, and the provision of clean water and sanitation (Sections 0 and 1.4.5)<sup>62</sup>.

### Education

In Mauritania, government expenditure on education amounts to ~2.6% of GDP, which is lower than both the regional average for sub-Saharan Africa (4.0%) and the average for lower-middle-income countries (LMICs: 4.5%)<sup>63</sup>. To strengthen human capital in Mauritania, the United Nations International Children's Emergency Fund (UNICEF) estimates that children need to complete at least nine years of basic education<sup>64</sup>. At present, the mean years of schooling completed by Mauritians is ~4.7 years, while the expected years of schooling for children born in 2019 is ~8.6 years<sup>65</sup>.

Over the past three decades, the gross enrolment ratio (GER)<sup>66</sup> for primary education in Mauritania has increased by ~64 percentage points — from ~46% in 1990 to ~100% in 2019<sup>67</sup>. Despite this major improvement, the primary school completion rate remains low (~68%)<sup>68</sup>. Approximately one-third of students drop out before completing the full primary education cycle, and ~25% of children aged 6–15 years are not enrolled in school<sup>69</sup>. As a result, ~57% of the youth in Mauritania have received an incomplete primary education<sup>70</sup>. Since 2020, the COVID-19 pandemic has further threatened the provision of basic education services; the temporary closure of schools prevented thousands of children from pursuing their regular learning process and increased the risk of dropout<sup>71</sup>. As a result of low school retention rates, the GER for secondary school is estimated at ~39%<sup>72</sup>, while only ~6% of the population is enrolled in tertiary education<sup>73</sup>.

One of the factors contributing to Mauritania's low HCI score (38) is the generally poor quality of schooling. Approximately 35% of Mauritanian teachers are underqualified and ~11% of schools have a pupil-teacher ratio of 80:1, usually in multi-grade classrooms<sup>74</sup>. The national youth literacy rate is

<sup>59</sup> WB Group. 2019. Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total) — Mauritania. Available at: <https://data.worldbank.org/indicator/SH.DTH.COMM.ZS?locations=MR>.

<sup>60</sup> WB Group. 2019. Cause of death, by non-communicable diseases (% of total) — Mauritania. Available at: <https://data.worldbank.org/indicator/SH.DTH.NCOM.ZS?locations=MR>.

<sup>61</sup> WHO. 2016. Country cooperation strategy: Mauritania. Available at: [http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief\\_mrt\\_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1](http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief_mrt_en.pdf;jsessionid=0576FF9DD45CA08C392DBC6DC6304655?sequence=1).

<sup>62</sup> German Federal Ministry for Economic Cooperation and Development (BMZ). 2021. Climate risk profile: Mauritania. Available at: [https://www.adaptationcommunity.net/wp-content/uploads/2021/02/GIZ\\_Climate-Risk-Profile-Mauritania\\_EN\\_final.pdf](https://www.adaptationcommunity.net/wp-content/uploads/2021/02/GIZ_Climate-Risk-Profile-Mauritania_EN_final.pdf).

<sup>63</sup> WB Group. 2020. Human Capital Index 2020 — Mauritania Available at: [https://databank.worldbank.org/data/download/hci/HCI\\_2pager\\_MRT.pdf](https://databank.worldbank.org/data/download/hci/HCI_2pager_MRT.pdf).

<sup>64</sup> United Nations International Children's Emergency Fund (UNICEF). 2018. Schools for Africa — phase IV — country profile: Mauritania. Available at: <https://www.schoolsforafrica.org/media/551/file/Mauritania-SFA-Profile.pdf>.

<sup>65</sup> UNDP. 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>66</sup> Number of students enrolled in a given level of education, regardless of age, expressed as a percentage of the official school-age population corresponding to the same level of education.

<sup>67</sup> WB Group. 2019. School enrollment, primary (% gross) — Mauritania. Available at: <https://data.worldbank.org/indicator/SE.SEC.ENRR?locations=MR>.

<sup>68</sup> FHI 360. 2018. Mauritania — National education profile 2018 update. Available at: [https://www.epdc.org/sites/default/files/documents/EPDC\\_NEP\\_2018\\_Mauritania.pdf](https://www.epdc.org/sites/default/files/documents/EPDC_NEP_2018_Mauritania.pdf).

<sup>69</sup> WB Group. 2018. Mauritania education support project: Project information document/Integrated safeguards data sheet (PID/ISDS). Available at: <https://documents1.worldbank.org/curated/en/209611537995952900/pdf/Concept-Project-Information-Documents-Integrated-Safeguards-Data-Sheet-Mauritania-Education-Support-Project-P163143.pdf>.

<sup>70</sup> FHI 360. 2018. Mauritania — national education profile 2018 update. Available at: [https://www.epdc.org/sites/default/files/documents/EPDC\\_NEP\\_2018\\_Mauritania.pdf](https://www.epdc.org/sites/default/files/documents/EPDC_NEP_2018_Mauritania.pdf).

<sup>71</sup> UNICEF. 2022. Humanitarian action for children — Mauritania. Available at: <https://reliefweb.int/sites/reliefweb.int/files/resources/2022-HAC-Mauritania.pdf>.

<sup>72</sup> WB Group. 2019. School enrollment, secondary (% gross) — Mauritania. Available at: <https://data.worldbank.org/indicator/SE.SEC.ENRR?locations=MR>.

<sup>73</sup> WB Group. 2019. School enrollment, tertiary (% gross) — Mauritania. Available at: <https://data.worldbank.org/indicator/SE.SEC.ENRR?locations=MR>.

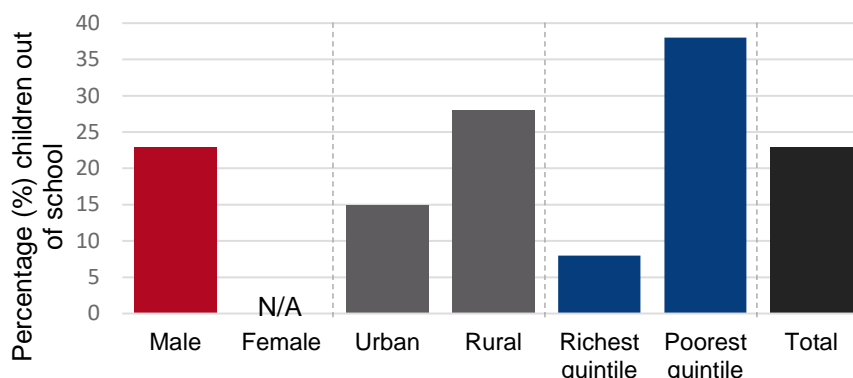
<sup>74</sup> UNICEF. 2018. Schools for Africa — phase IV — country profile: Mauritania. Available at: <https://www.schoolsforafrica.org/media/551/file/Mauritania-SFA-Profile.pdf>.



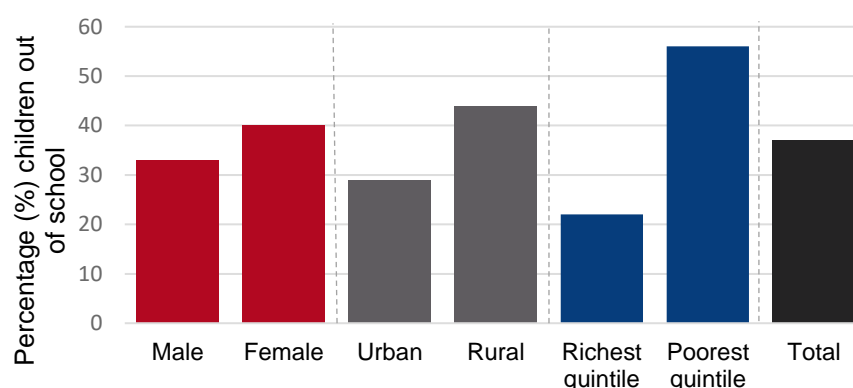
~56%, which falls well below the median of ~95% for countries in the LMIC category<sup>75</sup>. Additionally, on average, primary school students acquire complete knowledge of only ~23% of the prescribed Arabic programme and ~13% of the French programme<sup>76</sup>. After adjusting for the level of content learned in Mauritania, the expected number of schooling years is reduced from ~8.6 to ~4.2 years<sup>77</sup>.

Large disparities in both access to education and the quality of education exist across regions, income groups and gender groups (Section 1.2.4). As shown in Figure 6, the proportion of children out of school is generally higher for girls and children from rural communities and households within the poorest quintile at both primary and secondary school levels<sup>78</sup>.

**A.** Percentage of primary school-aged children out of school



**B.** Percentage of secondary school-aged children out of school



**Figure 6.** Bar graphs indicating the percentage of children out of school in Mauritania, disaggregated by gender, urbanicity and income. **A.** Percentage of primary school children (aged 6–11 years) out of school. **B.** Percentage of primary school children (aged 12–18 years) out of school<sup>79</sup>.

Within the proposed project's target regions, school enrolment rates and literacy rates fall well below the national averages. In the Adrar wilayah (Aoujeft), the gross primary enrolment rate is ~63%. Approximately 20% of the local population has not received any formal education, with only one in

<sup>75</sup> FHI 360. 2018. Mauritania — national education profile 2018 update. Available at: [https://www.epdc.org/sites/default/files/documents/EPDC\\_NEP\\_2018\\_Mauritania.pdf](https://www.epdc.org/sites/default/files/documents/EPDC_NEP_2018_Mauritania.pdf).

<sup>76</sup> UNICEF. 2018. Schools for Africa — phase IV — country profile: Mauritania. Available at: <https://www.schoolsforafrica.org/media/551/file/Mauritania-SFA-Profile.pdf>.

<sup>77</sup> WB Group. 2020. Human Capital Index 2020 — Mauritania Available at: [https://databank.worldbank.org/data/download/hci/HCI\\_2pager\\_MRT.pdf](https://databank.worldbank.org/data/download/hci/HCI_2pager_MRT.pdf).

<sup>78</sup> FHI 360. 2018. Mauritania — national education profile 2018 update. Available at: [https://www.epdc.org/sites/default/files/documents/EPDC\\_NEP\\_2018\\_Mauritania.pdf](https://www.epdc.org/sites/default/files/documents/EPDC_NEP_2018_Mauritania.pdf).

<sup>79</sup> FHI 360. 2018. Mauritania — national education profile 2018 update. Available at: [https://www.epdc.org/sites/default/files/documents/EPDC\\_NEP\\_2018\\_Mauritania.pdf](https://www.epdc.org/sites/default/files/documents/EPDC_NEP_2018_Mauritania.pdf).



four people recorded as being literate<sup>80</sup> — 22% of men; 27% of women<sup>81</sup>. The gross primary enrolment rate in the Tagant wilayah (Rachid) is ~72%. More than 33% of the local population has not received any formal education, with only one in three people (~39%) recorded as literate — ~42% of men; ~34% of women<sup>82</sup>. The wilayahs of Hodh El Gharbi (Tamcheket) and Hodh Chargui (Nema) are among those with the weakest education infrastructure. Only 16–28% of primary schools in these regions are both operational and complete, covering the full education cycle (grades 1–6)<sup>83</sup>. As a result, the gross primary enrolment rate falls below 50% in Hodh El Gharbi and below 30% in Hodh Chargui<sup>84</sup>.

According to the global average, each additional year of education increases a country's GDP by ~18% and boosts individual income by ~10%<sup>85</sup>. High dropout rates and poor-quality education, therefore, limit Mauritania's GDP growth and exacerbate poverty by reducing individuals' access to higher-paid jobs. Additionally, education is considered an important component of adaptation readiness and, more specifically, social readiness<sup>86</sup>. Limited access to quality education, therefore, increases the population's vulnerability to environmental, political and economic shocks (Section 0).

### *Income and poverty*

Between 1990–2019, the GNI per capita in Mauritania increased by ~15%, representing an average increase in individual earnings of ~0.5% per year<sup>87</sup>. This growth was accompanied by accelerated poverty reduction in the early 2000s during a global commodities boom<sup>88,89</sup>. Between 2008 and 2014, the poverty rate<sup>90</sup> in Mauritania fell from ~10.9% to ~6%<sup>91</sup>. Rural communities — particularly in the wilayahs of Hodh Chargui, Tagant, Adrar, Gorgol and Brakna<sup>92</sup> — benefitted most from accelerated poverty reduction. In contrast, the capital city of Nouakchott experienced a slight increase in poverty.

The poverty reduction in rural areas was mainly driven by: i) increased agricultural and livestock production; ii) favourable food prices; and iii) the out-migration of poor households to urban centres<sup>93</sup>. During the 2000s commodities boom, per capita household expenditure grew by more than 33% for net food-producing households, compared with ~1.4% for net consumer households in Mauritania. Livestock farmers benefitted from particularly high meat prices, which outperformed inflation by more than 15% because of increased domestic demand and exportation<sup>94</sup>. Conversely, poverty increased in Nouakchott as a result of i) an influx of poor migrants into urban zones; and ii) higher living costs

<sup>80</sup> The ability to read and write.

<sup>81</sup> Appendix 1

<sup>82</sup> Appendix 1

<sup>83</sup> WB Group. 2018. Mauritania education support project: Project information document/Integrated safeguards data sheet (PID/ISDS). Available at: <https://documents1.worldbank.org/curated/en/209611537995952900/pdf/Concept-Project-Information-Documents-Integrated-Safeguards-Data-Sheet-Mauritania-Education-Support-Project-P163143.pdf>.

<sup>84</sup> Ministère des Affaires Economiques et du Développement. 2015. Présentation des résultats définitifs du recensement général de la population et de l'habitat (RGPH-2013). Available at: <https://catalog.ihnsn.org/catalog/6307/download/78186>.

<sup>85</sup> Brandt Y, UNICEF. 2015. Education: The most powerful investment in our future. Available at: <https://blogs.unicef.org/blog/education-the-most-powerful-investment-in-our-future/#:~:text=Evidence%20shows%20that%2C%20on%20average,GDP%20by%2018%20per%20cent>.

<sup>86</sup> Social readiness captures the social factors that enhance the mobility of investment to be converted to adaptation actions. Indicators include social inequality, information and communications technology infrastructure, education and innovation.

<sup>87</sup> UNDP. 2020. Human development reports — Mauritania. Available at: <https://hdr.undp.org/en/countries/profiles/MRT#>.

<sup>88</sup> The 2000s commodities boom, also known as the commodities super cycle, encompassed the rise of many of the prices of physical commodities — those of food, fuel, oil, metals and chemicals — from 2000 to 2014, following the Great Commodities Depression of the 1980s and 1990s.

<sup>89</sup> WB Group. 2018. Country partnership framework for the Islamic Republic of Mauritania for the period FY18–FY23. Available at: <https://documents1.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf>.

<sup>90</sup> Measured at the international poverty line (2011 purchasing power parity USD1.9 per day)

<sup>91</sup> WB Group. 2020. Poverty & equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>92</sup> WB Group. 2018. Country partnership framework for the Islamic Republic of Mauritania for the period FY18–FY23. Available at: <https://documents1.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf>.

<sup>93</sup> WB Group. 2020. Poverty & equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>94</sup> WB Group. 2018. Country partnership framework for the Islamic Republic of Mauritania for the period FY18–FY23. Available at: <https://documents1.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf>.

— since food consumption constitutes ~54% of total household expenditure in Nouakchott<sup>95</sup>. Notwithstanding these trends, poverty remains a predominantly rural phenomenon in Mauritania. Approximately 70% of the country's impoverished households live in rural areas, while coastal urban centres exhibit the lowest poverty rates<sup>96</sup>. This disparity can be attributed to uneven access to assets and services, which are generally concentrated in urban areas.

Income poverty in Mauritania is exacerbated by high levels of unemployment and limited labour-force participation, particularly among women and the youth. The overall unemployment rate is estimated at ~11% (2020), with this figure being higher for women (~13%) and considerably higher for the youth aged between 15–24 (~23%)<sup>97</sup>. The total labour force participation rate in Mauritania is ~45%, indicating that more than half of the country's working-age population (aged 15 years or older) is not engaged in economic activity<sup>98</sup>. Only ~29% of working-age women are economically active, compared with ~64% of working-age men<sup>99</sup>, which reflects the extent to which cultural norms and conventional gender roles prevent women from entering the workforce (Section 1.2.4). Within the proposed project's target region, labour-force participation falls below the national average. For example, in the wilayahs of Tagant (Rachid) and Hodh El Gharbi (Tamcheket), labour force participation rates are estimated at ~42% and ~38% respectively<sup>100</sup>.

In addition to income poverty, ~51% of the population in Mauritania experiences multidimensional poverty<sup>101</sup>, which reflects low consumption levels, limited educational attainment and gaps in access to drinking water, sanitation and electricity<sup>102</sup>. Moreover, ~19% of the population is classified as 'vulnerable to multidimensional poverty'<sup>103</sup>, implying that individuals who live above the income poverty line may still experience deprivations in health, education and standard of living<sup>104</sup>. The incidence of multidimensional poverty is estimated at ~61% in Tagant (Rachid), ~75% in Hodh El Gharbi (Tamcheket) and ~58% in Hodh Chargui (Nema)<sup>105</sup> — which are three of the proposed project's target wilayahs.

Since 2020, the impacts of the COVID-19 pandemic on Mauritania's economy (Section 1.2.2) have had repercussions for both the labour market and the living conditions of the population<sup>106</sup>. Extreme poverty — measured at USD1.9 per day (2011 purchasing power parity<sup>107</sup>) — increased from 5.4% in 2019 to 6.1% in 2020, which corresponds with ~38,000 people falling into extreme poverty over that period<sup>108</sup>. Moreover, in 2021, ~75% of households in Mauritania reported a fall in income and ~94% claimed to have been affected by higher food prices<sup>109</sup>. Economic recovery is expected to reduce the poverty rate to its pre-pandemic level (5.4%) by 2023. However, if the spread of COVID-

<sup>95</sup> WB Group. 2018. Country partnership framework for the Islamic Republic of Mauritania for the period FY18–FY23. Available at: <https://documents1.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf>.

<sup>96</sup> WB Group. 2020. Poverty & equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>97</sup> WB Group. 2022. World Bank open data. Available at: <https://data.worldbank.org/>.

<sup>98</sup> International Labour Organization. 2019. State of skills — Mauritania. Available at: [https://www.ilo.org/wcmsp5/groups/public/---ed\\_emp/---ifp\\_skills/documents/genericdocument/wcms\\_742225.pdf](https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/genericdocument/wcms_742225.pdf).

<sup>99</sup> World Economic Forum. 2021. Global gender gap report 2021: Insight report. Available at: [https://www3.weforum.org/docs/WEF\\_GGGR\\_2021.pdf](https://www3.weforum.org/docs/WEF_GGGR_2021.pdf).

<sup>100</sup> Appendix 1.

<sup>101</sup> UNDP. 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>102</sup> WB Group. 2020. Poverty & equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>103</sup> UNDP. 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>104</sup> UNDP. 2020. The next frontier: Human development and the Anthropocene — Mauritania. Available at: <https://hdr.undp.org/sites/default/files/Country-Profiles/MRT.pdf>.

<sup>105</sup> Appendix 1.

<sup>106</sup> WB Group. 2022. The World Bank in Mauritania: Overview — context. Available at: <https://www.worldbank.org/en/country/mauritania/overview>.

<sup>107</sup> PPP exchange rates are used to adjust for differences in price levels across countries.

<sup>108</sup> WB Group. 2021. Macro-poverty outlook: Sub-Saharan Africa. Available at: <https://thedocs.worldbank.org/en/doc/77351105a334213c64122e44c2efe523-0500072021/related/mpo-am21-ssa.pdf>.

<sup>109</sup> WB Group. 2021. Macro-poverty outlook: Sub-Saharan Africa. Available at: <https://thedocs.worldbank.org/en/doc/77351105a334213c64122e44c2efe523-0500072021/related/mpo-am21-ssa.pdf>.

19 is not contained, the pandemic — together with extreme climate events — will continue to represent a substantial risk to poverty reduction efforts over the medium term<sup>110</sup>.

### *Gender equality*

Mauritania has a Gender Inequality Index (GII) value of 0.634, ranking it 151<sup>st</sup> out of 162 countries globally. The GI reflects gender-based inequalities in three dimensions: i) reproductive health ii) economic activity; and iii) political empowerment<sup>111</sup>.

Firstly, reproductive health in Mauritania is relatively low. For every 100,000 live births, ~766 women die from pregnancy-related causes, and the adolescent birth rate is ~71 births per 1,000 women aged 15–19<sup>112</sup>. Secondly, only ~29.1% of working-age women are economically active, compared with ~63.9% of working-age men<sup>113</sup>, which reflects the extent to which cultural norms and conventional gender roles prevent women from entering the workforce. Low employment rates in women are exacerbated by low levels of education in girls. Compared with ~25% of adult men, only ~13% of adult women have attained at least a secondary level of education, reflecting gender disparities in access to quality education. Lastly, only ~20% of parliamentary seats are held by women, which limits the capacity to promote legislation which addresses the needs of women. However, although men and women do not yet have equal representation in electoral positions, a legislated quota reserving 20% of Mauritania's parliamentary seats for women is considered relatively progressive in the context of Islamic jurisprudence<sup>114</sup>. Additionally, political parties which elect more women than required by the quota obtain a financial benefit; therefore, some incentives for the appointment of women in positions of political power do exist<sup>115</sup>.

Mauritania is also ranked 146<sup>th</sup> out of 156 countries on the Global Gender Gap Index (GGGI), which benchmarks the evolution of gender-based gaps among four dimensions: i) economic participation and opportunity; ii) educational attainment; iii) health and survival; and iv) political empowerment. In 2021, the country received an overall GGGI score of 0.606 — where 0 represents complete disparity and 1 represents complete parity — placing it 14<sup>th</sup> out of 19 countries in the Middle East and North Africa<sup>116</sup>. Gender considerations and factors contributing to the observed gender gap in Mauritania are expanded upon in Section 1.2.4 and Annex 8 of the Funding Proposal.

## 1.2.2 Major economic sectors

Mauritania is a least-developed country (LDC) with a GDP of ~USD7.9 billion and a GDP per capita of ~USD1,700<sup>117</sup>. The country has a GNI per capita of ~USD\$1,670, which falls within the range used to define a lower-middle-income economy (USD1,036–USD\$4,045)<sup>118</sup>. Over the last 20 years, Mauritania's economic growth has fluctuated, mainly resulting from the economy's dependence on

<sup>110</sup> WB Group. 2021. Macro-poverty outlook: Sub-Saharan Africa. Available:

<https://thedocs.worldbank.org/en/doc/77351105a334213c64122e44c2efe523-0500072021/related/mpo-am21-ssa.pdf>.

<sup>111</sup> World Economic Forum. 2021. Global gender gap report 2021: Insight report. Available at:

[https://www3.weforum.org/docs/WEF\\_GGGR\\_2021.pdf](https://www3.weforum.org/docs/WEF_GGGR_2021.pdf).

<sup>112</sup> World Economic Forum. 2021. Global gender gap report 2021: Insight report. Available at:

[https://www3.weforum.org/docs/WEF\\_GGGR\\_2021.pdf](https://www3.weforum.org/docs/WEF_GGGR_2021.pdf).

<sup>113</sup> World Economic Forum. 2021. Global gender gap report 2021: Insight report. Available at:

[https://www3.weforum.org/docs/WEF\\_GGGR\\_2021.pdf](https://www3.weforum.org/docs/WEF_GGGR_2021.pdf).

<sup>114</sup> Human understanding of the divine Islamic law as revealed in the Quran and the Sunnah (the teachings and practices of the Islamic prophet Muhammad and his companions).

<sup>115</sup> International Institute for Democracy and Electoral Assistance (IDEA). 2022. Mauritania. Available at: <https://www.idea.int/data-tools/data/gender-quotas/country-view/214/35>

<sup>116</sup> World Economic Forum. 2021. Global gender gap report 2021: Insight report. Available at:

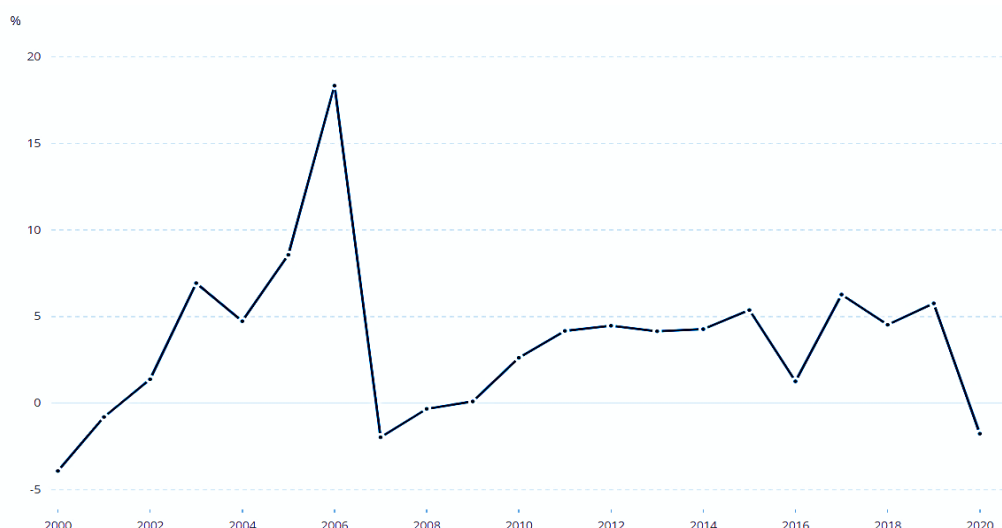
[https://www3.weforum.org/docs/WEF\\_GGGR\\_2021.pdf](https://www3.weforum.org/docs/WEF_GGGR_2021.pdf).

<sup>117</sup> World Bank. 2020. Country Profile – Mauritania. Available at:

[https://databank.worldbank.org/views/reports/reportwidget.aspx?Report\\_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT](https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT)

<sup>118</sup> Hamadeh N, van Rompaey C & Metreau E. 2021. New World Bank country classifications by income level: 2021-2022. Available at: <https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022>

volatile international food and commodity prices<sup>119,120</sup>. Annual GDP growth reached a peak of ~18% in 2006 — coinciding with the start of major oil production and export in the country that year — but decreased rapidly thereafter, reaching a low of -1.9% in 2007 (Figure 7)<sup>121</sup>. This rapid decline in GDP growth was primarily the result of persistent technical difficulties within the oil sector, which reduced oil production from ~22,000 barrels per day in December 2006 to ~14,000 barrels per day by August the following year<sup>122</sup>.



**Figure 7.** Mauritania's annual GDP growth (%) between the years 2000 and 2020.

From 2008–2019, Mauritania's annual GDP growth steadily increased, reaching 5.9% in 2019. However, with the onset of the COVID-19 pandemic in 2020, deterioration of the global economy resulted in a 33% drop in iron ore exports and a halt in fisheries exports, which caused the GDP to contract by 3.6%. Economic growth is projected to resume in 2022, with the potential to reach a 4.2% increase in GDP by the end of the year, provided that COVID-19-related restrictions subside<sup>123</sup>. The largest contributors to Mauritania's GDP, disaggregated by sector, are: i) services (~45%), including trade, government activities, tourism, transportation and finance; ii) industry (~25%), including mining, energy production and construction; iii) agriculture (~21%), including farming, fishing and forestry; and iv) manufacturing (~6%)<sup>124,125</sup>.

Extractive resources such as mineral products, oil and gas, shellfish and frozen fish constitute ~75% of the country's exports. The country's coastal fishing grounds produce ~1,8 million tonnes of fish for both export and national consumption annually, making Mauritania's coastline one of the most

<sup>119</sup> International Trade Administration (ITA). 2021. Mauritania – Country Commercial Guide. Available at: <https://www.trade.gov/country-commercial-guides/mauritania-market-overview?section-nav=10119>

<sup>120</sup> CIA World Factbook. 2022. Mauritania – Economy. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#economy>

<sup>121</sup> WB. 2020. Country Profile – Mauritania. Available at: [https://databank.worldbank.org/views/reports/reportwidget.aspx?Report\\_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT](https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT)

<sup>122</sup> International Monetary Fund. 2007. Islamic Republic of Mauritania: Second review under the three-year arrangement under the Poverty Reduction and Growth Facility and Request for a Waiver of Performance Criterion: Staff Report; Staff Supplement; Press Release on the Executive Board Discussion; and Statement by the Executive Director for the Islamic Republic of Mauritania. Available at: <https://doi.org/10.5089/9781451827651.002>

<sup>123</sup> African Development Bank (AfDB) Group. 2021. Mauritania Economic Outlook. Available at: <https://www.afdb.org/en/countries/mauritania/mauritania-economic-outlook>

<sup>124</sup> WB. 2020. Country Profile – Mauritania. Available at: [https://databank.worldbank.org/views/reports/reportwidget.aspx?Report\\_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT](https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=MRT)

<sup>125</sup> German Federal Ministry for Economic Cooperation and Development (BMZ). 2021. Climate Risk Profile: Mauritania Summary. Available at: [https://www.pik-potsdam.de/en/institute/departments/climate-resilience/projects/project-pages/agrica/giz\\_climate-risk-profile-mauritania\\_en\\_final](https://www.pik-potsdam.de/en/institute/departments/climate-resilience/projects/project-pages/agrica/giz_climate-risk-profile-mauritania_en_final)

resource-rich globally. However, overexploitation by both foreign and national fleets threatens the sustainability of this revenue source<sup>126</sup>. Consequently, GDP growth has been driven mainly by foreign investment in the mining and oil industries in the last decade. The country's extensive mineral resources include iron ore, gold, copper, gypsum and phosphate rock, while exploration for tantalum, uranium, crude oil, and natural gas remains ongoing<sup>127</sup>. Planned extraction of gas from the Grand Tortue Ahmeyim (GTA) natural gas field — located on the maritime border between Mauritania and Senegal — in 2023 is expected to double the government's annual revenue that year. However, despite recent developments in the oil and gas sectors, more than 50% of Mauritania's population still depend on farming and raising livestock for their livelihoods<sup>128</sup>.

In all four of the project's target hubs — Aoujeft, Rachid, Tamcheket and Nema — animal husbandry and oasis agriculture contribute considerably to the local economy. Aoujeft is located in the country's main palm-date region (Adrar wilayah<sup>129</sup>), which produces ~45% of the national date yield. Additionally, market gardens<sup>130</sup> provide income-generating opportunities for many residents in Aoujeft, particularly for women and the youth<sup>131</sup>. In Rachid (Tagant wilayah), agriculture is focused on date palms, cereals and market gardens. Traditional cereals (sorghum, wheat and barley) and cowpea are the main products of rainfed crops and small-scale market gardening of vegetables is usually carried out by women's cooperatives<sup>132</sup>. In the regional hub of Tamcheket (Hodh El Gharbi wilayah), animal husbandry constitutes the largest economic sector, employing ~37% of the active population. Similarly, the Hodh Chargui wilayah, where Nema is located, is considered to have the highest livestock production potential in the country and produces ~30% of the national fodder yield<sup>133</sup>. Animal husbandry and fodder production are, therefore, important economic activities in this hub, along with cereal crop production<sup>134</sup>. However, given that Mauritania's agriculture is primarily rainfed, many nomadic and subsistence farmers have been driven into urban areas by recurrent droughts in the 1970s, 1980s, 2000s and 2017<sup>135</sup>. The resultant rural exodus has adversely impacted national food security and forced reliance on food imports, which account for a substantial portion of the government's total import costs (~21% in 2020)<sup>136</sup>.

In 2020, Mauritania's total public sector debt amounted to ~79% of the GDP<sup>137</sup> — a figure well above the 40% threshold considered sustainable by the International Monetary Fund (IMF)<sup>138</sup>. As a percentage of GDP, the country experienced a record trade deficit<sup>139</sup> of ~18% and a fiscal deficit<sup>140</sup> of ~4%, despite being in surplus the previous year. These domestic economic shortfalls were primarily caused by: i) decreased tax revenues resulting from an economic slowdown during the COVID-19 recession; ii) a decline in export revenues and inflated import costs; iii) the easing of taxes on certain

<sup>126</sup> CIA World Factbook. 2022. Mauritania — Economy. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#economy>

<sup>127</sup> CIA World Factbook. 2022. Mauritania — Economy. Available at: <https://www.cia.gov/the-world-factbook/countries/mauritania/#economy>

<sup>128</sup> International Trade Administration. 2021. Mauritania - Country Commercial Guide. Available at: <https://www.trade.gov/country-commercial-guides/mauritania-market-overview?section-nav=10119>

<sup>129</sup> Mauritania is divided into 15 regions, or districts, called wilayahs — which can be further divided into hubs.

<sup>130</sup> A market garden is the relatively small-scale production of fruits, vegetables and flowers as cash crops, frequently sold directly to consumers.

<sup>131</sup> Appendix 1

<sup>132</sup> Appendix 1

<sup>133</sup> Republique Islamique De Mauritanie. 2002. Initiative Elevage Pauvrete Et Croissance (IEPC). Available at: [http://hubrural.org/IMG/pdf/mauritanie\\_doc\\_national\\_iepc.pdf](http://hubrural.org/IMG/pdf/mauritanie_doc_national_iepc.pdf)

<sup>134</sup> Appendix 1

<sup>135</sup> International Trade Administration. 2021. Mauritania - Country Commercial Guide. Available at: <https://www.trade.gov/country-commercial-guides/mauritania-market-overview?section-nav=10119>

<sup>136</sup> International Monetary Fund. 2021. Islamic Republic of Mauritania: Sixth Review. Available at: <https://www.imf.org/en/Publications/CR/Issues/2021/03/11/Islamic-Republic-of-Mauritania-Sixth-Review-Under-the-Extended-Credit-Facility-Arrangement-50255>

<sup>137</sup> International Monetary Fund. 2021. Islamic Republic of Mauritania: Sixth Review. Available at: <https://www.imf.org/en/Publications/CR/Issues/2021/03/11/Islamic-Republic-of-Mauritania-Sixth-Review-Under-the-Extended-Credit-Facility-Arrangement-50255>

<sup>138</sup> International Monetary Fund. 2020. Islamic Republic Of Mauritania: Fifth Review. Available at: <https://www.imf.org/external/pubs/ft/dsa/pdf/2020/dsacr20274.pdf>

<sup>139</sup> When a country's imports exceed its exports during a fiscal year.

<sup>140</sup> When government expenditure exceeds revenue generated during a fiscal year.

staples to provide economic relief during the pandemic; and iv) an increase in health spending to combat COVID-19 infections. The COVID-19 recession also impacted foreign direct investment in Mauritania, which fell from a projected USD937 million to USD594 million in 2020<sup>141</sup>. Projections indicate that Mauritania's fiscal deficit should decrease to ~2% of GDP in 2022, provided that the COVID-19 pandemic continues to remain under control and the country's public finance situation improves. With the resumption of iron ore and fisheries exports, the trade deficit is predicted to narrow to ~14% of GDP. Additionally, developing the GTA offshore gas field is expected to accelerate the country's economic recovery. This economic outlook, however, is expected to be undermined if: i) the COVID-19 pandemic continues and associated health-spending remains high; ii) COVID-19-related trade restrictions are not lifted; iii) commodity prices fall; or iv) the country experiences extreme climatic events<sup>142</sup>.

Although Mauritania's domestic public debt is predicted to decrease, the country's external debt remains high (~68% of GDP in 2022). This debt includes a passive debt in arrears to Kuwait (~12.8% of GDP), which has been under negotiation since the early 2000s. In 2020, many of Mauritania's creditors — including Saudi Arabia, Kuwait, China and the Arab Fund for Economic and Social Development — confirmed their participation in the Debt Service Suspension Initiative (DSSI) established by G20<sup>143</sup> and the Paris Club<sup>144</sup>. Under the DSSI, an estimated USD96 million (~1.2% of GDP) of Mauritania's debt service payments were rescheduled for 2022–2024<sup>145</sup> to help create fiscal space for pandemic relief. Additionally, in 2021, Saudi Arabia provided a further three-year grace period for its \$300 million (~3.7% of GDP) deposit at the Central Bank of Mauritania, now to be paid back in full by 2028<sup>146</sup>. If Mauritania's debt service payments go ahead as planned — with continued debt services support from the IMF, World Bank (WB) and African Development Bank (AfDB) — the country's external public debt is projected to decrease to ~54% of the GDP by 2026<sup>147</sup>.

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<sup>141</sup> AfDB Group. 2021. Mauritania Economic Outlook. Available at: <https://www.afdb.org/en/countries/mauritania/mauritania-economic-outlook>

<sup>142</sup> AfDB Group. 2021. Mauritania Economic Outlook. Available at: <https://www.afdb.org/en/countries/mauritania/mauritania-economic-outlook>

<sup>143</sup> An intergovernmental forum comprising 19 countries and the European Union (EU) whose role is to address threats to the global economy.

<sup>144</sup> A group of officials from major creditor countries whose role is to find co-ordinated and sustainable solutions to the payment difficulties experienced by debtor countries.

<sup>145</sup> International Monetary Fund. 2021. Islamic Republic of Mauritania: Sixth Review. Available at: <https://www.imf.org/en/Publications/CR/Issues/2021/03/11/Islamic-Republic-of-Mauritania-Sixth-Review-Under-the-Extended-Credit-Facility-Arrangement-50255>

<sup>146</sup> International Monetary Fund. 2021. Islamic Republic of Mauritania: Sixth Review. Available at: <https://www.imf.org/en/Publications/CR/Issues/2021/03/11/Islamic-Republic-of-Mauritania-Sixth-Review-Under-the-Extended-Credit-Facility-Arrangement-50255>

<sup>147</sup> International Monetary Fund. 2021. Islamic Republic of Mauritania: Sixth Review. Available at: <https://www.imf.org/en/Publications/CR/Issues/2021/03/11/Islamic-Republic-of-Mauritania-Sixth-Review-Under-the-Extended-Credit-Facility-Arrangement-50255>

### 1.2.3 Vulnerability of the population

Vulnerability describes the propensity of a population to be negatively impacted by hazards or unwanted events<sup>148</sup>. Some populations are more vulnerable to the impacts of climate change than others because of geographical location or socio-economic conditions<sup>149</sup>. A negative relationship exists between vulnerability and readiness, whereby increased capacity to make effective use of investments for adaptation actions generally reduces vulnerability<sup>150,151,152</sup>.

In 2019, Mauritania was ranked the 20<sup>th</sup> most vulnerable country to climate change and other global challenges on the Notre Dame Global Adaptation Initiative (ND-GAIN) country index. The country's overall sensitivity score (0.602) — which reflects the extent to which the country depends on 'climate change sensitive' sectors<sup>153</sup> — was rated the highest globally, based on prevailing insecurity within the food and water sectors<sup>154</sup>. Of 182 countries on the ND-GAIN readiness index, Mauritania was ranked as the 75<sup>th</sup> least ready to respond to climate change and other global challenges, with education and control of corruption comprising the country's worst-scoring readiness indicators<sup>155</sup>. The long-standing vulnerability of Mauritania's population, therefore, results from complex interactions between multiple baseline factors, including, *inter alia*: i) water scarcity; ii) food insecurity; iii) limited access to basic services, including healthcare and education; iv) widespread poverty; and v) political instability<sup>156</sup>. These factors are discussed in detail below.

#### **Water scarcity**

Approximately 75% of Mauritania's territory is covered by the Sahara Desert, with the remaining proportion falling in the semi-arid Sahel zone<sup>157,158</sup>. Given the prevalence of water scarcity in these environments, Mauritanian communities are exposed to the recurrent threat of drought, which drives chronic food and water shortages, malnutrition and livelihood fragility<sup>159</sup>. Although Mauritania's per capita water share (~2,800 m<sup>3</sup>/person/yr) is above the threshold that determines national water scarcity (1,700 m<sup>3</sup>/person/yr)<sup>160</sup>, the country's water resources are unequally distributed and difficult to mobilise (Section 1.4.1). As a result, Mauritanian communities are regularly confronted with acute water shortages — particularly in remote, inland areas such as the wilayahs of Hodh Chargui and Hodh El Gharbi<sup>161</sup>. Water insecurity is further exacerbated by the fact that ~96% of Mauritania's renewable water resources originate from upstream countries via the Senegal River, while only ~4%

<sup>148</sup> Intergovernmental Panel on Climate Change (IPCC). 2022. Climate change 2022: Impacts, adaptation and vulnerability — summary for policymakers. Available at: [https://report.ipcc.ch/ar6wg2/pdf/IPCC\\_AR6\\_WGII\\_FinalDraft\\_FullReport.pdf](https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf).

<sup>149</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index technical report. Available at: [https://gain.nd.edu/assets/254377/nd\\_gain\\_technical\\_document\\_2015.pdf](https://gain.nd.edu/assets/254377/nd_gain_technical_document_2015.pdf).

<sup>150</sup> Sarkodie SA & Strezov V. 2019. Economic, social and governance adaptation readiness for mitigation of climate change vulnerability: Evidence from 192 countries. *Science of the Total Environment*, 656:150–164.

<sup>151</sup> Sarkodie SA, Ahmed MF & Owusu PA. 2022. Global adaptation readiness and income mitigate sectoral climate change vulnerabilities. *Humanities and Social Sciences Communications*, 9:113. Available at: <https://www.nature.com/articles/s41599-022-01130-7.pdf>.

<sup>152</sup> IPCC. 2022. Climate change 2022: Impacts, adaptation and vulnerability — Summary for policymakers. Available at: [https://report.ipcc.ch/ar6wg2/pdf/IPCC\\_AR6\\_WGII\\_FinalDraft\\_FullReport.pdf](https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf).

<sup>153</sup> WB Group. 2021. Climate change knowledge portal: Mauritania — vulnerability. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/vulnerability>.

<sup>154</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index — Mauritania. Available at: <https://gain.nd.edu/our-work/country-index/rankings/>.

<sup>155</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index — Mauritania. Available at: <https://gain.nd.edu/our-work/country-index/rankings/>.

<sup>156</sup> United Nations Country Team (UNCT) Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>157</sup> The Sahel is a semi-arid region of western and north-central Africa, extending from Senegal eastward to Sudan. It forms a transitional zone between the arid Sahara (desert) to the north and the belt of humid savannas to the south.

<sup>158</sup> UNDP. 2022. Climate change adaptation — Mauritania. Available at: <https://www.adaptation-undp.org/explore/africa/mauritania>.

<sup>159</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>160</sup> World Water Assessment Programme (WWAP). 2012. The United Nations world water development report 4: Managing water under uncertainty and risk. Paris, UNESCO.

<sup>161</sup> Alliance Sahel. 2020. Strengthening access to drinking water supply and sanitation in Mauritania. Available at: <https://www.alliance-sahel.org/en/news/strengthening-access-to-drinking-water-supply-and-sanitation-in-mauritania/>.

are produced internally<sup>162,163</sup>, resulting in the GoM's limited control over both the quality and availability of water within the country's national borders. Moreover, the cumulative storage capacity of Mauritania's dams totals only ~0.9 km<sup>3</sup>, reflecting limited investment in infrastructure for harvesting, storing and distributing rainfall during the dry season<sup>164,165</sup>. For example, communities in the regional hub of Tamcheket rely on winter rainfall ~80 km away to feed ephemeral *wadis*<sup>166</sup> and, in isolated rural areas, water gatherers often travel several kilometres to the nearest water source each day<sup>167</sup>. Mauritania's dam capacity and water dependence ratio were consequently among the country's three worst-scoring indicators on the 2019 ND-GAIN vulnerability index<sup>168</sup>. Without year-round access to safe and reliable water supplies for drinking, sanitation and agriculture, Mauritania's population is vulnerable to substantial economic losses, damage to agricultural lands and compromised human health<sup>169</sup>.

## Food insecurity

Historical and prevailing water deficits have severely limited Mauritania's agricultural production, forcing the country to import 70–85% of its food each year since the early 1960s<sup>170</sup>. The population of Mauritania is still recovering from the 2011–2012 food and nutrition crisis in the Sahel<sup>171</sup>, during which chronic drought resulted in the loss of one-third of the country's cereal harvest. Additionally, high international food prices resulting from the 2011–2012 global food price spike<sup>172</sup> led to a reduction in the quantity of food imported for domestic consumption, further contributing to food insecurity<sup>173</sup>. In 2017, Mauritania's food security was further threatened by severe drought and an unusually long lean season<sup>174</sup>. As a result, ~550,000 individuals experienced food insecurity and ~124,000 were affected by malnutrition in 2018<sup>175</sup>. Although acute malnutrition<sup>176</sup> is a persistent cycle in Mauritania, with peaks

<sup>162</sup> Food and Agriculture Organisation (FAO). 2018. AQUASTAT – Mauritania. Available at: <https://www.fao.org/aquastat/statistics/query/results.html>

<sup>163</sup> United Nations Global Compact. 2020. Water action hub — Mauritania. Available at: <https://wateractionhub.org/geos/country/139/d/mauritania/>.

<sup>164</sup> UN Water Action Hub. 2022. Mauritania — Country overview. Available at: [https://wateractionhub.org/media/files/2020/08/20/Country\\_Profile\\_-\\_2020-08-20T100144.891.pdf](https://wateractionhub.org/media/files/2020/08/20/Country_Profile_-_2020-08-20T100144.891.pdf)

<sup>165</sup> Programme de Développement Durable des Oasis (PDDO). 2015. Oasis sustainable development programme project performance assessment. Available at: [https://www.ifad.org/documents/38714182/39731872/Mauritania+PPA+-+Executive+Summary\\_2016.pdf/599900e9-0722-4758-9327-5b5e9e4d0706](https://www.ifad.org/documents/38714182/39731872/Mauritania+PPA+-+Executive+Summary_2016.pdf/599900e9-0722-4758-9327-5b5e9e4d0706).

<sup>166</sup> Islamic Republic of Mauritania. 2017. Management plan for a resilient development of Tamcheket and its ecosystems. In: United Nations Environmental Programme (UNEP). 2019. Concept note: Strengthening the resilience of ecosystems and populations in four regional hubs in northern Mauritania. Available at: <https://www.greenclimate.fund/sites/default/files/document/22260-strengthening-resilience-ecosystems-and-populations-four-regional-hubs-northern-mauritania.pdf>.

<sup>167</sup> IRIN News. 2009. Water treks grow longer, rougher. Available at: <https://www.thenewhumanitarian.org/report/82178/mauritania-water-treks-grow-longer-rougher>.

<sup>168</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index — Mauritania. Available at: <https://gain.nd.edu/our-work/country-index/rankings/>.

<sup>169</sup> WB Group. 2021. Climate change knowledge portal: Mauritania — vulnerability. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/vulnerability>.

<sup>170</sup> Famine Early Warning Systems Network. 2018. Mauritania price — bulletin. Available at: [https://reliefweb.int/sites/reliefweb.int/files/resources/Mauritania\\_2018\\_01\\_PB\\_EN.pdf](https://reliefweb.int/sites/reliefweb.int/files/resources/Mauritania_2018_01_PB_EN.pdf).

<sup>171</sup> In 2011, poor rains combined with high food prices and a significant drop in migrants' remittances from Libya, Côte d'Ivoire and Europe signalled the start of a severe food and nutrition crisis across the Sahel. In December 2011, the Food Crisis Prevention Network estimated a cereal deficit of 2.6 million tons for the Sahel. Production was ~25% lower compared with estimates from 2010 and ~2% below the five-year average. By December 2011, the five most affected countries — Niger, Mauritania, Mali, Burkina Faso and Chad — had declared a crisis and called for humanitarian assistance. By the end of 2012, more than 18 million people had been impacted by the regional food crisis.

<sup>172</sup> In early 2011, after declining by ~30% from mid-2008 to mid-2010, The Bank Food Price index rose sharply, reaching a peak in February 2011. Thereafter, in mid-2012, world food prices escalated again. The Bank Food Price Index rose a further ~14% from January to August 2012, with world maize prices reaching an all-time high in July 2012 — surpassing their 2011 peak and rising by ~45% within a month. A possible reason for the increase in food prices may have been the increase in oil prices at the time, which resulted in increased demand for and production of biofuels.

<sup>173</sup> Humanitarian Aid Department of the European Commission (ECHO). 2013. 2012 Sahel food & nutrition crisis: ECHO's response at a glance. Available at: [https://ec.europa.eu/echo/files/aid/countries/ECHO\\_2012\\_Response\\_Sahel\\_Crisis\\_en.pdf](https://ec.europa.eu/echo/files/aid/countries/ECHO_2012_Response_Sahel_Crisis_en.pdf).

<sup>174</sup> The period between harvests that typically lasts from May to August in the Sahel.

<sup>175</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>176</sup> Acute malnutrition is a nutritional deficiency resulting from either inadequate energy or protein intake. Children with primary acute malnutrition are common in developing countries as a result of inadequate food supply caused by social, economic, and environmental factors.



occurring during the lean season (May–August) each year<sup>177</sup>, the country's nutritional status has further deteriorated since the start of the COVID-19 pandemic. In 2021, more than 1.3 million Mauritians experienced food insecurity and the acute malnutrition rate reached 11%<sup>178</sup>. As a result, the country's Ministry of Health estimates that ~136,000 acutely malnourished children — including ~33,000 cases of severe acute malnutrition — will require urgent care in 2022<sup>179</sup>. Malnutrition also severely impacts the country's refugee population; rates of delayed growth development in children are estimated to be ~24% within the Mbera refugee camp, of which ~5% are severe cases<sup>180</sup>.

Early response is critical for mitigating lean-season nutritional impacts. However, although food assistance operations typically require two to three months to procure and deliver food to vulnerable communities, funding for humanitarian aid is usually only received during the peak of the lean season<sup>181</sup>. For example, in 2018, the bulk of funding for food programmes was received between May–July — too late to cater for the population's needs during the peak of the lean season. As a result, aid is often delivered only after the population has experienced the most severe food shortages, with food assistance often unable to support the population's dietary needs.

## Limited access to services

### Healthcare

Mauritania's healthcare system is characterised by a shortage of both doctors (~0.2 physicians per 1,000 people)<sup>182</sup> and treatment facilities (~0.4 hospital beds per 1,000 people)<sup>183</sup>, particularly in rural areas. This is largely because most infrastructure projects are centralised around the capital city of Nouakchott<sup>184</sup>. Moreover, the national insurance programme only covers government officials and citizens who are formally employed, which further excludes the rural population and poverty-stricken people from equitable access to healthcare<sup>185</sup>. As a result of these inequalities, the country's healthcare system is ill-equipped to address the health impacts of climate change, such as the increased risk of heat stroke and water-borne diseases, and other global challenges — for example, the COVID-19 pandemic.

Mauritania's health status is defined by high morbidity and mortality rates, particularly in isolated rural areas, where access to healthcare is a major challenge. The country's epidemiological profile is dominated by communicable diseases of infectious and parasitic origin<sup>186</sup>. For example, more than 200,000 cases of malaria are reported in Mauritania each year. In 2011, malaria accounted for ~25% of morbidity and ~39% of mortality in health centres located in the Sahel zone<sup>187</sup>. In addition, it is estimated that ~2,150 Mauritians, including ~1,700 children below the age of five, die from diarrhoeal symptoms annually, with ~90% of these deaths resulting directly from insufficient access

<sup>177</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>178</sup> Food Security Commission of Mauritania. 2021. Cadre harmonisé Mars. Available at: [https://reliefweb.int/sites/reliefweb.int/files/resources/CH\\_Regional\\_Acute\\_Food\\_and\\_Nutrition\\_Insecurity\\_2021MarAug.pdf](https://reliefweb.int/sites/reliefweb.int/files/resources/CH_Regional_Acute_Food_and_Nutrition_Insecurity_2021MarAug.pdf).

<sup>179</sup> UNICEF. 2022. Humanitarian action for children — Mauritania. Available at: <https://reliefweb.int/sites/reliefweb.int/files/resources/2022-HAC-Mauritania.pdf>.

<sup>180</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>181</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>182</sup> WB. 2018. Physicians (per 1,000 people) — Mauritania. Available at: <https://data.worldbank.org/indicator/SH.MED.PHYS.ZS?locations=MR>.

<sup>183</sup> WorldData.info. 2022. Healthcare in Mauritania. Available at: <https://www.worlddata.info/africa/mauritania/health.php>.

<sup>184</sup> Bielskis O & the Borgen Project. 2020. 5 facts about healthcare in Mauritania. Available at: <https://borgenproject.org/healthcare-in-mauritania/>.

<sup>185</sup> Bielskis O & the Borgen Project. 2020. 5 facts about healthcare in Mauritania. Available at: <https://borgenproject.org/healthcare-in-mauritania/>.

<sup>186</sup> WHO. 2016. Country cooperation strategy — Mauritania. Available at: [http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief\\_mrt\\_en.pdf;jsessionid=EBB144F37EEC119F6040104A0E0058D0?sequence=1](http://apps.who.int/iris/bitstream/handle/10665/136941/ccsbrief_mrt_en.pdf;jsessionid=EBB144F37EEC119F6040104A0E0058D0?sequence=1).

<sup>187</sup> Malaria Control Unit. Mauritanian Ministry of Health. 2011. Plan stratégique de lutte contre le paludisme 2011–2015: Nouakchott.

to clean water and sanitation<sup>188</sup>. Only ~47% of malnutrition centres in Mauritania's rural and semi-urban areas have access to drinking water and sanitation services, which further reduces the quality of care provided and increases the admission time of patients in treatment<sup>189</sup>.

In addition to the aforementioned diseases, COVID-19 has further aggravated Mauritania's health and nutrition security. In the period of January–March 2021, Mauritania registered over 3,000 COVID-19 cases and 100 COVID-related deaths<sup>190</sup>. To address the ongoing pandemic, a vaccination campaign was initiated to protect the most exposed and vulnerable people; however, challenges that have limited the campaign's successful rollout include: i) securing enough vaccines; and ii) setting up logistics for transporting and storing vaccines in remote areas<sup>191</sup>. Approximately 1.4 million people, including ~740,000 children, have been identified as priority beneficiaries of the vaccine<sup>192</sup>.

### Education

Mauritania's youth represent almost half of the population. Education — particularly secondary and tertiary education — is therefore considered an important strategy for improving social readiness and identifying adaptation solutions in a local context<sup>193,194</sup>. Despite this status, education is one of Mauritania's worst-scoring indicators on the ND-GAIN readiness index<sup>195</sup>.

In 2020, Mauritania's gross enrolment rate for tertiary education was ~6% (~7% for men; ~4% for women); this estimate falls well below the global average of 40%<sup>196</sup>. The transition from primary education to secondary education is also low, with only ~39% of children aged 12–15 years attending secondary school in 2020<sup>197</sup>. To strengthen human capital, UNICEF suggests that children need to attain at least nine years of basic education<sup>198</sup>. Currently, the mean number of schooling years completed by adults over the age of 25 in Mauritania — after correcting for the level of content learned — is ~4.7 years (5.6 years for men; 3.8 years for women)<sup>199</sup>. Moreover, the COVID-19 pandemic has negatively impacted education in Mauritania, with the temporary closure of schools having prevented thousands of children from engaging in their regular learning process<sup>200</sup>.

Education improves youths' chances of being employed and plays an important role in building stable, resilient societies<sup>201</sup>. Accordingly, low levels of schooling in Mauritania increase the population's vulnerability to extreme environmental impacts, and economic and political shocks.

### Poverty

<sup>188</sup> WHO. 2013. Environmental health challenges in Mauritania. Available at: <https://www.who.int/news-room/feature-stories/detail/who-environmental-health-challenges-in-mauritania#:~:text=Around%20150%20Mauritanians%2C%20including%201700, sanitation%20and%20lack%20of%20hygiene.>

<sup>189</sup> UNICEF. 2022. Humanitarian action for children — Mauritania. Available at: <https://reliefweb.int/sites/reliefweb.int/files/resources/2022-HAC-Mauritania.pdf>.

<sup>190</sup> UNICEF. 2021. Mauritania COVID-19 situation report #01. Available: <https://www.unicef.org/media/96481/file/Mauritania-COVID-19-SitRep-March-2021.pdf>.

<sup>191</sup> UNICEF. 2021. Mauritania COVID-19 situation report #01. Available: <https://www.unicef.org/media/96481/file/Mauritania-COVID-19-SitRep-March-2021.pdf>.

<sup>192</sup> UNICEF. 2021. Mauritania COVID-19 situation report #01. Available: <https://www.unicef.org/media/96481/file/Mauritania-COVID-19-SitRep-March-2021.pdf>.

<sup>193</sup> Mercer J. 2010. Disaster risk reduction or climate change adaptation: Are we reinventing the wheel? *Journal of International Development*, 22(2):247–64.

<sup>194</sup> Tol R & Yohe GW. 2007. The weakest link hypothesis for adaptive capacity: An empirical test. *Global Environmental Change*, 17(2):218–27.

<sup>195</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index — Mauritania. Available at: <https://gain.nd.edu/our-work/country-index/rankings/>.

<sup>196</sup> WB. 2020. School enrollment, tertiary (gross %) — Mauritania. Available at: <https://data.worldbank.org/indicator/SE.TER.ENRR?locations=MR>.

<sup>197</sup> UNICEF. 2019. State of the world's children – 2019. Available at: <https://www.unicef.org/media/63016/file/SOWC-2019.pdf>.

<sup>198</sup> UNICEF. 2019. State of the world's children – 2019. Available at: <https://www.unicef.org/media/63016/file/SOWC-2019.pdf>.

<sup>199</sup> United Nations Development Program. 2020. Human development report — Mauritania. Available at: <https://hdr.undp.org/en/countries/profiles/MRT>.

<sup>200</sup> UNICEF. 2021. Mauritania COVID-19 situation report #01. Available: <https://www.unicef.org/media/96481/file/Mauritania-COVID-19-SitRep-March-2021.pdf>.

<sup>201</sup> Lewis SG. 2016. Reducing vulnerability and risk through educational planning. Available at: <https://www.globalpartnership.org/blog/reducing-vulnerability-and-risk-through-educational-planning>.

The vulnerability of Mauritania's population is exacerbated by high levels of poverty and dependence on 'climate change sensitive' sectors, including agriculture, fisheries, mining and livestock<sup>202</sup>. Approximately 6% of Mauritania's population live below the international poverty line (2011 purchasing power parity USD1.9 per day)<sup>203</sup> and ~28% below the national poverty line<sup>204</sup>. Moreover, 70% of the country's impoverished households live in rural areas and are mainly engaged in agriculture and livestock-rearing. As a result, access to basic services and facilities is unequal between rural and urban areas and major obstacles are encountered by those attempting to transition out of poverty, including: i) low consumption levels; ii) limited educational attainment; and iii) insufficient access to drinking water, sanitation and electricity within rural areas<sup>205</sup>.

Poverty is reinforced by low levels of education (as discussed above), which reduce individuals' formal employment opportunities and potential to earn a sufficient income. Low public education spending by the GoM has reduced the quality of Mauritania's public schools and reinforced discriminatory educational divides, as only the most affluent population can afford to enrol children in private schools, which cost ~4 times more than government-funded schools<sup>206</sup>. COVID-19-related private health expenditure and rising food prices have exacerbated financial burdens imposed on poverty-stricken households<sup>207</sup>, further limiting the capacity of vulnerable communities to adapt to climate change.

### Political instability

Mauritania's political history is characterised by considerable instability. Following its independence in 1960, the country's complex political climate has been underpinned by politicisation based on ethnic identity and the military's involvement in politics<sup>208</sup>. For example, every head of state has been an active or retired military officer (2007 is an exception to this) and every changeover in leadership preceding 2019 was in the form of a *coup d'état*<sup>209</sup>. For the first time in Mauritania's history, a change of succession occurred through a presidential election in 2019, with General Ould Ghazouani — representing the Union for the Republic political party — obtaining 52% of the population's votes<sup>210</sup>. Since 2019, however, two prime ministers and their entire government cabinets have resigned, with the most recent cabinet resignation occurring in March 2022<sup>211</sup>. As a result, government-affiliated projects and programmes have encountered several disruptions, reducing the country's governance readiness and capacity to adapt to global challenges, including those posed by climate change.

Because Mauritania's government is characterised by 'hyper-presidentialism' — wherein the electorate has limited power over decisions made by the president — corruption is a considerable challenge in Mauritania's government, and 'control of corruption' was rated one of Mauritania's worst-scoring indicators on the 2019 ND-GAIN readiness index<sup>212</sup>. The gross misappropriation of public funds by government officials — for example, via unlawful public land transactions and the

<sup>202</sup> WB Group. 2021. Climate change knowledge portal: Mauritania — vulnerability. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/vulnerability>.

<sup>203</sup> WB Group. 2020. Poverty and equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>204</sup> United Nations High Commissioner for Refugees (UNHCR) Mauritania. 2021. Protection and solutions strategy. Available at: <https://reliefweb.int/sites/reliefweb.int/files/resources/UNHCR%20strategy%20in%20Mauritania%202021-2025-1-32.pdf>.

<sup>205</sup> WB Group. 2020. Poverty and equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>206</sup> Association des Femmes Chefs de Familles & the Global Initiative. 2019. The violation of the right to education in Mauritania following the sale of public school lands. Available at: [https://tbinternet.ohchr.org/Treaties/CCPR/Shared%20Documents/MRT/INT\\_CCPR\\_CSS\\_MRT\\_35109\\_E.pdf](https://tbinternet.ohchr.org/Treaties/CCPR/Shared%20Documents/MRT/INT_CCPR_CSS_MRT_35109_E.pdf).

<sup>207</sup> WB Group. 2020. Poverty and equity brief — Mauritania. Available at: [https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global\\_POVEQ\\_MRT.pdf](https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/SM2020/Global_POVEQ_MRT.pdf).

<sup>208</sup> Bertelsmann Stiftung. 2022. BTI 2022 country report — Mauritania. Gütersloh: Bertelsmann Stiftung.

<sup>209</sup> Bertelsmann Stiftung. 2022. BTI 2022 country report — Mauritania. Gütersloh: Bertelsmann Stiftung.

<sup>210</sup> Bertelsmann Stiftung. 2022. BTI 2022 Country Report — Mauritania. Gütersloh: Bertelsmann Stiftung.

<sup>211</sup> North Africa Post. 2022. Mauritania: Government resigns. Available: <https://northafricapost.com/56660-mauritania-government-resigns.html>.

<sup>212</sup> University of Notre Dame Global Adaptation Initiative. 2022. Country index — Mauritania. Available at: <https://gain.nd.edu/our-work/country-index/rankings/>.

mismanagement of oil revenues — has reduced Mauritania's governance readiness and restricted the GoM's capacity to adapt to unwanted events, thereby increasing the vulnerability of the population.

## Refugees

Mauritania has maintained an open-door policy for refugees, particularly from the neighbouring country of Mali, where ongoing violence has forced over 140,000 people to leave their homes<sup>213,214</sup>. The wilayahs of Hodh Chargui and Hodh El Gharbi, which share a border with Mali, are among Mauritania's most rural and poverty-stricken areas. The influx of asylum seekers into these regions places additional pressure on already strained infrastructure and weak basic services — particularly in Hodh Chargui, where Mbera camp hosts ~70,000 refugees<sup>215,216</sup>. Mbera camp is highly dependent on the GoM and external humanitarian assistance<sup>217</sup>. Prior to the arrival of refugees in 2012, only ~36% of Mauritania's population had access to safe drinking water. The additional needs of over 80,000 displaced individuals have exacerbated constraints within the country's water and sanitation sectors<sup>218</sup>. Many Malian refugees migrated with their livestock, intensifying pressure on Mauritania's limited water and fodder supplies — which are barely sufficient to meet the needs of the local population<sup>219</sup>. In addition, refugees are dependent on food assistance, which is at risk after funding gaps throughout 2018 brought about a considerable decrease in the number of rations to be distributed<sup>220</sup>. With more than 28,000 school-aged refugee children in the Mbera refugee camp alone<sup>221</sup>, the subsequent overburdening of the education system in host districts has also negatively impacted the provision of education services within the most deprived areas<sup>222</sup>.

Despite a peace agreement in 2015, continued armed conflict in Mali prevents the safe return of asylum seekers. With no indication of the refugee crisis ending in the near future, local communities' perception of inequality in access to resources and basic services is growing<sup>223</sup>. As a result, the risk of tension between host populations and refugees is heightened, increasing individuals' susceptibility to the influence of nearby extremist groups<sup>224</sup>. The refugee crisis in Mauritania, therefore, increases the vulnerability of both locals and refugees by: i) exacerbating food and water shortages; ii) overburdening the country's health and education systems; iii) increasing the risk of radicalisation; and iv) placing additional pressure on the GoM's financial resources, thereby reducing the country's readiness and capacity to adapt to future climate change.

### 1.2.4 Gender and vulnerable groups considerations

<sup>213</sup> UNHCR. 2022. Mauritania. Available at: <https://reporting.unhcr.org/mauritania>.

<sup>214</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>215</sup> Alliance Sahel. 2020. Strengthening access to drinking water supply and sanitation in Mauritania. Available at: <https://www.alliance-sahel.org/en/news/strengthening-access-to-drinking-water-supply-and-sanitation-in-mauritania/>.

<sup>216</sup> ACAPS. 2022. Mauritania — Malian refugees. Available at: <https://www.acaps.org/country/mauritania/crisis/malian-refugees#:~:text=Over%2079%2C600%20Malian%20refugees%20and,asylum%20seekers%20in%20urban%20areas>.

<sup>217</sup> ACAPS. 2022. Mauritania — Malian refugees. Available at: <https://www.acaps.org/country/mauritania/crisis/malian-refugees#:~:text=Over%2079%2C600%20Malian%20refugees%20and,asylum%20seekers%20in%20urban%20areas>.

<sup>218</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>219</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>220</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>221</sup> UNICEF. 2020. Humanitarian action for children — Mauritania. Available at: <https://www.unicef.org/media/78031/file/2020-HAC-Mauritania.pdf>.

<sup>222</sup> UNICEF. 2018. Schools for Africa — Mauritania. Available at: <https://www.schoolsforafrica.org/media/551/file/Mauritania-SFA-Profile.pdf>.

<sup>223</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

<sup>224</sup> UNCT Mauritania. 2019. Mauritania: Fighting chronic vulnerabilities. Available at: <https://reliefweb.int/report/mauritania/mauritania-fighting-chronic-vulnerabilities-may-2019>.

Mauritania's legal system combines colonially inherited French Civil Law and Islamic Law<sup>225</sup>, which depends on local interpretation of *Sharia*<sup>226</sup>. For example, Article 1 of the country's Constitution<sup>227</sup> states that all citizens are equal before the law, prohibiting discrimination on several bases, including gender. However, in the absence of codified laws, the rules of Islamic legal theory (or *fiqh*<sup>228</sup>) apply, which often align with local conservative religious values<sup>229</sup>. Consequently, the duality of local religious customs and Mauritania's Constitution needs to be considered when discussing gender and vulnerable groups.

## Gender

In 2001, the GoM ratified the International Convention on the Elimination of all forms of Discrimination Against Women (CEDAW). However, a general reservation was entered upon accession, stipulating that only those articles in agreement with *Sharia*-based laws and the Mauritanian Constitution would be drafted into the country's Personal Status Code (PSC)<sup>230</sup>. Although this general reservation was partially removed in 2014, the GoM has not yet lifted reservations applying to articles 13(a) and 16 of CEDAW, which relate to: i) eliminating discrimination in family benefits; and ii) requiring equality in marriage and family matters. In 2014, the Organisation for Economic Co-operation and Development (OECD) rated Mauritania's inequality as 'Very High' on the Social Institutions and Gender Index<sup>231</sup>. Moreover, in 2020, the country was ranked 177<sup>th</sup> out of 190 economies globally on the index for Women, Business and the Law (WBL), which evaluates how women are affected by national legislation at several stages of their lives<sup>232</sup>. Mauritania's worst-scoring indicators in the WBL assessment included: i) women's access to assets; and ii) legal constraints relating to marriage — both of which received a score of 0 out of 100<sup>233</sup>, signifying that Mauritanian women remain subject to inequality within the country's legal framework.

Mauritania's PSC, established in 2001, serves as the primary codified law governing marriage and family relations in Mauritania<sup>234</sup>. Despite the equality guarantee under Article 1 of Mauritania's Constitution, Article 56 of the PSC provides a marital framework based on male guardianship over women and children<sup>235</sup>. This disparity is evident at the household level, where men hold legal authority and women are expected to assist in managing the family. Moreover, Mauritania's formal Labour Code reinforces conventional gender roles in the household by prohibiting women from working in specific industries (discussed in more detail below). However, ~50% of households in the focal hubs of Aoujeft, Rachid and Tamcheket are headed by women — mainly resulting from divorce, widowhood and the migration of men from rural to urban areas in search of work<sup>236</sup>.

Mauritanian women often enter marriage agreements at a young age. Although the legal age of marriage is 18 for both men and women, Article 6 of the PSC enables male guardians to contract a young girl into marriage should the arrangement be deemed in the minor's best interest. However,

<sup>225</sup> Serge ZN. 2009. Researching the Legal System and Laws of the Islamic Republic of Mauritania. Available at:

<https://www.nyulawglobal.org/globalex/Mauritania.html#legalsystem>

<sup>226</sup> *Sharia* is considered the fundamental religious concept of Islam. It is the ideal form of divine guidance that Muslims follow in an effort to live a righteous life. *Sharia* is derived from two main sources: i) the Quran (Islam's holy book); and ii) *Sunnah* (sayings and practices attributed to the Prophet Mohammed).

<sup>227</sup> Constitute Project. 2021. Mauritania. Available at: <https://www.constituteproject.org/countries/Africa/Mauritania?lang=en>

<sup>228</sup> *Fiqh* describes human interpretation of *Sharia*. It forms the basis of Islamic legal theory in many countries.

<sup>229</sup> Musawah. 2017. Mauritania: Overview of Muslim family laws & practices. Available at: <https://www.musawah.org/wp-content/uploads/2019/03/Mauritania-Overview-Table.pdf>

<sup>230</sup> United Nations Treaty Collection. 2022. Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) — Mauritania. Available at:

<https://treaties.un.org/Pages/Declarations.aspx?index=Mauritania&lang=en&chapter=4&treaty=334#EndNotes%20Section>

<sup>231</sup> Organisation for Economic Co-operation and Development (OECD). 2014. Social Institutions and Gender Index: Mauritania. Available at: <https://www.genderindex.org/wp-content/uploads/files/datasheets/MR.pdf>

<sup>232</sup> WB. 2020. Women, Business and the Law (WBL). Washington, DC: <https://doi.org/10.1596/978-1-4648-1532-4>

<sup>233</sup> WB. 2021. WBL 2021: Mauritania. Available at: <https://wbl.worldbank.org/content/dam/documents/wbl/2021/snapshots/Mauritania.pdf>

<sup>234</sup> Musawah. 2017. Mauritania: Overview of Muslim family laws & practices. Available at: <https://www.musawah.org/wp-content/uploads/2019/03/Mauritania-Overview-Table.pdf>

<sup>235</sup> Musawah. 2017. Mauritania: Overview of Muslim family laws & practices. Available at: <https://www.musawah.org/wp-content/uploads/2019/03/Mauritania-Overview-Table.pdf>

<sup>236</sup> Appendix 1

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since the PSC does not specify what these ‘best interests’ entail, young girls are often married off to alleviate family members of the financial responsibilities associated with childcare. Indeed, Mauritanian girls are more likely to marry early if they live in rural areas and are from poorer socio-economic groups<sup>237</sup>. As a result, child marriage remains widespread in Mauritania, particularly in rural areas, where there is no minimum age for customary marriage<sup>238</sup>. More than one third (~34%) of Mauritanian women between the ages of 20–49 were married before the age of 18. Additionally, ~25% of women within the same age group had given birth to their first child before the age of 18<sup>239,240</sup>. In contrast, ~4% of Mauritanian boys marry before the age of 18<sup>241</sup>.

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<sup>237</sup> Male, Chata; Wodon, Quentin. 2016. Basic Profile of Child Marriage in Mauritania. Health, Nutrition and Population Knowledge Brief;. WB, Washington, DC. © World Bank. Available: <http://hdl.handle.net/10986/24551>

<sup>238</sup> WB. 2021. WBL 2021: Mauritania. Available at: <https://wbl.worldbank.org/content/dam/documents/wbl/2021/snapshots/Mauritania.pdf>

<sup>239</sup> WB. 2021. Mauritania Economic Update: Why it is Essential to Enable Women to Participate Fully in Economic Activity? Available at: <https://www.worldbank.org/en/country/mauritania/publication/mauritania-economic-update-why-it-is-essential-to-enable-women-to-participate-fully-in-economic-activity>

<sup>240</sup> WB. 2021. Quatrième rapport sur la Situation Économique en Mauritanie: Un meilleur avenir: accélérer la relance économique en misant sur le potentiel des femmes © World Bank. Available at: <https://documents1.worldbank.org/curated/en/961341622141230195/pdf/Rapport-sur-la-Situation-Economique-en-Mauritanie-Un-Meilleur-Avenir-Accelerer-la-Relance-Economique-en-Misant-sur-le-Potentiel-Femmes.pdf>

<sup>241</sup> Islamic Republic of Mauritania. 2016. Enquête par grappes à indicateurs multiples MICS 2015. Available: [https://mics-surveys-prod.s3.amazonaws.com/MICS5/West%20and%20Central%20Africa/Mauritania/2015/Final/Mauritania%202015%20MICS\\_French.pdf](https://mics-surveys-prod.s3.amazonaws.com/MICS5/West%20and%20Central%20Africa/Mauritania/2015/Final/Mauritania%202015%20MICS_French.pdf)

## Education

Although the gross enrolment rates for boys and girls in Mauritania are approximately equal, child marriage and early childbearing jeopardise girls' chances of completing school. Between 2010 and 2018, only ~56% of Mauritanian girls completed primary school, compared with ~64% of boys. Moreover, in 2018, ~40% of secondary school-aged girls were out of school compared with 33% of boys in the same age group. However, secondary school completion rates for the same period were low for both girls and boys (15% and 14% respectively<sup>242</sup>), reflecting low levels of teacher competence, poor management of the education sector, the poor condition of school facilities and low continuity in the education cycle<sup>243</sup>. Although the literacy rate for Mauritanian women (~57%) is considerably higher than the average for women in the Sahel region (~33%)<sup>244</sup>, it remains low compared with the literacy rate for Mauritanian men (~70%)<sup>245</sup>. This discrepancy is particularly evident in the Tagant wilayah (Rachid hub), where the women's literacy rate is ~34%, compared with the men's literacy rate of ~42%. Within the Adrar wilayah (Aoujeft hub), the women's literacy rate (~27%) is slightly higher than the men's (~22%); however, both are considerably lower than the national average, reflecting limited access to education for both girls and boys in rural areas<sup>246</sup>. As a result of low women's literacy rates and the PSC's reinforcement of conventional gender roles, young women are also ~50% less likely to enrol in tertiary education than young men<sup>247</sup>.

## Labour force participation

Although the GoM has ratified International Labour Organisation conventions on discrimination and equal remuneration in the workplace, women's labour force participation remains low (~31% of total work force<sup>248</sup>) and employed women are still subjected to a pronounced gender pay gap<sup>249</sup>. Article 57 of the PSC stipulates that married women have the right to choose and practise their profession within the bounds permitted by *Sharia*; however, there is no clear description of what these bounds entail<sup>250</sup>. Under the national Labour Code, women are prohibited from working night hours in specific environments, including factories, plants and mining quarries. In addition, the Labour Code prohibits women from working in occupations considered dangerous, arduous or immoral<sup>251</sup>, including, *inter alia*: i) work within the transport industry; ii) work involving 'heavy lifting' or the use of large machinery; and ii) work taking place within chemical treatment plants<sup>252</sup>. To evade labour policies restricting their participation in the formal sector, women often seek employment opportunities in unregulated environments. Women are therefore over-represented in the informal sector (~58% of informal work force), where they forego social security benefits and protection by labour laws<sup>253</sup>. As a result, many

<sup>242</sup> UNICEF. 2019. State of the World's Children – 2019. Available at: <https://www.unicef.org/media/63016/file/SOWC-2019.pdf>

<sup>243</sup> WB. 2020. Mauritania: Improving Education to Foster Social Cohesion and Support Economic Development. Available at: <https://www.worldbank.org/en/country/mauritania/publication/improving-education-to-foster-social-cohesion>

<sup>244</sup> UNESCO Institute for Lifelong Learning (UIL). 2020. UIL launches study on literacy in the Sahel region. Available at: <https://uil.unesco.org/literacy/uil-launches-study-literacy-sahel-region>

<sup>245</sup> WB. 2021. Quatrième rapport sur la Situation Économique en Mauritanie: Un meilleur avenir: accélérer la relance économique en misant sur le potentiel des femmes © World Bank. Available at: <https://documents1.worldbank.org/curated/en/961341622141230195/pdf/Rapport-sur-la-Situation-Economique-en-Mauritanie-Un-Meilleur-Avenir-Accelerer-la-Relance-Economique-en-Misant-sur-le-Potentiel-Femmes.pdf>

<sup>246</sup> Appendix 1

<sup>247</sup> WB. 2021. Quatrième rapport sur la Situation Économique en Mauritanie: Un meilleur avenir: accélérer la relance économique en misant sur le potentiel des femmes © World Bank. Available at: <https://documents1.worldbank.org/curated/en/961341622141230195/pdf/Rapport-sur-la-Situation-Economique-en-Mauritanie-Un-Meilleur-Avenir-Accelerer-la-Relance-Economique-en-Misant-sur-le-Potentiel-Femmes.pdf>

<sup>248</sup> WB. 2020. Labor force, female (% of total labor force) – Mauritania. Available at: <https://data.worldbank.org/indicator/SL.TLF.TOTL.FE.ZS?locations=MR>

<sup>249</sup> OECD. 2019. Social Institutions and Gender Index: Mauritania. Available at: <https://www.genderindex.org/wp-content/uploads/files/datasheets/2019/MR.pdf>

<sup>250</sup> Musawah. 2017. Mauritania: Overview of Muslim family laws & practices. Available at: <https://www.musawah.org/wp-content/uploads/2019/03/Mauritania-Overview-Table.pdf>

<sup>251</sup> OECD. 2019. Social Institutions and Gender Index: Mauritania. Available at: <https://www.genderindex.org/wp-content/uploads/files/datasheets/2019/MR.pdf>

<sup>252</sup> International Labour Organization. 2017. Mauritania — Maternity protection — 2011. Available at: [https://www.ilo.org/dyn/travail/travmain.sectionReport1?p\\_lang=en&p\\_structure=3&p\\_year=2011&p\\_start=1&p\\_increment=10&p\\_sc\\_id=2000&p\\_countries=MR&p\\_print=Y#:~:text=No%20woman%20or%20pregnant%20woman,work%20in%20mines%20or%20quarries.](https://www.ilo.org/dyn/travail/travmain.sectionReport1?p_lang=en&p_structure=3&p_year=2011&p_start=1&p_increment=10&p_sc_id=2000&p_countries=MR&p_print=Y#:~:text=No%20woman%20or%20pregnant%20woman,work%20in%20mines%20or%20quarries.)

<sup>253</sup> OECD. 2019. Social Institutions and Gender Index: Mauritania. Available at: <https://www.genderindex.org/wp-content/uploads/files/datasheets/2019/MR.pdf>

women and young girls are vulnerable to discrimination and sexual harassment in the workplace, particularly in rural areas<sup>254</sup>.

### *Proprietary rights*

Under the Constitution, women and men are guaranteed equal rights to own property and land. However, under customary *Sharia* law, women cannot purchase or transfer land without the authorisation of a third party — generally a male guardian or family member. Women's access to land ownership is therefore limited, particularly in rural areas where governance is generally weak and common use of customary law has helped maintain the tradition of denying women equal access to land<sup>255</sup>. In rural communities in northern Mauritania, property ownership is considered a major life goal and achievement; however, a customary patrilineal inheritance system prevents most women from acquiring land and the issue of land tenure remains complicated. In 2015, women represented only 7.9% of registered landowners in Mauritania and only ~4% of landowners in rural areas<sup>256</sup>. Since agricultural practices provide an important source of income in rural areas, limited access to farmlands indirectly excludes women from participating in this economic activity. Compounding women's difficult access to land ownership are: i) high poverty rates; ii) low levels of education among women; and iii) challenges associated with retaining property after being divorced or widowed<sup>257</sup>.

### *Access to finance and income*

Under the Constitution, Mauritanian men and women have equal rights to open a bank account, access credit and register a business, regardless of their marital status. However, as a result of cultural norms and gender roles — which designate administrative decision-making power to men and restrict women's participation in certain economic activities, as discussed above — only ~15% of women held bank accounts in 2017, compared with 26% of men. Similarly, in 2017 only ~3% of registered Mauritanian companies were majority-owned by women<sup>258</sup>. Between 2009–2012, the GoM developed a National Plan of Action for Rural Women<sup>259</sup>, in which it laid out specific actions to strengthen the role of women in business. These included: i) promoting savings in rural communities; ii) strengthening and developing microfinance structures; and iii) establishing financial tools and fiscal management training programs for rural women. However, many women still face challenges in accessing formal financial services, including: i) the traditional roles of men as the head of the household and decision-makers in the family; ii) women's limited access to land and livestock or other assets that could be used as a collateral guarantee; and iii) low levels of literacy and education among women<sup>260</sup>.

### **Disabled peoples**

In 2019, ~33,920 people living with a disability were recorded in Mauritania, of which 18.4% were under 15 years old<sup>261</sup>. Although the GoM has ratified the Convention on the Rights of Persons with

<sup>254</sup> CEDAW. 2014. Concluding observations on the combined second and third periodic reports of Mauritania. Available at: <https://digitallibrary.un.org/record/779095?ln=en>

<sup>255</sup> WB. 2015. Women's Access to Land in Mauritania: A case Study in Preparation for the COP. Washington D.C. Available at: <https://documents1.worldbank.org/curated/pt/224621467991907919/pdf/100049-WP-PUBLIC-Box393216B-Women-s-Access-to-Land-in-Mauritania.pdf>

<sup>256</sup> WB. 2015. Women's Access to Land in Mauritania: A case Study in Preparation for the COP. Washington D.C. Available at: <https://documents1.worldbank.org/curated/pt/224621467991907919/pdf/100049-WP-PUBLIC-Box393216B-Women-s-Access-to-Land-in-Mauritania.pdf>

<sup>257</sup> Salamata B, Baro M & O'Sullivan N. 2015. Women's access to land in Mauritania: a case study in preparation for the COP. In: OECD. 2019. Social Institutions and Gender Index: Mauritania. Available at: <https://www.genderindex.org/wp-content/uploads/files/datasheets/2019/MR.pdf>

<sup>258</sup> WB. 2021. Quatrième rapport sur la Situation Économique en Mauritanie: Un meilleur avenir: accélérer la relance économique en misant sur le potentiel des femmes © World Bank. Available at: <https://documents1.worldbank.org/curated/en/961341622141230195/pdf/Rapport-sur-la-Situation-Economique-en-Mauritanie-Un-Meilleur-Avenir-Accelerer-la-Relance-Economique-en-Misant-sur-le-Potentiel-Femmes.pdf>

<sup>259</sup> Islamic Republic of Mauritania. 2008. Plan d'action national pour la femme rurale (2009-2012). Available at: <https://www.ilo.org/dyn/natlex/docs/MONOGRAPH/96687/114335/F1693895911/MRT-96687.pdf>

<sup>260</sup> CEDAW. 2014. Concluding observations on the combined second and third periodic reports of Mauritania. Available at: <https://digitallibrary.un.org/record/779095?ln=en>

<sup>261</sup> UNICEF. Mouna, au-delà du handicap: Camp de réfugiés de Mbera (Hodh Ech Chargui — Mauritanie). Available: <https://www.unicef.org/mauritania/recits/mouna-au-del%C3%A0-du-handicap>



Disabilities (CRPD) and its Optional Protocol<sup>262</sup>, persons with disabilities remain vulnerable to exclusion from socio-economic development initiatives, since the Mauritanian Constitution contains no specific provisions addressing disability. Approximately 50% of persons with disabilities have not received an education, with only ~13% having undergone primary education and even fewer having received quality inclusive<sup>263</sup> education<sup>264</sup>. An act passed in 1975 (Article 9 of Act 5-203) provides that disabled students may be permanently excluded from schooling by the regional director of basic education after consulting the Council of Teachers on the basis of a medical certificate, or for behaviour that jeopardises the smooth running of the school<sup>265</sup>. Since 1985, UNICEF, the Ministry of Health and Social Affairs, the Ministry of National Education, national disabled peoples' organisations and other civil society organisations, have worked with caregivers and communities to: i) identify children with special needs in Mauritania; ii) transform schools and public facilities into disability-friendly spaces; and iii) ensure that teachers have sufficient training to support children with disabilities. In 2014, with support from these organisations, the GoM established the country's first government-run centre for the training and social promotion of children with disabilities<sup>266</sup>. To further strengthen the inclusion of all people within Mauritanian communities, the specific needs of persons with disabilities should be given special consideration when planning project interventions.

## Refugees

Since 2012, ongoing conflict in Mali — following a failed military *coup d'état*, renewed fighting between Government forces and Tuareg rebels, and seizure of the country's northern territory by radical extremists — has driven the displacement of Malian citizens into Mauritania. As a result of its comparatively stable political situation and open-door policy for refugees and asylum-seekers, Mauritania has long been a transit and destination country for refugees and migrants passing through to North Africa and Europe<sup>267</sup>. In 2021, over 79,600 refugees and asylum seekers from Mali were registered in Mauritania. Of these, ~67,800 refugees live within Mbera camp — the country's largest refugee camp — which is dependent on the GoM and international humanitarian aid<sup>268</sup>. Humanitarian organisations' strategies for the camp focus on: i) ensuring access to basic services, such as healthcare, education and the provision of water and sanitation; ii) supporting economic empowerment through support for micro- and small enterprises, cultivation of gardens and on-the-job training for men and women from both refugee and host communities; and iii) ensuring durable solutions and peaceful coexistence with the local community. Undocumented refugees, including pre-registered asylum seekers, face several protection risks in Mauritania, including arrests, movement restrictions and exploitation within the informal employment sector. Moreover, in recent years, refugees' access to humanitarian relief has been unpredictable, largely as a result of security concerns and lockdowns relating to the COVID-19 pandemic<sup>269</sup>. In 2021 — with support from the United Nations High Commissioner for Refugees (UNHCR) and the World Food Programme (WFP) — the GoM announced that refugee households would be included in the National Social Registry of Mauritania. This decision has allowed eligible refugees to benefit from free primary healthcare, monthly food and cash distributions and other forms of assistance provided under national social protection programmes<sup>270</sup>.

<sup>262</sup> International Disability Alliance. 2012. Mauritania Ratifies the CRPD. Available at: <https://www.internationaldisabilityalliance.org/blog/mauritania-ratifies-crpdt>

<sup>263</sup> Opportunity that does not discriminate by gender, disability or geography.

<sup>264</sup> UNICEF. 2018. Schools for Africa: Mauritania. Available at: <https://www.schoolsforafrica.org/media/551/file/Mauritania-SFA-Profile.pdf>

<sup>265</sup> UNESCO. 2021. Mauritania — Inclusion. Available at: <https://education-profiles.org/sub-saharan-africa/mauritania/~inclusion>

<sup>266</sup> Chembe K & Fagbayibo Y. 2018. Country report: Republic of Mauritania. *African Disability Rights Yearbook*, 6: 184-212. Available at: <http://doi.org/10.29053/2413-7138/2018/v6n1a9>

<sup>267</sup> United Nations News. 2022. Mali: Security Council warned of 'endless cycle of instability'. Available: <https://news.un.org/en/story/2022/01/1109552>

<sup>268</sup> ACAPS. 2022. Mauritania. Available at: <https://www.acaps.org/country/mauritania/crisis/malian-refugees#:~:text=Over%2079%2C600%20Malian%20refugees%20and,asylum%20seekers%20in%20urban%20areas.>

<sup>269</sup> ACAPS. 2022. Mauritania

<sup>270</sup> UNHCR-World Food Programme (WFP). 2021. Mauritania: Supporting inclusion of refugees in the national social safety net. Available at: <https://data2.unhcr.org/en/documents/details/85513>

### 1.3 Climate baseline

Using the Koppen-Geiger climate classification system, the climate for the majority of Mauritania is classified as a hot, arid desert<sup>271</sup>, with a small section within the southern Sahel region defined as hot, arid steppe<sup>272,273</sup>. Although both climate types have average annual temperatures above 18°C and low precipitation, the hot, arid desert is defined as having less precipitation than the hot, arid steppe. Mauritania's climate is affected primarily by: i) north-eastern trade winds and the north-east or easterly *harmattan* wind<sup>274</sup> in the north of the country, the combination of which brings dry air and sand from the Sahara<sup>275</sup>; ii) the Inter-Tropical Convergence Zone (ITCZ), which oscillates between the northern and southern tropics and controls the country's wet and dry seasons<sup>276</sup>; and iii) ocean moisture transfer to the mainland from the West African Monsoon (WAM)<sup>277</sup>. The sections below describe the country's temperature, rainfall and wind patterns, as well as major existing climate hazards. The specific climate conditions from 1981–2010 in the four target hubs are also presented using data from four representative weather observation stations, namely Néma (Nema, Hub 1), Aïoun (Tamcheket, Hub 2), Tidjikja (Rachid, Hub 3) and Atar (Aoujeft, Hub 4)<sup>278</sup>.

#### 1.3.1 Temperature

Mauritania's average annual temperature is 28°C, with an average minimum and maximum temperature of 21°C and 36°C, respectively<sup>279</sup>. The country shows a distinct seasonal variation in temperature, with the minimum and maximum temperatures of winter and summer, respectively, varying considerably. The winter months of December to February have the lowest average minimum (13–15°C) and maximum (28–31°C) values across the year, while the summer months of June and July show the highest temperatures (minimum of 26°C and maximum of 41–42°C; Figure 8). In addition to the seasonal variation, the country exhibits a distinct spatial temperature gradient, with the north-western areas having cooler temperatures on average compared with the hotter south-eastern regions (Figure 9). The annual temperature range across the country varies from 13–40°C, with coastal areas having the lowest temperature range and the inland regions of the north-east exhibiting the highest temperature range. This spatial variation results from changes in latitude and distance from the coast and the corresponding moderating influence of the ocean (Figure 9).

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<sup>271</sup> Hot arid desert is defined by a climate where the annual precipitation is less than 50% of a predetermined precipitation threshold and where average annual temperatures are above 18°C within low latitude areas.

<sup>272</sup> Hot arid steppe otherwise known as hot semi-arid climate is defined by a climate where the annual precipitation is more than 50% of a predetermined precipitation threshold and where average annual temperatures are above 18°C within low latitude areas.

<sup>273</sup> Peel MC, Finlayson BL & McMahon TA. 2007. Updated world map of the Koppen-Geiger climate classification. *Hydrological Earth System Science*, 11: 1633–1644.

<sup>274</sup> The *harmattan* is a dry north-east or easterly wind that is strongest from late November to mid-March and which is known for carrying large amounts of sand and dust.

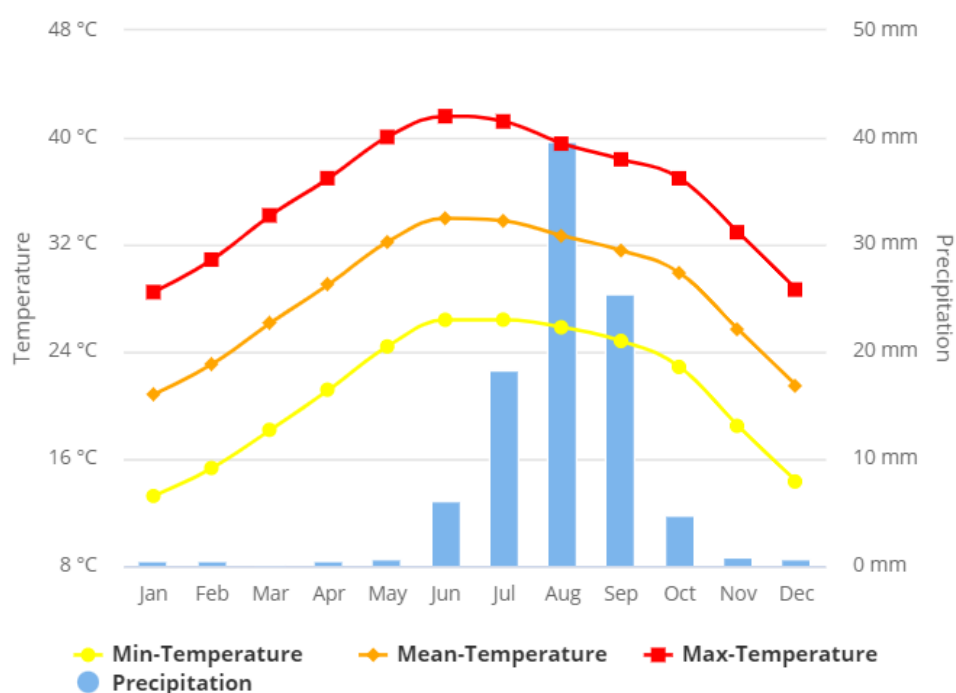
<sup>275</sup> Federal Ministry for Economic Cooperation and Development. N.d. Climate risk profile: Mauritania. Available at: [https://publications.pik-potsdam.de/rest/items/item\\_25252\\_1/component/file\\_25270/content](https://publications.pik-potsdam.de/rest/items/item_25252_1/component/file_25270/content).

<sup>276</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology.

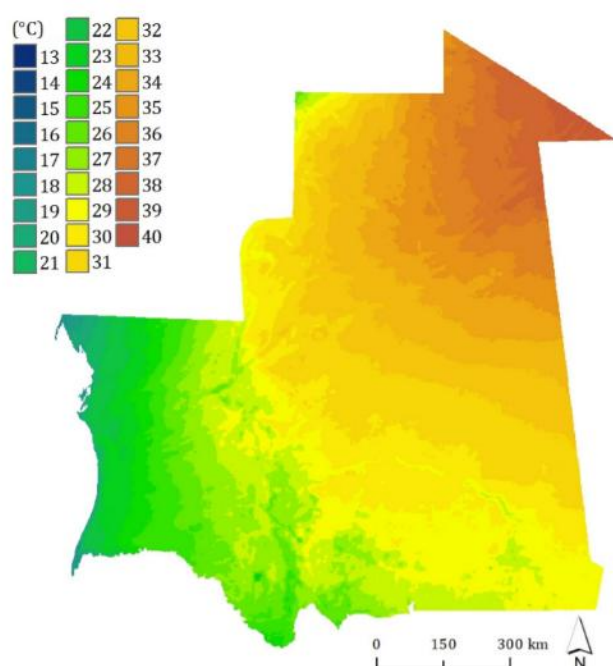
<sup>277</sup> The West African Monsoon is a major wind system that influences West African countries and is characterised by winds that blow south-westerly during the warmer months and north-easterly during the cooler months of the year.

<sup>278</sup> Appendix 3

<sup>279</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-historical>.



**Figure 8.** Minimum, average and maximum monthly temperature, as well as monthly precipitation for Mauritania for the period from 1991-2020<sup>280</sup>.



**Figure 9.** Annual temperature variation for Mauritania<sup>281</sup>.

Across the four project hubs, the recorded temperatures from 1981–2010 range from an average daily minimum of 22°C to an average daily maximum of 35°C<sup>282</sup> (Table 2). The highest daily maximum

<sup>280</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-historical>.

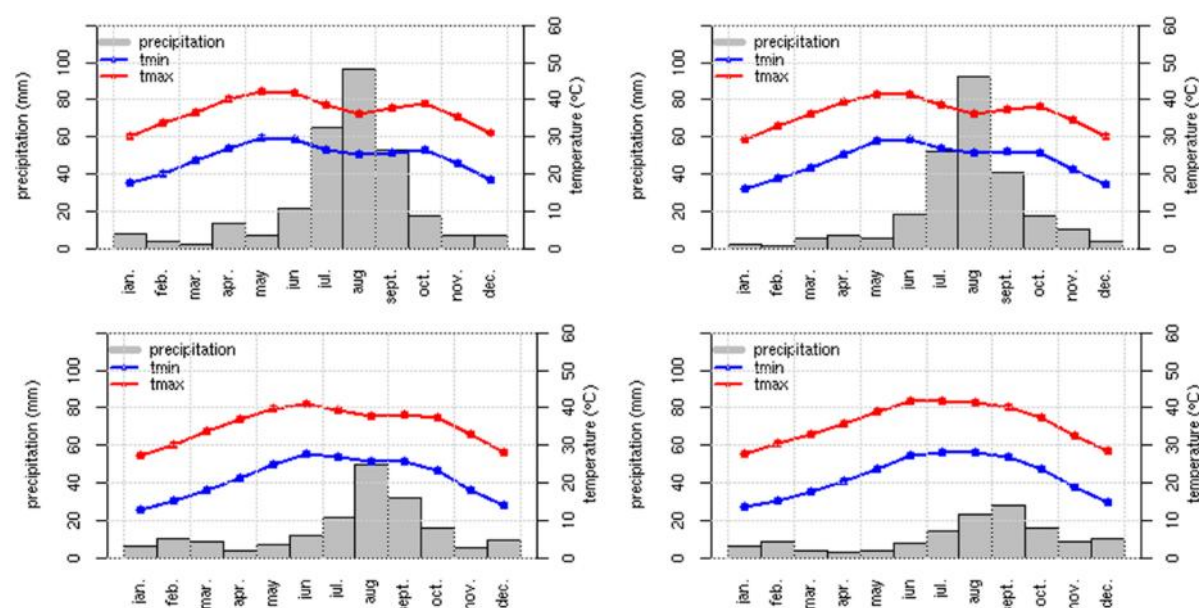
<sup>281</sup> Fick SE & Hijmans RJ. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37: 4302-4315. Available at: <https://www.worldclim.org/>.

<sup>282</sup> Appendix 3

temperature across the four hubs is 48°C. Aoujeft has the highest temperature range of the four hubs, varying from 5–48°C, as a result of it being the most northerly hub. The average monthly temperatures for the hubs are lowest in the winter months of December to February and highest in the summer months of May to July (Figure 10) — which is the same as the national average trend discussed above.

**Table 2.** Daily minimum and maximum temperatures recorded for the four hubs from 1981 to 2010<sup>283</sup>.

Weather station/hub	Daily minimum temperature (°C)		Daily maximum temperature (°C)	
	Average	Observed range	Average	Observed range
Nema	25	8–38	37	18–47
Tamcheket	24	8–37	37	17–47
Rachid	22	6–34	36	17–47
Aoujeft	22	5–37	36	17–48



**Figure 10.** Monthly average minimum and maximum temperature (°C) and precipitation (mm) from 1981–2010 for the four target hubs, showing Nema (top left), Tamcheket (top right), Rachid (bottom left) and Aoujeft (bottom right)<sup>284</sup>.

### 1.3.2 Rainfall

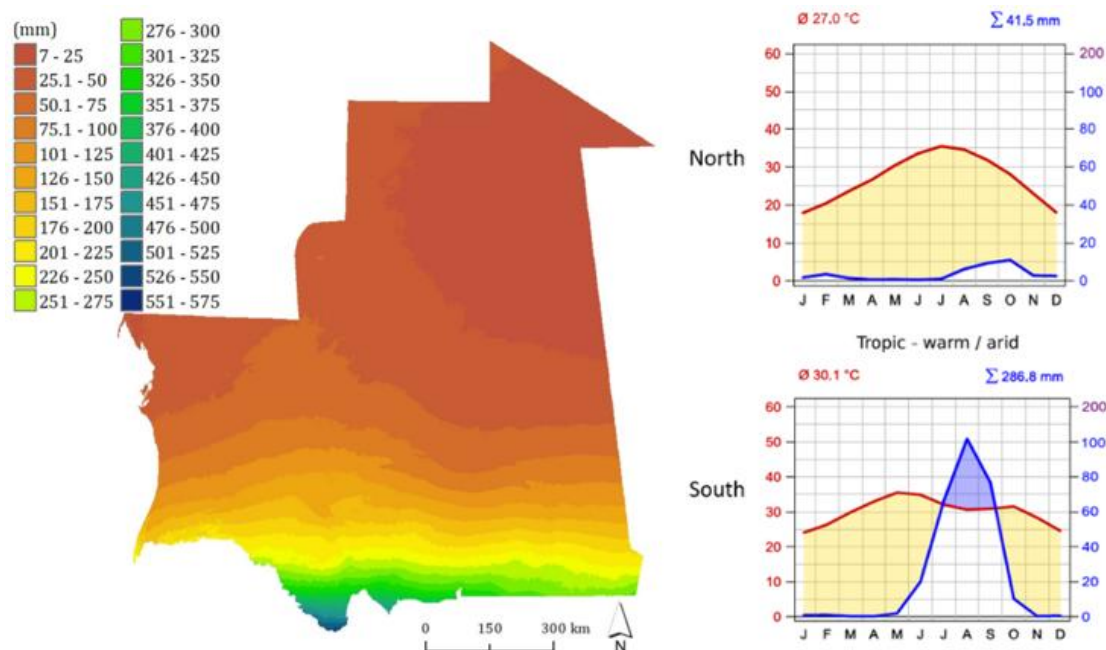
Mauritania's average annual precipitation is 98 mm<sup>285</sup>, which varies from 7–575 mm per year in different parts of the country<sup>286</sup>. There is a clear latitudinal gradient in rainfall, with the wettest areas found in the south of the country near the Senegal River — coinciding with the hot and arid steppe climate type — and precipitation decreasing sharply in the central and northern regions, which fall within the hot arid desert climate (Figure 11). This spatial variation in precipitation — in combination with geographical differences in temperature — affects the distribution of ecosystems across the country (Section 1.5). Mauritania has one wet season from June to October, with August being the wettest month, with an average rainfall of 40 mm (Figure 11). The length of the wet season and degree of rainfall decreases from the southern to the northern regions of the country (Figure 11).

<sup>283</sup> Appendix 3

<sup>284</sup> Appendix 3

<sup>285</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-historical>.

<sup>286</sup> Fick SE & Hijmans RJ. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37: 4302-4315. Available at: <https://www.worldclim.org/>.



**Figure 11.** Annual precipitation for Mauritania<sup>287</sup> showing temperature and rainfall regimes in the north and south of the country<sup>288</sup>.

In line with the rainfall patterns described above, the southern hubs of Nema and Tamcheket receive the highest annual rainfall over the greatest number of days, averaging 216 mm per year over 18 and 20 days, respectively (Table 3). In contrast, Aoujeft and Rachid receive less than half of the annual precipitation compared with Nema and Tamcheket, which occurs over 9 and 10 days. Nema experiences the highest variability in rainfall out of the four hubs, ranging from 43–454 mm per year. Across the four hubs, the wet season occurs from July to September and is least pronounced in the Aoujeft hub (Figure 10).

**Table 3.** Annual precipitation (mm) and number of days with precipitation per year for the four hubs<sup>289</sup>.

Hub	Annual precipitation (mm)			Number of days with precipitation/year		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Nema	216	43	454	18	8	28
Tamcheket	216	117	379	20	13	30
Rachid	95	4	286	10	2	18
Aoujeft	76	7	207	9	2	19

<sup>287</sup> Fick SE & Hijmans RJ. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37: 4302-4315. Available at: <https://www.worldclim.org/>.

<sup>288</sup> Federal Ministry for Economic Cooperation and Development. N.d. Climate risk profile: Mauritania. Available at: [https://publications.pik-potsdam.de/rest/items/item\\_25252\\_1/component/file\\_25270/content](https://publications.pik-potsdam.de/rest/items/item_25252_1/component/file_25270/content).

<sup>289</sup> Appendix 3

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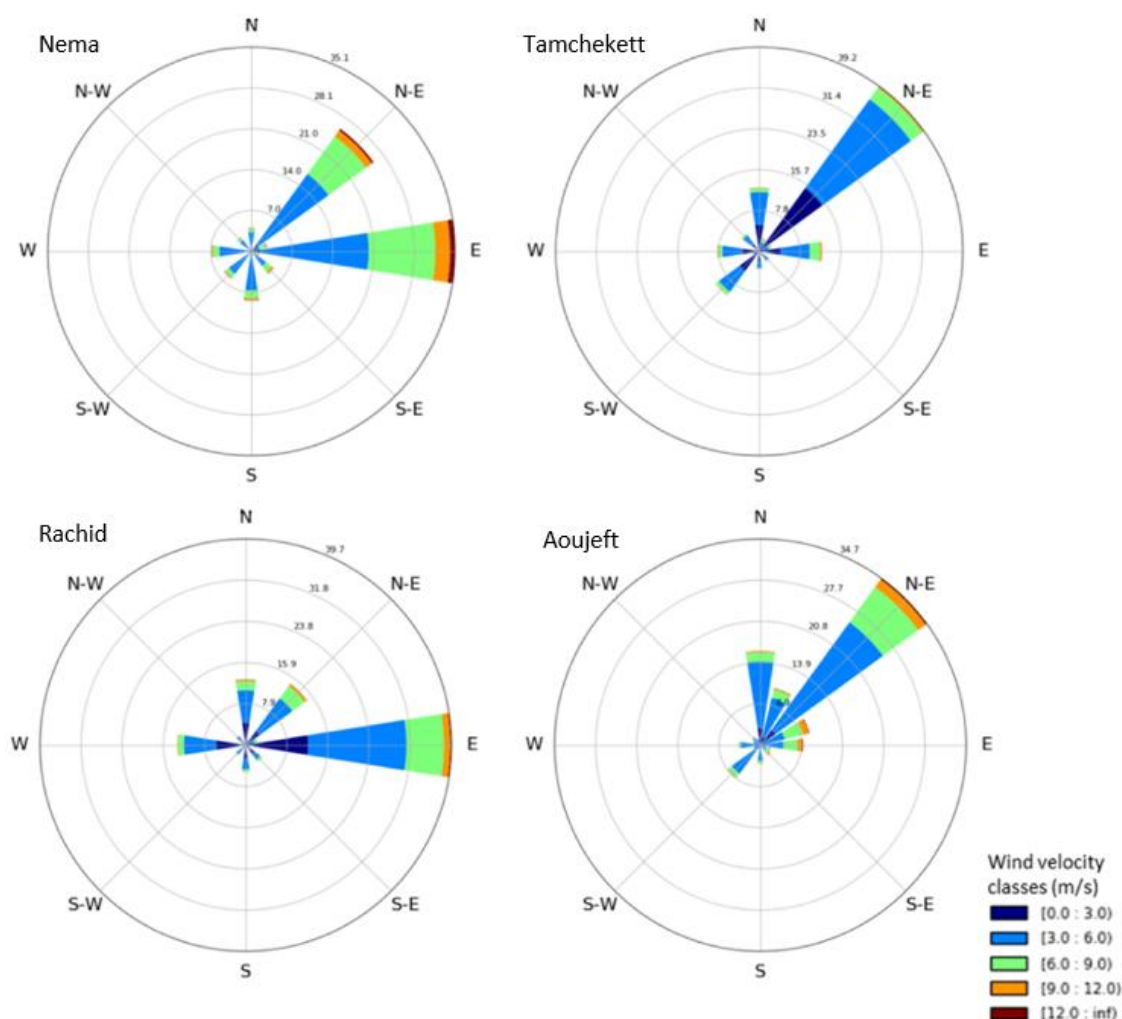
### 1.3.3 Wind speed and direction

The prevailing wind direction for Nema and Rachid is easterly, while the prevailing wind for Tamcheket and Aoujeft is north-easterly<sup>290</sup>. In addition, strong winds (6 m/s and above) — capable of transporting sand — predominantly originate from the Sahara Desert, blowing from the east and northeast. These winds contribute to increasing desertification within the hubs (Figure 12) by removing nutrient-rich soils from some areas and inundating vegetation with sand in others (Section 1.3.4). Average, minimum and maximum wind speeds are similar across the four hubs, with maximum wind speeds reaching between 44–57 m/s (

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<sup>290</sup> Appendix 3

Table 4), which are classified as violent storm or hurricane-level winds according to the Beaufort scale<sup>291</sup>. On average, across the target hubs, wind occurs on 83–87% of days per year, while 20–44% of days per year have strong wind conditions (winds of 6 m/s or more).



**Figure 12.** Wind roses for each of the four project hubs, showing Nema (top left), Tamchekett (top right), Rachid (bottom left) and Aoujeft (bottom right)<sup>292</sup>.

<sup>291</sup> RMetS. 2018. The Beaufort Scale: How is wind speed measured? Available at: <https://www.rmets.org/resource/beaufort-scale>.

<sup>292</sup> Appendix 3

**Table 4.** Average, minimum and maximum values for the daily maximum wind speed (m/s), number of days with wind and number of days with strong wind (6 m/s or above) for the four target hubs<sup>293</sup>.

Hub	Daily maximum wind speed (m/s)			Number of days with wind per year			Number of days with strong wind per year		
	Average	Min	Max	Average	Min	Max	Average	Min	Max
Nema	6	1	57	310	220	363	160	51	295
Tamcheket	5	1	54	318	148	363	74	12	184
Rachid	5	2	55	306	89	364	105	28	202
Aoujeft	6	1	44	318	9	361	149	4	260

#### 1.3.4 Climate hazards

Mauritania experiences several climate-related hazards, including extreme heat conditions and heatwaves, sandstorms, bushfires, droughts and floods. These hazards have multiple negative impacts on communities and ecosystems within Mauritania, all of which are projected to increase under future climate change (Section 2). Descriptions of these hazards and their observed impacts on Mauritania and the target hubs are given in the sub-sections below.

##### **Heatwaves**

All areas of Mauritania are at high risk of heatwaves. Currently, extreme heat conditions — particularly during April, May and June — occur at least once every five years<sup>294</sup>. Within the target hubs, the annual warm spell duration index<sup>295</sup> (WSDI) — used as an indicator of heatwave occurrences — averaged 12–15 days per year from 1981–2010 (Table 5). In extreme years, 13–17% of days across the year have daily maximum temperatures above the 90<sup>th</sup> percentile.

**Table 5.** Average and maximum WSDI for the four target hubs<sup>296</sup>.

	Average	Maximum
<b>Nema</b>	13	61
<b>Tamcheket</b>	12	49
<b>Rachid</b>	12	61
<b>Aoujeft</b>	15	53

Heatwaves have severe implications for public health, including life-threatening conditions such as heat exhaustion and heat stroke<sup>297,298</sup>. In addition, extreme heat can lead to severe dehydration and acute cerebrovascular conditions and contribute to the development of blood clots. Elderly populations, impoverished individuals, outdoor workers and the inhabitants of dense urban areas — as a result of urban heat capture — are particularly at risk. The communities consulted in all four target hubs highlighted the risk of heatwaves to health, with three deaths recorded in Aoujeft in 2021 and 2022 and three deaths in Rachid during 2020<sup>299</sup>.

In addition to impacting human health, heatwaves negatively affect numerous economic sectors, of which the agricultural sector is most severely affected<sup>300</sup>. The disproportionate impact on the agricultural sector results from heatwaves pushing crops, livestock and farm workers past their physiological tolerances to heat and water stress, prompting declines in agricultural productivity and, subsequently, reduced food security. Within the target hubs, heatwaves have been associated with shorter lactation periods, abortions in goats, camels and cattle, and a general decline in animal

<sup>293</sup> Appendix 3

<sup>294</sup> Think Hazard! N.d. Mauritania: Extreme heat. Available at: <https://thinkhazard.org/en/report/159-mauritania/EH>.

<sup>295</sup> The warm spell duration index is the annual count of days with at least three consecutive days where the daily maximum temperature is higher than the 90<sup>th</sup> percentile.

<sup>296</sup> Appendix 1.

<sup>297</sup> Symptoms of heat stroke include faintness, dry, warm skin, swelling in the lower limbs, heat rash, cramps, headaches, irritability, lethargy, weakness and potentially death.

<sup>298</sup> WHO. 2021. Heatwaves. Available at: [https://www.who.int/health-topics/heatwaves#tab=tab\\_2](https://www.who.int/health-topics/heatwaves#tab=tab_2).

<sup>299</sup> Appendix 1.

<sup>300</sup> FutureEarth. 2019. Issue Brief: Heatwave. Available at: [https://futureearth.org/wp-content/uploads/2019/07/issuebrief\\_07\\_11.pdf](https://futureearth.org/wp-content/uploads/2019/07/issuebrief_07_11.pdf).



productivity. Lactation periods during droughts and heatwaves, for example, reduce milk production by two-thirds. Heatwaves also negatively impact ecosystems by reducing plant growth, which leads to reduced vegetation cover and increased desertification<sup>301</sup>.

### Sand and dust storms

Sand and dust storms (SDS) are defined as events where blowing dust reduces visibility to one kilometre or less<sup>302</sup> (Figure 13). These events generally occur in arid or semi-arid regions comprising large areas of unprotected, dry sediments. The Sahara Desert is the most substantial source of SDS globally<sup>303</sup>, with West African countries on the desert's western boundary frequently impacted by SDS in the dry season months of January to April<sup>304</sup>. SDS are more prominent in the dry season as a result of reductions in already sparse vegetation cover and an increase in winds during this time. Mauritania has been predicted to have ~80 SDS per year<sup>305</sup>.



**Figure 13.** Dust storm in Iwik, northeast Mauritania<sup>306</sup>.

Multiple negative impacts on communities and ecosystems are attributed to SDS, both in regions where sediments originate and where they are deposited<sup>307</sup>. For example, wind erosion associated with SDS is a major contributor to land degradation — particularly in areas where the sediments originate — resulting in the removal of finer soil particles from the surface of the soil. This process is highly detrimental to natural and agricultural vegetation as these finer particles comprise the most critical component for retaining nutrients and organic matter in the soil. Specifically, the removal of these fine particles alters the chemical, physical and biological properties of the soil, leading to reduced soil productivity and an impaired capacity for soils to provide ecosystem services (ESSs), such as hydrological regulation. In areas where sediment is deposited, crops and natural vegetation become: i) covered by dust, which reduces their rates of photosynthesis; ii) damaged mechanically by abrasion; or iii) completely buried by sand. SDS impacts on the soil and vegetation result in reduced

<sup>301</sup> Appendix 1.

<sup>302</sup> Lancaster N. 2021. Encyclopedia of Geology (Second Edition): Volume 2.

<sup>303</sup> UN Environment Frontiers. 2017. Sand and dust storms: Subduing a global phenomenon. Available at: [https://wedocs.unep.org/bitstream/handle/20.500.11822/22267/Frontiers\\_2017\\_CH4\\_EN.pdf?sequence=1&isAllowed=y](https://wedocs.unep.org/bitstream/handle/20.500.11822/22267/Frontiers_2017_CH4_EN.pdf?sequence=1&isAllowed=y).

<sup>304</sup> Al Jazeera Media Network. 2020. Sandstorms hit part of West Africa. Available at: <https://www.aljazeera.com/news/2020/2/28/sandstorms-hit-parts-of-west-africa>.

<sup>305</sup> Brown LR. 2007. Environment: Around the globe, farmers losing ground. Available at: <http://www.ipsnews.net/2007/06/environment-around-the-globe-farmers-losing-ground/>.

<sup>306</sup> Merkel U, Rousseau D-D, Stuut J-BW & Winckler G. 2014. Present and past mineral dust variations — a cross-disciplinary challenge for research. PAGES Magazine, 22: 59–60.

<sup>307</sup> UNEP. 2016. Global assessment of sand and dust storms. Available at: [https://uneplive.unep.org/redesign/media/docs/assessments/global\\_assessment\\_of\\_sand\\_and\\_dust\\_storms.pdf](https://uneplive.unep.org/redesign/media/docs/assessments/global_assessment_of_sand_and_dust_storms.pdf).

crop and fodder productivity for farmers, which consequently increases food insecurity for impacted communities.

In addition to the impacts discussed above, SDS negatively affect water sources at sediment deposit sites, particularly where deposited sediment results in the siltation of open surface water bodies (Section 1.4). Wadis, wells, springs and dams, for example, are inundated with sand and dust, reducing the water quality as well as the carrying capacity of these water sources<sup>308</sup>. Community members in all of the project's target hubs have highlighted that the siltation of water points is a notable concern. In Rachid, for example, seven rivers and five wells have disappeared as a result of siltation, while seven wadis have been lost in Tamcheket and at least five in Nema<sup>309</sup>. The loss of water sources as a result of siltation reduces the availability of clean surface drinking water for target communities and increases their dependence on limited groundwater resources.

Along with the impact on the availability of clean drinking water discussed above, SDS have other notable direct effects on human health. Particle pollution — including natural dust — has a greater negative impact on people than other types of pollutants because of its prevalence<sup>310</sup>. As it consists of adhered chemical and biological components and various mineral components, dust induces inflammatory lung injury and aggravates allergen-related nasal and pulmonary immune responses<sup>311</sup>. Chronic exposure to fine particles carried by SDS increases the risk of premature deaths resulting from cardiovascular and respiratory diseases, lung cancer and acute lower respiratory infections<sup>312</sup>. Anthropogenic atmospheric pollutants, such as ammonium, sulphate and nitrate ions, and heavy metal compounds may also be transported through SDS, leading to health complications for local communities.

SDS-related sand inundation has additional indirect impacts on the health of isolated communities — including towns in the target hubs — by restricting or delaying critical health services. This is because transport infrastructure may become damaged or blocked by sand for extended periods of time. More vulnerable individuals such as women, children and the elderly are particularly affected by this limited access to emergency health services<sup>313</sup>.

The combined impacts of SDS on health, ecosystems and water sources contribute to short- and long-term negative consequences on the economy. The major impacts of SDS with ramifications for the economy are summarised in Table 6. Overall, high dust concentrations and SDS cost the Middle East and North Africa (MENA) region over USD150 billion annually and ~3% of GDP for most of the region's countries<sup>314</sup>. Health-related costs of SDS are the largest contributor to overall costs, with welfare losses<sup>315</sup> as a result of ambient PM<sub>2.5</sub> pollution<sup>316</sup> within the MENA region amounting to USD141 billion in 2013<sup>317</sup>. There are also direct impacts of SDS on livelihoods, including losses resulting from: i) the disappearance of crop or pastoral land through sand inundation; ii) damage to crops; iii) livestock mortalities; iv) reduced labour productivity; and v) interruptions to transport and communications — resulting in disruptions to businesses (Figure 14). In severe cases of SDS and dune encroachment, some settlements and agricultural lands across Mauritania and within the target hubs have been completely abandoned because of sand inundation<sup>318</sup> (Figure 15). Damage to

<sup>308</sup> Opp C, Groll M, Abbasi H & Foroushani MA. 2021. Causes and effects of sand and dust storms: What has past research taught us? A survey. *Journal of Risk and Financial Management*, 14: 326.

<sup>309</sup> Appendix 1.

<sup>310</sup> WHO. 2013. Review of evidence on health aspects of air pollution. REVIHAAP Project Technical Report.

<sup>311</sup> Fussell JC & Kelly FJ. 2021. Mechanisms underlying the health effects of desert sand dust. *Environment International*, 157: 106790.

<sup>312</sup> UNEP. 2016. Global assessment of sand and dust storms. Available at:

[https://uneplive.unep.org/redesign/media/docs/assessments/global\\_assessment\\_of\\_sand\\_and\\_dust\\_storms.pdf](https://uneplive.unep.org/redesign/media/docs/assessments/global_assessment_of_sand_and_dust_storms.pdf).

<sup>313</sup> Appendix 1.

<sup>314</sup> WB. 2019. Sand and dust storms in the Middle East and North Africa region: Sources, costs, and solutions.

<sup>315</sup> Welfare costs represent the cost of premature deaths.

<sup>316</sup> PM<sub>2.5</sub> pollution refers to particulate matter with a diameter of less than 2.5 microns.

<sup>317</sup> WB and Institute for Health Metrics and Evaluation (IHME). 2016. The cost of air pollution: Strengthening the economic case for action. WB Group, Washington.

<sup>318</sup> Appendix 1.

infrastructure leads to direct costs for repair or sand removal and can additionally result in deaths linked to building collapses. For example, nine deaths reported in Mauritania's Tagant region in 2017 were attributed to building collapses during a sandstorm<sup>319</sup>. An increase in fatalities during SDS is also attributed to reduced visibility and increased road accidents.

**Table 6.** Economic impacts of SDS<sup>320</sup>.

Immediate impacts	Long-term impacts
Immediate human health problems (such as respiratory problems) and mortalities	Cumulative human health problems (for example, bronchitis and cardiovascular disorders)
Annual and perennial crop damage	Soil erosion and reduced soil quality
Increased livestock mortality	Soil pollution through the deposition of toxic biological materials (for example, fungi and bacteria), heavy metals, or salts
Infrastructural damage to, <i>inter alia</i> , buildings, electricity structures, power facilities and water facilities	Disruption of global climate regulation through feedbacks involving global warming, ocean productivity and carbon dioxide production, precipitation changes, global ice volume, sea level, hydrological cycles and vegetation cover
Direct costs of clearing sand and dust from infrastructure such as roads, airports, dams, irrigation canals, flood control structures, ditches and power facilities	
Interruptions to transport and communications, increased air and road traffic accidents	



**Figure 14.** Examples of sand inundation from SDS and desertification, including: i) sand encroachment of an oasis in the Aoujeft hub (left); and ii) dune obstruction of a road (right)<sup>321</sup>.

<sup>319</sup> Anadolu Agency. 2017. Sandstorm kills at least 9 in central Mauritania. Available at: <https://www.aa.com.tr/en/africa/sandstorm-kills-at-least-9-in-central-mauritania/825319>.

<sup>320</sup> UNEP. 2016. Global assessment of sand and dust storms. Available at: [https://uneplive.unep.org/redesign/media/docs/assessments/global\\_assessment\\_of\\_sand\\_and\\_dust\\_storms.pdf](https://uneplive.unep.org/redesign/media/docs/assessments/global_assessment_of_sand_and_dust_storms.pdf).

<sup>321</sup> Appendix 1



**Figure 15.** The derelict structures visible on the ridge are an example of a village that has been inundated, and eventually abandoned, because of advancing dunes. A date palm plantation is visible in a depressional basin (*grara*) in the foreground, with the village having relocated to the opposite side of the depression (not shown in the figure).

## Bushfires

The high prevalence of extreme climate conditions such as strong winds, high temperatures and drought in Mauritania increases the likelihood and intensity of bushfires. However, ignitions are most commonly caused by human activities, including disposing of ash and uncontrolled burning<sup>322</sup>.

The bushfire risk in Mauritania varies from very low<sup>323</sup> in the northern wilayahs, such as Adrar, to high in the southern wilayahs, including Tagant and Hodh Chargui<sup>324,325</sup>. The discrepancy in the bushfire risk between northern and southern Mauritania is related to the increased presence of Sahelian vegetation in the southern regions compared with the sparser desert ecosystems of northern Mauritania, which have limited vegetation to fuel bushfires. From 2015–2020, Mauritania experienced an average of 205 bushfires per year<sup>326</sup>. Most of these fires occurred during October to December following the wet season (Figure 16).

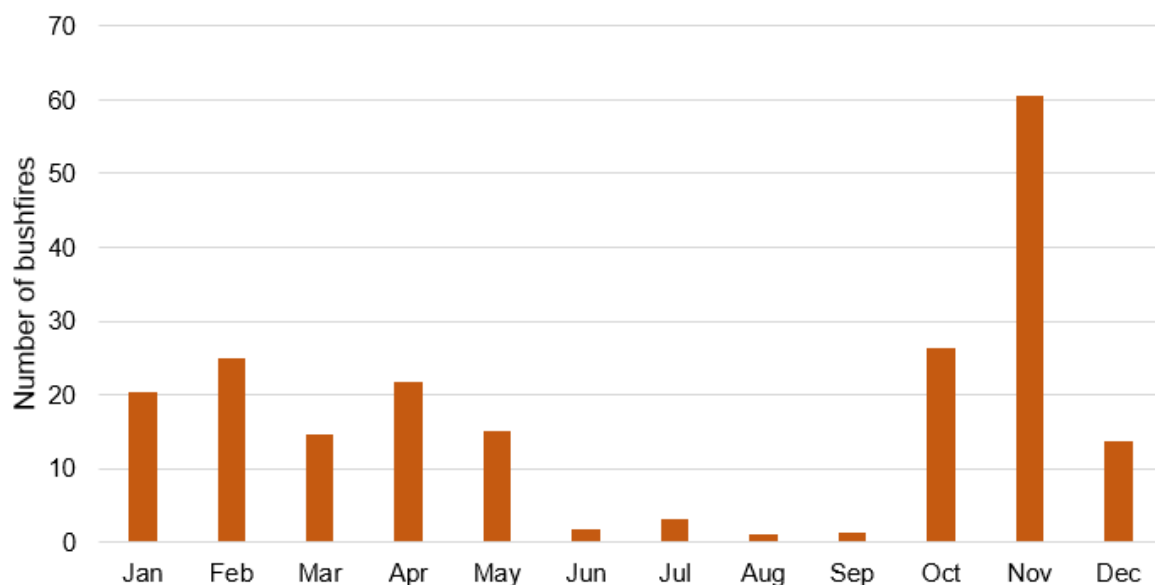
<sup>322</sup> Appendix 1.

<sup>323</sup> A very low bushfire risk means that there is less than a 4% chance of experiencing weather that could support bushfires with a minor chance of causing disruptions in any given year.

<sup>324</sup> A high bushfire risk means that there is a more than 50% chance of encountering weather that could support considerable bushfires capable of resulting in losses to life and property.

<sup>325</sup> Think Hazard! N.d. Mauritania: Wildfire. Available at: <https://thinkhazard.org/en/report/159-mauritania/WF>.

<sup>326</sup> Global Forest Watch. 2021. Fires in Mauritania. Available at: <https://www.globalforestwatch.org/>.



**Figure 16.** Average monthly bushfires for Mauritania for the period from 2015–2020<sup>327</sup>. Numbers are based on high confidence VIIRS<sup>328</sup> fire alerts.

Bushfires cause considerable financial losses in Mauritania. On average, ~300,000 ha of pasture is burnt by bushfires per year, resulting in financial losses of USD166 million<sup>329</sup>. Within the four target hubs, the areas most affected by bushfires are Tamcheket and Nema, with the latter hub having an average of 41,000 ha per year burnt from 2017–2020<sup>330</sup>. Bushfires negatively impact these areas by inhibiting the ability of ecosystems to provide ESSs (Section 1.5.4). Critically, this includes reducing the ability of rangelands to provide forage for livestock.

## Droughts

Drought is defined as a relative deficiency in precipitation over an extended period — usually a season or more — resulting in a water shortage<sup>331</sup>. Droughts are classified into several types depending on which systems are most impacted, including: i) meteorological droughts, defined as periods with insufficient rainfall; ii) hydrological droughts, when available water supplies are insufficient to meet human and animal demands; iii) agricultural droughts, where crop and livestock production become affected by insufficient water access; iv) socio-economic droughts, when the supply and demand of various commodities are impacted by reduced water supply; and v) ecological droughts, where natural ecosystems become degraded by prolonged water shortages.

Most droughts are triggered by natural phenomena such as cyclical changes in weather patterns. Across the Sahel region, one such example is the effect of sea surface temperature changes on the WAM<sup>332</sup>. Warming in the Atlantic Ocean weakens the moisture-laden WAM, which causes a southwards shift in the ITCZ, resulting in drier conditions in large parts of West Africa. El Niño<sup>333</sup> conditions similarly lead to a weakening of the WAM and drier conditions in the Sahel region.

<sup>327</sup> Global Forest Watch. 2021. Fires in Mauritania. Available at: <https://www.globalforestwatch.org/>.

<sup>328</sup> Visible Infrared Radiometer Suite

<sup>329</sup> Agence de Presse Africaine. 2019. Bushfires cost Mauritania over USD160m a year. Available at: <http://apanews.net/en/news/bushfires-cost-mauritania-over-160m-a-year-minister>.

<sup>330</sup> Appendix 1.

<sup>331</sup> National Integrated Drought Information System. N.d. What is drought. Available at: <https://www.drought.gov/what-is-drought/drought-basics>.

<sup>332</sup> Epule ET, Peng C, Lepage L & Chen Z. 2013. The causes, effects and challenges of Sahelian droughts: A critical review. Regional Environmental Change, DOI 10.1007/s10113-013-0473-z.

<sup>333</sup> El Niño is a natural phenomenon which occurs every two to seven years and is defined by the abnormal warming of sea surface temperatures in the central and eastern equatorial Pacific Ocean, which disrupts global atmospheric circulation patterns.



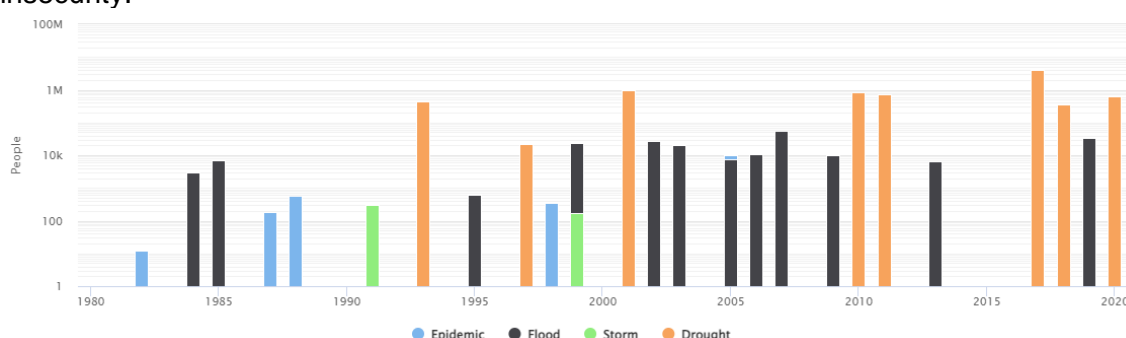
The occurrence of droughts has also partially been attributed to SDS. This link between SDS and droughts is related to the accumulation of Sahelian dust in the atmosphere, which suppresses rainfall production by promoting the formation of small cloud droplets that are incapable of forming rainfall droplets<sup>334</sup>. In addition, dust aerosols from SDS contribute to surface heating, increasing atmospheric stability and reducing convection processes that lead to cloud formation. As droughts themselves often result in dust accumulation and consequently SDS formation, a dust feedback loop may occur, where drier conditions from droughts discourage the production of rain by contributing to more dust in the atmosphere, which in turn results in drought-intensifying SDS events.

Mauritania is exposed to cycles of intense drought periods that can last for several years. Approximately two-thirds of the country is at high risk<sup>335</sup> of droughts and associated water scarcity, while some of the wetter southern wilayahs — including Hodh El Gharbi and Tagant — have a medium risk level<sup>336,337</sup>. Within the four target hubs, the average number of the longest periods of consecutive dry days (CDDs)<sup>338</sup> — used as an indicator of drought — ranges from 229–246 days over the period 1981–2010 (Table 7). During the most extremely dry years, the maximum period of CDDs in the target hubs ranged from 80–89% of the year.

**Table 7.** Average, minimum and maximum CDDs for the four target hubs<sup>339</sup>.

	Average	Minimum	Maximum
<b>Nema</b>	237	142	292
<b>Tamcheket</b>	229	132	302
<b>Rachid</b>	246	144	326
<b>Aoujeft</b>	237	94	324

Historically, notable droughts have occurred in Mauritania in the 1910s, 1940s and in 1968<sup>340</sup>. The 1910 drought extended until 1916; it was the most severe drought recorded in the Sahel region since 1850 and resulted in widespread famine. Although only eight major droughts have been recorded nationally from 1990 until 2020, each event has impacted orders of magnitude more people than other major natural hazards, including floods, storms or epidemics (Figure 17). Between 1985–2020, the number of people directly affected by droughts ranged from 21,000 people in 2010 to 3,894,000 people in 2017. The direct and indirect ways drought impacts ecosystems, communities and livelihoods are numerous and considerable. They include, *inter alia*, reduced plant productivity, dehydration stress or disease in wildlife, shifts in vegetation types or ranges, and water and food insecurity.



**Figure 17.** Major natural hazards and the number of people impacted in Mauritania from 1980–2020<sup>341</sup>.

<sup>334</sup> Epule ET, Peng C, Lepage L & Chen Z. 2013. The causes, effects and challenges of Sahelian droughts: A critical review. Regional Environmental Change, DOI 10.1007/s10113-013-0473-z.

<sup>335</sup> A high risk level means that droughts are expected to occur on average every five years.

<sup>336</sup> A medium risk level means that there is up to a 20% chance droughts will occur within a 10 year period.

<sup>337</sup> Think Hazard! N.d. Mauritania: Water scarcity. Available at: <https://thinkhazard.org/en/report/159-mauritania/DG>.

<sup>338</sup> Consecutive dry days is an indicator of drought based on the annual maximum number of consecutive days with daily precipitation less than 1 mm.

<sup>339</sup> Appendix 1.

<sup>340</sup> Bazza M, Kay M & Knutson C. 2018. Drought characteristics and management in North African and the Near East. FAO Water Reports 45.

<sup>341</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania vulnerability.

In extreme cases, extended droughts cause substantial losses in vegetation cover that result in permanent degradation and desertification<sup>342</sup>. This degradation diminishes the ability of ecosystems to provide critical services to communities, including hydrological regulation and food or forage production. Ecosystem vulnerability to droughts increases when the area is impacted by environmental degradation, deforestation, or the overexploitation of natural resources. The impacts of drought on ecosystems are present in the four target hubs, where the loss in biodiversity and disappearance of ecosystems have resulted in reductions in vegetation cover<sup>343</sup>. This loss in plant cover leads to sand inundation and the advancement of dunes, resulting in permanent desertification of larger areas. In regions prone to bushfires — including Nema — droughts also impact ecosystems by further increasing the risk of fires, resulting in further vegetation losses<sup>344</sup>.

Along with increasing the degradation of ecosystems, droughts decrease water availability for croplands, livestock and communities. As a result of insufficient rainfall, reduced infiltration rates related to vegetation loss and the over-extraction of water for urban and agricultural use, the level of groundwater tables within the hubs has fallen. For example, groundwater levels around Aoujeft have dropped from a depth of 6 m to 12 m over the last several decades<sup>345</sup>. Decreases in surface and groundwater supply levels not only reduce water availability, but also increase their salinity, which negatively affects water quality and further reduces the amount of water available for consumption.

With a high dependence on water for sufficient production, the agricultural sector is extremely vulnerable to droughts, with prolonged dry spells resulting in insufficient crop harvests to support crop farmer livelihoods, high food prices and livestock loss<sup>346</sup>. Crops are affected directly by droughts through increased moisture stress and indirectly by greater vulnerability to fungal and insect pests. Droughts increase pests through several mechanisms, including: i) creating a more favourable thermal environment for the proliferation of multiple insect pests as droughts often coincide with high temperatures; and ii) reducing the physiological immunity of crops to parasites. As a result of sowing failures and poor crop development during drought years, yield losses for rainfed crops potentially exceed 70%, while communities in the target hubs have reported reductions in flood irrigated crops of 90%.

Livestock productivity is affected during drought periods by the decline in palatable fodder species, reduced availability of grazing areas, decreased access to water and the increased prevalence of diseases<sup>347</sup>. Within the target hubs, the decline in productivity associated with drought includes reductions in milk production of up to two-thirds in drought years, fewer livestock births and increased mortalities. In response to ongoing periods of drought, nomadic herders within the hubs have shifted to sedentary lifestyles centred around more permanent water sources or urban areas with access to food aid. The trend accelerated following the 1984/1985 drought period and continues to contribute to the increasing degradation of ecosystems surrounding these areas.

Reductions in agricultural production have considerable ramifications on the food security of communities in Mauritania. For example, the 1960 drought reduced crop yields and increased food prices in local markets, contributing to the financial losses for impacted communities<sup>348</sup>; more than one million people across Mauritania had little to no access to enough food or clean water during this period. Examples of the impacts of droughts, such as this one, suggest that droughts inevitably aggravate the severe nutritional situation present in the country. When last recorded, 32% of children under the age of five suffered from chronic malnutrition and are considered underweight. Malnutrition

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<sup>342</sup> UNHCR. N.d. Climate risk profile: Sahel.

<sup>343</sup> Appendix 1.

<sup>344</sup> United Nations Office for Disaster Risk Reduction (UNDRR). 2021. GAR Special report on drought 2021.

<sup>345</sup> Appendix 1

<sup>346</sup> UNDRR. 2021. GAR Special report on drought 2021.

<sup>347</sup> Appendix 1.

<sup>348</sup> WFP. 2015. WFP Mauritania brief

linked to droughts — combined with the health risks of corresponding heatwaves — accounts for 5% of deaths in children under five years of age and 35% in children older than five<sup>349</sup>.

## Floods

Flooding in Mauritania occurs most frequently in September as a result of infrequent torrential rainfall events. The risk of these flooding events is not evenly distributed across the country. For example, the southern wilayahs of the country — which receive more rainfall than the rest of the country and include the target hub wilayahs of Hodh El Gharbi and Hodh Chargui — show a medium to high risk<sup>350</sup> of flooding<sup>351</sup>. In comparison, wilayahs in the central areas of Mauritania — including Adrar and Tagant — experience a low risk of flooding, while the northern regions have a very low risk<sup>352</sup>.

Of the 12 years in which notable flooding events occurred between 1985–2017, up to 54,120 people were impacted each year across Mauritania (Figure 17)<sup>353</sup>. These impacts on communities are varied and include, *inter alia*, the proliferation of diseases or other health conditions, deaths, the disruption of livelihoods and direct damage to homes and critical infrastructure. Standing water from flood events also increases the proliferation of disease vectors — such as mosquitoes and water-borne diseases — in certain areas, resulting in increased instances of malaria, Rift Valley fever, dengue fever and diarrhoea.

In communities where agriculture is a primary livelihood, floods result in the waterlogging of soils used for crops, leading to the death of seeds and seedlings<sup>354</sup>. This damage to young crops substantially reduces agricultural productivity during the following harvesting season, resulting in the loss of livelihoods and increased malnutrition for individuals dependent on these crops as their primary food supply. Agricultural lands — as well as natural ecosystems — are also affected by floods through degradation resulting from severe water erosion, which reduces the quality of soils in these landscapes. The nutrient-rich sediment removed from ecosystems and agricultural lands is deposited in sources of surface water, such as rivers, wells and dams, resulting in their siltation and subsequent reduction in carrying capacity<sup>355</sup>. Moreover, the sedimentation of rivers and other water bodies — combined with rising water temperatures and slower flow rates — has led to the increase in invasive floating aquatic plants, such as water lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*) and typha species (*Typhaceae*). The increased prevalence of these invasives reduces the biodiversity and productivity of local water systems<sup>356</sup>.

As noted above, flooding events can also result in substantial damage to homes, livelihoods and critical infrastructure in Mauritania. For example, the wilayah of Hodh Chargui, located in the southeast of the country, experienced torrential rains that flooded various cities in 2020 (Figure 18) — including the region's capital, Nema. This flood led to considerable damage to the city's infrastructure, including roads, bridges, protective dikes, markets and water supply sources. According to preliminary assessments, ~9,282 people and ~1,380 households were affected<sup>357</sup>. Other impacts from floods reported in the target hubs include damage to palm trees, direct livestock deaths and damage to gabion sills. A summary of the damages and losses from notable flood events in each hub is presented in Table 8, while Figure 19 provides examples of flood damage within the project's target hubs.

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<sup>349</sup> Appendix 1.

<sup>350</sup> A medium to high risk of flooding means that damaging and life-threatening floods have a 20% or higher chance of occurring at least once every 10 years.

<sup>351</sup> Think Hazard! N.d. Mauritania: River Flood. Available at: <https://thinkhazard.org/en/report/159-mauritania/FL>.

<sup>352</sup> A low to very low risk of flooding means that there is less than a 20% chance that potentially damaging and life-threatening floods will occur in the coming 10 years.

<sup>353</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania vulnerability.

<sup>354</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania vulnerability.

<sup>355</sup> Appendix 1.

<sup>356</sup> Appendix 1.

<sup>357</sup> Relief Web, Mauritania: Floods – Sep 2020. Available at: <https://reliefweb.int/disaster/fl-2020-000199-mrt>





**Figure 18.** Flooding in the city of Bassiknou, Hodh Chargui, in September 2020<sup>358</sup>.

**Table 8.** Notable flooding events that resulted in damages and losses in the target hubs in the last 20 years.

Hub	Year and flood impact
Nema	2002: Floods damaged 15 homes and led to 400 livestock deaths.
Tamcheket	2004: Flooding in the town of Sava which resulted in livestock and materials being washed away. 2007: Substantial damage to the town of Tintane from a flash flood equating to billions of Mauritanian Rupee in losses. Approximately 3,000 families were displaced following the flood <sup>359</sup> . 2019: Damage to the Sogueni Dam. 2020: Damage to the Boutleyhniya Dam.
Aoujeft	2003: Floods resulted in five deaths and the destruction of 1,000 palm groves. 2016: The Seguelil dam overflowed from flooding and damaged a portion of the town of Ain Ehel Taya. 2017: A section of the Atar-Tidjikja Road washed away. 2019: Considerable damage to the newly constructed Seguelil dam and the waterlogging of date palm fields.



**Figure 19.** Examples of damage to infrastructure from flooding within the target hubs, including: i) ravine formation from erosion and road damage from runoff along the Taoujeft bridge near Rachid (left); and ii) damage to an embankment junction in Tamcheket (right).

<sup>358</sup> Mauritanian Red Crescent. 2020. Emergency plan of action (EPoA) Mauritania/Bassiknou: Floods.

<sup>359</sup> Red Cross and Red Crescent Society. 2007. DREF Bulletin. Mauritania: Floods. Available at: <https://www.ifrc.org/docs/appeals/07/MDRMR002.pdf>.

## 1.4 Status of water resources in Mauritania

### 1.4.1 Current status of water resources in Mauritania

Located in the Sahel and Saharan zones, Mauritania's climate is characteristically hot and dry, receiving very little rainfall throughout the year (Section 1.3). At 91 m<sup>3</sup>/year (ranked 11<sup>th</sup> lowest globally in 2018<sup>360</sup>), the country's limited renewable internal<sup>361</sup> freshwater resources per capita support a very small agricultural network — only 0.4% of the country's total area is cultivated, of which ~10% is irrigated<sup>362</sup>. Notably, these already-scarce water resources have, alongside arable land and food resources, seemingly decreased since the end of the 12th century<sup>363</sup>, with a sustained decline in rainfall since measurements began in the 1800s<sup>364</sup>.

The uneven distribution of water resources in Mauritania is the defining factor in the availability of water in the country. Considerable external surface water resources along the country borders mask the high-water stress experienced in the rest of the country. Most renewable water resources (99%) derive from external flow from border rivers, mainly concentrated in the south in the alluvial plain of the Senegal River and its tributaries, which form the border between Mauritania and Senegal. The rest of the surface water resources are mainly represented by scattered irrigation dams in the south and central parts of the country. These limited surface water resources are supplemented by precipitation (national average of 98 mm/year<sup>365</sup>) that is highly variable in time and space — a variation of 7–575 mm/year<sup>366</sup> in different parts of the country. In a like manner, the country has considerable groundwater resources, with estimated total reserves among the largest in Africa<sup>367</sup>, but these are similarly characterised by marked geographical disparities<sup>368</sup>.

### 1.4.2 Water availability

#### **Surface water**

##### *Surface water across Mauritania*

At a total of 11.1 km<sup>3</sup>/year, Mauritania's surface water resources account for ~97% of its total renewable water resources. A dependency ratio of 96% indicates that much of that water derives from outside the country, mainly as accounted flow from border rivers concentrated in the southwest. Aside from these permanent watercourses along the border between Senegal and Mauritania, surface water resources in Mauritania are represented by ephemeral streams, permanent and temporal lakes and dams (Figure 20)<sup>369</sup>.

<sup>360</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 19 July 2022.

<sup>361</sup> 'Internal freshwater resources' refers to the flow of rivers and recharge of aquifers generated from precipitation within the boundaries of the country; 'external water resources' refers to river and aquifer flows that are not generated within the country but derive from inflows from upstream countries or part of the water from border lakes or rivers.

<sup>362</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 27 July 2022.

<sup>363</sup> McDougall E. 1985. The view from Awdaghust: war, trade and social change in the southwestern Sahara, from the eighth to the fifteenth century. *The Journal of African History*, 26(1):1–31.

<sup>364</sup> Ahmedou O, Nagasawa R, Osman A, Hittori K. 2008. Rainfall variability and vegetation dynamics in the Mauritanian Sahel. *Climate Research*, 38(1):75–81.

<sup>365</sup> WB Group. 2021. Climate Change Knowledge Portal: Mauritania climatology.

<sup>366</sup> Fick SE & Hijmans RJ. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. *International Journal of Climatology* 37: 4302–4315. Available at: <https://www.worldclim.org/>.

<sup>367</sup> MacDonald AM, Bonsor HC, Dochartaigh BÉO, Taylor RG. 2012. Quantitative maps of groundwater resources in Africa. *Environmental Research Letters*, 7: 024009.

<sup>368</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>369</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.



**Figure 20.** Distribution of primary water resources in Mauritania<sup>370</sup>. Symbols for major towns (*villes*), permanent rivers (*fleuves*), ephemeral watercourses (*cours d'eau intermittents*), water bodies (*plans d'eau*), administrative boundaries (*limites administratives*) and international borders (*frontières internationales*) are explained in the legend at the bottom left.

The Senegal River — the second longest river in West Africa at 1,800 km — is Mauritania's lifeline. This river and its tributaries are the country's main renewable external surface water resources, providing 11 of the 11.1 km<sup>3</sup>/year of total surface water available in Mauritania. The country has a 26% share of the river basin, spanning an area of 75,500 km<sup>2</sup>. Transboundary water agreements successfully govern the joint use of the resources from the Senegal River, despite some local conflict (Section 1.4.5.1). The river's main tributaries, the Bafing, Bakoye and Faleme rivers, originate in Guinea and Mali and produce 80% of the river's flow. The lesser ephemeral tributaries of the Senegal River located in Mauritania are the Gorgol, Karakoro and Kolimbine Rivers<sup>371</sup>. The river's flow regime depends mainly on rainfall in the upper basin in Guinea, particularly in the Fouta Djallon Mountains, which adds up to ~2,000 mm/year.

Year-round water supply from the Senegal River for agricultural activities and human settlements, specifically subsistence farmers and their families, is facilitated by interventions such as dams, dykes and irrigation systems. These interventions are of particular importance given the overall aridity of the river basin, which is situated in the Sahel zone where total annual rainfall in the low-lying areas rarely exceeds 400 mm.<sup>372</sup> The total dam capacity in Mauritania is 0.5 km<sup>3</sup>, although the actual amount of

<sup>370</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>371</sup> UNEP. 2010. Africa water atlas.

<sup>372</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

water stored in its dams will be less as a result of silting and water stress<sup>373</sup>. The Fom Gleita Dam, the most consequential dam administrated by Mauritanian authorities, was constructed in 1988 in the Gorgol Noir River in the Senegal River Basin, with the primary purpose of supplying water for irrigation agriculture in the region<sup>374</sup>. The Diama Dam is located near the town of Saint-Louis, 22 km from the mouth of the Senegal River, straddling Mauritania and Senegal; this is an 18-meter-high gravity dam with a reservoir capacity of 0.25 km<sup>3</sup> that was completed in 1986<sup>375</sup>. It was constructed to: i) block seawater intrusion; ii) raise the level of the upstream water bodies to increase irrigation potential; and iii) facilitate the filling of, among others, the Lake R'kiz and the Aftout-es-Saheli depression in Mauritania<sup>376,377</sup>. Although not located in Mauritania, the construction of the Manantali Dam in the Bafing River in Mali in 1988 has contributed to better flow regulation in the Senegal River<sup>378</sup>. Both the Manantali and Diama dams were constructed during an AfDB-funded project in response to several challenges experienced by communities in the region — drought, degradation of natural resources, emigration — that were exacerbated by the recurring droughts of the 1970s<sup>379</sup>. The effects of dam construction were not all positive, however, with the degradation of ecosystems and an increase in water-related diseases emerging as major concerns<sup>380</sup>.

Aside from the perennial Senegal River, the Gorgol River — which joins the Senegal River at the city of Kaédi and flows in the northeast of the Gorgol district of Mauritania (Figure 20) — is the only other watercourse in Mauritania where some stretches along its course have permanent water stands<sup>381</sup>. Other seasonal watercourses only experience water flow during periods of heavy rains<sup>382</sup>. These are scattered across the country, but the densest hydrographic network is found in the southwest of the country in the regions of Guidimaka and Aftout, which drains into the Senegal River<sup>383</sup>. In addition to seasonal streams, this hydrographic network contains several natural lakes and pans. Situated in the Senegal River Basin, Lake R'kiz is a narrow, semi-permanent lake with an average depth of 1.61 m<sup>384</sup>. Its total wetland area, which becomes inundated in the rainy season, spans 12,970 ha, and provides fish and thatching reeds to the people in the area. Numerous ephemeral streams feed the lake, which drains via the Laouinga Stream into the Senegal River to the south. Another lake near the source of the Guéllouâr River, Lake de Mâl, consists of two basins — a seasonally inundated upper basin and a permanent lower basin. Another notable lake in the southwest is Lake d'Aleg, a 4 km long and 1 km wide semi-permanent brackish lake with no outflow surrounded by a broad seasonal floodplain. Near the town of Néma, the Mahmouda is a large seasonal lake and floodplain that can persist for many months once filled, while Lake le Bheyr in the Assaba region is a perennial spring-fed lake that provides water for animal husbandry practices in the nearby settlements. Finally, there are numerous permanent lakes on the Mauritanian side of the Senegal River delta, such as Lake Tianbrank. Runoff from heavy rains also occasionally accumulates in shallow depressions, forming temporary lakes or ponds known as *sebkhas*. These *sebkhas* are not only found in the alluvial plains

<sup>373</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 27 July 2022.

<sup>374</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>375</sup> FAO. 2005. AQUASTAT profil de pays — Sénégal. Available at: <https://www.fao.org/3/ca0209fr/CA0209FR.pdf>

<sup>376</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>377</sup> Duvail S, Hamerlynck O. 2003. Mitigation of negative ecological and socio-economic impacts of the Diama Dam on the Senegal River Delta wetland (Mauritania), using a model-based decision support system. *Hydrology and Earth System Sciences*, 7(1): 133–146.

<sup>378</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>379</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>380</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>381</sup> Fall MD, Fall NKS, Hmeyade BL, Bacar SH, 2017. Integrated and sustainable management of shared aquifer systems and basins of the Sahel region: Senegalo-Mauritanian Basin, RAF/7/011. IAEA, Vienna, Austria.

<sup>382</sup> FAO. 2005. AQUASTAT profil de pays — Sénégal. Available at: <https://www.fao.org/3/ca0209fr/CA0209FR.pdf>

<sup>383</sup> Fall MD, Fall NKS, Hmeyade BL, Bacar SH, 2017. Integrated and sustainable management of shared aquifer systems and basins of the Sahel region: Senegalo, Mauritanian Basin, RAF/7/011. IAEA, Vienna, Austria.

<sup>384</sup> Deutsches Geodätisches Forschungsinstitut. Database for hydrological time series of inland waters. Available at: <https://dahiti.dgfi.tum.de/en/2865>. Accessed on 28 July 2022.

of the south but are scattered across the country. However, particularly in the north of Mauritania, they can remain dry for years.<sup>385</sup>

#### *Surface water in the four regional hubs*

##### Aoujeft

The Adrar wilayah<sup>386</sup>, where Aoujeft is situated, has several endorheic<sup>387</sup> watercourses, most notably the Séguélil wadi<sup>388</sup> and the El Abiod wadi. These ephemeral watercourses converge in the Aïn Ehel Taya area, whence they flow into the Yagref flood plain, with the lowest point being 110 m above sea level. The Séguélil wadi originates on the Amogjar plateau at an altitude of 820 m. It is made up of several distinguishable watercourses: i) the Amdar wadi and its primary subsidiary, the Tawaz wadi; and ii) the Toueïderguitt wadi and its subsidiaries, the Grâret wadi, the El Gceïba wadi and the Bathât Et Rijl wadi<sup>389</sup>.

Upon closer inspection, there are many distinct ephemeral watercourses on the *moughataa*<sup>390</sup> level. The main wadis of the Aoujeft *moughataa* are the Aoujeft, Terguint, Marveg, Oum Chenad, Ten Mour, Timoline, Timinit, Ijerijan, Nkedei, Bou Aboun, Ain Lebgar and Tiroutanène. The two main wadis of the Chinguïetti *moughataa* are the Chinguïetti wadi — with its two tributaries, Oued Ouarane and Bou Aglal — and the Regheywiya wadi. The Ouadana *moughataa* contains the Ouadane, Tenlaba and Hsey Dhib wadis.<sup>391</sup>

Several infrastructure developments, including dams and dykes, have been built to improve access to surface water in the Adrar wilayah (Table 9). Infrastructure and water resources at these wadis are threatened by advancing sand dunes. For example, shifting sand dunes — or, occasionally, heavy flooding — can bury wells<sup>392</sup>.

**Table 9.** Status of built water infrastructure implemented under *Programme de développement durable des oasis* (PDDO) and *Direction de l'Aménagement Rural* (DAR) in the Adrar wilayah by 2014.<sup>393</sup>

<b>Inventory of water reservoirs</b>	<b>2008</b>	<b>2014</b>
<b>Total number of built water reservoirs</b>	40	44
<b>Surface area (ha)</b>	3,749	4,239

##### Rachid

The wadis Tamourt and Naaj — main watercourses in the south and southwest of the Tagant wilayah, where Rachid is situated — and the wadi El Abiod — a secondary watercourse in the north and north-west — are important water resources in the wilayah. These wadis merge downstream of N'Beïka and flow to altitudes of 85 m in the area near Lake Gabou. Another important watercourse is the El Khatt depression, which receives water from the Iziv, Anzak, Tijikja and Rachid wadis. The watershed of the Iziv wadi, which originates in the Tarf Eyara *moughataa* at an altitude of 544 m, is formed by the Baghdada, Anzak and Erch El Mowj wadis. Finally, other important waterways are the Achram wadi and streams from the Tagant plateau that eventually flow into the Gorgol River.<sup>394</sup> In terms of manmade infrastructure, there are at least 130 built water reservoirs in the wilayah (Table 10).

<sup>385</sup> Hughes RH, Hughes JS. 1992. A directory of African wetlands. IUCN, Gland, Switzerland and Cambridge, UK/UNEP, Nairobi/WCTC, Cambridge, UK.

<sup>386</sup> Administrative region

<sup>387</sup> Having no outflow to an external body of water, with the only water loss through evaporation or infiltration.

<sup>388</sup> Seasonal streams and other watercourses that often form oases.

<sup>389</sup> Appendix 1.

<sup>390</sup> Administrative division below the level of wilayah

<sup>391</sup> Appendix 1.

<sup>392</sup> Appendix 1.

<sup>393</sup> Ministère de l'Agriculture. 2016. Plan de national de développement agricole (PNDA) 2015–2025.

<sup>394</sup> Appendix 1.



**Table 10.** Status of built water infrastructure implemented under PDDO and DAR in the Tagant wilayah by 2014<sup>395</sup>.

Inventory of water reservoirs	2008	2014
Total number of built water reservoirs	116	130
Surface area (ha)	11,384	13,924

### Tamcheket

The Tamcheket wadi is primarily fed by waters from the sandstone plateau of El Aguer, located in the commune of Radhi, 80 km from the town of Tamcheket in the south-east of the *moughataa*<sup>396</sup>. Watercourses in this *moughataa* are further fed by the R'Kiz massif via the Rag Tayar Dam.

At the Tamcheket hub, the watercourses flow in several directions:

- South-west, passing successively through Kitana, Lehbila, Legraé, Anzaï, Teydouma, Guirj, Amhar, Mreïmida 1 and 2, Bargatani, Ganata, Agouenit, Boghrelli, Diouba, El Miguengi, Oumoulgab, Melgué and Karakoro before joining the Senegal River upstream of Ghabou;
- North-west, passing through the Guelaba, Ségui, Goub N'Wamer, Boïssif, Marvagh, Sava and Toueïmirt dams, whence it bypasses the town of Tamkechett and flows in an easterly direction, where water sometimes accumulates in a *guembé*<sup>397</sup> at the height of the rainy season;
- North-west and central, passing through the Tegwa wadi and crossing the Rag Tayar and Maham dams;
- North-east into the Seïyada *tamourt*<sup>398</sup>, passing through the touristic site of Benmoura, a network of streams including the *tamourts* of Barbar, Loussékhiya, Argheimiya, Kibidi, Zoulékha, Aguirj El Kheir, T'Khailatt and Bou-Kharxa and the Akoumb Jreïb dam;
- North-west from Radhi, crossing the Ghlig El Ghodg, Badrat, Sayadat, Lehneïkat, El Mabrouk and Takhtamet dams and the Tamcheket *guembé*;
- From the El Aguer plateau through the Tintane wadi; and
- East, passing through Doueïrara on the Route de l'Espoire between Tintane and Aïoun before flowing into a depression.

There are at least 142 built water reservoirs in the Hodh El Gharbi wilayah, where Tamcheket is located (Table 11).

**Table 11.** Status of built water infrastructure implemented under PDDO and DAR in the Hodh El Gharbi wilayah by 2014<sup>399</sup>.

Inventory of water reservoirs	2008	2014
Total number of built water reservoirs	138	142
Surface area (ha)	6,991	7,466

### Nema

The Hodh Chargui wilayah, where Nema is situated, is characterised by the presence of seasonal watercourses — 215 *tamourts* and ponds — that collect water from extensive watersheds during the winter<sup>400</sup>. Some settlements and 90% of livestock in the area rely on these surface water sources<sup>401</sup>.

The hydrographic network that supplies water to the Afarat depression, which is situated 14 km north of Agouïenit, is comprised of the following<sup>402</sup>:

<sup>395</sup> Ministère de Agriculture. 2016. Plan de national de développement agricole (PNDA) 2015–2025.

<sup>396</sup> Fayien M, Mouchard E. 2007. Conservation et utilisation des Zones Humides dans le Hodh El Gharbi mauritanien. Secrétariat d'État auprès du Premier Ministre chargé de l'Environnement (SEE)/Coopération Technique Allemande (GTZ)/Programme Gestion des Ressources Naturelles (ProGRN), Nouakchott, Mauritanie.

<sup>397</sup> Water pit

<sup>398</sup> Forested closed basins

<sup>399</sup> Ministère de Agriculture. 2016. Plan de national de développement agricole (PNDA) 2015–2025.

<sup>400</sup> Appendix 1.

<sup>401</sup> Appendix 1.

<sup>402</sup> Appendix 1.

- The Bourjemane wadi north of Nema, which splits into the Ajar Akhtet Charib and Aiar Chams streams that flow directly into the depression;
- A network of wadis in and to the north of Nema — Kraa Ould Zeyane, Bat'ha N'Gady, Ajar Némaa and Bat'ha Nema;
- Kraa Bouzeyane;
- The Dakhla Mariama and Bat'ha Rajad watercourses, which first cross the Nema-Amourj road and the Route de l'Espoire before joining watercourses upstream of the Sheikh Tourad dam to flow to the depression; and
- A stream that leaves the main Agoueïnit wadi upstream of the Sheikh Tourad Dam to flow to the depression.

South of this depression, the watercourses that supply the Mahmouda *mare*<sup>403</sup> near Nema contain the two Nawdar wadis, the three tributaries of the Kraa Lakhdar wadi — N'Djaguenaye, Sbih and Magta Tachtaya — and the Kraa Lakhdar wadi itself<sup>404</sup>.

## Groundwater

### *Groundwater across Mauritania*

Mauritania's hydrogeology is characterised by two interconnected primary groundwater basins: i) the Senegalo-Mauritanian Aquifer Basin (SMAB) to the south; and ii) the Taoudéni-Tanezrouft Basin (TTB) to the north<sup>405</sup>. The SMAB is the most developed groundwater resource in Mauritania<sup>406</sup> — its resources are shared with the Gambia, Guinea Bissau and Senegal<sup>407</sup>. The deep aquifers in this basin are mostly made up of Maastrichtian fossil and Continental Terminal formations, while the shallow aquifers are mostly represented by the alluvial aquifer present at various depths across the floodplain. The groundwater recharge of the shallow alluvial aquifer is supplied by the Senegal River and its tributaries, causing the aquifer's water level to fluctuate with the hydrological regime, seasons and overall river level. The construction of dams and dykes has disrupted the flooding of the basin, reducing the area of the natural recharge zones but also contributing to better flow regulation during low-water periods. Overall, this has led to a considerable modification of the groundwater recharge patterns in the basin. The salinity of the aquifers is variable, with the saltiest waters found in depressions such as the Aftout-es-Saheli *sebkhas*<sup>408</sup>.

The other major groundwater resource, the TTB, is located towards the interior of Mauritania, which coincides with the project area. This resource is shared with the Western Sahara, Mali, Burkina Faso and Algeria<sup>409</sup>. The only permanent watercourse that flows to the basin is the Niger River, outside of Mauritania, which crosses the basin for over 1,700 km, with infiltration estimated at ~12.6 billion m<sup>3</sup>/yr<sup>410</sup>. In Mauritania, groundwater from the TTB is the main water source of the population living in the area covered by the basin. In the northern expanses of the basin, population density, and therefore water abstraction, is low. Conversely, in the southern reaches of the basin, growing populations lead to higher abstraction rates. Generally, over abstraction leads to a decreasing water table and lower water quality across the basin. For example, in the Atar region, the wells that are fed from the Quaternary alluvial aquifer that dominates the area have highly variable yield and regularly

<sup>403</sup> Seasonal pond or lake

<sup>404</sup> Appendix 1.

<sup>405</sup> Friedel MJ, Finn C. 2008. Hydrogeology of the Islamic Republic of Mauritania, Open-File Report 2008–1136. US Geological Survey, Virginia, USA.

<sup>406</sup> Friedel MJ, Finn C. 2008. Hydrogeology of the Islamic Republic of Mauritania, Open-File Report 2008–1136. US Geological Survey, Virginia, USA.

<sup>407</sup> UNESCO World Water Assessment Programme. 2022. The United Nations world water development report 2022. Groundwater: making the invisible visible.

<sup>408</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>409</sup> Friedel MJ, Finn C. 2008. Hydrogeology of the Islamic Republic of Mauritania, Open-File Report 2008–1136. US Geological Survey, Virginia, USA.

<sup>410</sup> Upton K, Ó Dochartaigh BÉÓ, Bellwood-Howard I. 2018. Africa groundwater atlas: hydrogeology of Mauritania. British Geological Survey.

dry up after periods of drought<sup>411</sup>. There are four recharge areas in the TTB, with inter-basin transfer from the TTB to the SMAB<sup>412</sup>. In addition to infiltration from the Niger River, rainfall is the main source of replenishment for the aquifers. Increasing anthropogenic activities and decreasing rainfall is affecting the recharge of the aquifers in the basin<sup>413</sup>.

Mauritania has one of the largest reserves of groundwater storage in Africa — the total reserve is ~23,400 km<sup>3</sup>, based upon the estimated effective porosity of the different rock types and the aquifer thickness<sup>414</sup>. However, exploitation of these reserves is hampered by low levels of groundwater recharge, among the lowest levels on the continent, which limits aquifers' ability to recover rapidly after a drought<sup>415</sup>. To be precise, only 0.3 km<sup>3</sup>/year of renewable groundwater is supplied via aquifer recharge through the hydrological cycle<sup>416</sup>. Aquifer recharge comes from either underground feeding, which can be slow, or by rainfall, which can be faster but is low because of the arid climate and high rates of evapotranspiration<sup>417</sup>. The two most productive aquifers in the country are the Trarza aquifer, which is located in Mauritania's coastal basin (marked in blue in Figure 21 below), and the Taoudéni basin aquifer, which is located in the south and south-east region of Mauritania (marked in lavender in Figure 21 below). Moreover, several low-productivity aquifers border Mauritania's coastal zone in the north. The dunes in the central areas of the country are often permeable, with local high groundwater storage potential, but the actual volume of the groundwater systems is dependent on rainfall<sup>418</sup>.

Groundwater is a crucial source of water for the areas situated to the north of the Senegal River<sup>419</sup>, where they feed unevenly distributed oases, which, along with surrounding pastoral lands, support agricultural activities that make a considerable contribution to national agricultural production. In 1994, a total of 218 oases covered 4,851 ha of Mauritania's land, most situated in Adrar, Tagant and Assaba in southern and central Mauritania. Water extraction in oases is performed manually (83% in 2004), via *shaduf* irrigation devices (0.6% in 2004) or by motor pump (16.4% in 2004)<sup>420</sup>. Notably, pumps are increasingly being used to access water at oases. Despite the importance of groundwater for rural water supply, there is limited data available in the national water point database BADIHA<sup>421</sup> on the groundwater systems and levels across the country<sup>422</sup>.

<sup>411</sup> Moulla AS, Smati A, Kabore Komi RA, Galbane A, Kone S, Thiam A, Hmeyade BL, Bacar SH, 2017. Integrated and sustainable management of shared aquifer systems and basins of the Sahel region: Taoudeni Basin, RAF/7/011. IAEA, Vienna, Austria.

<sup>412</sup> Friedel MJ, Finn C. 2008. Hydrogeology of the Islamic Republic of Mauritania, Open-File Report 2008–1136. US Geological Survey, Virginia, USA.

<sup>413</sup> Moulla AS, Smati A, Kabore Komi RA, Galbane A, Kone S, Thiam A, Hmeyade BL, Bacar SH, 2017. Integrated and sustainable management of shared aquifer systems and basins of the Sahel region: Taoudeni Basin, RAF/7/011. IAEA, Vienna, Austria.

<sup>414</sup> MacDonald AM, Bonsor HC, Dochartaigh BÉÓ, Taylor RG. 2012. Quantitative maps of groundwater resources in Africa. *Environmental Research Letters*, 7: 024009.

<sup>415</sup> MacDonald AM, Lark RM, Taylor RG, Abiye T, Fallas HC, Favreau G, Goni IB, Kebede S, Scanlon B, Sorensen JPR, Tijani M, Upton KA, West C. 2021. Mapping groundwater recharge in Africa from ground observations and implications for water security. *Environmental Research Letters*, 16(3): 034012.

<sup>416</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 27 July 2022.

<sup>417</sup> Friedel MJ, Finn CA, Horton, JD. 2015. Hydrogeologic map of the Islamic Republic of Mauritania (Phase V, Deliverable 56), synthesis of hydrologic data (Deliverable 57), and chemical hydrologic map of the Islamic Republic of Mauritania (added value)

<sup>418</sup> Upton K, Ó Dochartaigh BÉÓ, Bellwood-Howard I. 2018. Africa groundwater atlas: hydrogeology of Mauritania. British Geological Survey.

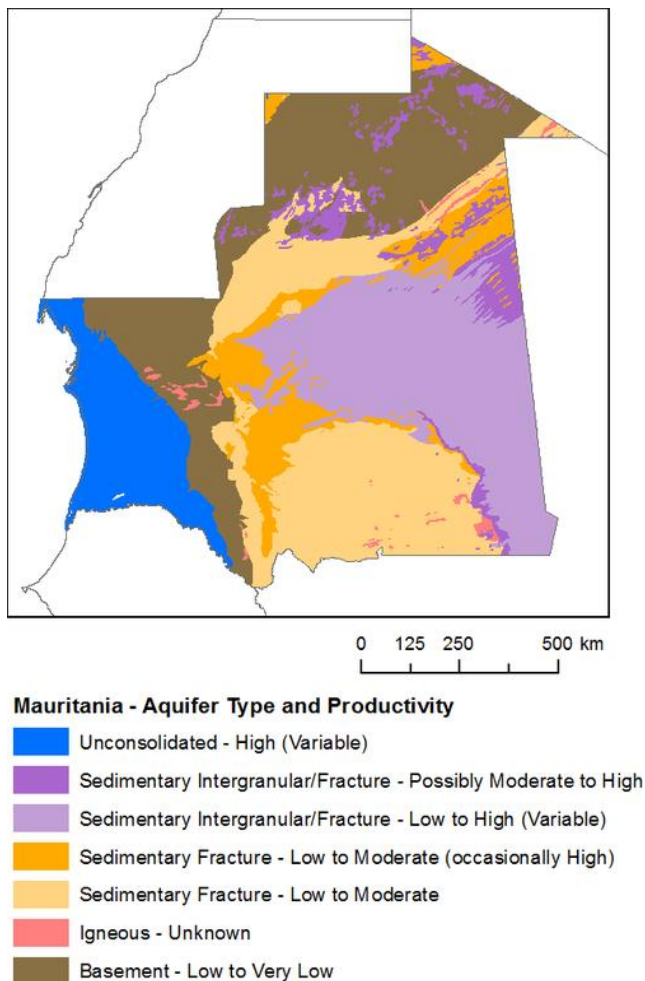
<sup>419</sup> Upton K, Ó Dochartaigh BÉÓ, Bellwood-Howard I. 2018. Africa groundwater atlas: hydrogeology of Mauritania. British Geological Survey.

<sup>420</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>421</sup> Base de de Données des Investissements d'Hydraulique et d'Assainissement

<sup>422</sup> Ministère de L'Hydraulique et de l'Assainissement. 2016. Stratégie nationale pour un accès durable à l'eau et à l'assainissement à l'horizon 2030. SNEADEA – 2030.





**Figure 21.** Aquifer type and productivity of Mauritania<sup>423</sup>.

### *Groundwater at the four regional hubs*

#### Aoujeft

The Adrar wilayah is characterised by two hydrogeological features — the Mauritanides range and the Reguibat ridge to the west and north-west, respectively, and the Taoudéni basin in the center and to the east. The aquifers of the Reguibat ridge are highly fractured and contain low groundwater levels. Nonetheless, in some cases, they play an important role in the water levels of the wadis in the region. Found at depths of 6–80 m, these aquifers are recharged by surface water infiltration and often contain brackish water. The aquifers of the Taoudéni Basin relevant to the project area have been the subject of numerous hydrogeological surveys, which found water resources at depths of 20–220 m in the Agueni sandstone and the Atar and Toueiderguilt limestone formations<sup>424</sup>.

#### Rachid

The Tagant massif in this wilayah — made up of quartzite and calcareous sandstone — is intensely fractured, with valleys that have cut into the rock formations. Three types of aquifers are characteristic of this massif: i) the discontinuous sandstone aquifers; ii) the discontinuous limestone aquifers; and iii) the continuous aquifer. Discontinuous aquifers are exploitable by drilling. The sandy formation of the N'Beika plain contains a shallow, continuous aquifer that is both productive and not highly mineralised. The productive alluvial aquifer of the Tamourt En Naage depression has higher mineralisation and remarkable electrical conductivity. In 2007, the Tagant wilayah had 473 water

<sup>423</sup> Upton K, Ó Dochartaigh BÉÓ, & Bellwood-Howard I. 2018. Africa groundwater atlas: hydrogeology of Mauritania. British Geological Survey.

<sup>424</sup> Appendix 1.

points to access the groundwater in the area, of which ~56% were traditional wells, boreholes made up ~24% and modern wells were ~20%<sup>425</sup>, as set out in more detail in Table 12.

**Table 12.** Boreholes and wells per *moughataa* in the Tagant wilayah in 2007<sup>426</sup>.

<i>Moughataa</i>	Boreholes	Modern wells	Traditional wells	Other wells	Total
Moudjéria	52	37	216	1	305
Tichitt	14	8	5	0	27
Tidjikja	46	51	44	4	141
<b>Total</b>	112	96	265	5	473

### Tamcheket

There are several aquifers in this area<sup>427</sup>:

- In the sandstones of Assaba and the sands of Aouker — Tagant and Assaba are geologically and climatically continuous and contain aquifers in the Kiffa series with significant flow rates, in particular in the Karakoro region.
- In the sandstones of Aïoun — stratified soft sandstone formations of Infracambrian age are found, with heterogeneous hydrodynamic characteristics. Their permeability is dependent on fissured zones and they are characterised by high flow rates, low mineralisation and high conductivity in plains and depressions.
- In the pelites of Hodh — clay sediments, injected by basic dolerites, are found. They are generally impermeable, of Cambrian age and contain water only in fractures or contact zones between pelites and dolerites. They are characterised by variable salinity and flow rate.

Groundwater recharge seems to occur indirectly after rainfall through infiltration in riverbeds<sup>428</sup>.

<sup>425</sup> Appendix 1.

<sup>426</sup> Appendix 1.

<sup>427</sup> EnterpriseWorks/VITA, UNICEF, Practica Foundation. 2010. Mauritanie: étude de faisabilité des forages manuels: identification des zones potentiellement favorables.

<sup>428</sup> Appendix 1.

## Nema

Similar to Mauritania as a whole, groundwater resources are unevenly distributed in this region. Some areas in the Hodh Chargui wilayah have continuous aquifers with significant water resources — such as the Dhar de Nema aquifer — located in the east near the border with Mali, covering an area of ~10,000 km<sup>2</sup>, with highly promising reserves estimated at 10 km<sup>3</sup> — and the Aouker aquifer — covering an area of 100,000 km<sup>2</sup>, with excellent freshwater reservoirs but low exploitation potential due to the sparse habitation of the surrounding area. The underground water resources in these productive areas are contained in the continental sandstone aquifers — the source of the freshest waters — and in the fracture layers. Other areas are largely unexploitable and are only exploited via a few inaccessible wells<sup>429</sup>.

In this wilayah, ~96% of drinking water was supplied by the available 3,303 groundwater access points in 2013, including wells (3,157), standpipes (105) and probes (41)<sup>430</sup>. *Moughataa*-specific details of water access points are given in Table 13.

**Table 13.** Number of water access points per *moughataa* in the Hodh Chargui wilayah<sup>431</sup>.

<i>Moughataa</i>	Standpipes	Wells	Probes	Total
Amourj	15	745	2	762
Basseknou	22	82	2	106
Djiguenni	16	366	3	385
Nema	34	392	14	440
Oualata	3	51	0	54
Timbedra	9	1,489	16	1,514
N'Beikett Lehouach	6	32	4	42
Total	105	3,157	41	3,303

## Alternative water sources

There is very little information available about alternative water sources in Mauritania, such as rainwater harvesting, desalination of brackish water or wastewater treatment. Based on the total capacity of water desalination installations, an estimated 0.002 km<sup>3</sup>/year of desalinated water is produced<sup>432</sup>. Of the 0.0214 km<sup>3</sup>/year of wastewater produced, only 0.0007 km<sup>3</sup>/year is treated, but no information is available on what proportion of this water is collected or used after treatment<sup>433</sup>.

### 1.4.3 Water access and use

#### Water access and use across Mauritania

The geographical and climatic characteristics of Mauritania make water accessibility a major, permanent historical challenge. More than 96% of the renewable surface water is concentrated in the alluvial plains of the Senegal River Basin with its fertile agricultural lands. The rest of the country is covered in Saharan desert and Sahel semi-desert zones characterised by low, variable precipitation and limited water resources. The extreme geographical disparity in water availability is suggested by the discrepancy between the total renewable water resources per capita of 2,589 m<sup>3</sup>/year in 2018 and the much lower total water withdrawal per capita at only 306.6 m<sup>3</sup>/year. In the light of this, the Millennium Development Goal Indicator 7.5 — freshwater withdrawal in a given year as a percentage of the total renewable water resources — was only ~12% in 2018<sup>434</sup>. Similarly, water stress — the

<sup>429</sup> Appendix 1.

<sup>430</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>431</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>432</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.

<sup>433</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.

<sup>434</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.

ratio between the total freshwater withdrawn by all major sectors and the total renewable freshwater resources — was ~13% in 2018<sup>435</sup>.

The favourable nationwide indicators of water availability mask regional disparities. Approximately 39% of Mauritians were deemed deprived of drinking water, with no access to an improved source within a 30-minute round trip collection time in 2019<sup>436</sup>. In the southwest of Mauritania, only about half the estimated daily drinking water requirement of 100,000 m<sup>3</sup> from the Trarza aquifer is met at a production level of around 55,000 m<sup>3</sup> per day<sup>437</sup>. The discrepancy in water access for rural and urban populations is stark — in 2020, ~89% of urban inhabitants in Mauritania had access to basic drinking water<sup>438</sup> services, with only ~50% of their rural counterparts with similar access<sup>439</sup>. The recurrent severe water shortages in arid rural areas lead to urban migration<sup>440</sup>. Consequently, water withdrawal for municipal use is increasing in urban centres. Since 2011, water has been pumped at a rate of 120,000 m<sup>3</sup>/day from the Senegal River to Nouakchott, the capital of Mauritania<sup>441</sup>.

Since 2008, the GoM has invested heavily in improving water access infrastructure, such as the installation of 1,100 drinking water supply networks and 650 wells across the country — benefiting ~1.2 million Mauritians. In May 2019, Mauritania signed an agreement with France for an amount of ~USD11.5 million to finance more water projects<sup>442</sup>. In the Senegal River Basin, dam construction has generally led to better access to drinking water for the local communities near the dams<sup>443</sup>.

Agriculture is by far the greatest water user in Mauritania. By sector as a proportion of total water withdrawal in 2018, agricultural water withdrawal was ~91%, industrial water withdrawal was ~7% and municipal water withdrawal was ~2%. Agricultural water withdrawal as a percentage of the total renewable water resources was ~11% in 2018, with a total withdrawal of 1.223 km<sup>3</sup>/year, all towards irrigation agriculture<sup>444</sup>. Notably, the withdrawal of water for irrigation agriculture is increasing. Historically, rain-dependent and flood-recession crops were grown in the Senegal River Basin, but recurring drought cycles such as those of the 1970s made irrigated crops more profitable<sup>445</sup>. Consequently, irrigation agriculture is expanding rapidly, particularly after the filling of two dams in 1986 and 1988<sup>446</sup>. Most crops are irrigated by surface water, but ~11% of the area equipped for irrigation that derives its water from groundwater sources. As of 2018, the ratio between irrigated and rainfed crop yields is 3.569. Importantly, water use efficiency across all sectors — which can be seen as the economic value added by every litre of water withdrawn — is low at 3.93 USD/m<sup>3</sup> in 2018<sup>447</sup>.

In northern Mauritania's arid pastoral and oasis farming systems, shallow groundwater or surface water make agricultural activities possible, with intense irrigation agriculture close to the water point and associated pastoral systems on the periphery. Water access in these areas is subjected to

<sup>435</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.

<sup>436</sup> WHO/UNICEF Joint Monitoring Programme. 2021.

<sup>437</sup> AfDB. Available at: <https://www.afdb.org/en/news-and-events/mauritania-on-track-to-beating-drinking-water-shortages-18743>. Accessed on 08 July 2021.

<sup>438</sup> Drinking water from an improved source within a 30-minute round trip collection time.

<sup>439</sup> WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) database. Available at: <https://washdata.org/data/household#!/dashboard/new>. Accessed on 19 August 2022.

<sup>440</sup> AfDB. Available at: <https://www.afdb.org/en/news-and-events/mauritania-on-track-to-beating-drinking-water-shortages-18743>. Accessed on 08 July 2021.

<sup>441</sup> Mohamed A-S, Leduc C, Marlin C, Wagué O, Sidi-Cheikh M-A. 2017. Impacts of climate change and anthropisation in groundwater resources in the Nouakchott urban area (coastal Mauritania). *Comptes Rendus Geoscience*, 349: 280–289.

<sup>442</sup> Feukeng L. 2019. Mauritania: government plans to install 300 boreholes by 2020. *Afrik21*. Available at:

<https://www.afrik21.africa/en/mauritania-government-plans-to-install-300-boreholes-by-2020/>.

<sup>443</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>444</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 18 July 2022.

<sup>445</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>446</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>447</sup> FAO. AQUASTAT database. Available at: <https://fao.org/aquastat/statistics>. Accessed on 27 July 2022.

traditional community water management<sup>448</sup>. In major wadis, such as Lagueila in Mauritania, flood recession farming is possible, which can contribute to the grain supply of populations living around oases. At the Assaba palm plantations, the palm trees access the shallow groundwater directly and no irrigation is necessary<sup>449</sup>.

## Water access and use at the four regional hubs

### *Aoujeft*

In the Adrar wilayah, the water supply sources are as follows: i) ~12% of the population accesses water from the public drinking water networks; ii) ~3% from public fountains; iii) ~25% from wells; and iv) the remaining ~60% from unidentified sources<sup>450</sup>, as set out in Table 14. In terms of drinking water, 32.2% of households most often get their drinking water from a truck or cistern, while 21.8% of households use uncovered wells. Average daily water use is ~38 litres/inhabitant, with daily need estimated as ~75 litres/inhabitant, which is indicative of a water shortage in the area. Moreover, water deficits at the pastoral wells have been recorded during the dry season from March to August prior to the rainy season, along with shortages in drinking water during the date harvest period between June and August when agricultural water use intensifies. These shortages are coupled with the high cost of maintenance and manual drilling of wells in Aoujeft, which limits upkeep and expansion of water supply sources<sup>451</sup>.

**Table 14.** Water supply source in the Adrar wilayah and in Mauritania in 2013<sup>452</sup>.

Water source	Adrar	National
	Share (%)	Share (%)
Public drinking water network	11.7	15.0
Public fountains	3.1	25.7
Wells	24.6	37.3
River	0	13.0
Other	60.6	9.0
Total	100	100

### *Rachid*

In the Tagant wilayah, 27% of households get their drinking water from an outside tap on their properties, with only ~4% obtaining water from a tap inside their dwelling. Most households (~32%) do not have access to drinking water on their own properties and obtain water from uncovered wells. Neighbours' taps, boreholes, standpipes and covered wells are also common sources of water supply for households<sup>453</sup> (Table 15). In this wilayah, where the water table is receding, traditional wells have dried up in most of the oases, whilst others have been buried by shifting sand dunes or flooding of the wadis<sup>454</sup>. Given the receding water table, the required depth for productive new boreholes ranges between 90–100 m. Further, the rural communities are not able to afford the costs associated with the mechanical deepening of wells<sup>455</sup>.

**Table 15.** Main water source for households in the Tagant wilayah, distribution (%) per *moughataa* in 2013<sup>456</sup>.

Main source	Moudjéria	Tichit	Tidjikja
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<sup>448</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>449</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>450</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>451</sup> Appendix 1.

<sup>452</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>453</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>454</sup> Appendix 1.

<sup>455</sup> Appendix 1.

<sup>456</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

Tap in the house	3.8	0.8	5.4
Tap in the yard	25.9	25.7	28.4
Neighbour's tap	5.9	8	7.6
Standpipe	2.1	21.7	3.9
Borehole	4.4	10	2.5
Covered well	5	4.4	2.9
Uncovered well	42	28.5	20.6
Tank truck	1.3	0.8	3
Charette	0.3	0.2	16.4
River or stream	0.6	0	0
Dam, lake, pond, irrigation channel	1.9	0	2.8
Rainwater	0.6	0	0.7
Others	6.2	0	5.7
Total	100	100	100

#### *Tamcheket*

In the Hodh El Gharbi wilayah, ~43% of households acquire their drinking water from uncovered wells, ~20% from an outside tap on their properties, ~8% from covered wells outside their properties and ~7% from a tap inside their dwellings. More detail on the *moughataa* level is provided in Table 16. Tamcheket has two unfenced water towers, and drinking water service infrastructure from Aïoun and Kiffa is in need of repair.

**Table 16.** Main water source for households in the Hodh El Gharbi wilayah, distribution (%) per *moughataa* in 2013<sup>457</sup>.

Main source	Aïoun	Koubenni	Tamcheket	Tintane	Total
Tap in the house	13.4	4.8	1.7	6.9	7.0
Tap in the yard	32.9	10.6	15.3	20.5	19.5
Neighbour's tap	8.7	3.3	2.9	4.3	4.8
Standpipe	8.9	5.3	6.8	1.9	5.1
Borehole	1.2	2.7	5.6	2.4	2.6
Covered well	5.9	9.0	10.5	6.2	7.6
Uncovered well	24.1	54.9	45.7	44.3	43.2
Tank truck	1.7	0.2	0.0	1.7	1.0
Charette	2.7	6.2	6.1	9.0	6.4
River or stream	0	0	0	0	0
Dam, lake, pond, irrigation channel	-	2.3	2.9	0.8	1.4
Rainwater	-	0.2	0.1	0.0	0.1
Other	0.5	0.5	2.3	1.9	1.2
Total	100	100	100	100	100

<sup>457</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

## Nema

The largest proportion of households in the Hodh Chargui wilayah, ~48%, acquire their drinking water from uncovered wells outside their properties. Quite a number, ~27%, acquire their drinking water from charettes, with ~5% having a tap in the dwelling and ~6% an outside tap on their properties<sup>458</sup>. More details on the *moughataa* level distribution of these water sources are given in Table 17.

**Table 17.** Main water source for households in the Hodh Chargui wilayah, distribution (%) per *moughataa* in 2013<sup>459</sup>.

Main source	Amourj	Bassiknou	Djiguéni	Nema	Oualata	Timbédra	N'Beïket Lehouach	Total
Tap in the house	1.9	9	3.2	5.4	12.7	5.8	9.2	4.8
Tap in the yard	2.2	16	6.3	7.8	4.3	3.2	17.8	6.1
Neighbour's tap	0.7	6.7	2.9	3.4	1.0	2.0	6.1	2.6
Standpipe	5.8	7.5	4.7	3.6	1.8	0.5	5.7	4.1
Borehole	0.3	5.6	0.2	4.4	0.1	0.7	21.5	2.2
Covered well	2.8	0.9	1.4	4.6	2.5	4.1	0.4	3.0
Open well	55.1	28.0	62.6	45.2	75.1	36.9	38.5	47.6
Tank trunk	0	3	0.1	1.3	0.1	0.7	0	8
Charette	28.5	19	17.7	22.5	1.2	45.2	0.5	26.8
River or stream	0	0	0	0	0	0	0	0
Dam, lake, <i>mare</i> , irrigation channel	0.7	3.7	0	0	0.1	0	0	0.6
Rainwater	0.7	0.2	0	0.5	0	0	0	0.3
Other	1.2	0.4	1	1.3	1.2	0.8	0.3	1
Total	100	100	100	100	100	100	100	100

### 1.4.4 Water governance, projects and targets

At a global level, following Sustainable Development Goal 6 of clean water and sanitation, the implementation of integrated water resources management (IWRM) is a main target. The implementation of IWRM is divided into four dimensions: i) institutions and participation<sup>460</sup>; ii) enabling environment<sup>461</sup>; iii) financing and budgeting<sup>462</sup>; and iv) managing instruments<sup>463</sup>. Mauritania scores 59% in institutions and participation, 53% in enabling environment, 44% in financing and budgeting, and 33% in managing instruments, with an overall score of 47% at implementing IWRM across the country<sup>464</sup>.

Since most of Mauritania's renewable freshwater resources are contained in border rivers, regional agreements for internationally shared water resources are of the utmost importance. The 'Convention declaring the status of the Senegal River' (*Convention relative au statut de fleuve Sénégal*, 1972) guarantees freedom of navigation and the equal treatment of users. Mali, Mauritania and Senegal collaborate according to the 'Convention creating the OMVS' (*Convention portant création de*

<sup>458</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>459</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat.

<sup>460</sup> 'Institution and participation' refers to the range and roles of political, social, economic and administrative institutions and other stakeholder groups that help to support implementation.

<sup>461</sup> 'Enabling environment' refers to the conditions that help to support the implementation of IWRM, which include the most typical policy, legal and strategic planning tools.

<sup>462</sup> Financing and budget are those made available and used for water resources development and management from various sources.

<sup>463</sup> Management tools encompass the tools and activities that enable decision-makers and users to make rational and informed choices between alternative actions.

<sup>464</sup> UN SGD Data. Available at: [https://www.sdg6data.org/country-or-area/mauritania#anchor\\_6.5.1](https://www.sdg6data.org/country-or-area/mauritania#anchor_6.5.1). Accessed on 14 July 2021.



*l'Organisation pour la mise en valeur du fleuve Sénégal*, 1972). Guinea's collaboration is ensured via a framework cooperation agreement (*Protocole d'accord-cadre de coopération entre la République de Guinée et l'OMVS*, 1992). Two complementary conventions, namely the 'Convention concerning the legal status of jointly-owned structures' (*Convention relative au status juridique des ouvrages communs*, 1978) and the 'Convention concerning the financing of jointly-owned structures' (*Convention relative aux financements des ouvrages communs*, 1982), declare property rights and expenses as mutual benefits and responsibilities of all the OMVS members.

Two entities, both created in 1997, manage the jointly-owned structures for the OMVS — the *Société de gestion et d'exploitation du barrage de Diama* is dedicated to the management and development of the Diama Dam and the *Société de gestion de l'énergie de Manantali* is dedicated to the Manantali Dam. The 'Senegal River charter' (*Charte des eaux du fleuve Sénégal*, 2002) establishes the procedures and principles to allocate water to the various water users, including new projects, and establish regulations for environmental protection. These legal frameworks rely on an extensive organisational framework to ensure the participation and management of all actors and stakeholders. The environmental impacts of the power generation activities in the Senegal River are alleviated by an intergovernmental programme (*Plan d'atténuation et de suivi des impacts sur l'environnement*) overseen by the Permanent Water Commission.

On a national level, the mandates of the agencies involved in water resources management in Mauritania are listed below:

- The Ministry of Water and Sanitation (MHA) is the national owner of hydraulic infrastructure.
- The National Safe Drinking Water and Sanitation Agency is an independent agency that brings together all actors of civil society to manage drinking water networks in rural and semi-urban (small town) areas.
- The National Water Resources Centre (CNRE) is responsible for exploration, assessment, monitoring and protection of water resources nationwide.
- The Directorate of Water, a department within MHA, has overall responsibility for the supply of drinking water across the country. It installs wells and boreholes and is responsible for water distribution in secondary centres.
- The National Water and Electricity Company is a state-owned public corporation responsible for the production, transmission and distribution of water and electricity in large urban centres.
- The Ministry of Rural Development and Environment and the Department of Environment and Rural Development increase the added value of agriculture and improve food security.
- The Mauritanian National Office for Rural Water Services (ONSER) is responsible for supplying water to more than 800 rural centres.

#### 1.4.5 Challenges related to water resources in Mauritania

In a country largely defined by aridity, water availability dictates the fates of people, livestock and natural environments. In this precarious environment, baseline economic, social and environmental issues have huge impacts on water resources.

##### **Water conflict**

Despite the existence of treaties and regulations, the scarcity of water makes it a contested resource within Mauritania and with its neighbouring countries. The sharing of water from the Senegal River is characterised by cooperative management between the countries involved and can be seen as a model of effective and peaceful transboundary water management<sup>465</sup>. However, this does not mean that there is no conflict on the local level. The 1989 interethnic conflict between villages on the Mauritanian and Senegalese banks of the Senegal River was ultimately caused by water disputes

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<sup>465</sup> UNEP. 2010. Africa water atlas.



between traditional herdsman and irrigation farmers<sup>466</sup>. In the same region, an increase in the intensity of agricultural activities due to improved irrigation and an increase in the concentration of transhumance around the river in response to aridity further afield led to an increase in competition between these lifestyles<sup>467</sup>. Large-scale hydroelectric and agricultural investments made by both the Senegalese and Mauritanian governments in this area have led to economic opportunities with starkly different impacts on the sedentary and nomadic people groups in the area. These shifts in fortunes have shaped both migration, resource use and conflict in the area and have even led to some uncomfortable diplomatic incidents<sup>468</sup>.

Similarly, the artificial flooding of the northern banks of the Senegal River causes conflict between fishermen, stock breeders and irrigation crop farmers, which is why interventions must be carefully timed and managed<sup>469</sup>. Participatory processes that develop joint management programmes based upon hydraulic modelling seem to be a successful management strategy<sup>470</sup>.

Across the rest of the country, water pumping at oases is controlled by laws and regulations; however, these are often violated, leading to overuse that negatively affect marginalised groups, specifically women<sup>471</sup>. An example of this situation is in the region surrounding Nema — one of the project's hubs — where access to dams is limited to members of certain communities, a requirement that causes frequent disputes around infrastructure<sup>472</sup>.

### **Population growth and urbanisation in response to water scarcity**

Mauritania is experiencing an overall trend of urbanisation, with water scarcity in rural areas acting as a major driver<sup>473</sup>. In this regard, the Senegal River is a particularly interesting case. The population of the Senegal River Basin is increasing steadily at rates slightly above the national average of 2.7%<sup>474</sup>, but this is countered by emigration among the younger generations to major cities such as Nouakchott<sup>475</sup>. Many of these emigrants return to the basin during the rainy season for seasonal work, and many provide financial support to their households, which often keeps families afloat in times of drought<sup>476</sup>. In response to declining revenue from animal husbandry in the area, increased aridity and competition with irrigation agriculture, nomadic ethnic groups have also abandoned their activities along the banks of the Senegal River in favour of life in urban centres<sup>477</sup>. Consequently, the groundwater resources of the SMAB are under pressure from population growth, rapid urbanisation and agricultural developments that lead to an increasing demand for water<sup>478</sup> and a deterioration in water quality<sup>479</sup>.

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<sup>466</sup> Gleditch NP, Furling K, Hegre H, Lacina B, Owen T. 2006. Conflicts over shared rivers: resource scarcity or fuzzy boundaries? *Political Geography*, 25(4): 361–382.

<sup>467</sup> Heinriks P. 2010. Security implications of climate change in the Sahel region: policy considerations. OECD Sahel and West Africa, Paris, France.

<sup>468</sup> Niasse M. 2005. Climate-induced water conflict risks in West Africa: recognizing and coping with increasing climate impacts on shared watercourses. Human security and climate change: an international workshop, Asker, Sweden.

<sup>469</sup> Duvail S, Hamerlynck O. 2003. Mitigation of negative ecological and socio-economic impacts of the Diama Dam on the Senegal River delta wetland (Mauritania), using a model-based decision support system. *Hydrology and Earth System Sciences*, 7(1): 133–146.

<sup>470</sup> Duvail S, Hamerlynck O. 2003. Mitigation of negative ecological and socio-economic impacts of the Diama Dam on the Senegal River delta wetland (Mauritania), using a model-based decision support system. *Hydrology and Earth System Sciences*, 7(1): 133–146.

<sup>471</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). *Farming systems and food security in Africa*. Routledge: London.

<sup>472</sup> Appendix 1.

<sup>473</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>474</sup> WB Group. 2022. World Development Indicators. Available at: <https://data.worldbank.org/>.

<sup>475</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>476</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>477</sup> Heinriks P. 2010. Security implications of climate change in the Sahel region: policy considerations. OECD Sahel and West Africa, Paris, France.

<sup>478</sup> UNESCO World Water Assessment Programme. 2022. The United Nations world water development report 2022: groundwater: making the invisible visible.

<sup>479</sup> Lapworth DJ, Nkhuwa DCW, Okotto-Okotto J, Pedley S, Stuart ME, Tijani MN, Wright J. 2017. Urban groundwater quality in sub-Saharan Africa: current status and implications for water security and public health. *Hydrogeology Journal*, 25: 1093–1116.

Focussing on the project areas in the arid rural areas to the north of the Senegal River Basin, human settlements have likewise shifted in response to dwindling water sources. The repeated droughts of the 1970s and 1980s led to the migration and permanent settlement of many traditionally nomadic herders, as well as changes in herd ownership at the Aoujeft hub. At the Nema hub, the overall degradation in the living conditions of people in the area acts as a catalyst for a massive rural exodus to larger cities<sup>480</sup>.

### **Scarcity related to insufficient water infrastructure management**

Widespread migration to urban centres has changed the water demands of cities in Mauritania and placed great stress on the available water infrastructure. The increased supply of domestic water from the Senegal River to Nouakchott and the absence of efficient wastewater management adds large volumes of water to the Trarza Quaternary aquifer through infiltration from overburdened water and sanitation networks<sup>481</sup>. The subsequent rise in the groundwater table has far-reaching consequences in the city, from the abandonment of flooded buildings and districts to the emergence and proliferation of disease<sup>482</sup>.

In rural areas, the restoration and creation of water management infrastructure at oases can lead to more efficient and sustainable water use, promote groundwater recharge and lead to more productive agriculture<sup>483</sup>. For this reason, the conservation, mobilisation and utilisation of water management facilities is one of the priority intervention strategies for the management of the Adrar oasis in Mauritania<sup>484</sup>. However, topographic features of certain regions can make water management infrastructure less efficient. For example, the Maleh, Zira and Dombaï districts in the Tagant wilayah are at altitudes too high to be properly serviced by the water tower and reservoir in the region<sup>485</sup>. Water management techniques are sometimes not appropriate, such as in the Hodh Chargui wilayah<sup>486</sup>. In mismanaged areas, agricultural land under irrigation is often abandoned because of the short duration of development, limited maintenance and problems with salinity caused by the absence of drains in water infrastructure<sup>487</sup>.

### **Social inequality and water resources**

The degree of impact associated with the uneven distribution of water resources in Mauritania varies between social groups. These differences can largely be attributed to gender roles, the equity gap between rural and urban populations, and ethnicity.

Gender serves as a determining factor in the ability for certain gender groups to respond to water scarcity. For example, considerably more women and girls (41%) are involved in water collection compared with men and boys (21%)<sup>488</sup>. The increased time spent collecting water during water shortages, therefore, has a much larger effect on women's time spent on domestic responsibilities than men. This disparity is particularly prevalent in the four project areas, where sources of drinking water are located a considerable distance from dwellings<sup>489</sup>.

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<sup>480</sup> Appendix 1.

<sup>481</sup> Mohamed A-S, Leduc C, Marlin C, Wagué O, Sidi-Cheikh M-A. 2017. Impacts of climate change and anthropisation in groundwater resources in the Nouakchott urban area (coastal Mauritania). *Comptes Rendus Geoscience*, 349: 280–289.

<sup>482</sup> Mohamed A-S, Leduc C, Marlin C, Wagué O, Sidi-Cheikh M-A. 2017. Impacts of climate change and anthropisation in groundwater resources in the Nouakchott urban area (coastal Mauritania). *Comptes Rendus Geoscience*, 349: 280–289.

<sup>483</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). *Farming systems and food security in Africa*. Routledge: London.

<sup>484</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). *Farming systems and food security in Africa*. Routledge: London.

<sup>485</sup> Appendix 1.

<sup>486</sup> Appendix 1.

<sup>487</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>488</sup> WHO/UNICEF. 2017. Safely managed drinking water — thematic report on drinking water 2017. Geneva, Switzerland: WHO.

<sup>489</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat

The large equity gap between rural and urban populations' access to basic water supply and sanitation services is another factor that impacts water access in Mauritania. Approximately 89% of the urban population had access to basic drinking water services in 2019, which is substantially more than the ~50% with access in rural areas<sup>490</sup>. In particular, the majority of households in the project area — more than half in all *moughataas* in the target wilayahs — do not have a water source on their own properties. As a result, these households rely on public water access points to support their domestic water consumption needs. However, many of these public water points are not suitable for drinking purposes. For example, the uncovered wells that support ~48% of households in the Hoch Ech Chargui wilayah (where Nema is situated) pose a health risk as they are more prone to contamination by naturally-occurring sources, such as microorganisms, as well as human activities, including sewerage and animal waste from livestock farming. This proportion is similarly high in the Hodh El Gharbi wilayah (where Tamcheket is situated), where ~43% depend on public water points<sup>491</sup>.

Ethnicity also plays a role in the access to and use of water resources in Mauritania. Traditional herdsman, such as the Fulani, possess extensive indigenous knowledge on the location and detection of groundwater and the estimation of water quality, using topography, geological features and vegetation<sup>492</sup>. However, they are often displaced by agricultural activities, particularly in the Senegal River Basin<sup>493</sup>.

### **Degradation of water ecosystems, resources and quality**

The degradation of aquatic ecosystems and other water features due to human activities and natural disasters in Mauritania causes instability in water-stressed regions. Mining, infrastructure construction, agricultural activities, overexploitation of resources and recurring floods and droughts lead to loss of ESSs, reduction in water quality and the proliferation of water-borne diseases. These factors not only lead to a direct degradation of living conditions for the population of Mauritania, but they are also limiting factors in the development of economic opportunities, particularly in poverty-stricken rural areas.

In particular, the degradation of oases across northern Mauritania is of concern. These fragile ecosystems and their water resources are under increasing stress, with adverse effects on the economic activities that rely on them. Decreasing water resources at oases has several causes, including: i) urban development adjacent to the water sources that competes with palm plantations for available water; ii) development of private pumping systems that leads to unregulated water use and gradual depletion of groundwater; and iii) deep pumping of water from aquifers to support intensifying palm plantations and water supply for human activities that causes non-renewable water resource depletion<sup>494</sup>. To worsen matters, most palm plantations in Mauritania are not part of fully developed oasis agroecosystems, which means that the plantations do not support the cultivation of various crops or sustainable water resource use<sup>495</sup>. In turn, the loss in ESSs from oases is detrimental to agricultural activities. For example, in the Tagant wilayah, palm trees experience high mortality as they can no longer reach the gradually dropping water table<sup>496</sup>.

Water availability in the arid areas of Mauritania is further impacted by drought and flood cycles. In the Adrar wilayah, the combination of strong winds and long droughts causes the siltation of rivers. On the other hand, recorded floods in the Adrar wilayah — most recently in 1984, 2003 and 2010 —

<sup>490</sup> WHO/UNICEF Joint Monitoring Programme. 2021.

<sup>491</sup> Office Nationale de la Statistique. 2013. Recensement général pour la population et l'habitat

<sup>492</sup> UNEP. 2010. Africa water atlas.

<sup>493</sup> Heinrigs P. 2010. Security implications of climate change in the Sahel region: policy considerations. OECD Sahel and West Africa, Paris, France.

<sup>494</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>495</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>496</sup> Appendix 1.

can lead to fatalities, wash away palm trees, cause soil erosion and bury wells used to access water<sup>497</sup>.

When looking at the alluvial ecosystems, there has been a considerable degradation of surface water quality in the Senegal River Basin, primarily caused by eutrophication in response to: i) the lowered flow velocity and oxygenation caused by dam and dyke construction; ii) the proliferation of water weeds; and iii) pollution caused by the discharge of fertiliser, wastewater and pesticides<sup>498</sup>. In particular, the increased fertiliser usage that is a result of elevated agricultural activities in the basin has led to a decrease in water quality downstream, both in inland and coastal waters<sup>499</sup>. In addition, dam construction in the Senegal River Basin has had many detrimental effects on the floodplain ecosystems and the people that rely on them, mainly as a result of the reduction in the regular natural flooding of wetlands, lakes and ponds — as in Lake Diawling in southwestern Mauritania<sup>500</sup>. The permanent presence of freshwater upstream of the Diama Dam in the Senegal River Basin's middle delta is linked to the proliferation of invasive water plants such as *Salvinia molesta*, *Pistia stratiotes* and *Typha australis*, which causes eutrophication, impairs waterway access, slows river flow, provides habitat for bird species that feed on cultivated crops<sup>501</sup> and contributes to the homogenisation of ecosystems across the region<sup>502</sup>. Another distinct negative impact of dam, dyke and irrigation system construction is riverbank erosion, which specifically leads to loss of agricultural land and changes in water flow in the upper areas of the basin<sup>503</sup>. Finally, dam development in the Senegal River has led to an increased incidence of water-related diseases<sup>504</sup>. This is a consequence of the modified ecology of the region, which has caused a proliferation in diseases such as bilharzia, malaria and gastrointestinal disease<sup>505</sup>.

Mining, in particular along the coast and in the southwestern regions of Mauritania, is another anthropogenic activity with detrimental effects on aquatic ecosystems and water quality. The physical or chemical contamination of watersheds by mining is a major threat to the health of Mauritania's water supply. The mining-induced loss of wetlands has far-reaching effects, including an increase in downstream pollution, increased flooding and loss of biodiversity<sup>506</sup>. Moreover, it is predicted that mining activities will increase in the Senegal River Basin because of the energy provided by the Manantali Dam in Mali and the completion of the river navigation project<sup>507</sup>.

Water quality in Mauritania — both in the Senegal River Basin and further north at the project's hubs — is greatly challenged by increasing salinisation brought about by seawater intrusion and overexploitation. For example, the overexploitation of oases in the Adrar wilayah has led to insufficient recharge of groundwater resources, drops in the water table and a gradual salinisation of groundwater resources<sup>508</sup>. The similarly increasing water salinity in the Tagant wilayah, such as in Argoub and Timbehra, has negative impacts on economic development, restricting the extension of the water

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<sup>497</sup> Appendix 1.

<sup>498</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>499</sup> UNEP. 2010. Africa water atlas.

<sup>500</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>501</sup> Dumas D, Mietton M, Hamerlynck O, Pesneaud F, Kane A, Coly A, Duvail S, Baba MLO. 2010. Large dams and uncertainties: the case of the Senegal River (West Africa). *Society and Natural Resources*, 23(11): 1108–1122.

<sup>502</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>503</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>504</sup> Sow S, de Vlas SJ, Engels D, Gryseels B. 2002. Water-related disease patterns before and after the construction of the Diama dam in northern Senegal. *Annals of Tropical Medicine and Parasitology*, 96:575–586.

<sup>505</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>506</sup> UNEP. 2010. Africa water atlas.

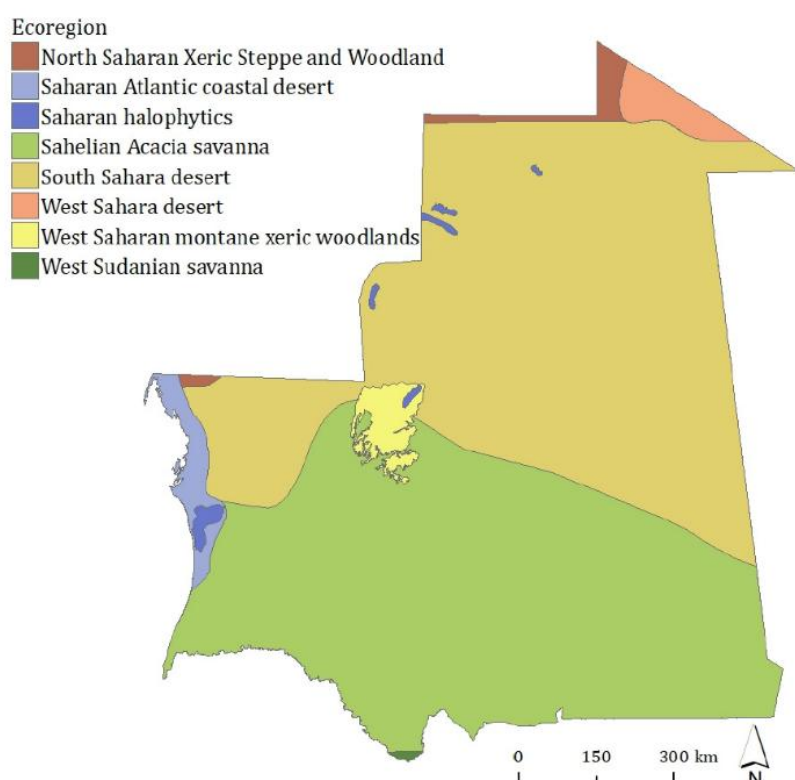
<sup>507</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>508</sup> Appendix 1.

network<sup>509</sup>. Conversely, seawater intrusion into the groundwater of the Senegal River Basin was greatly countered by the building of the Diama Dam near the mouth of the river<sup>510</sup>.

## 1.5 Natural ecosystems

Mauritania is situated in the transition zone between the Palearctic — which covers North Africa and Eurasia — and Afro-tropical — south of the Sahara Desert — biogeographical realms. These realms are divided into biomes, which are further sub-divided into ecoregions. Although Mauritania has an arid climate, its position on the transition zone between the Palearctic and Afro-tropics has resulted in its ecoregions showing notable floral and faunal diversity. Eight ecoregions occur in Mauritania (Figure 22), which are spread across three biomes, namely: i) flooded grasslands and savannas in *sebkhas*<sup>511</sup> that are scattered across the north of the country; ii) deserts and xeric shrubland in the north; and iii) tropical and subtropical grasslands, savannas and shrublands in the south.



**Figure 22.** Terrestrial ecoregions in Mauritania<sup>512</sup>.

### 1.5.1 Flooded grasslands and savannas biomes

The flooded grasslands and savannas biome — the smallest biomes in Mauritania — comprises a single ecoregion, namely the Saharan halophytic ecosystem<sup>513,514</sup>. This ecoregion includes primarily saline habitats that host unique, salt-tolerant plant species known as halophytes. Freshwater oases within this ecoregion offer a critical water source for animals, plants and communities, particularly during the dry season. Saharan halophytes, however, are threatened by increasing desertification,

<sup>509</sup> Appendix 1.

<sup>510</sup> UNESCO World Water Assessment Programme. 2003. The United Nations world water development report 2003: water for people, water for life.

<sup>511</sup> A *sebkha* is a flat, often saline plain that may form a shallow lake after rainfall events.

<sup>512</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Bideserts report EN-02.

<sup>513</sup> Halophytes refers to the presence of vegetation that is naturally tolerant of high salt concentrations.

<sup>514</sup> Naia M & Brito JC. 2021. Geographical atlas of Mauritania. Bideserts report EN-02.

which is exacerbated by climate change. This desertification has the potential to lead to the replacement of wetland habitats with less productive salt flats or sand plains<sup>515</sup>.

### 1.5.2 Deserts and xeric shrublands biome

Most of the country's ecoregions fall within the deserts and xeric shrubland biome, including: i) north Saharan xeric steppe and woodland; ii) West Sahara Desert; iii) South Sahara Desert; iv) Saharan Atlantic coastal desert; and v) west Saharan montane xeric woodlands. North Saharan xeric steppe and woodland is characterised by drought-tolerant Palearctic species adapted to various harsh environments such as mountains, sand seas, dry riverbeds, depressions and plateaus of unconsolidated soil<sup>516</sup>. Located in the country's north, the West Sahara Desert is mostly barren, consisting of empty plateaus, dry valleys and large flats, with sparse oases and green spaces only appearing after rainfall events<sup>517</sup>. The South Sahara Desert is the largest ecoregion in the deserts and xeric shrublands biome and contains some of the most hostile conditions to flora and fauna in the world<sup>518</sup>. As a result of the high aridity in this ecoregion, plants and animals are heavily dependent on freshwater springs and rare rainfall events. Located along the coastline of Mauritania, the Saharan Atlantic coastal desert ecoregion consists of a mosaic of dunes, rocky cliffs, coastal swamps and mangroves<sup>519</sup>. Compared with other parts of the Sahara, this ecoregion has a relatively dense vegetation cover and high richness in plant diversity.

One of the ecoregions in the deserts and xeric shrubland biome occurs within the four project target hubs, namely the West Saharan montane xeric woodlands (Figure 23) — occurring within the Aoujeft hub. This ecoregion exists on volcanic, mountainous plateaus, which provide cooler temperatures and increased moisture because of the higher altitude in comparison with the surrounding desert plains<sup>520</sup>. As a result, species diversity and population numbers are higher than in other ecoregions in the area. The vegetation consists of xerophytic shrubs and woodlands, while notable animal species include the critically endangered northwest African cheetah (*Acinonyx jubatus hecki*) and the Barbary sheep (*Ammotragus lervia*). Human threats to this ecoregion include poaching and illegal timber extraction.

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<sup>515</sup> UNEP-WCTC Author Team. N.d. One Earth: Saharan halophytic. Available at: <https://www.oneearth.org/ecoregions/saharan-halophytic/>.

<sup>516</sup> UNEP-WCTC Author Team. N.d. One Earth: North Saharan xeric steppe and woodlands. Available at: <https://www.oneearth.org/ecoregions/north-saharan-xeric-steppe-and-woodlands/>.

<sup>517</sup> UNEP-WCTC Author Team. N.d. One Earth: West Sahara desert. Available at: <https://www.oneearth.org/ecoregions/west-sahara-desert/>.

<sup>518</sup> UNEP-WCTC Author Team. N.d. One Earth: South Sahara desert. Available at: <https://www.oneearth.org/ecoregions/south-sahara-desert/>.

<sup>519</sup> UNEP-WCTC Author Team. N.d. One Earth: Saharan Atlantic coastal desert. Available at: <https://www.oneearth.org/ecoregions/saharan-atlantic-coastal-desert/>.

<sup>520</sup> UNEP-WCTC Author Team. N.d. One Earth: West Saharan montane xeric woodlands. Available at: <https://www.oneearth.org/ecoregions/west-saharan-montane-xeric-woodlands/>.





**Figure 23.** Mountains in the Adrar wilayah, demonstrating the West Saharan montane xeric woodland ecoregion<sup>521</sup>.

Within the Aoujeft hub, West Saharan montane xeric woodland vegetation is influenced by the topography of the areas and by seasonal changes<sup>522</sup>. Along wadis, for example, woody plant species include Indian jujube (*Ziziphus mauritania*), desert date (*Balanites aegyptica*), bare caper (*Capparis decidua*), giant milkweed (*Calotropis procera*), *Maerua crassifolia* and various *Acacia* species. Herbaceous species along wadis include Indian sandbur (*Cenchrus biflorus*), desert grass (*Panicum turgidum*), Senegal senna (*Cassia italica*) and puncture vine (*Tribulus terrestris*). Many of these species are also found on dunes during the wet season but are confined to wadi beds and depressions during the dry season. Stony desert sections of the hub have almost no vegetation cover other than acacias, bare caper, hanza (*Boscia senegalensis*) and some grasses.

### 1.5.3 Tropical and subtropical grasslands savannas and shrublands biome

The final biome within Mauritania, namely the tropical and subtropical grasslands, savannas and shrublands, consists of two ecoregions. These ecoregions include a small area of west Sudanian savanna along the Senegal River and the Sahelian Acacia savanna, which encompasses most of southern Mauritania. The west Sudanian savanna is located in an area with a more tropical climate than most of Mauritania and is highly seasonal. The vegetation consists of grasslands with scattered patches of thorny shrubland<sup>523</sup>.

Sahelian Acacia savanna (Figure 24), commonly referred to as the 'Sahel', is found across all target hubs<sup>524</sup>. Vegetation within the ecoregion consists of wooded grassland and deciduous bushland. Within wadis located in the hubs of Rachid, Tamcheket and Nema, wooded species include Indian jujube, desert date, giant milkweed, bare caper and gum Arabic (*Acacia nilotica*), African myrrh (*Commiphora africana*), *Acacia flava*, *M. crassifolia*, silver butterfly tree (*Bauhinia ruficens*), toothbrush tree (*Salvadora persica*), Egyptian privet (*Lawsonia inermis*) and *Grewia* species. Herbaceous species recorded in the wadis of these hubs include desert grass, Indian sandbur, Senegal senna, puncture vine, white Egyptian lotus (*Nymphaea lotus*), *Indigofera oblongifolia* and

<sup>521</sup> World Atlas. 2021. Ecological regions of Mauritania. Available at: <https://www.worldatlas.com/articles/ecological-regions-of-mauritania.html>.

<sup>522</sup> Appendix 1.

<sup>523</sup> UNEP-WCTC Author Team. N.d. One Earth: West Sudanian savanna. Available at: <https://www.oneearth.org/ecoregions/west-sudanian-savanna/>.

<sup>524</sup> UNEP-WCTC Author Team. N.d. One Earth: Sahel Acacia savannas bioregion. Available at: <https://www.oneearth.org/bioregions/sahel-acacia-savannas-at23/>.

*Ipomea* species. In addition to wadis, dune landscapes are also found within the Sahelian Acacia savanna. Dunes are predominantly bare on their ridges but hold vegetation on their slopes and bases, including desert date, bare caper, desert grass, umbrella thorn (*Acacia raddiana*) and *Leptadenia pyrotechnica*. Within these wadi plains and dunes, the above plant species are distributed across several vegetation types characterised and dominated by either *A. flava*, *L. pyrotechnica* or *M. crassifolia*. Stony desert areas — like West Saharan xeric woodlands — display low vegetation cover with limited species.



**Figure 24.** Example of the Sahel Acacia savanna ecoregion<sup>525</sup>.

Across the Sahel — including areas within the target hubs — are isolated islands of ephemeral wetland habitats<sup>526</sup>. These wetlands are critical sources of water and nutritious soils that support communities, fauna and flora, particularly during the dry season when they are often the only permanently vegetated areas. Ephemeral wetlands generally occupy depressions and drainage channels and include forested closed basins (*tamourts*), herbaceous closed basins or flats (*gaats*) and seasonal watercourses (*oueds*). *Tamourts* — characterised by stands of the gum Arabic tree and Indian jujube — are found in deeper depressions and therefore hold water for longer than other wetland features. In comparison, *gaats* occur in more shallow topography and are typically used for cultivation during the dry season. The larger wetland areas are important stop-over points for migratory birds — highlighting the high conservation potential of these wetland habitats.

The Sahel is the habitat of several endemic small mammal and reptile species — including the endangered flagship species — the African spurred tortoise (*Centrochelys sulcata*)<sup>527</sup>. Large mammals are mostly non-existent because of intensive hunting and habitat loss, except for several antelope species — such as dorcas gazelle (*Gazella dorcas*) and red-fronted gazelle (*Eudorcas rufifrons*) — which occur primarily in protected areas.

Climatic conditions and anthropogenic impacts have greatly altered the Sahel over the last thousand years<sup>528</sup>. Although the ecoregion is still extensive and continuous, large areas have become degraded. This degradation is highest around waterholes and urban regions, where livestock farming heavily impacts the ecosystem and invasive plant species outcompete native vegetation. Other

<sup>525</sup> UNEP-WCTC Author Team. N.d. One Earth: Sahel Acacia savannas bioregion. Available at: <https://www.oneearth.org/bioregions/sahel-acacia-savannas-at23/>.

<sup>526</sup> CILSS. 2016. West Africa: Land use and land cover dynamics. Case study: Dynamics of ephemeral wetlands in eastern Mauritania. Available at: <https://eros.usgs.gov/westafrica/case-study/dynamics-ephemeral-wetlands-eastern-mauritania>.

<sup>527</sup> UNEP-WCTC Author Team. N.d. One Earth: Sahel Acacia savannas bioregion. Available at: <https://www.oneearth.org/bioregions/sahel-acacia-savannas-at23/>.

<sup>528</sup> World Wildlife Fund. 2021. Sahelian Acacia savanna. Available at: <https://www.worldwildlife.org/ecoregions/at0713>.



human activities, such as the expansion of rainfed agriculture, fuelwood collection and intentional bushfire ignitions to clear land, further contribute to degradation. Ecosystem degradation is additionally exacerbated by increasingly frequent and intense climatic hazards — particularly droughts (Section 1.3.4). This degradation results in the loss of natural vegetation and, eventually, soil erosion in some areas and siltation in others. Desertification occurs as a result, leading to the expansion of the Sahara southwards and to the permanent loss of the Sahelian ecosystem.

#### 1.5.4 Ecosystem services (ESSs)

Mauritania's ecosystems provide numerous services to surrounding local communities. ESSs are defined as direct and indirect contributions that ecosystems make to human well-being<sup>529</sup>. These services are often divided into four categories, namely: i) provisioning services, which include material or energy outputs from ecosystems; ii) regulating services, which involve the regulation of critical environmental systems; iii) supporting services, which promote species and genetic diversity within an ecosystem; and iv) cultural services, which are the non-material benefits local communities gain from interacting with ecosystems<sup>530</sup>. The primary ESSs provided to local communities in Mauritania are food and fuel provision, hydrological regulation, carbon sequestration and biodiversity maintenance.

##### **Provisioning services**

The major provisioning services include food and fuel generation<sup>531</sup>. Food provision services primarily encompass the support of agricultural activities, specifically by providing fertile soils, water, suitable climatic conditions and plant and animal species. The main food products include cereals, meat, pulses and roots, accounting for 63%, 23%, 12% and 2% of agricultural production, respectively<sup>532</sup>. This agricultural production contributes directly to the adequate nourishment of local communities, either directly through subsistence farming or through the availability of food to be purchased. Food provisioning services additionally support livelihood security, as 64% of Mauritania's labour force is involved in crop or livestock production<sup>533</sup>.

Other than food, another provisioning service provided by natural ecosystems and plantations is the provision of fuelwood — which is the main source of energy in Mauritania. In areas where wood is limited, crop residues, camel dung or cattle dung are used as replacement fuel sources. The ability of local communities to access an energy resource is an essential component of human well-being, as it is critical for daily activities such as cooking and keeping warm. Fuelwood, charcoal and animal and plant wastes account for 30% of energy use, supporting 85% of the population<sup>534</sup>.

##### **Regulatory services**

Primary regulatory services include hydrological regulation and carbon sequestration<sup>535</sup>. Hydrological regulation involves the provision of clean water, the regulation of water flow and the control of flooding events. The major water sources include rainfall — which amounts to 95 million cubic meters (MCM) per year — and water from transboundary rivers such as the Senegal River — accounting for 11 MCM per year<sup>536</sup>. This water is then captured and stored by catchments in wetlands, wadis, lakes or groundwater aquifers. Healthy soils and adequate vegetation cover promote the infiltration and long-term storage of clean water, which communities use to maintain individual health, ensure food security and support livelihoods. In particular, the agricultural sector is highly influenced by water regulatory services and accounts for 92% of water consumption<sup>537</sup>.

<sup>529</sup> Earthwise Aware. 2021. What are ecosystem services? Available at: <https://www.earthwiseaware.org/what-are-ecosystem-services/>.

<sup>530</sup> Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: Synthesis.

<sup>531</sup> UNEP & IISD. 2005. Connecting poverty and ecosystem services: Focus on Mauritania.

<sup>532</sup> Famine Early Warning System Network. 2001. Mauritania: monthly report for November.

<sup>533</sup> Mauritania. 2000. Poverty reduction strategy paper.

<sup>534</sup> UNDP. 2004. Human development report.

<sup>535</sup> UNEP & IISD. 2005. Connecting poverty and ecosystem services: Focus on Mauritania.

<sup>536</sup> FAO Land and Water Development Division. 2000. Aquastat: summary table: renewable water resources by country.

<sup>537</sup> FAO Land and Water Development Division. 1997. Aquastat: Mauritania.

Along with ensuring the provision of sufficient supplies of clean water, healthy ecosystems assist in regulating carbon systems and, consequently, climatic feedback loops involving anthropogenic climate change<sup>538</sup>. The loss of vegetation through desertification releases carbon dioxide, contributing to global climate change. This, in turn, increases average temperatures and reduces precipitation in Mauritania, leading to further desertification — and the creation of a feedback loop. Drylands such as Mauritania are estimated to hold ~10% of global carbon<sup>539</sup>, meaning that these areas have considerable potential to contribute to overall greenhouse gas (GHG) storage. This carbon sequestration is primarily through inorganic soil carbonate, meaning that the loss of soils through wind or water erosion considerably reduces a dryland country's carbon store<sup>540</sup>.

### Supporting services

The major supporting ESS involves maintaining ecosystem, species and genetic diversity across Mauritania's habitats<sup>541</sup>. Numerous species themselves perform multiple services within an ecosystem that contribute to the overall functioning of that ecosystem and its ability to support human well-being.

### Threats to ESSs

Future climate change — combined with gradually increasing populations, resource demands and sedentary pastoral practices — is predicted to worsen current ecosystem degradation. This degradation will inhibit the ability of ecosystems to provide critical services to vulnerable communities. Climatic and non-climatic threats to the major ESSs are described below. Climate and climate change impacts on ecosystems are further elaborated in Sections 1.3 and 2.7.

Mauritania's environmental conditions have historically limited food production. Soils suitable for crop production, for example, cover less than 1% of the country, with 9,000 km<sup>2</sup> of soils being constrained by high salinity levels and 226,000 km<sup>2</sup> being covered by non-arable shallow soils<sup>542</sup>. Water availability is another critically limiting factor for food production, with natural freshwater being scarce away from the Senegal River. These naturally limiting factors mean that any changes in climate or land use will push natural and agricultural systems past their tolerance levels. Indeed, food production in Mauritania is already gradually declining, mainly attributable to increases in natural disasters such as floods, droughts and pests. Floods in 2002, for example, resulted in the deaths of 120,000 livestock and damage to 25% of crops, causing food insecurity for 250,000 people across the country<sup>543</sup>.

As with food provision, the ability of ecosystems to provide fuel has been declining. Natural forest area decreased by 30% from 1990–2000, with 9,971 ha being lost to deforestation per year<sup>544</sup>. The main causes of forest loss include an increase in droughts, bushfires, overgrazing, poor farming practices, unsustainable logging, expanding urban development and an increase in mining activities<sup>545</sup>.

Regulatory services — including water and carbon storage — are under considerable strain. Much of the stress on hydrological regulation relates to the naturally arid environment and high evaporation rates. These existing stressors are — and will continue to be — exacerbated by climate change and increasing water demand. The Senegal River, the country's only perennial river system, is additionally threatened by pollutants from livestock runoff, agricultural pesticides and domestic wastewater<sup>546</sup>.

<sup>538</sup> UNEP & IISD. 2005. Connecting poverty and ecosystem services: Focus on Mauritania.

<sup>539</sup> Salleh MN. 2000. Land degradation and the focal points of the GEF.

<sup>540</sup> Arnolds A. 2002. Carbon sequestration: An incentive for combatting desertification.

<sup>541</sup> UNEP & IISD. 2005. Connecting poverty and ecosystem services: Focus on Mauritania.

<sup>542</sup> FAO Land and Water Development Division. 2000. Aquastat: Summary table: Renewable water resources by country.

<sup>543</sup> United States Agency for International Development. 2002. Farming households in Mauritania face imminent famine.

<sup>544</sup> World Research Institute. 2003. Earthtrends country profile: Biodiversity and protected areas: Mauritania.

<sup>545</sup> FAO Forestry Department. 2000. Country profile: Forest area statistics: Mauritania.

<sup>546</sup> Organisation for the Development of the Senegal River. 2003. Senegal River Basin, Guinea, Mali, Mauritania and Senegal. In: 'Water for people water for life: A joint report by the twenty-three UN agencies concerned with freshwater', pp. 450–461. UNESCO Publishing, New York.

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This pollution results in the spread of pathogens, eutrophication, invasive weed infestation, aquatic organism deaths and reductions in overall water quality for human and animal consumption. An increase in dam and dyke construction also threatens water regulation in the Senegal River by slowing down water flow. The Diama Dam in the river's delta, for example, reduced the previously productive floodplain to a dry, saline desert area<sup>547</sup>.

Ecosystem degradation negatively impacts both biodiversity and carbon sequestration services. Critically endangered terrestrial animal species are threatened by habitat loss from infrastructure development and agricultural expansion, competition with livestock, hunting, tourism and human disturbance<sup>548</sup>. The proliferation of various invasive species — specifically mesquite (*Prosopis juliflora*) and aquatic plants such as *Hyacinth* — that outcompete native species, reduces overall biodiversity. Moreover, increasingly severe climatic conditions, overgrazing and increasing pastoralist sedentarisation result in the loss of vegetation, which simultaneously reduces biodiversity and carbon storage. This degradation ultimately results in the permanent desertification of areas and loss of critical species, which lead to areas not benefiting from ESSs and communities becoming more vulnerable to changing climate conditions.

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<sup>547</sup> IUCN Wetlands and Water Resources Programme. 2002. 2002 Progress and assessment report.

<sup>548</sup> UNEP & IISD. 2005. Connecting poverty and ecosystem services: Focus on Mauritania.

## 1.6 Agro-ecological and cultivated systems

Although the agricultural sector greatly contributes to employment and the economy within Mauritania (Section 1.2.2), the utilised agricultural area (UAA)<sup>549</sup> for arable land is 502,000 ha — less than 0.5% of the country's total area<sup>550</sup>. In addition, 44% of the UAA (~220,000 ha) is used for rainfed agriculture, which is dependent on adequate rainfall and rainwater storage infrastructure such as tanks and cisterns. Consequently, a large portion of Mauritania's agricultural production is heavily impacted by changes in climate and climatic variability.

### 1.6.1 Agro-ecological zones

As a result of the spatially different climatic conditions in Mauritania, crop and livestock production can be divided across five agro-ecological zones, namely: i) the arid zone; ii) western Sahel; iii) eastern Sahel; iv) Senegal River floodplains; and v) the coastal zone. These different zones are described in the paragraphs below.

#### **Arid zone**

The arid zone spans the northern border of Mauritania to the 150 mm isohyet in the south<sup>551</sup>. This zone occupies 80% of the country's total area and is characterised by high temperatures, regular droughts and limited rainfall. All crop production in this zone is centred around isolated oases and includes palm trees and irrigated crops, such as cereals, alfalfa, fruit and vegetables. Livestock production primarily involves extensive camel farming and is supported by pastoral grazing and browsing plant species, such as umbrella thorn, desert grass and *Stipagrostis pungens*. Despite the large area that the arid zone occupies, the total UAA within this zone is 12,000 ha; ~2.4% of the total UAA for the country<sup>552</sup>. The relatively low UAA area across the arid zone is ascribed to multiple drivers, including climatic impacts — most notable of which are sand encroachment and erosion after heavy storms. Sand encroachment results in the siltation of fields, dams and wells — particularly around oases — while erosion removes smaller sand particles and thereby reduces the physical and nutritional quality of agricultural soils.

#### **Western Sahel**

Southwest of the arid zone, the western Sahel covers 75,000 km<sup>2</sup> (7%) of the total area in Mauritania<sup>553</sup>. Livestock production is common in this zone and contains 25% of the country's nomadic herders. Crop production is focused on sorghum, maize and vegetables<sup>554</sup>. The UAA in the southern areas varies from 3–12% of the total country UAA, which is equivalent to 14,000–60,000 ha. Annual agricultural yields, which amount to 0.8 tonnes/ha, are negatively affected by several ecological threats. These threats — including limited and overexploited water resources, rangeland overgrazing and unsustainable fuelwood extraction<sup>555</sup> — result in ecosystem degradation that diminishes agricultural production, particularly around expanding urban centres.

#### **Eastern Sahel**

The eastern Sahel zone covers 100,000 km<sup>2</sup>, representing ~10% of the country. This zone consists primarily of an agro-pastoral system, where seasonally nomadic livestock movements occur over croplands of sorghum, millet and maize found in sandy, pluvial areas. Depending on annual rainfall, the UAA in the Sahel zone varies from 11–37% of the country's total UAA, which is equivalent to 57,000–184,000 ha. Overall crop yields in this area are low compared with the western Sahel, amounting to 0.3 tonnes/ha per annum. There is a greater potential for livestock production here than

<sup>549</sup> The utilised agricultural area is defined as arable land (including *inter alia* temporary pastures, fallow land, crops and smallholder gardens), areas with permanent grass cover and permanent crops.

<sup>550</sup> FAO. 2021. Family farming knowledge platform: Mauritania. Available at: <https://www.fao.org/family-farming/countries/mrt/en/>.

<sup>551</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>552</sup> FAO. 2021. Family farming knowledge platform: Mauritania. Available at: <https://www.fao.org/family-farming/countries/mrt/en/>.

<sup>553</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>554</sup> FAO. 2021. Family farming knowledge platform: Mauritania. Available at: <https://www.fao.org/family-farming/countries/mrt/en/>.

<sup>555</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

in the western Sahel zone, specifically because the rangelands in this agro-ecological region are less degraded.

### Senegal River floodplains

Floodplains north of the Senegal River cover 22,000 km<sup>2</sup>, or 2%, of Mauritania's total area<sup>556</sup>. The area around the Senegal River Valley is dominated by irrigation agriculture, though rainfed crop production and pastoralism are also common. Two different irrigation cropping systems exist<sup>557</sup>. The first uses complete water control through surface or sprinkler irrigation, accounting for ~30,000 ha or 6% of the total UAA. Three annual harvests are done under this system, including two rice harvests from July to October and from March to June, respectively, and fruit, vegetables, maize and sorghum from November to February. The second irrigation system uses flood recession or spate irrigation, where crops are either grown on floodplains that flood seasonally or in adjacent areas where water is redirected through canals. This system accounts for 7,000–40,000 ha, equating to 1–8% of the country's total UAA per annum. The main crops grown through this system are sorghum and maize. Major ecological challenges within the Senegal River floodplain zone include: i) the degradation of riverine forest areas; ii) damage to irrigation infrastructure from water and wind erosion; and iii) overgrazing of limited rangeland areas by livestock<sup>558</sup>.

### Coastal zone

The coastal zone is a narrow, 50 km-long strip spanning Nouadhibou in the north to the Senegal River delta in the south and covering 25,000 km, or ~3%, of the total country area<sup>559</sup>. This zone has cooler, humid conditions suitable for horticulture and orchards<sup>560</sup>. The total area of UAA in this zone is estimated as 12,000 ha per annum.

#### 1.6.2 Crop systems within the target hubs

Within the target hubs, oasis-based agriculture using existing surface or groundwater sources is a major source of crop production<sup>561</sup>. These oases are located either along wadis within rocky plateaus — such as in Aoujeft and Rachid — or within depressions between dunes — such as the Tamcheket and Nema hubs. Oasis-based agriculture along wadis has been practised for a considerable period of time in Aoujeft and Rachid, resulting in the gradual accumulation and establishment of indigenous knowledge regarding this agricultural method. In contrast, the use of oasis-based agriculture in Tamcheket and Nema is relatively recent, resulting in less traditional knowledge in these hubs.

Date palms are a primary oasis-based add crop within the target hubs (Figure 25). The Adrar wilayah in which the Aoujeft hub is situated produces ~12,727 tons of dates per annum (~45% of the country's date production)<sup>562</sup>, of which 60% is consumed locally following the harvest period, while ~28% is transported to major markets throughout the country and the remaining 12% is for reserve use or replanting in the oasis. The extent of date palm farming in the Adrar wilayah has increased over the last few decades, from 883,060 trees over 1,876 ha in 1993 to 1,212,876 trees over 5,759 ha in 2020. Although the influence this increase in date palm farming has on production is not clear, date production in the Tagant wilayah — where Rachid is located — has shown a decline over the same period, decreasing from 5,015 tonnes in 1992 to 3,832 tonnes in 2020.

<sup>556</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>557</sup> FAO. 2021. Family farming knowledge platform: Mauritania. Available at: <https://www.fao.org/family-farming/countries/mrt/en/>.

<sup>558</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>559</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>560</sup> FAO. 2021. Family farming knowledge platform: Mauritania. Available at: <https://www.fao.org/family-farming/countries/mrt/en/>.

<sup>561</sup> Appendix 1.

<sup>562</sup> Appendix 1.



**Figure 25.** Example of a date palm grove in Aoujeft. Photograph taken by Robert Raw.

The production intensity of date palms is not consistent throughout the year; palm groves are uninhabited until the pollination — January — and harvest — June — periods which require labourers to be present for hand pollination and date harvesting, respectively. During these times, entire populations settle in the associated oasis until the end of the harvest period<sup>563</sup>. Moreover, production varies from year to year as a result of climatic changes, palm varieties and agricultural practices. Another determining factor of date production is whether a palm grove is irrigated or not, with irrigated palm groves producing twice the yield of non-irrigated groves (30–50 kg per palm tree compared with 15–20 kg per palm tree, respectively). Date production is also influenced by the presence of parasites and diseases — including the date palm scale insect (*Parlatoria blanchardi*) and date palm mites (*Olygonycus afrasiaticus*) — which have the potential to substantially damage palm groves and reduce overall crop yield.

Several other crops are produced within the hubs using irrigated oasis-based agriculture, including various vegetables such as carrots, tomatoes and cabbages, cereals such as wheat and barley, as well as alfalfa and henna<sup>564,565</sup>. Small-scale vegetable production, particularly through market gardens<sup>566</sup>, is important as a potential source of income generation for women and the youth. Seed sowing for market gardens across the four hubs generally takes place in November, with harvesting occurring in April. As a result of this seasonality, income generation through market gardens only occurs during certain times of the year.

Across the four hubs, several constraints within the oasis-based agriculture value chain limit the overall productivity of crops and income for farming communities. These constraints are summarised in

<sup>563</sup> Appendix 1.

<sup>564</sup> Henna (*Lawsonia alba*) is also used as a dye.

<sup>565</sup> Appendix 1.

<sup>566</sup> Also called a micro-farm, market gardens are small plots of land where fruits and vegetables are grown and sold to the public.

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Table 18 below. In the Adrar wilayah, these constraints have been addressed to some extent through the establishment of a date and vegetable packaging plant, which assists in marketing, post-harvest processing and transport.



**Table 18.** Major constraints in oasis agriculture within the four target hubs<sup>567</sup>.

Theme	Constraints
Production	<ul style="list-style-type: none"> <li>• Inefficient management of water resources in the oases, including the over-extraction of groundwater and the limited dissemination of water-saving techniques and effective pumping systems.</li> <li>• Low availability and use of quality seeds suited to the environment and market demand, particularly for market garden vegetables.</li> <li>• Insufficient or non-existent financial products to meet the needs of communities.</li> <li>• Insufficient promotion and adoption of improved and climate-resilient agricultural techniques.</li> <li>• Low yield and ageing of palm groves or plantations.</li> <li>• Depletion of the palm trees' genetic pool and the disappearance of certain cultivars.</li> <li>• Low level of supervision or guidance on good practices.</li> <li>• Low organisational levels between producers and sector actors.</li> </ul>
Harvest, conditioning, drying, processing and transportation	<ul style="list-style-type: none"> <li>• Limited knowledge of improved harvesting techniques.</li> <li>• Insufficient knowledge of improved post-harvesting techniques, such as conditioning, stocking, processing and transport.</li> <li>• Long-distance transport of products under challenging conditions in non-specialised vehicles, which reduces the value of crop products — particularly for market garden produce.</li> <li>• Insufficient infrastructure for product conditioning and stocking.</li> </ul>
Commercialisation	<ul style="list-style-type: none"> <li>• Strong international market competition around the quality and price of dates with countries such as Morocco, Algeria, Tunisia and Saudi Arabia.</li> </ul>
Sector actors	<ul style="list-style-type: none"> <li>• Insufficient organisation and cooperation among actors in the sector, including producers, suppliers of goods and services, transporters, traders, extension services and advisory structures and consumers.</li> </ul>

Alongside oasis-based agriculture techniques, several crops are produced within the target hubs through flood recession agriculture or rainfed crop (*dieri*) production<sup>568</sup>. Flood recession agriculture occurs primarily in lowlands or behind dams on sandy loam soils. This agricultural technique produces an average annual yield of 0.6 tonnes/ha which mainly consists of sorghum and cowpea. Seed sowing under flood recession is done in October, while crops are harvested in February. Rainfed crops — including sorghum, wheat and barley — heavily depend on rainfall and produce average annual yields of 0.4 tonnes/ha (Figure 26 & Figure ). Seeds for rainfed crops are sown in June, with harvesting occurring in November and December.

<sup>567</sup> Appendix 1.

<sup>568</sup> Appendix 1.





**Figure 26.** Example of a rainfed agricultural field in Aoujeft. Photograph by Robert Raw.



**Figure 27.** Seasonal rainfed agriculture being practised by women in a natural depression (*grara*) in central Mauritania.

Crop yields for both crop production methods — particularly rainfed agriculture — vary based on the spatial and temporal distribution of rainfall, resulting in crop yield fluctuations of almost 200%<sup>569</sup>. Droughts in the 1970s, for example, severely disrupted rainfed agriculture production across the hubs, which reduced agricultural production and the amount of arable land. By contrast, better rainfall conditions in the 1980s resulted in the expansion of arable lands and the uptake of market gardening to supplement or replace rainfed crops. Other climatic hazards, including bushfires, sand silting and erosion from both water and wind, also directly impact rainfed and flood recession crop yields. In addition to these climatic hazards — and similar to oasis-based agriculture and market gardening — traditional rainfed and flood recession crop production is constrained by a number of challenges (summarised in Table 19)

<sup>569</sup> Appendix 1.

**Table 19.** Major constraints for rainfed and flood recession crop production in the four target hubs<sup>570</sup>.

Theme	Constraints
Land access	<ul style="list-style-type: none"> <li>• Fragmentation of agricultural holdings.</li> <li>• Absence of land estate cadastres<sup>571</sup> and insufficient land regularisation, particularly in rainfed areas.</li> </ul>
Facilities and infrastructure	<ul style="list-style-type: none"> <li>• Limited sustainable management and maintenance practices for critical infrastructure, resulting in the degradation of water-regulating structures, such as controlled flood perimeters, dams and water-retention dykes.</li> <li>• Insufficient facilities to support traditional cereal production.</li> </ul>
Financing	<ul style="list-style-type: none"> <li>• Difficult access to and mobilisation of financing for farmers.</li> <li>• Absence of a financing system that is orientated towards the support of traditional cereal production.</li> </ul>
Production process	<ul style="list-style-type: none"> <li>• High exposure to climate hazards, including droughts and floods.</li> <li>• Intensive population pressure in some areas, resulting in the alteration of traditional cropping systems and leading to, <i>inter alia</i>, the suppression of fallow land, a reduction in soil fertility and losses in biodiversity.</li> <li>• Depletion and fragility of soils exposed to water and wind erosion, overgrazing and siltation.</li> <li>• Limited access to high-quality crop seeds.</li> <li>• Insufficient measures to protect crops from pests and diseases, contributing to annual losses of up to 30%.</li> <li>• Limited measures to protect crops against climatic hazards (such as bushfires).</li> <li>• Insufficient quantity and maintenance of water storage infrastructure, including dams and wells.</li> <li>• Weak purchasing power of individuals, which leads to cycles of debt.</li> </ul>
Mechanisation	<ul style="list-style-type: none"> <li>• Very low level of mechanisation and insufficient agricultural equipment for soil preparation and crop maintenance.</li> </ul>
Harvesting	<ul style="list-style-type: none"> <li>• High labour requirements for harvesting and processing.</li> </ul>
Processing and storage	<ul style="list-style-type: none"> <li>• Insufficient grain mills and storage facilities, and poor storage conditions for cereals.</li> <li>• Current techniques negatively impacting the sanitation and nutritional quality of crop products.</li> <li>• Considerable losses resulting from poor transport conditions.</li> </ul>
Commercialisation	<ul style="list-style-type: none"> <li>• No market access scheme for the commercialisation of sorghum, millet and corn.</li> <li>• Limited marketable surpluses and low integration of levels with the national economy.</li> <li>• Isolation of certain production zones and high transportation costs.</li> </ul>
Advisory and support	<ul style="list-style-type: none"> <li>• Insufficient quality and quantity of human and logistical resources.</li> </ul>
Sector actors	<ul style="list-style-type: none"> <li>• Low organisation and cooperation levels between sector actors, including producers, goods and services suppliers, carriers, traders, advisory or support structures and consumers.</li> <li>• Weak organisation and management skills among producers.</li> <li>• Limited consultation frameworks between sector actors.</li> </ul>
Research	<ul style="list-style-type: none"> <li>• Weak research investment in: i) productive and short-cycle seeds; ii) major pest control; iii) adaptive agricultural practices; and iv) integration into the national economy.</li> <li>• Insufficient impact of agricultural research and technological innovation on the agricultural productivity of traditional cereals.</li> <li>• Insufficient local genetic and ecotypic<sup>572</sup> conservation banks.</li> </ul>

<sup>570</sup> Appendix 1.

<sup>571</sup> A cadastre is a comprehensive record of the existing land estate bounds within a country.

<sup>572</sup> Ecotypic refers to plant varieties that are geographically distinct genetically.

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### 1.6.3 Pastoral systems

Two main pastoral systems with unique characteristics and challenges exist across the five agro-ecological zones<sup>573</sup>, namely: i) transhumance<sup>574</sup>, or nomadism, which is a traditional method closely tied to natural ecosystems; and ii) sedentary or peri-urban, which involves intensive and modern forms of production. These two pastoral systems are described in the paragraphs below.

The transhumance system is used primarily for camel and goat farming and is characterised by seasonal movements that cover long distances and last several months<sup>575</sup>. Animals are herded north in the rainy season for as long as grazing and water resources enable. In years with infrequent winter rainfall, camels can remain north for longer periods than usual by grazing on succulent plant species that support all their water needs. Within the Senegal River agro-ecological zone, floodplains are alternately used for cropping and animal grazing, allowing for crop residues to be used to feed livestock and for manure from the animals — mainly cattle — to fertilise fields for the next cropping season.

The sedentary system is similar to the transhumance system in that cropping fields are often used for animal grazing; however, livestock herds are not nomadic and are grazed over smaller areas close to settlements<sup>576</sup>. There is also less coordination to ensure that livestock and crop production is synergistic. Although livestock still graze on crop residues in the sedentary system, more feed is lost through trampling and other sources of wastage. Sedentary livestock herds — comprising cattle or small ruminants — are also smaller and move shorter distances than transhumant herds. This lesser movement increases grazing pressure on the surrounding natural and agricultural fields, contributing to the degradation of natural ecosystems. The impact of this sedentary system is exacerbated by nomadic herds — typically camels — that routinely visit the area.

Increasingly rapid urbanisation in certain parts of Mauritania — and major droughts in the 1970s and 1980s — resulted in a shift from traditional production systems to sedentary livestock farming centred around urban areas<sup>577</sup>. Consequently, each major settlement is now surrounded by large stationary herds of camels, goats and cattle, which are kept primarily for milk production. However, the surrounding rangelands cannot sustainably support these large herds, with substantial ecosystem degradation occurring as a result. Without sufficient natural resources such as pasture to support these large, sedentary herds, their maintenance requires a considerable amount of purchased water and livestock feed, incurring higher costs than in more nomadic pastoral systems. The transition from transhumant to sedentary livestock systems is also associated with the transfer of camel herds from nomadic herders to wealthy settlement-based owners, resulting in the gradual loss of traditional herding practices and reduced sustainable use of natural resources.

### 1.6.4 Animal husbandry in the target hubs

Livestock production is an important economic activity within the four target hubs and includes herds of camels, cattle and small ruminants, such as sheep and goats<sup>578</sup>. The major products acquired from animal husbandry include meat, milk, hides and leathers. Accordingly, livestock production supports numerous livelihoods within the target communities, including, *inter alia*, shepherds, butchers, milk sellers and leather crafters. In particular, goat or camel milk and dairy production play an essential role in the local economy and contribute to food security.

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<sup>573</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>574</sup> Transhumance refers to the practice of moving livestock from one seasonal grazing area to another.

<sup>575</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>576</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>577</sup> Wilson RT & Thys E. 2018. Pastoralists, pastoralism and pastures in the Islamic Republic of Mauritania.

<sup>578</sup> Appendix 1.

Across the four target wilayahs, populations of all livestock have shown a gradual increase in numbers from 2014–2019 (Table 20). For most of the hub wilayahs — except Adrar — small ruminants represent 79–88% of livestock numbers, with considerably smaller numbers for cattle (~4–15%) and camels (5–8%). Adrar only has small cattle herds (total numbers are not available), with the percentage of livestock distributed evenly between camels and small ruminants (53% and 47%, respectively).

**Table 20.** The number of livestock for the wilayahs of Adrar (Aoujeft hub), Tagant (Rachid hub), Hodh El Gharbi (Tamcheket hub) and Hodh Chargui (Nema hub)<sup>579</sup>.

Location	2014	2015	2016	2017	2018	2019
<i>Cattle</i>						
Tagant	60,289	62,640	65,271	68,013	70,869	73,846
Hodh El Gharbi	339,884	353,140	367,972	383,427	399,531	416,311
Hodh Chargui	495,011	514,316	535,918	558,426	581,880	606,319
<i>Camels</i>						
Adrar	206,736	209,630	212,985	216,392	219,855	223,372
Tagant	129,226	131,035	133,132	135,262	137,426	139,625
Hodh El Gharbi	185,172	187,765	190,769	193,821	196,922	200,073
Hodh Chargui	237,449	240,773	244,626	248,540	252,516	256,557
<i>Small ruminants</i>						
Adrar	146,916	155,437	164,918	174,978	185,652	196,977
Tagant	1,169,548	1,237,382	1,312,862	1,392,947	1,477,917	1,568,070
Hodh El Gharbi	2,556,928	2,705,230	2,870,249	3,045,334	3,231,100	3,428,197
Hodh Chargui	2,394,835	2,533,735	2,688,293	2,852,279	3,026,268	3,210,871

Nomadic or transhumant livestock production is common across all the target wilayahs<sup>580</sup>. As a result of the pasture-rich rangelands, Adrar and Hodh El Gharbi, in particular, receive herds of camels and small ruminants from neighbouring wilayahs during the winter months. In the wet season, livestock herds are moved to the hubs' northern areas and are relocated to southern areas at the end of the wet season to use established ponds or other water points. For traditional transhumance practices, this movement of herds often takes half a year over long distances — sometimes beyond the borders of Mauritania and into neighbouring countries.

Fodder yields for livestock are dependent on the amount of rainfall and vary from year to year<sup>581</sup>. In the four target hubs, the main period of fodder deficit is from March to June, which coincides with a period of water scarcity for livestock. Pastural lands consist primarily of pockets of various shrubs used for browsing or grasses for grazing. Table 21 shows the total amount of fodder available in each wilayah in Mauritania and the balance between production and fodder needs. The wilayahs of Hodh Chargui, Hodh El Gharbi and Adrar — in which the hubs of Nema, Tamcheket and Aoujeft are found — contain the highest amounts of fodder in the country and have enough fodder to meet livestock needs. Hogh Ech Chargui, in particular, has the highest fodder production potential of any wilayah in the country and accounts for ~30% of the country's total production. The high production of fodder in Hodh Chargui is a result of the large size of the wilayah and the good rainfall relative to most of the country. In contrast, the wilayah of Tagant — Rachid hub — has one of the country's lowest annual fodder production rates and represents only 1% of total production in Mauritania. Its annual production of 95,013 tonnes of dry mass accounts for only 19% of the wilayah's total annual fodder needs.

**Table 21.** Potential annual livestock fodder production in tonnes of dry mass (T/DM) across all wilayahs in Mauritania. The wilayahs are ranked from highest to lowest total fodder production. The wilayahs containing the four target hubs are highlighted in blue<sup>582</sup>.

<sup>579</sup> Appendix 1.

<sup>580</sup> Appendix 1.

<sup>581</sup> Appendix 1.

<sup>582</sup> Appendix 1.

Wilayah	Grazing fodder dry mass (T)	Browsing fodder dry mass (T)	Total fodder production dry mass (T)	Fodder needs dry mass (T)	Balance in fodder dry mass (T)
Hodh Chargui	2,174,040	549,000	2,723,040	1,750,517	972,523
Hodh El Gharbi	1,268,784	320,400	1,589,184	1,324,993	264,192
Adrar	852,588	484,425	1,337,013	526,595	810,418
Assaba	923,967	233,325	1,157,292	1,011,511	145,781
Trarza	548,163	177,975	726,138	716,775	9,363
Gorgol	383,724	96,900	480,624	663,365	-182,741
Brakna	343,035	111,375	454,410	740,700	-286,290
Guidimakha	333,102	75,705	408,807	785,329	-376,522
Inchiri	125,433	71,269	196,702	288,947	-92,245
Tagant	60,588	34,425	95,013	500,838	-405,825
Tiris Zemmour	7,722	5,850	13,573	165,011	-151,438
Dakhlet-NDB	529	401	929	0	929
<b>Country total</b>	<b>7,021,675</b>	<b>2,161,050</b>	<b>9,182,725</b>	<b>8,474,581</b>	<b>708,144</b>

With the introduction of date palms and fodder-crop agriculture, some breeders have begun to offer food supplements to their livestock, particularly where farms are situated close to larger settlements<sup>583</sup>. Fodder production around oases enables pastoralism to transition to a more sedentary approach, with this shift accelerated by repeated droughts in the 1970s and 1980s. However, this sedentary approach is associated with several challenges regarding herd management, water resource infrastructure, overgrazing and frequent conflicts between farmers and herders over land use. Limited progress has been made in Adrar to address these challenges and sustainably integrate crop and livestock production. In contrast, this integration is more prominent in Tagant, where livestock feed on crop residues and natural vegetation. These and other challenges to livestock production are summarised in Table 22 below.

**Table 22.** Constraints and challenges to livestock production in the four target hub wilayahs<sup>584</sup>.

Theme	Challenges
Limited data and knowledge sharing	<ul style="list-style-type: none"> <li>Limited reliable statistical data on livestock numbers, herd structures and geographical distributions.</li> <li>Insufficient research on appropriate fodder crops.</li> <li>Limited appropriate technical topics or reliable information to improve traditional herd management.</li> <li>Insufficient knowledge of potential options for locally appropriate fodder species and animal breeds.</li> <li>Limited satellite-based monitoring data, which limits the ability of decision-makers to assess vegetative production and regeneration. Any available information is not adequately disseminated to rural pastoralists.</li> </ul>
Climate and environmental	<ul style="list-style-type: none"> <li>Low precipitation levels, leading to a reduction in groundwater levels and the drying of surface-water sources. This results in the degradation of vegetation cover, the silting up of grazing areas and a reduction in available natural fodder resources.</li> <li>Highly variable spatial and temporal distributions in rainfall, resulting in considerable fluctuations in fodder availability.</li> <li>Bushfires, which directly reduce vegetation cover.</li> </ul>
Livestock production practices	<ul style="list-style-type: none"> <li>Transition from nomadic to sedentary by rural populations, leading to increased pressure on fodder rangelands.</li> <li>Sedentarisation of livestock production, resulting in the expansion of other livelihood activities that degrade the surrounding landscape.</li> <li>Increased woodcutting, for example, eliminates trees that provide</li> </ul>

<sup>583</sup> Appendix 1.

<sup>584</sup> Appendix 1.

	<p>services such as soil retention for fodder species and shading for livestock.</p> <ul style="list-style-type: none"> <li>• Vast rangelands with good pasture are underutilised because of limited water points to support a transhumance approach and limited knowledge transfer of traditional nomadic routes.</li> <li>• Limited development of poultry farming, which experiences considerable annual losses.</li> </ul>
Fodder production and availability	<ul style="list-style-type: none"> <li>• Limited integration of crop and livestock production, resulting in the underutilisation of animal manure to promote crop production and of agricultural by-products to supplement fodder availability.</li> <li>• Limited harvesting of fodder for use in the winter months. This is related to insufficient equipment, transport and storage for fodder harvesting.</li> <li>• Insufficient irrigated fodder production as a source of supplementary feed.</li> </ul>
Livestock health	<ul style="list-style-type: none"> <li>• Insufficient control of animal diseases, a result of limited technical supervision and veterinary products and services.</li> </ul>
Resource management	<ul style="list-style-type: none"> <li>• Little consideration of livestock production in hydro-agricultural development plans.</li> <li>• Low participation of pastoralists and farmers in the management of natural resources.</li> </ul>
Financial	<ul style="list-style-type: none"> <li>• Limited pastoral credit for all economic agents operating at the different levels of the livestock sector.</li> </ul>

## 2 Climate change in Mauritania

### 2.1 Methodology

The climatological analyses performed for the project involved: i) the development of detailed historical climatological normals<sup>585</sup> — henceforth referred to as historical climatologies; ii) an assessment of observed climate variability and recently observed trends; and iii) an assessment of the future climate projections, developed using the most relevant high resolution climate models. Appendices 3 and 4 provide a detailed account of the full methodology used to conduct climatological analyses; however, a summarised version is contained in the text to follow.

<sup>585</sup> Climate normals are 30-year averages for climate variables such as temperature and precipitation. They provide a baseline that allows scientists to compare a location's current or predicted weather to average expected weather.

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## Climate risk

The Intergovernmental Panel on Climate Change (IPCC) defines climate risk according to the following equation:

$$\text{Risk} = \text{hazard} \times \text{vulnerability} \times \text{exposure}.$$

In the equation above:

- **‘hazard’** is defined as the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, health impacts or damage to property, livelihoods, service provision and environmental resources;
- **‘vulnerability’** is defined as the propensity or predisposition of people, infrastructure, resources or assets to be adversely affected by physical events; and
- **‘exposure’** is defined by the presence of people, infrastructure, resources or assets in locations that could be adversely impacted by physical events.

## Climate hazard

The climate component of risk is calculated using the probability and severity of climate hazards — that is, their impact potential. Climate hazard impact potential is defined as ‘the frequency or proportion of time that a climate condition crosses a threshold beyond which significant impacts are expected to occur if striking in a vulnerable area/community with exposed assets’.

To estimate the impact potential of climate hazards in Mauritania, both qualitative and quantitative analyses were performed using available climate data for five major climate hazards in the region — namely: i) an increase in the frequency of heavy rains; ii) an increase in the duration of droughts; iii) an increase in the intensity of the water balance deficit; iv) an increase in the frequency of heat waves; and v) an increase in the frequency of strong winds coming from north-east. The climate impacts associated with these hazards include:

- flooding of settlements;
- silting of houses and roads;
- impacts on water availability and quality;
- ecosystem degradation;
- impacts on crop and livestock productivity; and
- impacts on public security related to public health issues.

A climate screening was conducted to determine which climate variables are linked to the hazards and impacts listed above. Based on this screening, the following climate parameters were selected for climatological analyses: i) temperature increases; ii) changes in potential evapotranspiration; iii) changes in wind speeds and direction; and iv) changes in the intensity of rainfall. The links between climate impacts and climate hazards are summarized in Table 23, while Table 24 describes the indicators and parameters used to quantify the impact potential of climate hazards in Mauritania.

**Table 23.** Summary of association between climate impacts and climate hazards in Mauritania.

Sector	Department	Impacts	Climate hazards						
			Rainfall decrease	Temperature increase	PET increase	Strong winds	Heat waves	Drought	Heavy rains
Infrastructure	Housing	<ul style="list-style-type: none"> <li>Flooding of settlements</li> <li>Sand inundation</li> </ul>				X			X
	Roads	Sand inundation				X			X
Natural resources	Water resources	Water availability <ul style="list-style-type: none"> <li>Reduced availability of conventional water resources</li> <li>Water quality degradation</li> </ul>			X	X		X	
	Biodiversity & forests	Degradation of ecosystems				X	X	X	X
	Agriculture	Crop productivity <ul style="list-style-type: none"> <li>Reduced productivity of degraded land</li> <li>Yield loss due to water stress</li> <li>Reduced quantity &amp; quality of crop production as a result of limited access to water</li> </ul>	X	X	X	X		X	
	Livestock	Livestock productivity <ul style="list-style-type: none"> <li>Reduced availability of pastoral water</li> <li>Food availability decrease</li> <li>Loss of cattle as a result of limited access to pastoral water points</li> </ul>	X	X		X	X	X	
Social Services	Health	Public health <ul style="list-style-type: none"> <li>Local food insecurity and malnutrition</li> </ul>	X	X	X	X	X	X	X



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		<ul style="list-style-type: none"> <li>Increased occurrence of water borne diseases &amp; acute respiratory infections</li> <li>Flood-related loss of life</li> </ul>							
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**Table 24.** Summary of indicators and climate parameters used to quantify the impact potential of climate hazards in Mauritania.

Climate indicators	Parameters assessed and modelled	Climate hazards	Parameters assessed and modelled
Temperature	Daily Minimum (Tn) and maximum (Tx)	Heat waves	Annual number of consecutive days with Tx > percentile 95
Evapotranspiration (ETP)	Daily mean	Water balance deficit	Annual average potential ETP
Wind	Direction and speed of 10 minutes averaged wind each 3 hours	Days with strong winds coming from North-East.	Annual number of days with wind >6m/s, with north-east as prevailing direction
Precipitations (P)	Daily amount	Heavy rains	Annual number of days with P>10mm
		Drought intensity	Annual maximum number of consecutive days with daily precipitation less than 1 mm

Heavy rains, droughts and heatwaves were analysed using Expert Team on Climate Change Detection and Indices' (ETCCDI's<sup>586</sup>) indices, while strong winds were analysed using a customized index. A description of the indices used to conduct climatological analyses is provided below.

- Heatwaves were quantified using the warm spell duration index (WSDI), which counts the annual incidence of 'at least 3 consecutive days when daily maximum temperature is higher than 90th percentile of daily maximum temperature'.
- Heavy rains were quantified using the R10mm index, which records the annual number of days with more than 10 mm of precipitation.
- Droughts were quantified using the consecutive dry day (CDD) index, which measures the annual maximum number of consecutive days with daily precipitation values of less than 1 mm.
- Strong winds from the north-east were quantified by counting the annual number of days with north-easterly wind speeds exceeding 6 m/s. Wind speed is an important contributor to sand encroachment, since it determines the force of sand removal. Greater wind speeds have greater carrying capacities and, therefore, transport greater quantities of sand. The 6m/s value selected for this climate hazard index represents the threshold at which wind is strong enough to lift sand particles off the ground<sup>587</sup>.

A categorical scale of hazard impact potential was used to communicate the risk levels associated with each climate hazard, to assist in the prioritisation of adaptation interventions. Table 25 outlines the different climate hazard risk levels used in this study and the different criteria associated with each category. Different combinations of climate hazard intensity, frequency and projected change in frequency and/or intensity — represented by roman numerals — fall under each risk category.

<sup>586</sup> Climate Change Indices: [http://etccdi.pacificclimate.org/list\\_27\\_indices.shtml](http://etccdi.pacificclimate.org/list_27_indices.shtml)

<sup>587</sup> FAO. 2010. Fighting sand encroachment — lessons from Mauritania.

**Table 25.** Legend summarising the classification structure for climate hazard impact potential. Higher hazard ratings are associated with higher climate risk scores<sup>588</sup>.

Classification			Climate hazard criteria		
Colour	Hazard rating	Hazard category	Observed intensity	Observed frequency	Projected change in intensity and/or frequency (2050)
	5	Extremely high	i. Moderate ii. High iii. Moderate iv. High	High Moderate Moderate Rare	Moderate increase Moderate increase Strong increase Strong increase
	4	High	i. Moderate ii. High iii. Moderate iv. High v. Moderate	High Moderate Moderate High Rare	No change No change Moderate increase Moderate increase Strong increase
	3	Moderate	i. Moderate ii. High iii. Moderate iv. High v. Moderate	Moderate Rare High Moderate Rare	No change No change Decrease Decrease Increase
	2	Slight	i. Moderate ii. Moderate iii. Moderate	Low Moderate Rare	No change Decrease Increase
	1	Marginal	i. Low ii. Moderate iii. High	Rare Moderate Rare	No change Decrease Decrease
	0	Negligible	Frequency and intensity of event are negligible		

<sup>588</sup> Appendix 3.

## Historical climatologies

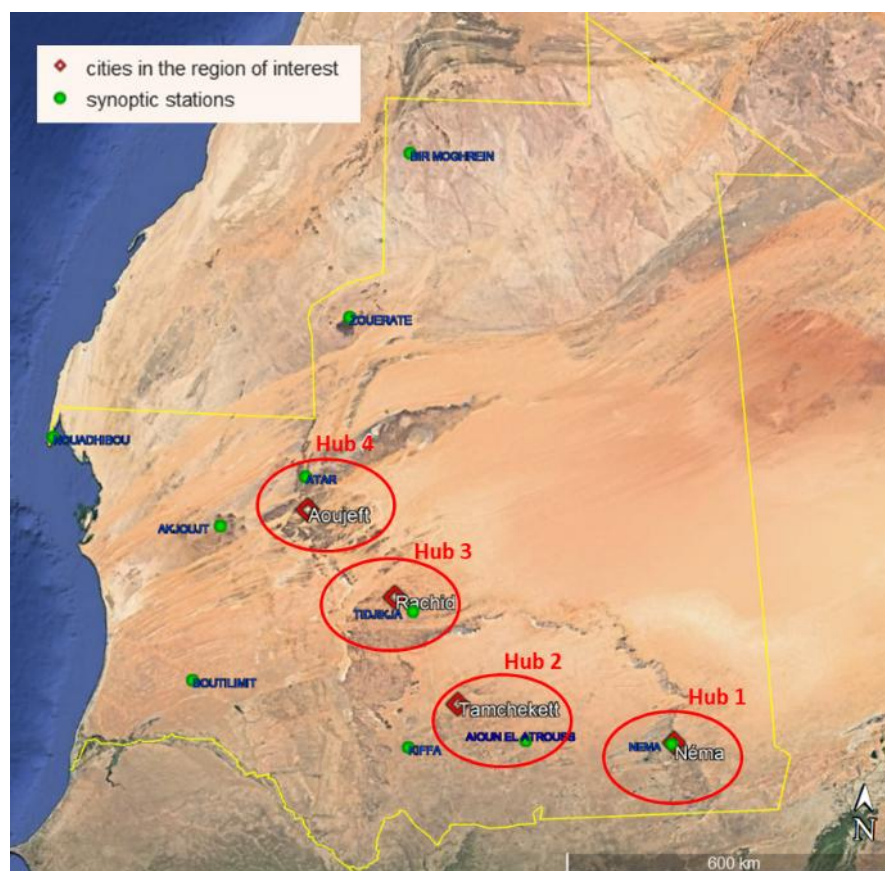
Historical climate trends were analysed using climate data from several databases and from local knowledge collected during field missions to the proposed project's four target rural-urban hubs. A description of how data were collected is provided in Appendix 2. Additionally, the sources and quality of climate data used in climatological analyses are described in Appendix 3.

Analyses of the parameters contained in Table 24 included i) analyses of means and variability; ii) spatial analyses for the four hubs; iii) analyses of seasonal cycles; iv) analyses of extreme values; and v) trend analyses to determine the evolution of each indicator (at least 30 years of data were required). The robustness of trends was determined using the Mann-Kendall statistical test, with a 10% significance level ( $\alpha=0.1$ ).

The analyses were mainly performed using data obtained from synoptic weather stations established by the national meteorological network in Mauritania — the *Office National de la Météorologie* (ONM). The national network includes 10 synoptic stations sparsely distributed over the country (Figure 28).

A single weather station is located in each of the proposed project's four target hubs:

- Néma station in Nema hub (hub 1);
- Aïoun station in Tamcheket hub (hub 2);
- Tidjikja station in Rachid hub (hub 3); and
- Atar station in Aoujeft hub (hub 4).



**Figure 28.** Locations of synoptic weather stations in Mauritania. The weather stations circled in red are located within the proposed project's target rural-urban hubs.

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A summary of data availability for climate parameters in the four target hubs is provided in Appendix 3.

#### *Climate projections*

The AFRICA-CORDEX, ARF-44 dataset (0.44-degree data, at 50 km resolution) — which comprises 19 GCM/RCM downscaling models — was selected for model validation and projected climate analyses. The 19 available models were compared with observational data for the historical reference period (1981–2010) at the locations of Nema, Tamcheket, Rachid and Aoujeft ONM synoptic stations.

For each model, the following climate variables are available:

- daily data of precipitation, surface temperature;
- maximum and minimum surface temperature; and
- two components ( $u$  and  $v$ ) of daily surface wind velocity.

The climate parameters used in comparisons between observations and models included:

- temperature ( $T_{\max}$  and  $T_{\min}$ );
- potential ETP;
- wind<sup>589</sup>;
- precipitation;
- heavy rains (R10mm index);
- droughts (CDD index); and
- heat waves (WSDI).

In addition to the hub-level climate evolutions simulated by the AFR-44 model, data obtained from the World Bank Climate Knowledge Portal were used to illustrate climate change results for Mauritania at the national level by 2100. The differences between observational data and modelled data were calculated and analysed for each location as described in Appendix 3.

#### **Emissions scenario and time frame selection**

In accordance with the Inception Report, the IPCC RCP8.5<sup>590</sup> and RCP4.5<sup>591</sup> global emissions scenarios were selected for all hub-level climate projections and the time frame of analysis was defined as the 2050 horizon. Therefore, all hub-level climate projections focused on RCP8.5 and RCP4.5, using the AFR-44 dataset for the period 2036–2065. For climate trends at the national scale, 2050 projections were mostly obtained via desktop research; therefore, the range of RCP emissions scenarios used to identify climate projections at the national scale varies in this report, depending on existing data availability.

#### **Vulnerability and exposure**

Assessments of exposure and vulnerability were conducted using both qualitative and quantitative data rated based on expert judgement and local knowledge collected during field visits to the four target hubs. The full complement of sectoral vulnerability and exposure

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<sup>589</sup> Wind data were not included in model validation as a result of the unavailability of daily maximum wind velocity data in the models and the high missing data rate in the observational data. Daily average wind velocity is not sufficient to characterise the appearance of strong wind and its direction, since the time scale needed to characterise wind is usually in the order of minutes.

<sup>590</sup> Pessimistic scenario without climate policy by 2100

<sup>591</sup> Intermediate scenario with effective climate policies to stabilize greenhouse gas concentrations by 2100

indicators rated by experts and local community members is included in Appendix 4 and the scoring grid used during the rating process is provided in Table 26 below. A scale of 0–4 was used for observed vulnerability and exposure scores, while in contrast, a scale of 0–5 was used for projected (2050) vulnerability and exposure scores.

**Table 26:** Scoring grid for exposure and vulnerability<sup>592</sup>.

<b>Scoring grid for exposure, vulnerability and climate hazards</b>		
<b>Rating</b>	<b>Exposure</b>	<b>Vulnerability</b>
<b>0</b>	Element not present Element not important No population presence No climate-related challenges	No sensitivity Not applicable Very high degree of adaptability
<b>1</b>	Element weakly present Low degree of importance Low population presence Low climate challenge	The element is not extremely sensitive or weak High degree of adaptability
<b>2</b>	Element present Medium importance Medium population presence Medium climate challenge	The element is moderately sensitive Moderate degree of adaptability
<b>3</b>	Element particularly present Significant degree of importance Significant population presence Significant climate challenge	The element is particularly sensitive Limited adaptability or means to adapt
<b>4</b>	Strongly present High degree of importance High population presence High climate challenge	The element is extremely sensitive Strong barriers to adaptation
<b>5</b>	Element extremely present Extremely high degree of importance Extremely high population presence Very high climate challenge	The element is extremely sensitive Extreme barriers to adaptation

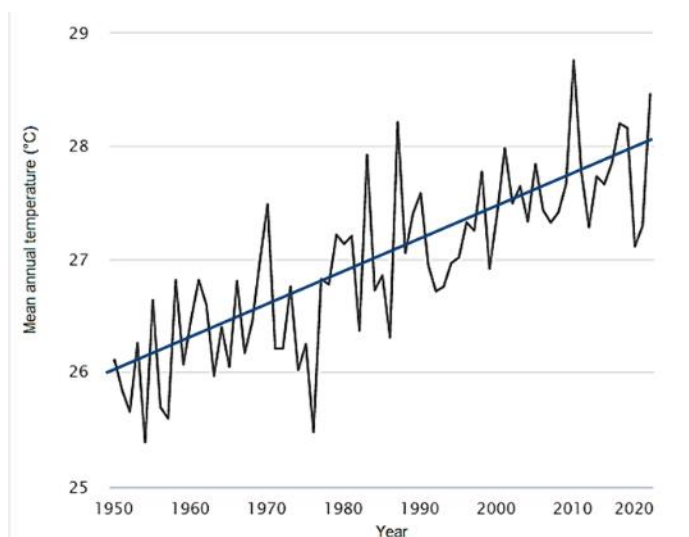
The scoring of non-climatic factors was informed by hypotheses proposed by national experts, based on their observations of current dynamics and their knowledge of past or ongoing plans or strategies that are already underway or soon to be implemented — independently of the proposed project. The results obtained for each sectoral assessment — with scores allocated to all vulnerability and exposure indicators — were aggregated to the climate hazard values derived from the IPCC RCP4.5 and RCP8.5 modelling results and hazard ratings, according to the calculations contained in Appendix 4.

<sup>592</sup> Appendix 3.

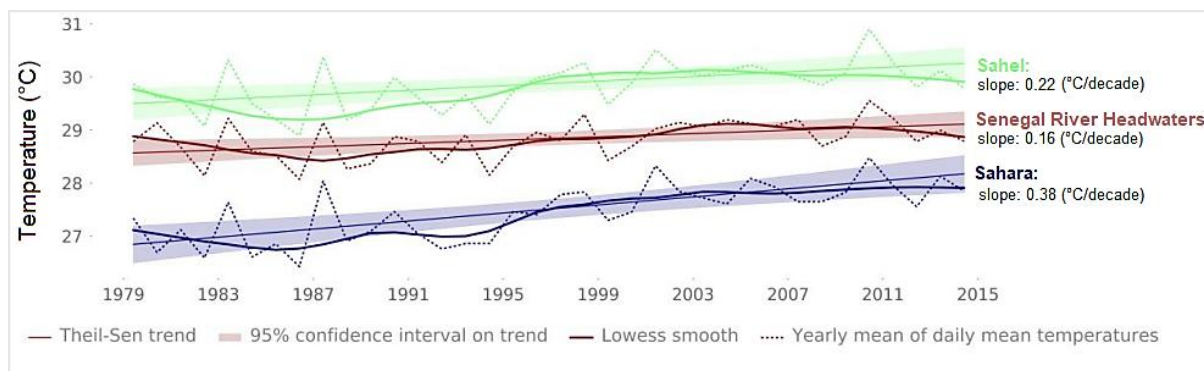
## 2.2 Temperature

### 2.2.1 Observed

Since 1950, the mean annual temperature in Mauritania has increased by  $\sim 0.3^{\circ}\text{C}$  per decade — from  $26.1^{\circ}\text{C}$  in 1950 to  $28.46^{\circ}\text{C}$  in 2020 (Figure 29)<sup>593</sup>. Although statistically significant warming has been observed across all major climatic zones in the country, temperature increases have been greatest over the Sahara Desert and smallest over the Senegal River headwaters (Figure 30)<sup>594</sup>.



**Figure 29.** Line graph showing the mean annual temperature trend for Mauritania (1950–2020)<sup>595</sup>.



**Figure 30.** Trends and variability in mean annual temperature across three major climatic zones in Mauritania (1979–2014)<sup>596</sup>.

Warming trends have also been observed at the hub level. The most recently available 30-year weather station data (1981–2010) indicate that, in general, temperatures have increased within the focal hubs of Aoujeft, Rachid, Tamcheket and Nema. This trend is more statistically

<sup>593</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

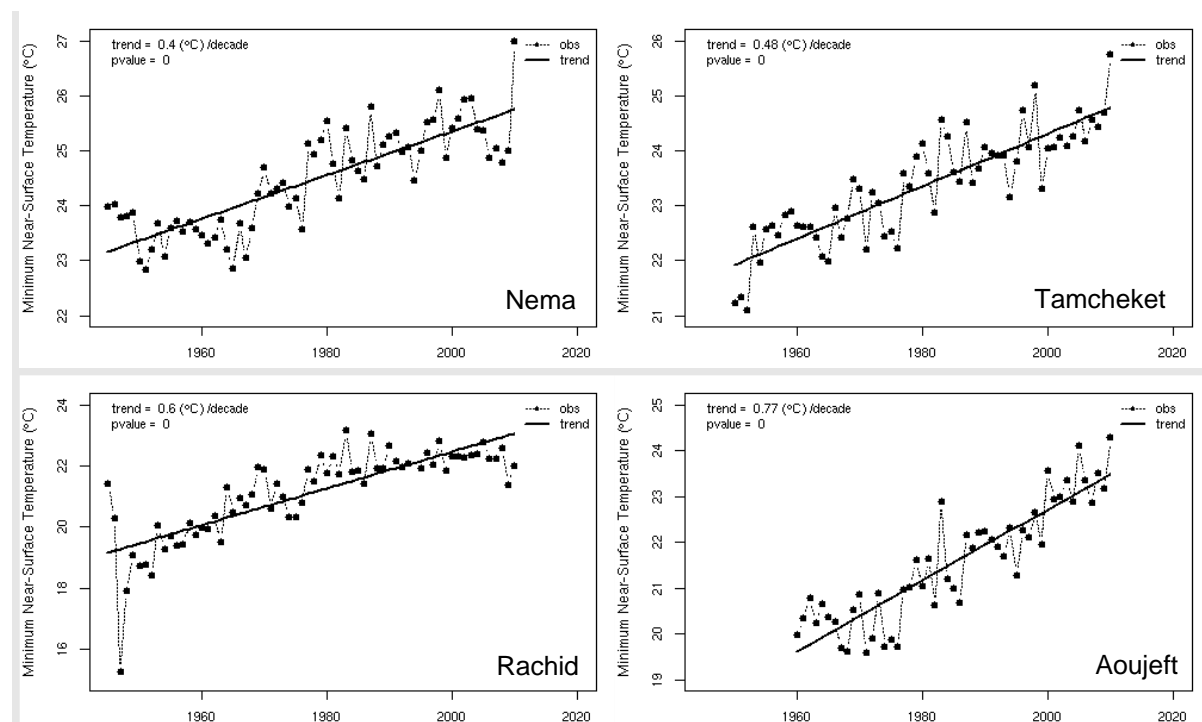
<sup>594</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>595</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

<sup>596</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

significant for minimum near-surface temperatures ( $T_{\min}$ ) than for maximum near-surface temperatures ( $T_{\max}$ )<sup>597</sup>.

Between 1981 and 2010, mean annual  $T_{\min}$  increased by  $\sim 0.77^{\circ}\text{C}/\text{decade}$  in Aoujeft;  $\sim 0.6^{\circ}\text{C}/\text{decade}$  in Rachid;  $\sim 0.48^{\circ}\text{C}/\text{decade}$  in Tamcheket; and  $\sim 0.4^{\circ}\text{C}/\text{decade}$  in Nema (Figure 31, Table 27). In all four hubs, the most significant minimum temperature increases have been observed between April and June (AMJ)<sup>598</sup>.



**Figure 31.** Observed changes in mean annual minimum temperature over time (1981–2010) in each of the proposed project's four target hubs<sup>599</sup>.

**Table 27.** Observed changes in minimum temperature ( $T_{\min}$ ) and maximum temperature ( $T_{\max}$ ) across all four of the proposed project's target hubs (1981–2010)<sup>600</sup>.

		Temperature trend ( $^{\circ}\text{C}/\text{decade}$ ) (1981–2010)	
		$T_{\min}$	$T_{\max}$
Weather station (hub)	Atar (Aoujeft)	+0.77	+0.20
	Tidjikja (Rachid)	+0.60	+0.20
	Aïoun (Tamcheket)	+0.48	+0.20
	Néma (Nema)	+0.40	+0.01

Note: A positive coefficient represents an increasing temperature trend, while a negative coefficient represents a decreasing temperature trend. Numbers in *italics* represent statistically non-significant trends ( $p > 0.01$ ).

<sup>597</sup> Appendix 3

<sup>598</sup> Appendix 3.

<sup>599</sup> Appendix 3.

<sup>600</sup> Appendix 3.



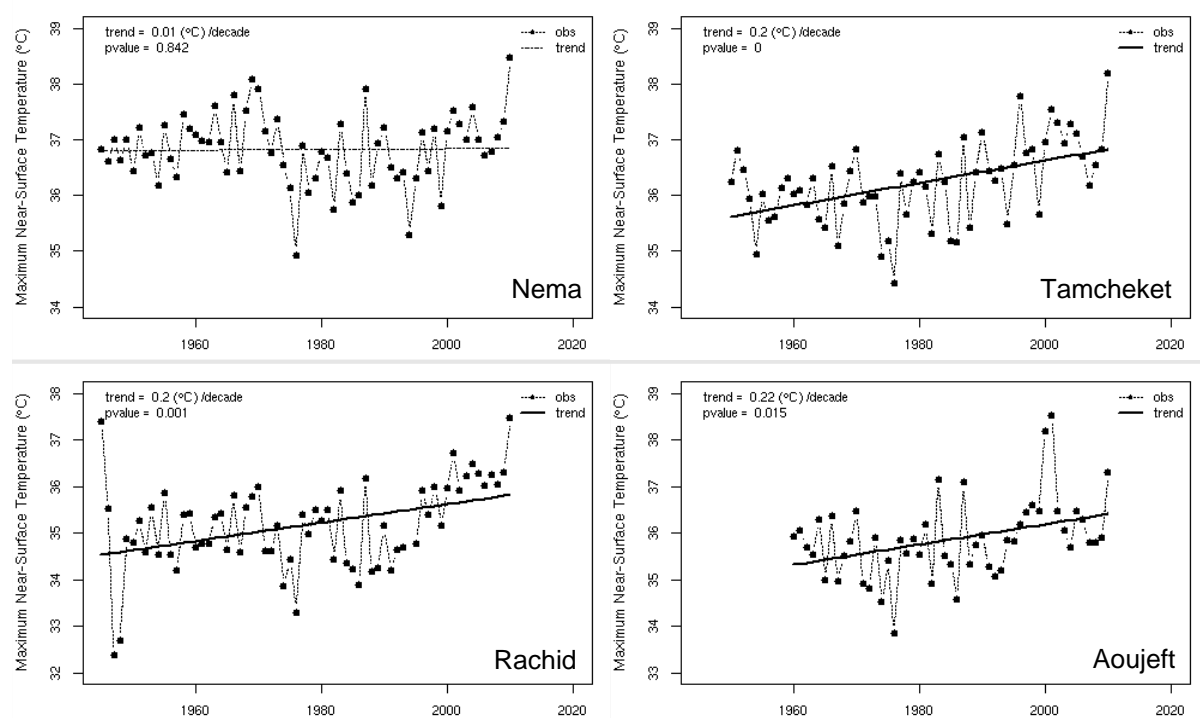
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Over the same period (1981–2010), mean annual  $T_{\max}$  increased by  $\sim 0.2^{\circ}\text{C}$  per decade in Tamcheket, Rachid and Aoujeft; however, no significant change was detected in Nema (Figure 32)<sup>601</sup>. Additionally,

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<sup>601</sup> Appendix 3.

**Table 28** summarises observed changes in the mean seasonal  $T_{\max}$  for all four target hubs. In Aoujeft, the greatest change in seasonal maximum temperature was observed between October to December (OND), while in Rachid, Tamcheket and Nema, the greatest increases in  $T_{\max}$  were observed between July and September (JAS).



**Figure 32.** Observed changes in mean annual maximum temperatures over time (1981–2010) in each of the proposed project's four target hubs<sup>602</sup>.

<sup>602</sup> Appendix 3.

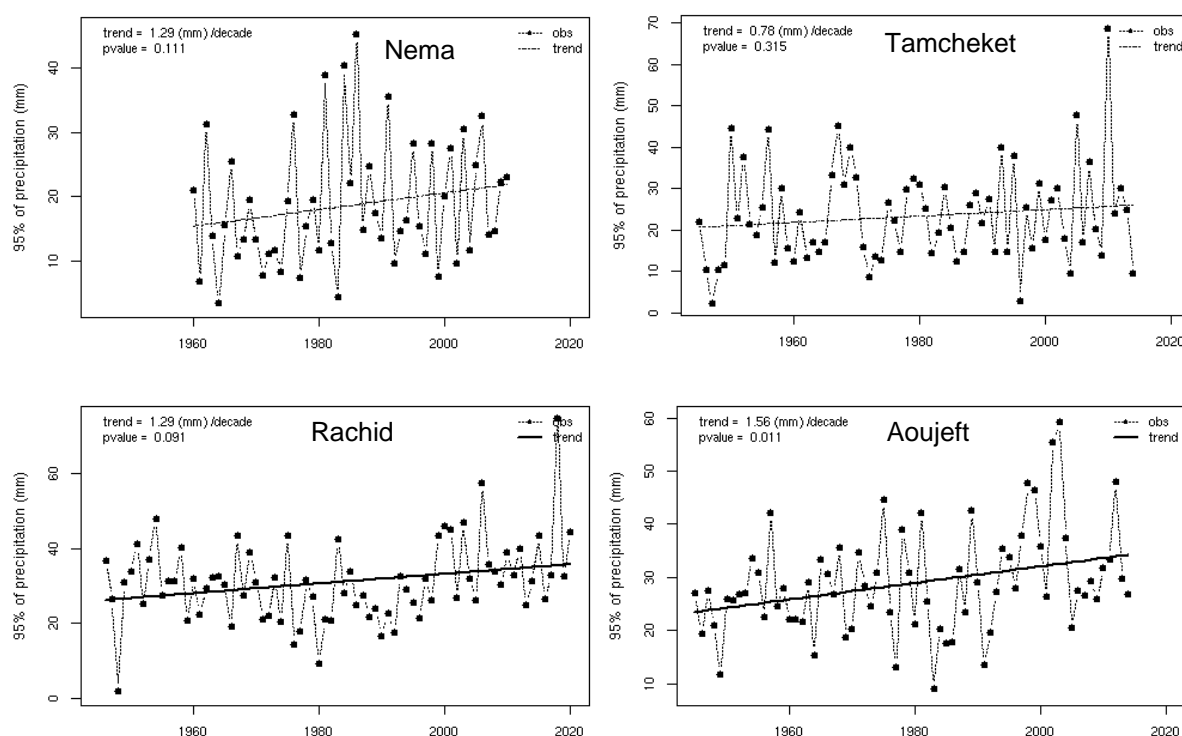
**Table 28.** Summary of observed changes in mean seasonal maximum near-surface temperature ( $T_{\max}$ ) in the proposed project's target hubs (1981–2010)<sup>603</sup>.

Change in mean seasonal $T_{\max}$ (°C/decade)				
Weather station (Hub)	January–March (JFM)	April–June (AMJ)	July–September (JAS)	October–December (OND)
Atar (Aoujeft)	+0.09	+0.27	+0.13	+0.31
Tidjikja (Rachid)	+0.18	+0.16	+0.25	+0.17
Aïoun (Tamcheket)	-0.02	+0.25	+0.41	+0.18
Néma (Nema)	-0.12	+0.02	+0.14	-0.01

Note: A positive sign represents an increasing maximum temperature trend, while a negative sign represents a decreasing maximum temperature trend. Numbers in italics indicate trends that are not statistically significant ( $p>0.1$ ).

Extreme daily maximum temperatures (95<sup>th</sup> percentile) have also increased across the proposed project's target regions (Figure 33). Increases were observed in Nema (0.04°C/decade) and Aoujeft (0.09°C/decade); however, these trends are not statistically significant ( $p>0.1$ ). In Nema, Rachid and Tamcheket, the greatest seasonal increase in maximum temperature has been observed between July–September (JAS), while in Aoujeft, the largest increase has occurred between October–December (OND).

<sup>603</sup> Appendix 3.



**Figure 33.** Observed changes in extreme daily maximum temperature over time (1981–2010) in each of the proposed project's four target hubs<sup>604</sup>.

Between 1981 and 2010, extreme maximum temperatures increased by  $\sim 0.23^{\circ}\text{C}/\text{decade}$  in Tamcheket and  $\sim 0.2^{\circ}\text{C}/\text{decade}$  in Rachid. Additionally, small increases were observed in Nema ( $\sim 0.04^{\circ}\text{C}/\text{decade}$ ) and Aoujeft ( $0.09^{\circ}\text{C}/\text{decade}$ ); however, these trends are not statistically significant ( $p > 0.1$ ). In Nema and Tamcheket, the greatest seasonal increase in extreme maximum temperature has been observed between July and September (JAS), while in Tamcheket and Aoujeft, the largest increase has occurred between January and March (JFM)<sup>605</sup>.

## 2.2.2 Projected

Across Mauritania, climate change is projected to induce a  $1\text{--}3^{\circ}\text{C}$  increase in mean annual temperature by 2050 and a  $3\text{--}6^{\circ}\text{C}$  increase by 2100 (Figure 34)<sup>606,607</sup>. Additionally, median climate model projections suggest that air temperatures over the country will rise by  $2\text{--}4.5^{\circ}\text{C}$  by 2080, depending on the greenhouse gas (GHG) emissions scenario applied. Under a low emissions scenario (RCP2.6), mean air temperatures are projected to increase by  $\sim 2.1^{\circ}\text{C}$  in 2030,  $\sim 2.3^{\circ}\text{C}$  in 2050, and  $\sim 2.5^{\circ}\text{C}$  in 2080. Under an intermediate–high emissions scenario (RCP6.0), air temperatures are expected to increase by  $\sim 2.1^{\circ}\text{C}$  in 2030,  $2.7^{\circ}\text{C}$  in 2050 and  $\sim 3.8^{\circ}\text{C}$  in 2080 (Figure 34)Figure <sup>608</sup>. While increasing air temperatures are expected for all major climatic zones in the country — including the Sahara Desert, semi-arid Sahel, and

<sup>604</sup> Appendix 3.

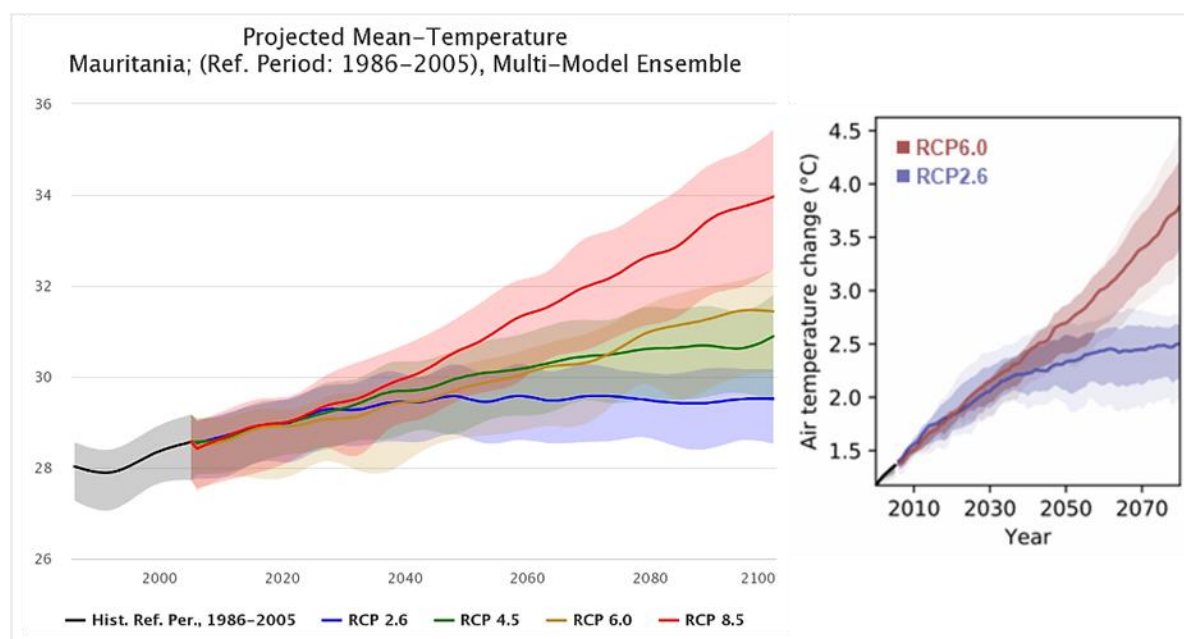
<sup>605</sup> Appendix 3.

<sup>606</sup> Appendix 3.

<sup>607</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>608</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agrica.de/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agrica.de/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).

Senegal River headwaters — warming is projected to be most prominent over the Sahara and Sahel regions<sup>609</sup>.



**Figure 34.** Projected changes in mean temperature<sup>610</sup> (left) and air temperature<sup>611</sup> (right) in Mauritania under various GHG emissions scenarios.

The evolution of temperature trends for the 2050 horizon (2036–2065) has also been analysed at the hub level — as described in Section 2.1 — for both a high (RCP8.5) and intermediate (RCP4.5) GHG emissions scenario. All four target hubs are projected to experience an increase in both minimum and maximum temperatures under future emissions scenarios. By 2050, mean minimum temperatures are expected to increase by 2.8–3.8°C in Aoujeft, 2–2.7°C in Rachid, 1.7–2.3°C in Tamcheket and 2.6–3.8°C in Nema relative to those observed during the reference period (1981–2010). The greatest increases in minimum temperature will, therefore, occur within the hubs of Aoujeft and Nema. Similarly, by 2050, mean maximum temperatures in all four of the proposed project's target hubs are projected to exceed those observed between 1981 and 2010 — by 2.4–3.2°C in Aoujeft, 2.1–2.7°C in Rachid, 2.1–2.8°C in Tamcheket and 2.4–3.2°C in Nema.

In all four hubs, the rate at which minimum temperatures are increasing is expected to slow towards the second half of the 21<sup>st</sup> century under both the RCP4.5 and RCP8.5 emissions scenarios. In contrast, the rate at which maximum temperatures are increasing is projected to double in Aoujeft, Rachid and Tamcheket and increase substantially in Nema<sup>612</sup>. Projected changes in mean temperature are summarised in Table 29, while projected changes in temperature trends are summarised in Table 30. The colour classification used in these tables corresponds with the different climate hazard ratings provided in Table 25. Projected changes in minimum and maximum temperature across all four hubs are summarised in

<sup>609</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>610</sup> Appendix 3.

<sup>611</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agrica.de/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agrica.de/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).

<sup>612</sup> Appendix 3.

Table 31.

**Table 29.** Projected changes in mean temperature across all four of the proposed project's target hubs, under both an intermediate (RCP4.5) and high (RCP8.5) emissions scenario<sup>613</sup>.

		Mean annual temperature (°C)		
Weather station (hub)	Variable	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
<b>Atar</b> (Aoujeft)	T <sub>min</sub>	22.4	25.2	26.2
	T <sub>max</sub>	36.1	38.5	39.3
<b>Tidjikja</b> (Rachid)	T <sub>min</sub>	22.2	24.2	24.9
	T <sub>max</sub>	35.5	37.6	38.2
<b>Aïoun</b> (Tamcheket)	T <sub>min</sub>	24.1	25.8	26.4
	T <sub>max</sub>	36.6	38.7	39.4
<b>Néma</b> (Nema)	T <sub>min</sub>	25.2	27.8	29.0
	T <sub>max</sub>	36.8	39.2	40.1

**Table 30.** Projected changes in minimum and maximum temperature trends across all four of the proposed project's target hubs under both an intermediate (RCP4.5) and high (RCP8.5) emissions scenario<sup>614</sup>.

		Temperature trend (°C/decade)		
Weather station (hub)	Variable	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
<b>Atar</b> (Aoujeft)	T <sub>min</sub>	+0.78	+0.42	+0.60
	T <sub>max</sub>	+0.22	+0.38	+0.55
<b>Tidjikja</b> (Rachid)	T <sub>min</sub>	+0.60	+0.34	+0.46
	T <sub>max</sub>	+0.20	+0.35	+0.46
<b>Aïoun</b> (Tamcheket)	T <sub>min</sub>	+0.48	+0.32	+0.43
	T <sub>max</sub>	+0.20	+0.34	+0.47
<b>Néma</b> (Nema)	T <sub>min</sub>	+0.40	+0.43	+0.62
	T <sub>max</sub>	+0.01	+0.42	+0.59

Note: A positive sign represents an increasing temperature trend, while a negative sign represents a decreasing temperature trend.

<sup>613</sup> Appendix 3.

<sup>614</sup> Appendix 3.

**Table 31.** Projected changes in minimum and maximum temperature across all four of the proposed project's target hubs under an intermediate (RCP4.5) and high (RCP8.5) emissions scenario<sup>615</sup>.

Weather station (hub)	Variable	Mean annual temperature (°C)			Temperature trend (°C/decade)		
		Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
<b>Atar</b> (Aoujeft)	T <sub>min</sub>	22.4	25.2	26.2	+0.78	+0.42	+0.60
	T <sub>max</sub>	36.1	38.5	39.3	+0.22	+0.38	+0.55
<b>Tidjikja</b> (Rachid)	T <sub>min</sub>	22.2	24.2	24.9	+0.60	+0.34	+0.46
	T <sub>max</sub>	35.5	37.6	38.2	+0.20	+0.35	+0.46
<b>Aïoun</b> (Tamcheket)	T <sub>min</sub>	24.1	25.8	26.4	+0.48	+0.32	+0.43
	T <sub>max</sub>	36.6	38.7	39.4	+0.20	+0.34	+0.47
<b>Néma</b> (Nema)	T <sub>min</sub>	25.2	27.8	29.0	+0.40	+0.43	+0.62
	T <sub>max</sub>	36.8	39.2	40.1	+0.01	+0.42	+0.59

## 2.3 Precipitation

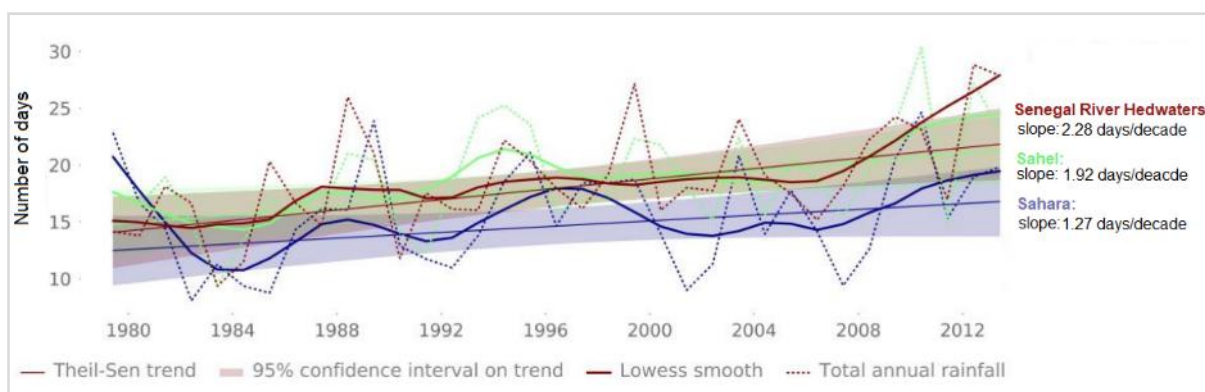
### 2.3.1 Observed

Since the 1960s, climate change in Mauritania has induced i) an increase in the frequency of extreme rainfall events and associated flash floods; and ii) a decline in low-intensity, long-duration precipitation events, which has contributed to extended dry spells<sup>616</sup>. Table 32 summarises important observed changes in precipitation in the four target hubs. Between 1979 and 2013, the number of extreme rainfall days has increased by ~2.3 days/decade over the Senegal River headwaters; by ~1.9 days/decade over the semi-arid Sahel; and by ~1.3 days/decade over the Sahara Desert (Figure 35). As a result, statistically significant ( $p < 0.1$ ) upward trends in total annual rainfall have been observed across all major climatic zones. The largest increase in mean annual rainfall has been observed in the Senegal River Valley (~38 mm/decade) and the smallest change in rainfall has been observed over the Sahara Desert (~6.9 mm/decade) (Figure 36)<sup>617</sup>.

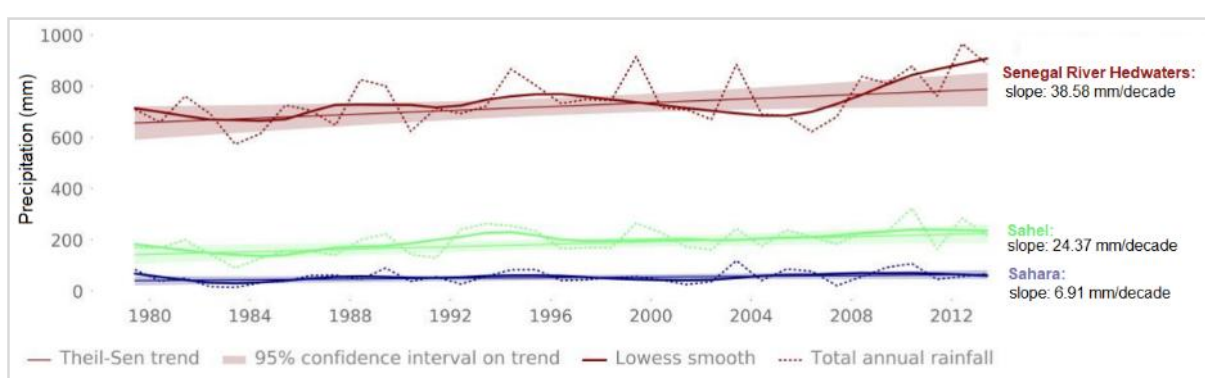
<sup>615</sup> Appendix 3: Trend and Climate Change Report.

<sup>616</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>617</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.



**Figure 35.** Number of extreme rainfall days (95<sup>th</sup> percentile) observed across three major climatic zones in Mauritania (1979–2013)<sup>618</sup>.



**Figure 36.** Mean annual precipitation across three major climatic zones in Mauritania (1979–2013)<sup>619</sup>.

**Table 32.** Observed precipitation trends across the proposed project's four target hubs for the year and the wet season (July–September).

Weather station (hub)	Precipitation trend (mm/decade) (1960–2010)			
	Mean precipitation (annual)	Mean precipitation (July–September)	Extreme daily precipitation (annual)	Extreme daily precipitation (July–September)
<b>Atar</b> (Aoujeft)	+1.2	+2.0	+1.3	+0.9
<b>Tidjikja</b> (Rachid)	-8.5	-5.3	+0.8	+0.5
<b>Aïoun</b> (Tamcheket)	-6.8	-6.1	+1.3	+1.1
<b>Néma</b> (Nema)	-18	-9.5	+1.6	+1.6

Note: A positive sign represents an increasing precipitation trend, while a negative sign represents a decreasing temperature trend. Numbers in *italics* represent statistically non-significant trends ( $p>0.01$ ).

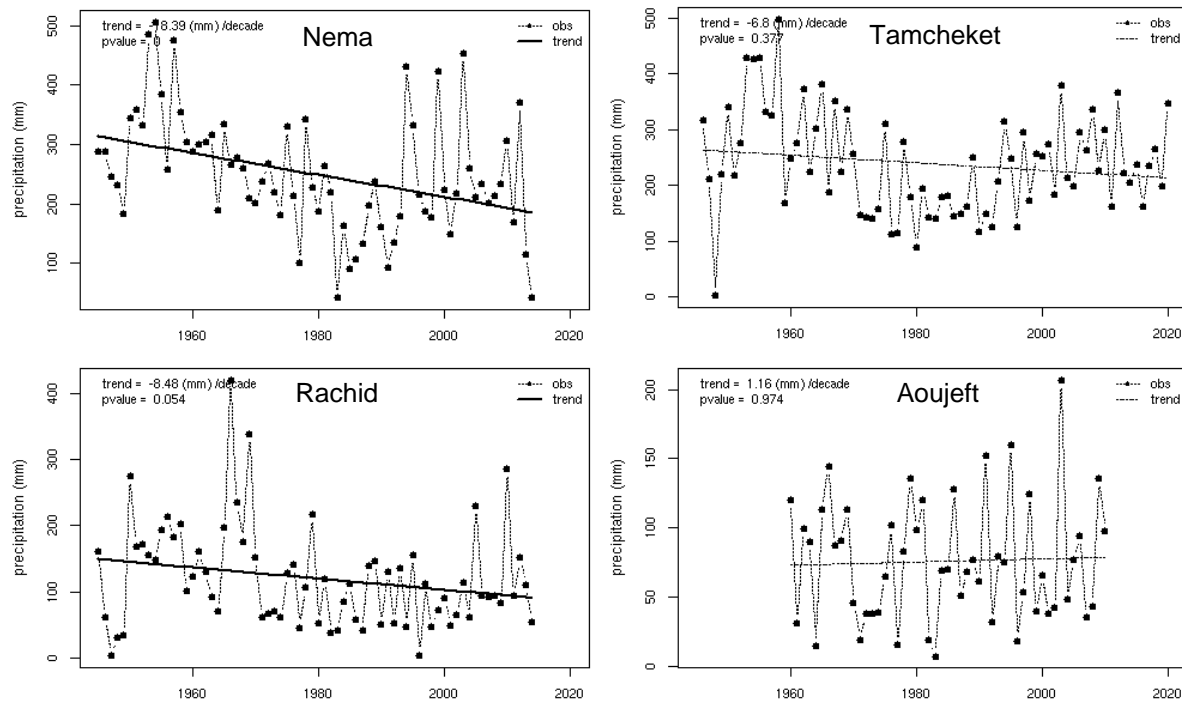
There is considerable variation in observed rainfall trends across the proposed project's target hubs. Between 1981 and 2010, Aoujeft and Rachid received mean annual rainfall of ~76 mm and ~95 mm, respectively. Over the same period, both Nema and Tamcheket recorded mean annual precipitation values of ~216 mm; however, larger inter-annual variability was observed

<sup>618</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>619</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.



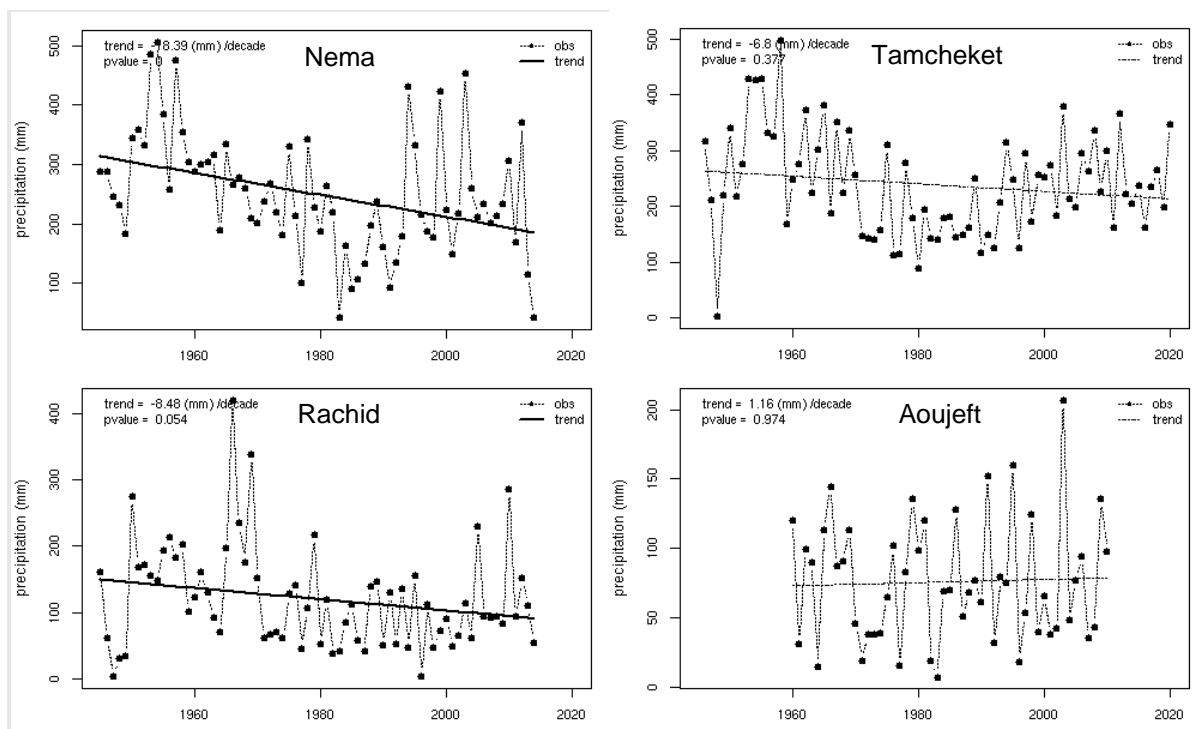
in Nema (~43–454 mm/yr)<sup>620</sup>. Additionally, the average number of days with precipitation was ~9 days/yr in Aoujeft and ~10 days/yr in Rachid, while larger values of ~17.8 days/yr and ~19.5 days/yr were observed in Nema and Tamcheket, respectively. The relatively low number of days with precipitation in each of the four hubs clearly reflects the frequency of drought events observed during the 20<sup>th</sup> century — particularly for Rachid and Aoujeft, where long periods with little or no rain were observed.



**Figure 37** shows annual precipitation changes over time (1960–2010) in each of the four target hubs. Annual precipitation decreased by ~18 mm/decade in Nema; ~6.8 mm/decade in Tamcheket and ~8.5mm/decade in Rachid. In contrast, annual precipitation increased slightly in Aoujeft, by ~1.2 mm/decade<sup>621</sup>. The greatest changes in mean seasonal precipitation have been observed during the wet season (JAS) in Rachid (-5.34 mm/decade), Tamcheket (-6.11 mm/decade) and Nema (-9.51 mm/decade). In contrast, Aoujeft has experienced a slight increase in rainfall during the wet season (+2.03 mm/decade) but a decrease in rainfall between October and November.

<sup>620</sup> Appendix 3.

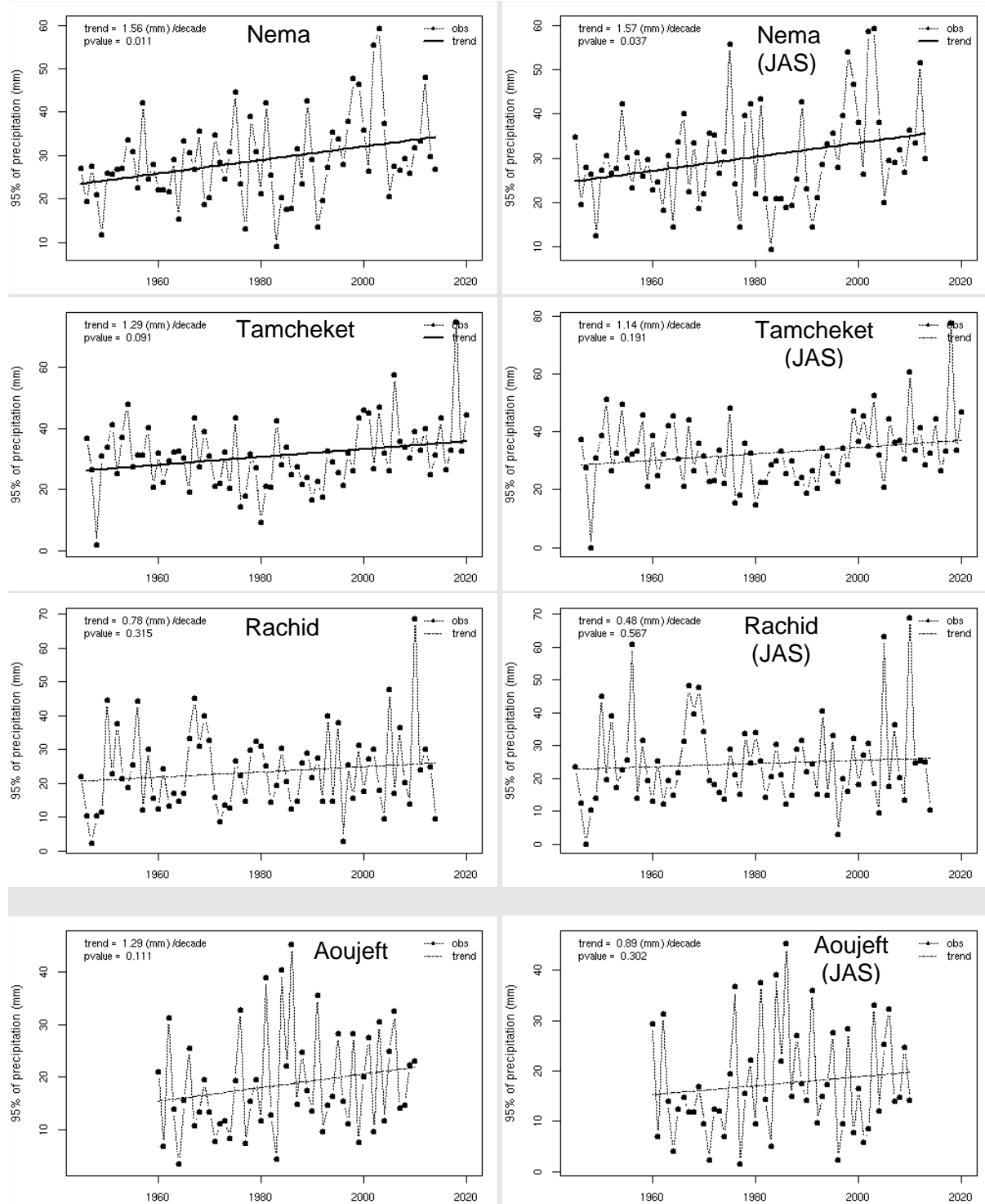
<sup>621</sup> Appendix 3.



**Figure 37.** Observed changes in mean annual precipitation across the proposed project's four target hubs for the period ranging from 1960 to 2010<sup>622</sup>.

Figure 38 shows the observed change in extreme daily precipitation (95<sup>th</sup> percentile) over time for both the entire year and the wet season (JAS). Between 1960 and 2010, extreme daily precipitation increased by ~1.6 mm/decade in Nema, ~1.3 mm/decade in Tamcheket hub, ~0.8 mm/decade in Rachid and ~1.3 mm/decade in Aoujeft over the entire year. However, only those increases observed in Nema and Tamcheket were statistically significant ( $p < 0.1$ ). During the wet season (JAS) alone, extreme daily precipitation increased by ~1.6 mm/decade in Nema; ~1.1 mm/decade in Tamcheket; ~0.48 mm/decade in Rachid; and ~0.9 mm/decade in Aoujeft.

<sup>622</sup> Appendix 3.

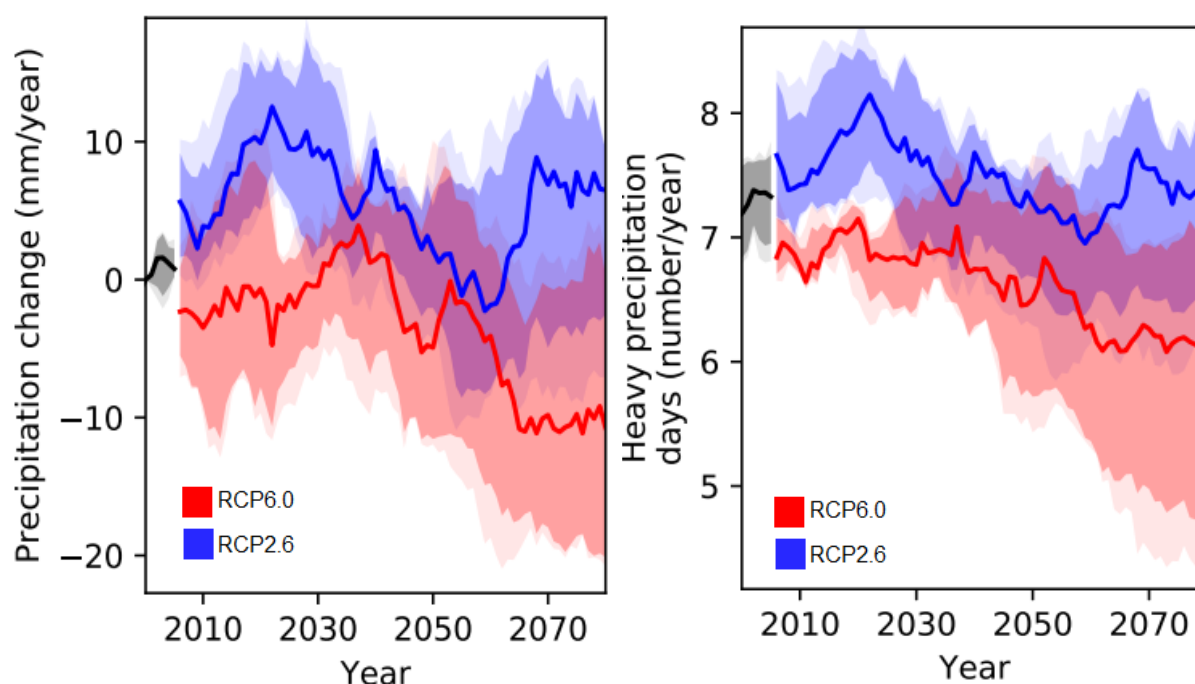


**Figure 38.** Observed changes in extreme daily precipitation (1960–2010) across the proposed project's four target hubs for the entire year (left) and for the wet season only (right)<sup>623</sup>.

<sup>623</sup> Appendix 3.

### 2.3.2 Projected

Rainfall projections across Mauritania do not return consistent data for annual total rainfall or for the frequency of rainfall events and extreme rainfall events<sup>624</sup>. Median climate model projections show a precipitation increase of ~6 mm per year by 2080 under RCP2.6. In contrast, under RCP6.0, median models predict a decrease of ~11 mm relative to the year 2000. Moreover, under RCP6.0, median climate models project a decrease in the number of days with heavy precipitation events — from 7 days per year in 2000 to 6 days per year in 2080. Under RCP2.6, however no change in heavy precipitation days is projected (Figure 39)<sup>625</sup>.



**Figure 39.** Projected changes in precipitation (left) and number of days with heavy precipitation (right) across Mauritania under both the RCP2.6 and RCP6.0 GHG emissions scenarios<sup>626</sup>.

Within the proposed project's target region, the projected evolution of precipitation trends varies between hubs. Expected changes in rainfall at the 2050 horizon (2035–2065) under both the RCP4.5 and RCP8.5 GHG emissions scenarios are summarised in Table 33 and Table 34. The colour classification used in these tables corresponds with the different climate hazard ratings provided in Table 25. Projected changes in mean annual precipitation across the four target hubs are summarised in

<sup>624</sup> AfDB. 2018. National climate change profile. Available at: <https://www.afdb.org/en/documents/mauritania-national-climate-change-profile>.

<sup>625</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agricade/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agricade/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).

<sup>626</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agricade/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agricade/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).

Table 35.

Under the RCP4.5 GHG emissions scenario, no change in precipitation is projected in Aoujeft by 2050. In Rachid, annual precipitation is expected to decrease by ~6.1 mm/decade during the first half of the 21<sup>st</sup> century, which translates to a decrease in rainfall of ~18 mm by 2050. In Tamcheket, rainfall is projected to decrease by ~17 mm/decade during the first half of the 21<sup>st</sup> century, so rainfall will decrease by ~62 mm by 2050 relative to the reference period (1981–2010). In Nema, the decreasing rainfall trend is estimated at ~8.1 mm/decade for the period between 1981 and 2065, so, annual rainfall in Nema is projected to decrease by ~44 mm relative to the reference period.

Under the RCP8.5 GHG emissions scenario, mean annual precipitation in Aoujeft will be similar to that observed during the reference period (~80 mm/yr). The annual precipitation trend for this hub is slightly positive but not statistically significant ( $p>0.1$ ). At the 2050 horizon, mean annual precipitation in Rachid is expected to decrease by ~14mm relative to the reference period, a total decrease of ~15%. In Tamcheket, an emphatic decrease of ~78 mm mean annual precipitation is predicted at the 2050 horizon, a ~36% decrease in rainfall relative to the reference period (1981–2010). The annual precipitation trend in this hub was slightly negative during the reference period, but projections indicate that it will become very sharp during the first half of the 21<sup>st</sup> century under RCP8.5, implying an intensification of the decrease in precipitation. At the 2050 horizon, mean annual precipitation in Nema will see a decrease of ~60 mm (~27%) relative to the period of reference. The negative annual precipitation trend will become less sharp during the first half of the 21<sup>st</sup> century, indicating that precipitation will continue to decrease, but at a slower rate.

**Table 33.** Projected changes in mean annual precipitation across the proposed project's four target hubs.

Weather station (hub)	Mean annual precipitation (mm)		
	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
Atar (Aoujeft)	76.3	81	80.9
Tidjikja (Rachid)	95.0	77.7	81.2
Aïoun (Tamcheket)	216	154	138
Néma (Nema)	216	172	156

**Table 34.** Projected changes in mean precipitation trends across the proposed project's four target hubs.

Weather station (hub)	Precipitation trend (mm/decade)		
	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
Atar (Aoujeft)	+1.2	+2.1	+0.94
Tidjikja (Rachid)	-8.5	-6.1	-4.0
Aïoun (Tamcheket)	-6.8	-17	-23
Néma (Nema)	-18	-8.1	-12

Note: A positive sign represents an increasing precipitation trend, while a negative sign represents a decreasing precipitation trend. Numbers in italics represent trends that are not statistically significant ( $p>0.1$ ).

**Table 35.** Projected changes in mean annual precipitation across the four target hubs.

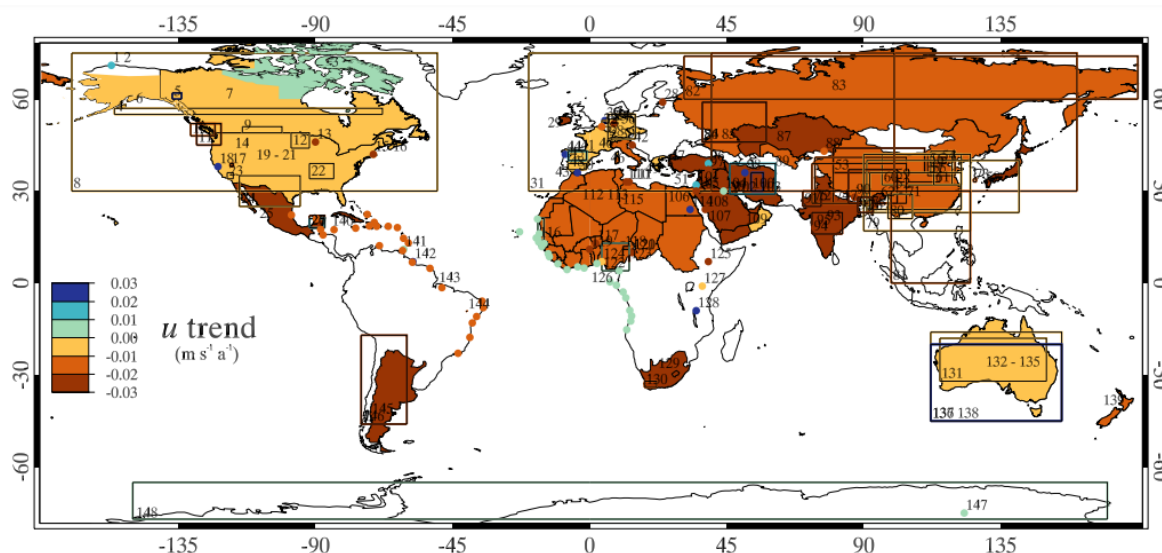
Weather station (hub)	Mean annual precipitation (mm)			Precipitation trend (mm/decade)		
	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
<b>Atar</b> (Aoujeft)	76.3	81	80.9	+1.2	+2.1	+0.94
<b>Tidjikja</b> (Rachid)	95.0	77.7	81.2	-8.5	-6.1	-4.0
<b>Aïoun</b> (Tamcheket)	216	154	138	-6.8	-17	-23
<b>Néma</b> (Nema)	216	172	156	-18	-8.1	-12

Note: A positive sign represents an increasing precipitation trend, while a negative sign represents a decreasing precipitation trend. Numbers in *italics* represent trends that are not statistically significant ( $p>0.1$ ).

## 2.4 Wind

### 2.4.1 Observed

The north of Mauritania is characterised by the prevalence of strong winds, including i) the north-eastern trade winds; and ii) the *harmattan* — a dry wind strongest from late November to mid-March. These strong winds carry large amounts of dust and sand across the territory. Wind erosion is a major source of soil degradation and is responsible for sand encroachment, dune movement and the development of unstable dunes, which pose a serious threat to agricultural lands, settlements, irrigation networks and transport systems. A global review of trends in terrestrial near-surface wind speeds reports that declines in wind speed have been geographically widespread since the 1950s. Indeed, a reduction in wind speeds has been observed across the tropics and at mid-latitudes, including Mauritania, where wind speeds have declined by  $\sim 0.03$  m/s each year (Figure 40)<sup>627</sup>.



**Figure 40.** Global distribution of observed terrestrial near-surface wind speed trends (1952–2010)<sup>628</sup>.

In addition to observed changes in wind speed, the direction of prevailing winds in Mauritania has shifted several times over the past few decades. Tri-hourly records obtained from the

<sup>627</sup> McVicar T, Roderick M, Donohue R, Li L, Niel T, Thomas A, Grieser J, Jhajharia D, Himri Y, Mahowald N, Mescherskaya A, Kruger A, Rehman S, Dinpashoh Y. 2012. Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation. *Journal of Hydrology*, 416–417.

<sup>628</sup> McVicar T, Roderick M, Donohue R, Li L, Niel T, Thomas A, Grieser J, Jhajharia D, Himri Y, Mahowald N, Mescherskaya A, Kruger A, Rehman S, Dinpashoh Y. 2012. Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation. *Journal of Hydrology*, 416–417.

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national weather station in Nouakchott show the emergence of four distinct periods, which are summarised in Table 36 below<sup>629</sup>.

**Table 36.** Variability of the prevailing wind origin, obtained by vectorial addition of tri-hourly records at the Nouakchott national weather station<sup>630</sup>.

Period	Origin of prevailing wind
1961–1985	West
1986–1995	East
1996–2005	North-west
2006–2016	North

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<sup>629</sup> Littaye A, Sidi Boba M, Ould Sidi Cheikh MA. 2018. Temporal variabilities of the climate along the Mauritanian coast over the last decades. *Journal of Earth Science and Climate Change*, 9:1.

<sup>630</sup> Littaye A, Sidi Boba M, Ould Sidi Cheikh MA. 2018. Temporal variabilities of the climate along the Mauritanian coast over the last decades. *Journal of Earth Science and Climate Change*, 9:1.

Over time, changes in wind regime have also been recorded within the proposed project's four target hubs.

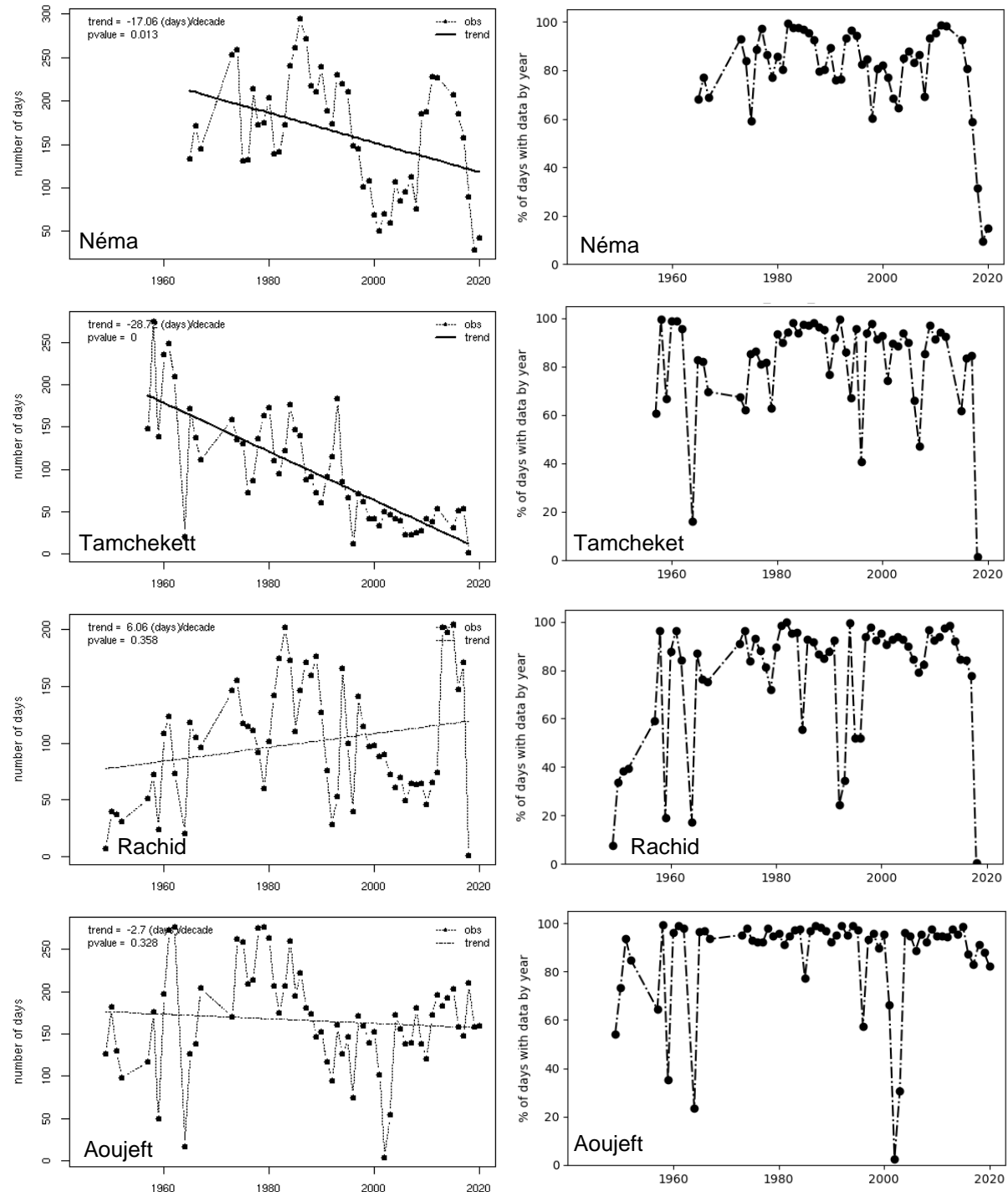


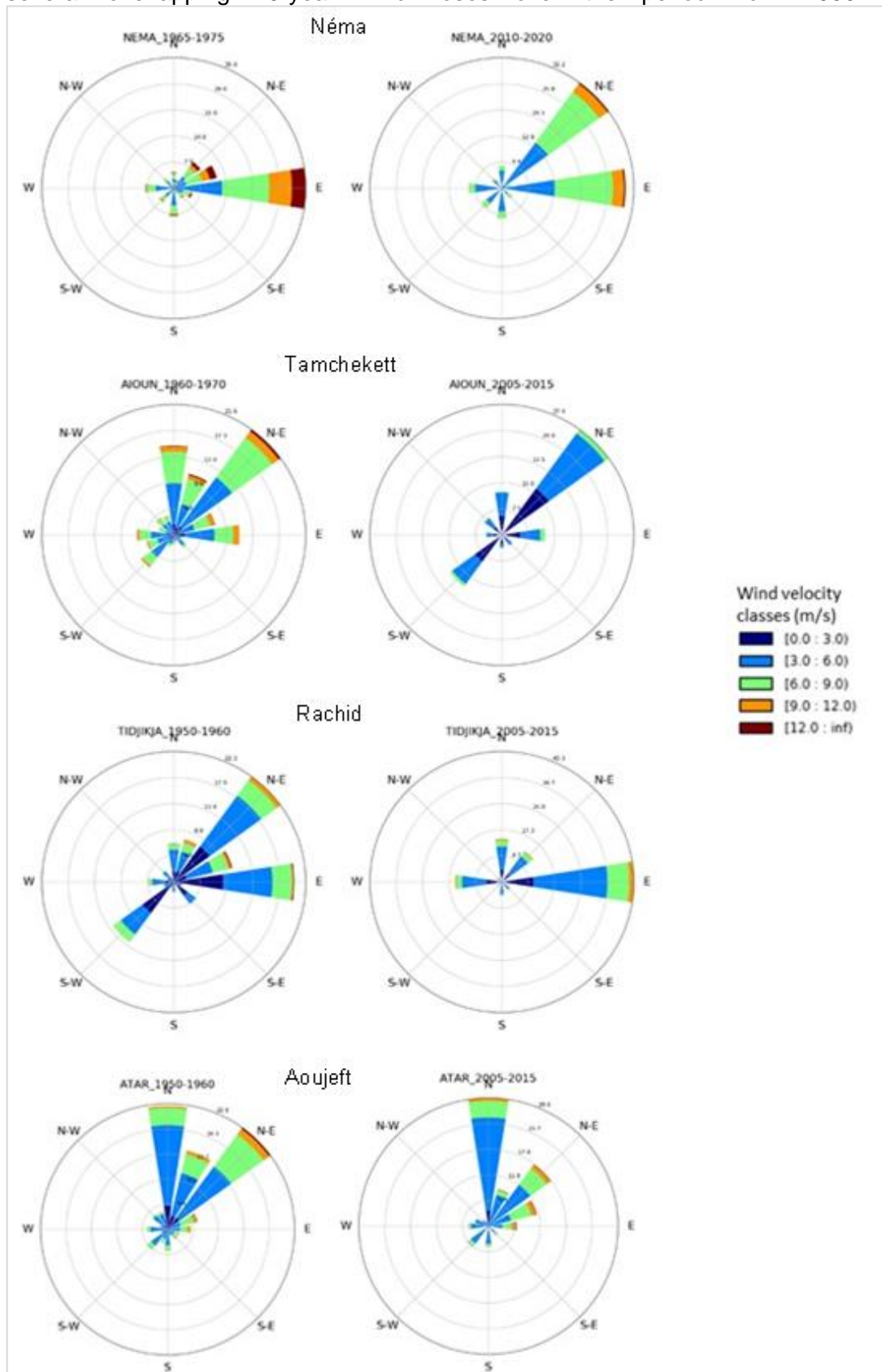
Figure 41 shows the observed change in the number of days per year with strong wind (velocity >6 m/s), as well as the percentage of days with available data for the four stations. Significant decreases in the frequency of strong winds have been observed at the weather stations in Nema and Tamcheket. In contrast, no remarkable change has been observed at the weather stations in Rachid and Aoujeft. The number of days with strong wind has significantly decreased by ~17 days/decade at Nema weather station and ~29 days/decade at Aïoun station (Tamcheket) ( $p < 0.1$ ). At the weather station in Aoujeft, the number of days with strong



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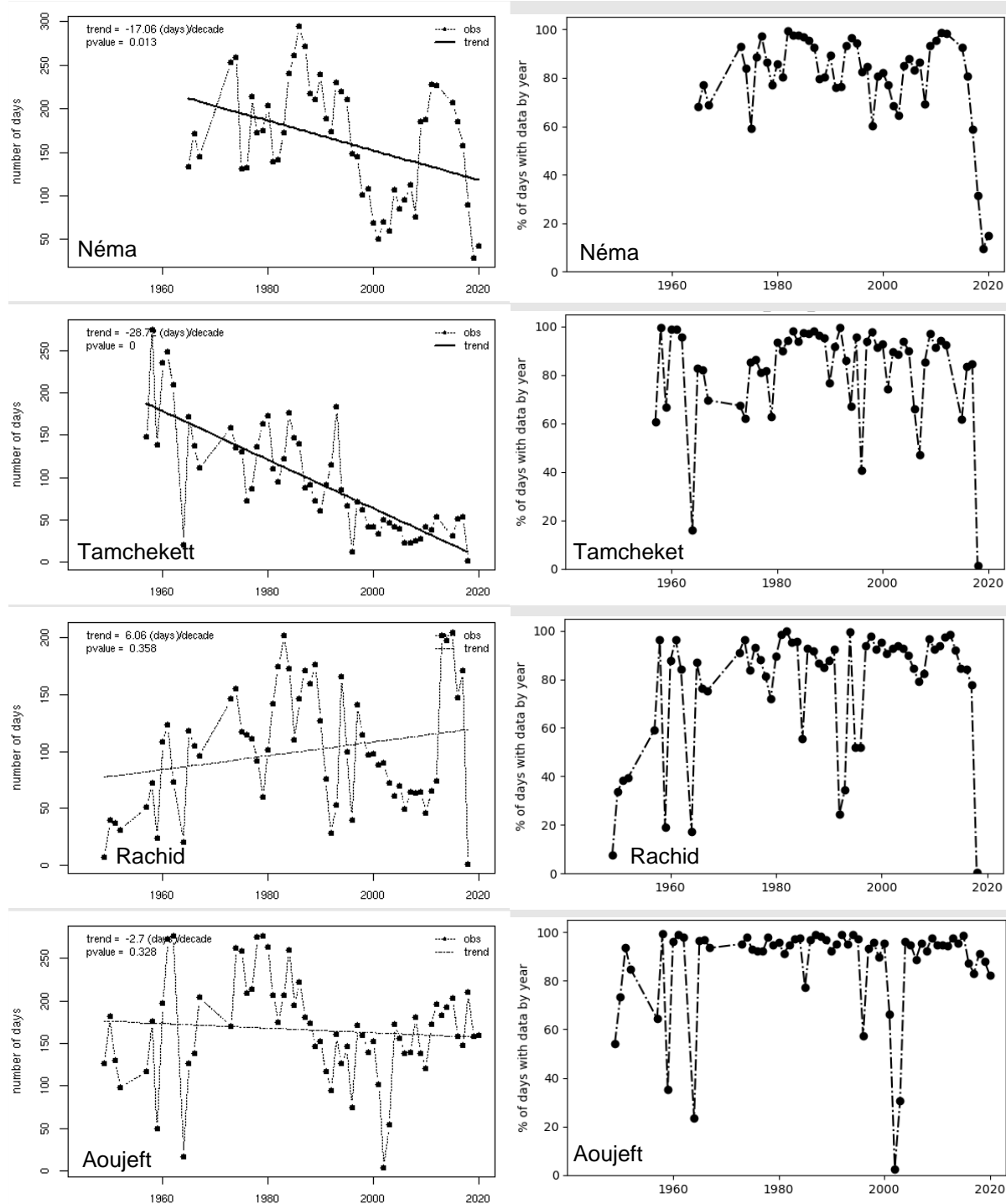
wind has decreased by ~3 days/decade, while in contrast, the number of days with strong wind has increased by ~6 days/decade at the Tidjikja weather station in Rachid. The trends observed in Aoujeft and Rachid are, however, not statistically significant ( $p > 0.1$ ). Given the large percentage of missing wind speed data, these trends should be interpreted with caution.

Observed changes in wind speed, direction and frequency have also been analysed by plotting several overlapping 10-year wind roses over the period from 1950 to 2020.

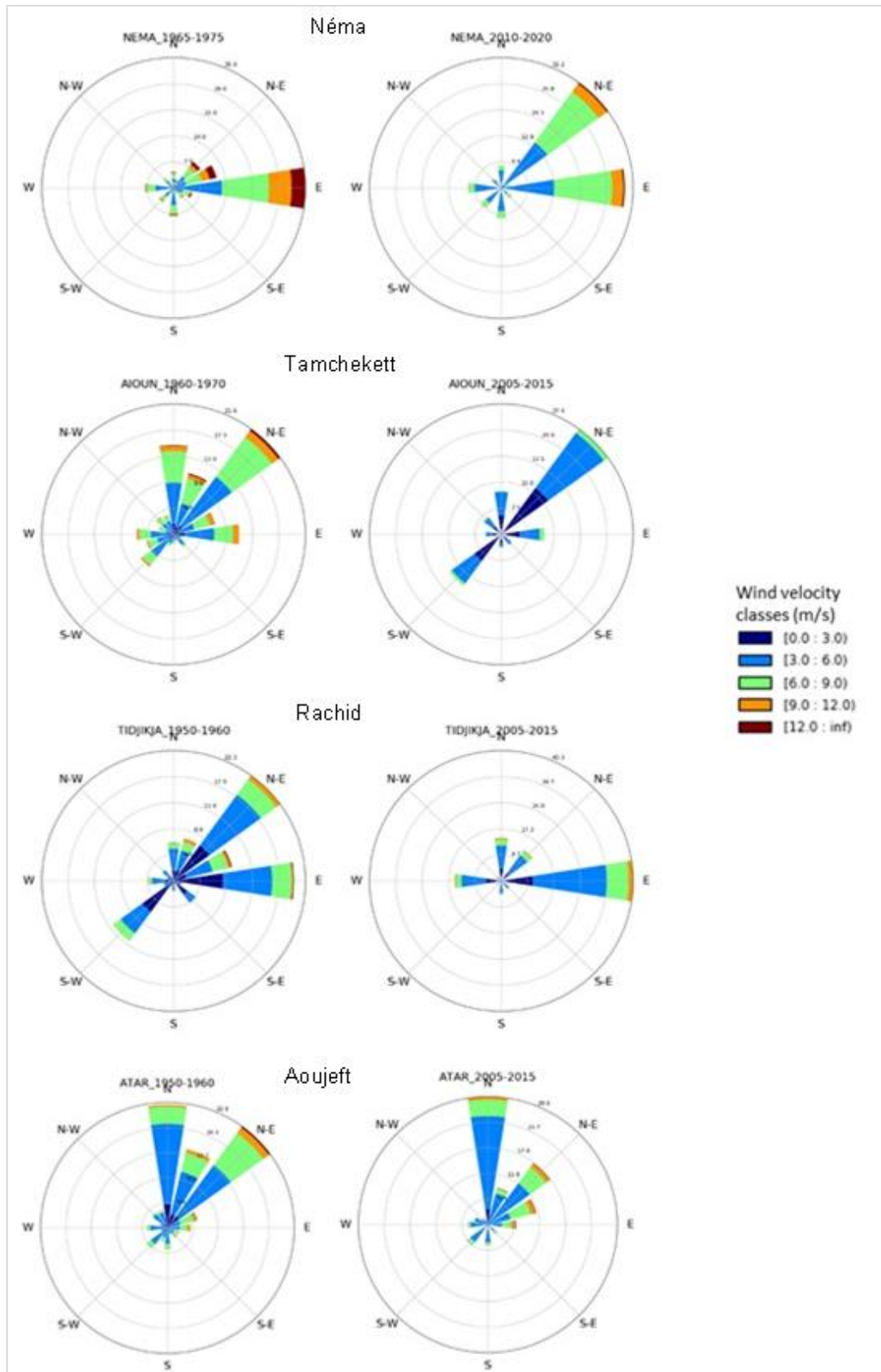


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Figure 42 contrasts the earliest available 10-year wind data with the most recently recorded wind data. Over time, the prevailing wind has changed from east only to north-east and east in Nema; from north, north-east and east to north-east only in Tamcheket; and from north-east and east to east only in Rachid. In Aoujeft, no significant change in wind direction has been observed. Although some shifts in wind direction have been observed, prevailing winds still originate from the Sahara Desert and blow southwards, carrying sand particles towards the Sahel. Additionally, strong winds are less frequent at the Nema and Aïoun (Tamcheket hub) weather stations relative to the 1960s, which suggests a potential reduction in the rate of silting. In contrast, there has been no significant change in the frequency of strong winds at the Tidjikja (Rachid hub) and Atar (Aoujeft hub) weather stations.



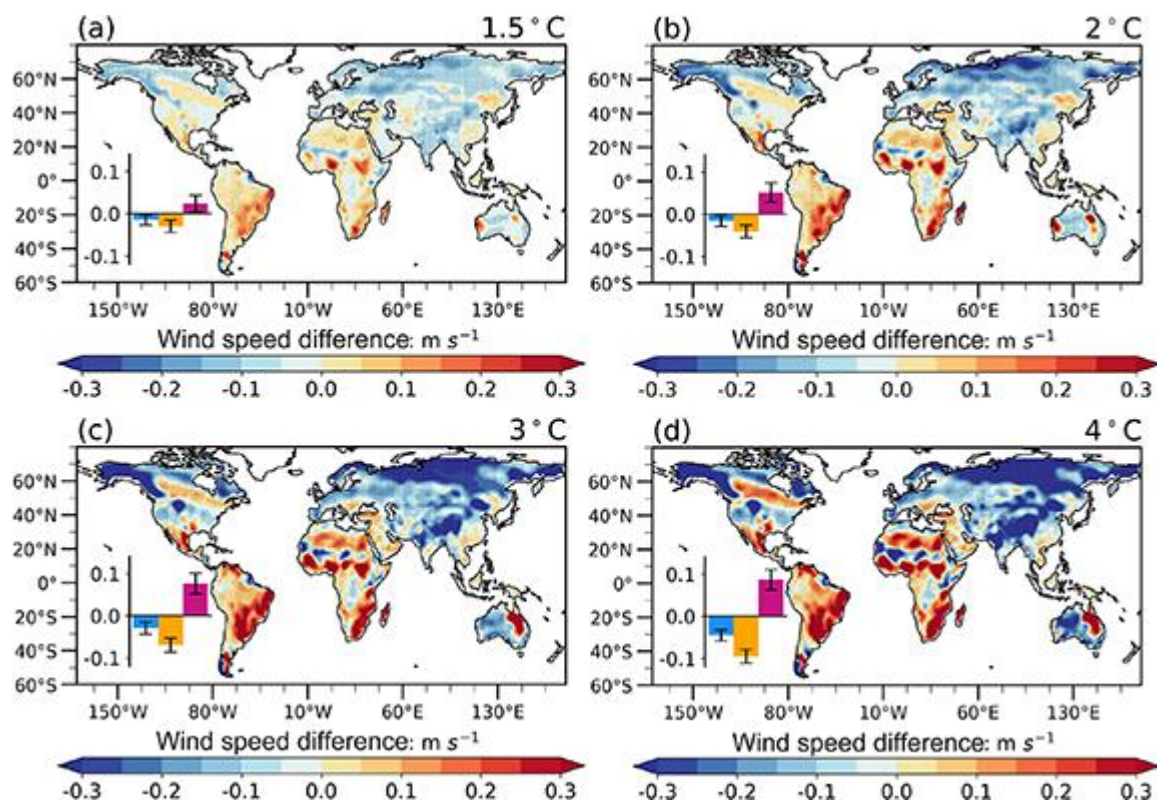
**Figure 41.** Annual number of days with strong wind (velocity >6 m/s) (left) and annual percentage of days with data (right) at the four weather stations within the proposed project's target regions.



**Figure 42.** Comparison of 10-year wind roses plotted using the earliest available wind data (left) and the most recently available wind data (right) for each of the proposed project's target hubs.

## 2.4.2 Projected

The availability of data regarding projected changes in wind regime across Mauritania is limited. However, a recent global review indicates that under future global warming scenarios (1.5–4°C above pre-industrial levels), near-surface wind speeds are projected to decrease over the parts of the Northern Hemisphere wherein Mauritania is located<sup>631</sup>; however, as a result of limited data availability, this trend is not statistically significant ( $p < 0.1$ ) (Figure 43)<sup>632</sup>.



**Figure 43.** Projected changes in terrestrial near-surface wind speed when global mean temperatures increase by 1.5–4°C above pre-industrial levels<sup>633</sup>.

At the hub level, models projecting changes in wind speed and direction under future climate change scenarios are currently unavailable; therefore, the assumption that wind conditions will remain constant under future climate scenarios has been applied to all hubs.

<sup>631</sup> Zha J, Shen C, Li Z, Wu J, Zhao D, Wenxuan F, Sun M, Azorin-Molina C & Deng K. 2021. Projected changes in global terrestrial near-surface wind speed in 1.5–4.0°C global warming levels. *Environmental Research Letters*. DOI: 10.1088/1748-9326/ac2fdd.

<sup>632</sup> Zha J, Shen C, Li Z, Wu J, Zhao D, Wenxuan F, Sun M, Azorin-Molina C & Deng K. 2021. Projected changes in global terrestrial near-surface wind speed in 1.5–4.0°C global warming levels. *Environmental Research Letters*. DOI: 10.1088/1748-9326/ac2fdd.

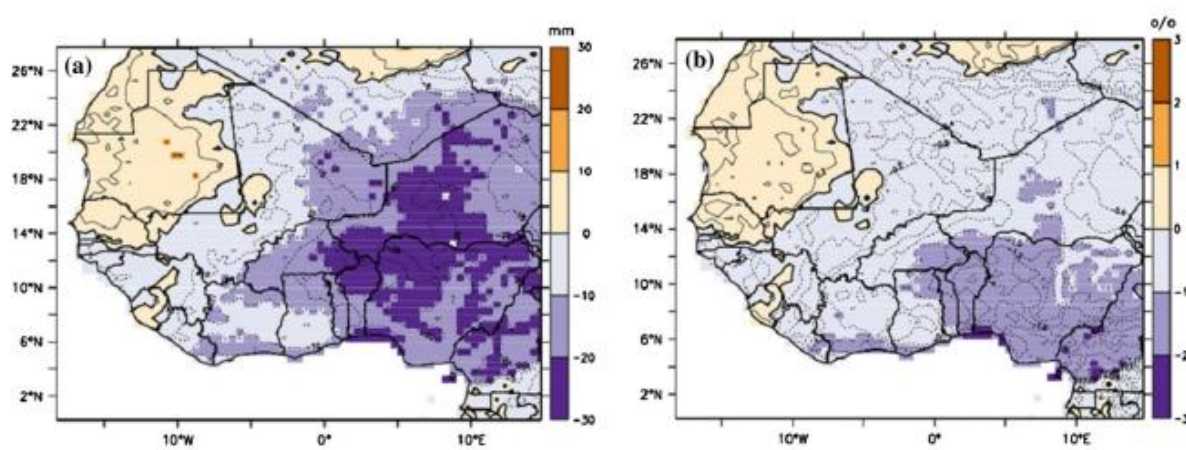
<sup>633</sup> Zha J, Shen C, Li Z, Wu J, Zhao D, Wenxuan F, Sun M, Azorin-Molina C & Deng K. 2021. Projected changes in global terrestrial near-surface wind speed in 1.5–4.0°C global warming levels. *Environmental Research Letters*. DOI: 10.1088/1748-9326/ac2fdd.



## 2.5 Evapotranspiration

### 2.5.1 Observed

Over the last four decades, changes in temperature, precipitation and wind regime across West Africa have altered both terrestrial and atmospheric conditions in the region, which has in turn influenced the rate of evapotranspiration across Mauritania. Figure 44 illustrates spatial changes in annual potential ETP<sup>634</sup> across West Africa from 1961 to 1990, relative to baseline data from 1931 to 1960. In most parts of Mauritania, observed changes in ETP have been positive (increase of ~10 mm or 1%)<sup>635</sup>, suggesting an increase in ETP over time at the national scale.



**Figure 44.** Change in annual potential ETP between the 1931–1960 and 1961–1990 reference periods: a) observed change (mm/yr) and b) percentage change (%)<sup>636</sup>.

Changes in evapotranspiration in Mauritania have also been analysed at the hub level. Table 37 presents a summary of: i) the potential ETP; ii) the difference between precipitation and evapotranspiration (P-ETP); and iii) the actual evapotranspiration (ETa)<sup>637</sup> observed in each of the proposed project's target hubs over the 1981–2010 period. Observed ETP values are very high in all four hubs (1,700–2,000 mm/year), with the highest values observed in Nema and Tamcheket. Additionally, all four hubs have negative P-ETP values, which indicates water loss via evapotranspiration exceeding water gained via precipitation. Large negative P-ETP values are associated with large water balance deficits. Lastly, actual evapotranspiration (ETa), which depends on water availability, is very low in each of the proposed project's target hubs, further reflecting low levels of precipitation across the region<sup>638</sup>.

<sup>634</sup> Potential evapotranspiration (ETP) is the water vapor flux under ideal conditions of complete ground cover by plants, uniform plant height and leaf coverage and an adequate water supply.

<sup>635</sup> Abiye OE, Matthew OJ, Sunmonu LA & Babatunde OA. 2019. Potential evapotranspiration trends in West Africa from 1906 to 2015. SN Applied Sciences, 1:1434.

<sup>636</sup> Abiye OE, Matthew OJ, Sunmonu LA & Babatunde OA. 2019. Potential evapotranspiration trends in West Africa from 1906 to 2015. SN Applied Sciences, 1:1434.

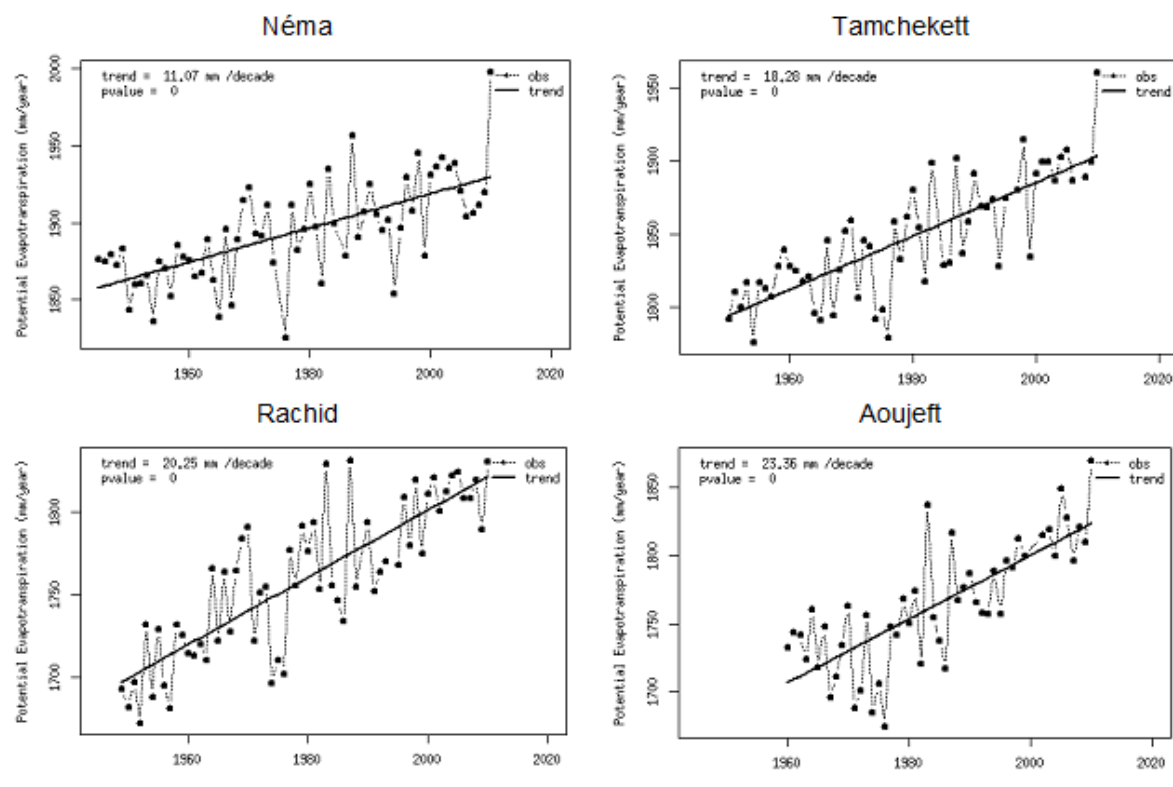
<sup>637</sup> Actual evapotranspiration is the quantity of water that is actually removed from a surface by the processes of evaporation and transpiration when water is limited.

<sup>638</sup> Appendix 3.

**Table 37.** Summary of potential ETP; P-ETP; and ETa for each of the proposed project's target hubs (1981–2010)<sup>639</sup>.

Hub	ETP (mm/yr)			P-ETP (mm/yr)			ETa (mm/yr)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Nema	1,914	1,854	1,998	-1,693	-1,892	-1,424	177	82	249
Tamcheket	1,877	1,817	1,960	-1,659	-1,775	-1,508	204	166	287
Rachid	1,792	1,734	1,831	-1,697	-1,805	-1,544	74	2	138
Aoujeft	1,790	1,717	1,870	-1,712	-1,830	-1,590	37	4	77

Potential ETP increased significantly ( $p < 0.1$ ) from 1951 to 2010 within all four of the proposed project's target hubs (Figure 45). The largest increases were observed in Aoujeft and Rachid, where increases of more than 20 mm/decade were recorded. In contrast, actual evapotranspiration (ETa) has shown no significant trend over the last four decades (Figure 46). This difference in ETP and ETa trends is well documented in water-limited regions<sup>640</sup>.



**Figure 45.** Observed changes in potential ETP within each of the proposed project's target hubs<sup>641</sup>.

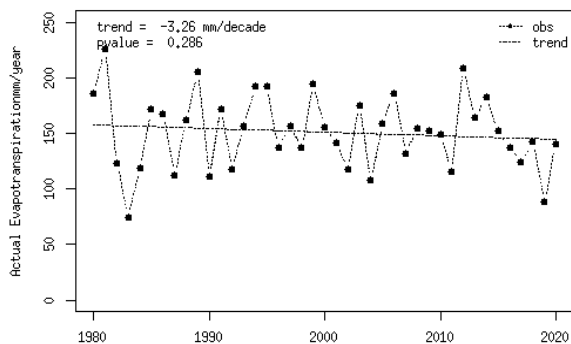
<sup>639</sup> Appendix 3.

<sup>640</sup> Appendix 3.

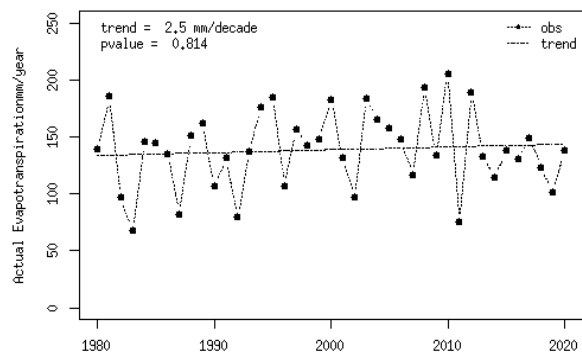
<sup>641</sup> Appendix 3.



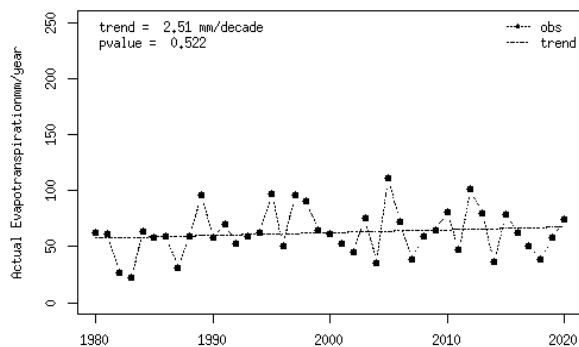
## Nema



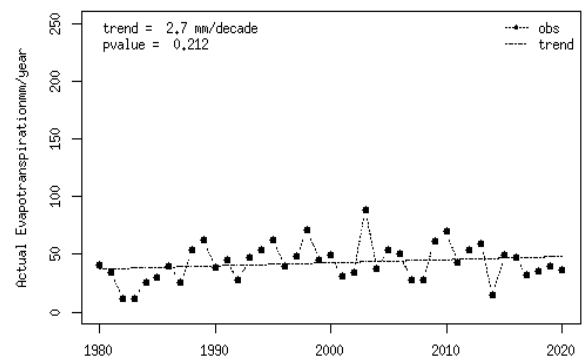
## Tamcheket



## Rachid



## Aoujeft



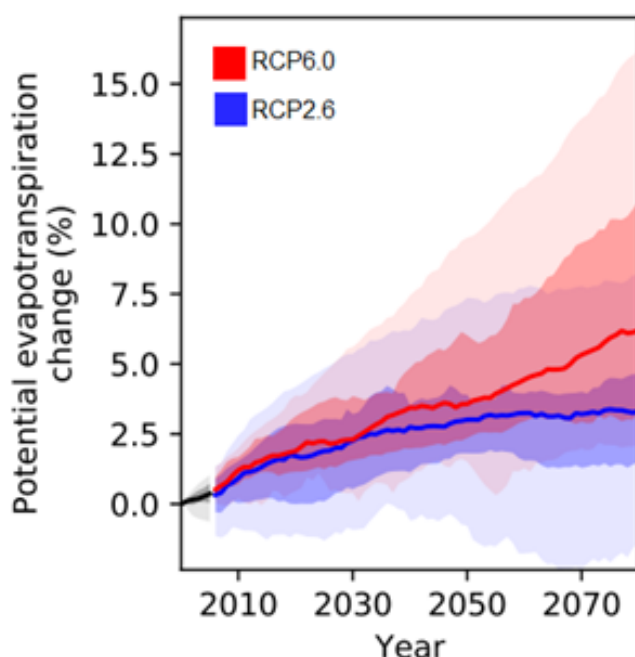
**Figure 46.** Observed changes in actual evapotranspiration (Eta) over time (1981–2020)<sup>642</sup>.

### 2.5.2 Projected

Changes in temperature, precipitation and wind regime in Mauritania are expected to influence the rate of evapotranspiration in Mauritania under future climate scenarios. Since warmer air can hold more water vapour, global warming is likely to induce an increase in potential evapotranspiration in most regions of the world. In line with this expectation, hydrological projections for Mauritania indicate a stronger rise of potential evapotranspiration under RCP6.0 than under RCP2.6. Under RCP6.0, potential evapotranspiration is projected to increase by ~2.3 % in 2030, ~3.6 % in 2050 and ~6.2 % in 2080 relative to ETP levels for the year 2000 (Figure 47)<sup>643</sup>.

<sup>642</sup> Appendix 3.

<sup>643</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agrica.de/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agrica.de/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).



**Figure 47.** Projected changes in potential evapotranspiration under a low (RCP2.6) and intermediate–high (RCP6.0) GHG emissions scenario<sup>644</sup>.

Potential evapotranspiration is also projected to increase at the hub level. Expected changes in potential evapotranspiration and water balance deficit throughout the proposed project's target region are summarised in Table 38 and Table 39 below. The colour classification used in these tables corresponds with the different climate hazard ratings provided in Table 25. Projected changes in annual potential ETP across the proposed project's four target hubs are summarised in Table 40. In addition to the annual potential ETP, Table 41 outlines the projected changes in annual water balance deficit (P-ETP) across the proposed project's four target hubs.

Under the RCP4.5 GHG emissions scenario, annual ETP is expected to increase by ~130 mm in Aoujeft, ~110 mm in Rachid, ~100 mm in Tamcheket and ~140 mm in Nema by 2050 relative to the reference period (1951–2019). Moreover, the increasing ETP trend is expected to be higher in all four hubs at the 2050 horizon relative to the reference period. By 2050, ETP is expected to be increasing by ~21 mm/decade in Aoujeft, ~18 mm/decade in Rachid and Tamcheket and ~23 mm/decade in Nema, with a stabilisation towards the end of the period<sup>645</sup>.

Under the RCP8.5 emissions scenario, mean annual ETP in Aoujeft is projected to increase by ~190 mm at the 2050 horizon relative to the 1951–2019 reference period. In Rachid, annual ETP is expected to increase by ~140 mm over the same period. Annual ETP in Tamcheket is projected to increase by ~130 mm in the next three decades, exceeding 2,000 mm/yr by 2050. Similarly, annual ETP in Nema is projected to exceed 2,000 mm/yr at the 2050 horizon, representing an increase of ~200 mm relative to the reference period (1951–2019). Moreover, the increasing ETP trend in all four hubs is projected to be higher in the first half of the 21<sup>st</sup> century relative to the reference period (1951–2019). As a result of increased ETP and limited rainfall, the water balance deficit (P-ETP) is projected to significantly increase ( $p < 0.1$ ) in all

<sup>644</sup> GIZ. 2021. Climate risk profile: Mauritania. Available at: [https://agrica.de/wp-content/uploads/2021/02/CRP\\_Mauritania\\_EN\\_20210208.pdf](https://agrica.de/wp-content/uploads/2021/02/CRP_Mauritania_EN_20210208.pdf).

<sup>645</sup> Appendix 3.

four target hubs under RCP8.5, reaching -1,900 mm in Aoujeft, -1,830 mm in Rachid, -1,880 mm in Tamcheket and -1,950 mm in Nema by 2050<sup>646</sup>.

**Table 38.** Projected changes in annual potential ETP across the proposed project's four target hubs<sup>647</sup>

Weather station (hub)	Variable	Potential evapotranspiration (mm/yr)		
		Historical (1951–2019)	RCP4.5 (2050)	RCP8.5 (2050)
Atar (Aoujeft)	Mean	1,790	1,925	1,980
	Trend	+23	+21	+31
Tidjikja (Rachid)	Mean	1,790	1,900	1,930
	Trend	+20	+18	+24
Aïoun (Tamcheket)	Mean	1,877	1,983	2,014
	Trend	+18	+18	+24
Néma (Nema)	Mean	1,910	2,050	2,110
	Trend	+11	+23	+32

Note: A positive sign represents an increasing trend, while a negative sign represents a decreasing temperature trend.

**Table 39.** Projected changes in annual water balance deficit (P-ETP) across the proposed project's four target hubs<sup>648</sup>.

Projected changes in mean annual water balance deficit (mm/yr)			
Weather station (hub)	Historical (1951–2019)	RCP4.5 (2050)	RCP8.5 (2050)
Atar (Aoujeft)	-1,710	-1,840	-1,900
Tidjikja (Rachid)	-1,700	-1,820	-1,830
Aïoun (Tamcheket)	-1,660	-1,830	-1,880
Néma (Nema)	-1,700	-1,880	-1,950

Note: A negative sign indicates that potential water lost via evapotranspiration exceeds the water gained via precipitation.

**Table 40.** Projected changes in annual potential ETP across the proposed project's four target hubs.

Weather station (hub)	Mean annual ETP (mm)			ETP trend (mm/yr)		
	Historical (1951–2019)	RCP4.5 (2050)	RCP8.5 (2050)	Historical (1981–2010)	RCP4.5 (2050)	RCP8.5 (2050)
Atar (Aoujeft)	1,790	1,925	1,980	+23	+21	+31
Tidjikja (Rachid)	1,790	1,900	1,930	+20	+18	+24
Aïoun (Tamcheket)	1,877	1,983	2,014	+18	+18	+24
Néma (Nema)	1,910	2,050	2,110	+11	+23	+32

Note: A positive sign represents an increasing trend, while a negative sign represents a decreasing temperature trend.

<sup>646</sup> Appendix 3.

<sup>647</sup> Appendix 3.

<sup>648</sup> Appendix 3.

**Table 41.** Projected changes in annual water balance deficit (P-ETP) across the proposed project's four target hubs.

Weather station (hub)	Projected changes in mean annual water balance deficit (mm/yr)		
	Historical (1951–2019)	RCP4.5 (2050)	RCP8.5 (2050)
<b>Atar</b> (Aoujeft)	-1,710	-1,840	-1,900
<b>Tidjikja</b> (Rachid)	-1,700	-1,820	-1,830
<b>Aïoun</b> (Tamcheket)	-1,660	-1,830	-1,880
<b>Néma</b> (Nema)	-1,700	-1,880	-1,950

Note: A negative coefficient indicates that potential water lost via evapotranspiration exceeds the water gained via precipitation.

## 2.6 Extreme events

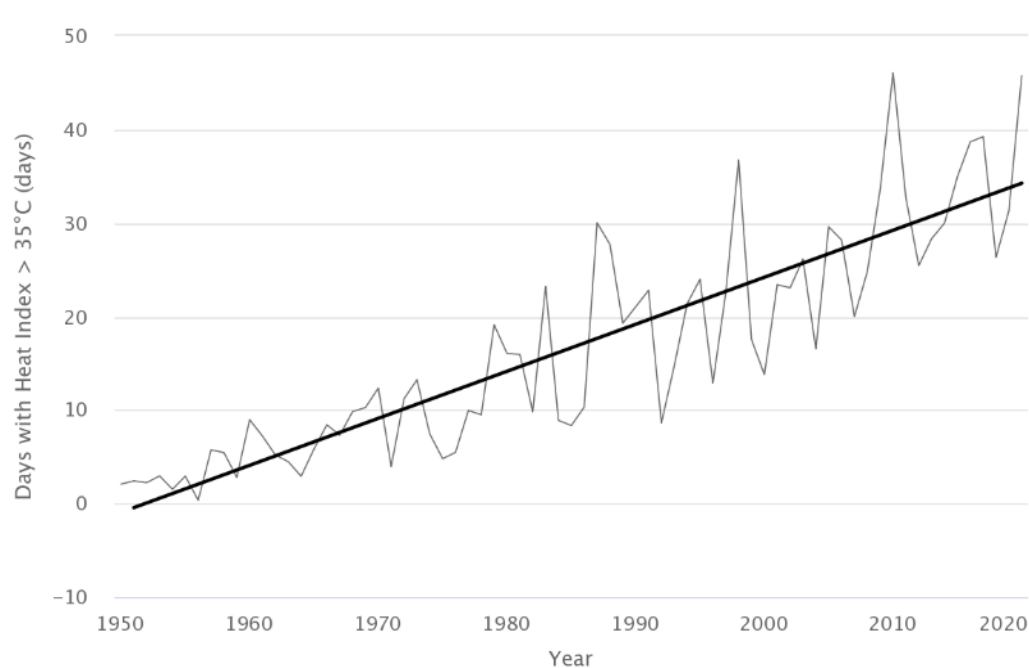
The observed changes in temperature, rainfall, wind and evapotranspiration discussed above have resulted in an observed increase in extreme climate conditions. Higher maximum temperatures, increased rainfall variability, reduced overall precipitation and greater evapotranspiration rates have increased the risk of climate hazards — particularly heatwaves and droughts — for vulnerable communities in the target hubs and Mauritania as a whole. The observed trends in these climate variables are predicted to continue as a result of climate change, which will further increase the risk of climate hazards to vulnerable communities and ecosystems. Observed and predicted changes in heatwaves, droughts and flood events as a result of climate change in Mauritania and the target hubs are described below.

### 2.6.1 Heatwaves

As described in Section 1.3.4, heatwaves negatively impact community health and reduce agricultural productivity across Mauritania. The increased frequency and intensity of future heatwaves under climate change will therefore result in greater negative impacts on vulnerable communities (described in Section 1.2.4).

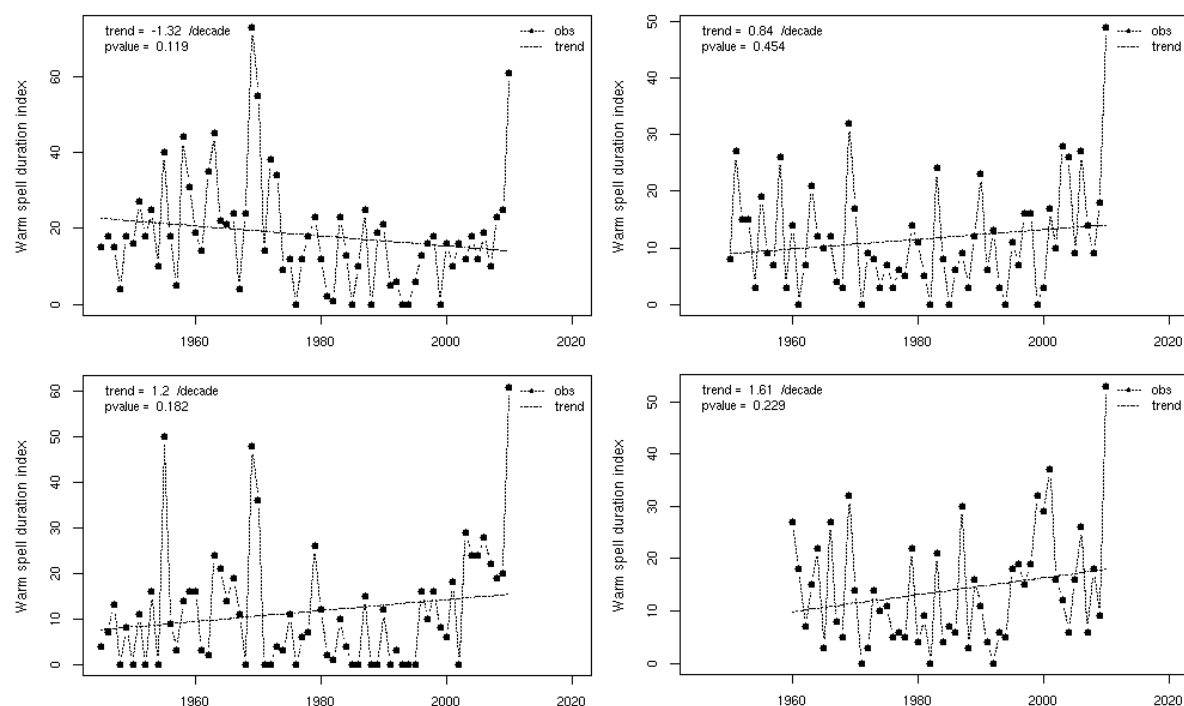
When considering historical trends, heatwaves have increased over the last half-century. The number of days with a heat index above 35°C at the national level has steadily increased from two days per year in 1950 to 46 days in 2020 (Figure 48). This change in hot days is most prominent in the summer months from May to September, with July having approximately five more days with temperatures above 35°C from 2011 to 2020 relative to the average number of hot days across the entire period from 1950 to 2020<sup>649</sup>.

<sup>649</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.



**Figure 48.** Change in days with a heat index above 35°C from 1950 to 2020, indicating yearly values (grey line) and the average trend (solid black line)<sup>650</sup>.

The above observed trend of an increase in heatwaves is also evident across most of the four target hubs. From 1945 to 2010, the Warm Spell Duration Index<sup>651</sup> (WSDI) has increased by 0.8 days/decade in Tamcheket, 1.2 days/decade in Rachid and 1.6 days/decade in Aoujeft. Nema, however, displayed a decrease in the WSDI of 1.3 fewer days/decade Figure 49).



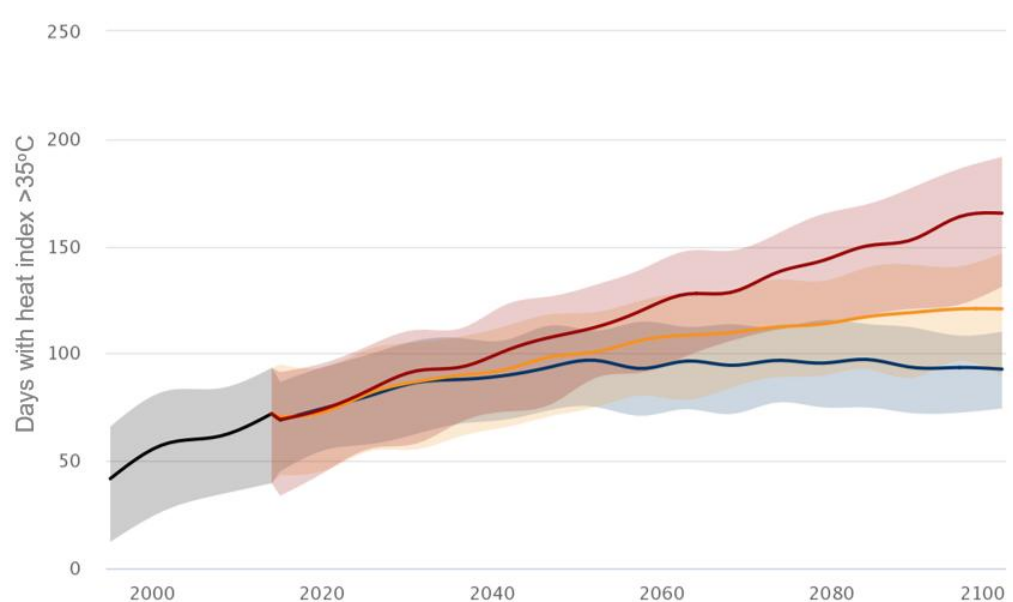
<sup>650</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at:

<https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

<sup>651</sup> The Warm Spell Duration Index (WSDI) represents the annual count of days contributing to 'warm spells', when the maximum temperature remains above its climatological 90th percentile. A spell must consist of at least six consecutive days to be qualify as a "warm spell"

**Figure 49.** Observed change in WSDI for Nema (top left, 1945–2010), Tamcheket (top right, 1950–2010), Rachid (bottom left, 1945–2010) and Aoujeft (bottom right, 1960–2010)<sup>652</sup>.

The observed trend of increasingly severe and prolonged heatwaves described above is expected to continue in the future under projected climate change at both the national- and hub levels. By 2040, the number of days with a heat index above 35°C is predicted to increase on average by 89 (SSP1-2.6), 91 (SSP2-4.5) or 99 days (SSP5-8.5) relative to historical values, depending on the Shared Socio-economic Pathway (SSP) scenario (Figure 50)<sup>653,654</sup>. By 2100, this anomaly is expected to increase on average by 93, 147 or 192 days for SSP1-2.6, SSP2-4.5 and SSP5-8.6, respectively. Accordingly, 25–53% of days throughout the year are predicted to experience temperatures above 35°C by 2100.



**Figure 50.** Projected change in the annual number of days with a heat index above 35°C for Mauritania from 2020 to 2099 using the historical reference period 1995–2014<sup>655</sup>. The median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.6 (red) are provided.

As observed historically, the increase in the number of days with a heat index above 35°C for Mauritania is not expected to be distributed evenly across any given year. Specifically, the greatest increase in hot days is predicted to be most pronounced during the summer months<sup>656</sup>. From 2020 to 2039, the months with the highest increase in days with a heat index above 35°C include May until October, with August and September displaying the highest increase of ~7 and 6 days, respectively (Figure 51, left). The period from 2080 to 2099 reflects a bimodal pattern in the number of days with a high heat index, with May and September showing the greatest change relative to the baseline (Figure 51, right). These peaks are most

<sup>652</sup> Appendix 3.

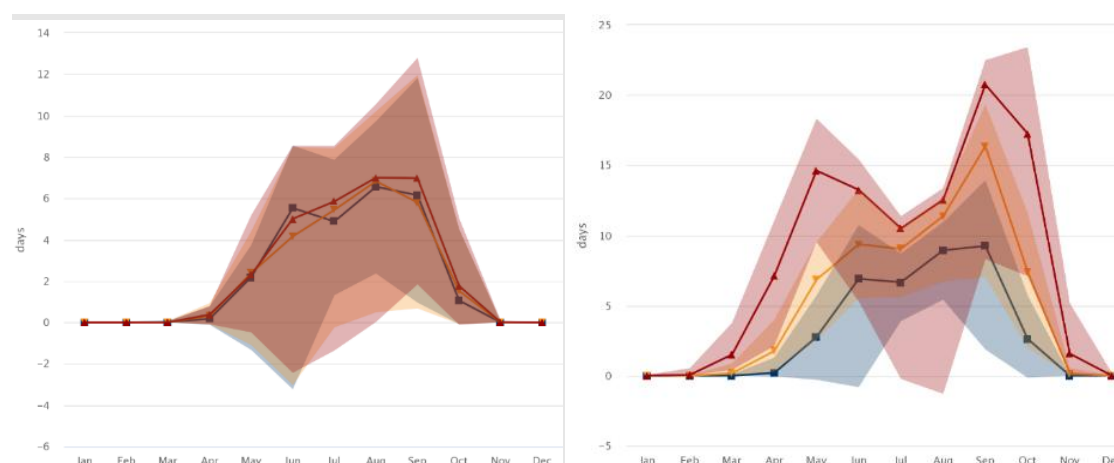
<sup>653</sup> The IPCC AR6 identifies five potential scenarios based on emission levels and Shared Socio-economic Pathways (SSPs) that are used to predict future climate change trends. SSP1-2.6 describes a 'green road' scenario whereby the world shifts towards a sustainable path, with CO<sub>2</sub> emissions reaching net zero by 2075. SSP2-4.5 describes a 'middle of the road' scenario whereby emissions remain around current levels before falling around the mid-century as socio-economic factors follow historic trends, with slow progress towards sustainability. SSP5-8.5 describes a worst-case scenario whereby CO<sub>2</sub> emissions double by 2050, with rapid economic growth dependent on fossil fuels and energy-intensive lifestyles.

<sup>654</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

<sup>655</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

<sup>656</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

pronounced for an SSP5-8.5 scenario, where it is predicted that May will display 15 more days with a heat index above 35°C and September will display 21 more days.



**Figure 51.** Projected change in the monthly number of days with a heat index above 35°C for Mauritania for the periods 2020–2039 (left) and 2080–2099 (right) against the historical reference period 1995–2014<sup>657</sup>. For each timeframe, the median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.5 (red) are provided.

When considering local projected changes, all target hubs are forecast to display a very strong increase in heatwaves under future scenarios<sup>658</sup>. Between 2000 and 2050, under the RCP4.5 and RCP8.5 scenarios, the increase in the number of days with heatwaves per decade is expected to be: i) 14–25 days in Nema; ii) 14–20 days in Tamcheket; iii) 12–17 days in Rachid; and iv) 12–19 days in Aoujeft. This means that by the middle of the century, the number of days with heatwaves is predicted to be: i) 73–110 days; ii) 59–76 days; iii) 38–54 days; and iv) 61–93 days higher than values in 2000 for Nema, Tamcheket, Rachid and Aoujeft, respectively. Projected changes in the numbers of days, with heatwaves per decade across all four target hubs for 2000–2050 are outlined in Table 42.

**Table 42.** Projected changes in the numbers of days, with heatwaves per decade across all four target hubs (2000–2050).

Weather station (hub)	Heatwave trend (days/decade) (2000–2050)		Total change (days) (2000–2050)	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
<b>Atar</b> (Aoujeft)	+12	+19	+61	+93
<b>Tidjikja</b> (Rachid)	+12	+17	+38	+54
<b>Aïoun</b> (Tamcheket)	+14	+20	+59	+76
<b>Néma</b> (Nema)	+14	+25	+73	+110

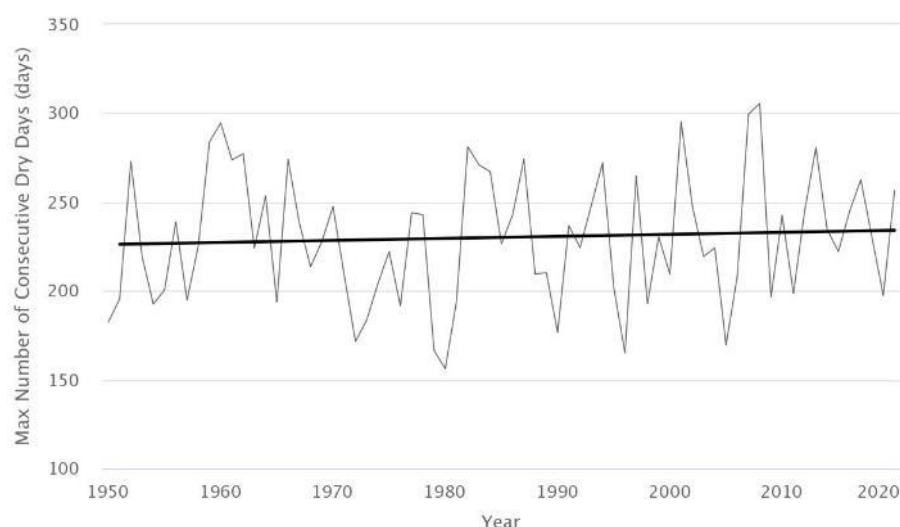
<sup>657</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

<sup>658</sup> Appendix 3.

## 2.6.2 Droughts

Droughts currently have a major impact on communities and ecosystems in Mauritania, including adversely affecting water security resulting in vegetation loss and reducing agricultural productivity (Section 1.3.4). The observed trends of increasingly severe drought conditions described below will likely continue as a result of climate change, with increasingly severe impacts on communities (described in Section 0).

For Mauritania, the number of CDDs has historically shown considerable natural variability from year to year, varying from a minimum of 156 days in 1980 to 306 days in 2008 (Figure 52)<sup>659</sup>. Within this variability, however, CDD has shown a slight increase of 0.1 days/decade from 1950 to 2020. This trend of increasing CDD is mirrored in monthly CDD values for the wet season months from July to October.



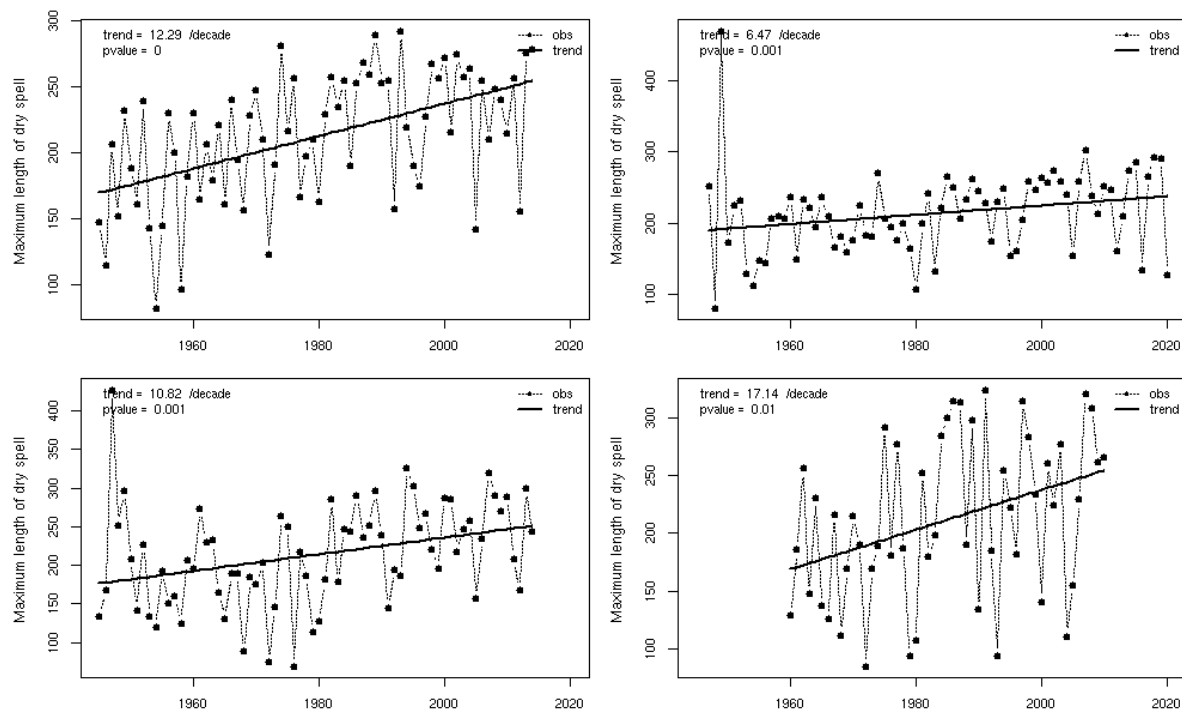
**Figure 52.** Change in the maximum number of CDDs from 1991 to 2020 for Mauritania, indicating yearly values (grey line) and the average trend (solid black line)<sup>660</sup>.

Similar to national trends, drought severity has increased over the last few decades across the target hubs. CDDs have increased by 12 days/decade in Nema, seven days/decade in Tamcheket, 11 days/decade in Rachid and 17 days/decade in Aoujeft (Figure 53). The lowest increase in CDDs is in Tamcheket, with approximately half the number of additional dry days per decade of the other hubs.

<sup>659</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

<sup>660</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

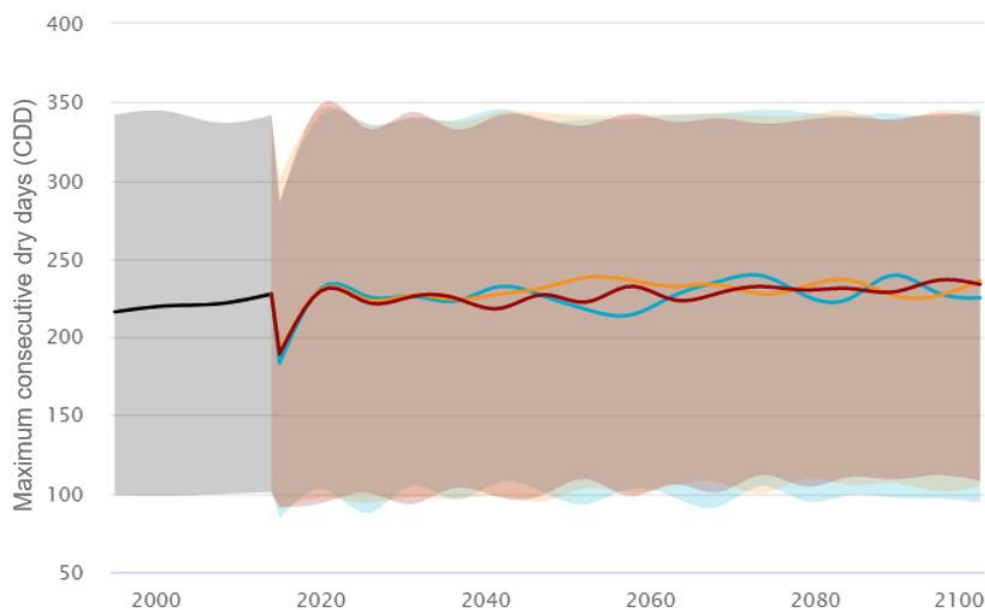




**Figure 53.** Observed change in CDDs for Nema (top left, 1945–2014), Tamcheket (top right, 1946–2020), Rachid (bottom left, 1945–2014) and Aoujeft (bottom right, 1960–2010)<sup>661</sup>.

Projected climate change will increase the extent and severity of droughts at the national and local levels. By 2040, the median CDD number for Mauritania is predicted to be ~219–230 days, compared with historical values in 1995 of 216 days (Figure 54). Annual CDD by 2100 is expected to be between 225 and 236 days, a change of 9–20 days relative to 1995 values. There is high variability between the 10 and 90 percentiles until 2100, ranging from ~100 to ~350 days.

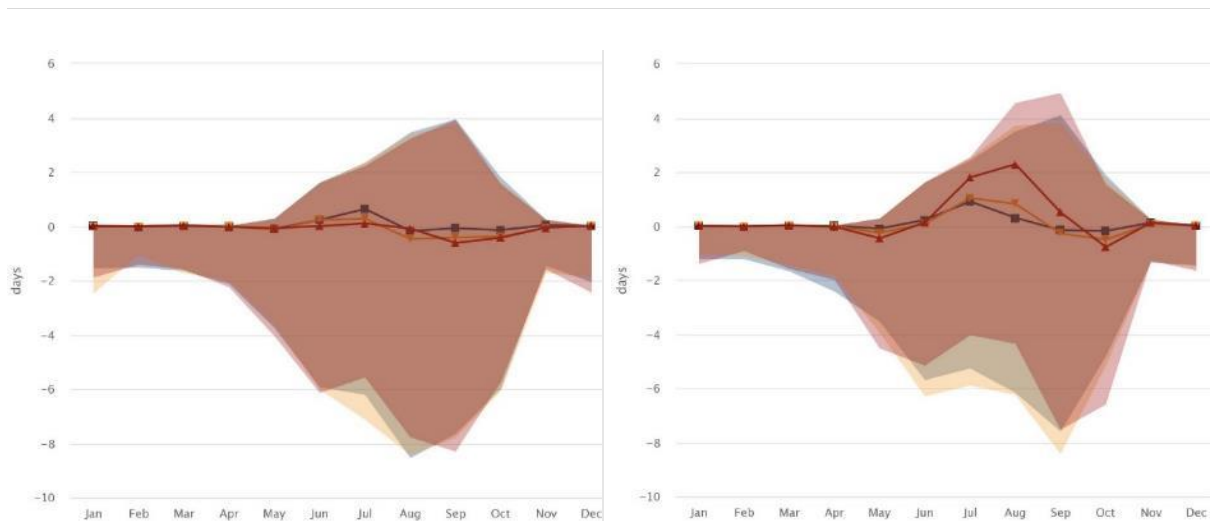
<sup>661</sup> Appendix 3.



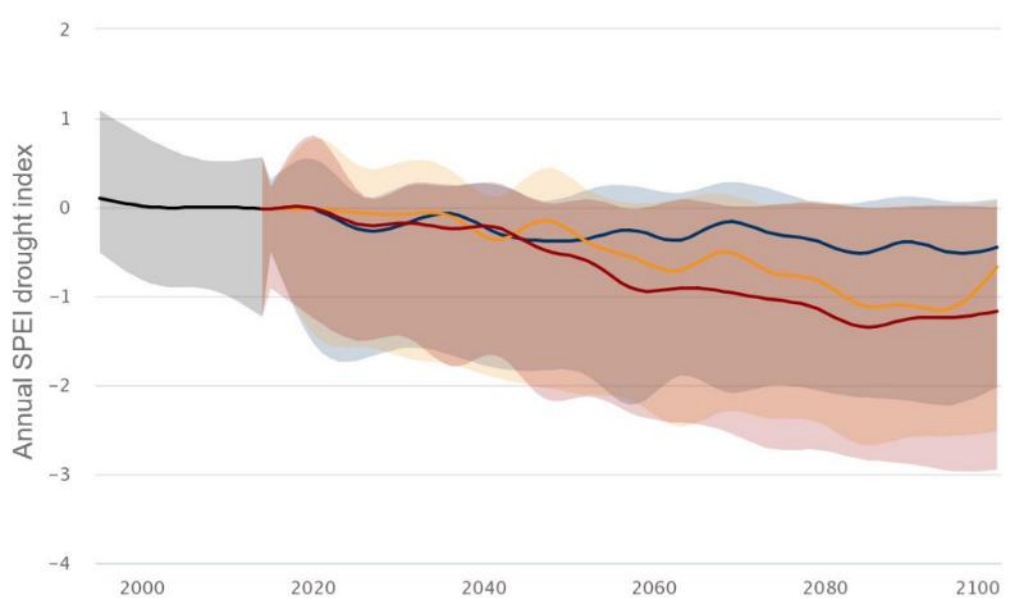
**Figure 54.** Projected change in Mauritania's maximum number of CDDs from 2020 to 2099 using the historical reference period 1995–2014<sup>662</sup>. The median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.6 (red) are provided.

At the monthly level, the projected number of CDD will reflect the greatest change in values during the summer months of June to October (Figure 55). From 2020 to 2039, median values in the summer months show a slight increase or decrease relative to historical values (1995–2014), ranging from a reduction of 0.1 days to an increase of 0.6 days. The monthly 10- and 90-percentile values show a high degree of variability, ranging from -8.5 to 3.5 CDD from 2020 to 2039. By the end of the century (2080–2099), median values display a greater shift to CDD values higher than historical values, ranging from a reduction of 0.8 CDD to an increase in 2.3 CDD between June and October. The 10 and 90 percentiles during this period range from -8.4 to 4.9 CDD.

<sup>662</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.



**Figure 55.** Projected change in the monthly maximum number of CDDs for Mauritania for the periods 2020–2039 (left) and 2080–2099 (right) against the historical reference period 1995–2014<sup>663</sup>. For each timeframe, the median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.6 (red) are provided.



**Figure 56.** Projected change in Mauritania's annual SPEI drought index from 2020 to 2099 using the historical reference period 1995–2014<sup>664</sup>. The median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.6 (red) are provided.

Another indicator of future drought conditions — the Standardised Precipitation-Evapotranspiration Index (SPEI)<sup>665</sup> — displays a clear future trend toward worsening drought conditions for Mauritania. All SSP scenarios predict that SPEI values will fall below 0 in the future, indicating an increase in dry years relative to the historical average (Figure 56). Depending on the SSP scenario, median SPEI is predicted to vary from -0.2 to -0.3 by 2040

<sup>663</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

<sup>664</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>.

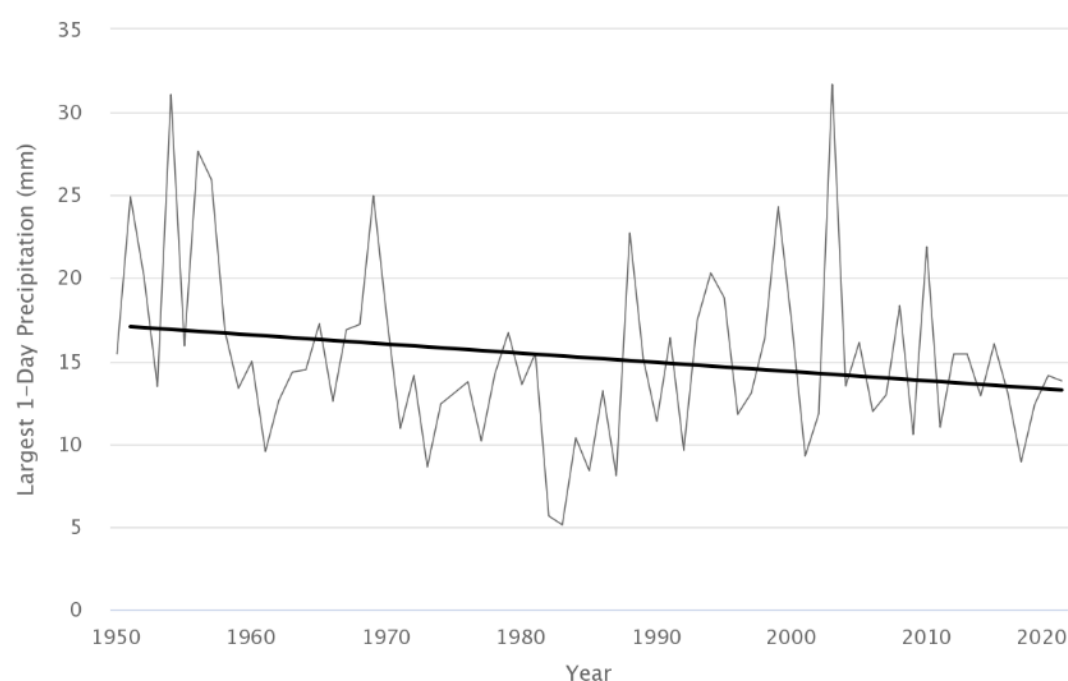
<sup>665</sup> The Standardised Precipitation-Evapotranspiration Index (SPEI) is an indicator of drought severity that accounts for precipitation and potential evapotranspiration. Values +2 or higher indicate extremely wet years, while values -2 or less indicate extremely dry years.

and from -0.5 to -1.8 by 2100. By 2100, ninety-percentile values are expected to fall below -2, indicating an increase in extremely dry years.

Similar to trends across the country, drought conditions within three of the four target hubs are predicted to increase as a result of climate change<sup>666</sup>. Compared with values in the historical period from 1981 to 2019, average CDD values in Nema are expected to increase by 6–13 days by 2050 at a rate of 2–3 days/decade under the RCP4.5 and RCP8.5 scenarios, respectively. For Tamcheket, CDD will increase by 12–16 days by 2050 at a similar rate as Nema, at 2–3 days/decade. Rachid shows the greatest degree of CDD change of the four hubs, reaching 58–66 days at a rate of 10–11 days/decade. In contrast, CDD for Aoujeft is expected to remain relatively constant by 2050 compared with historical values, indicating that drought conditions for this hub under RCP4.5 and RCP8.5 will stabilise until at least the middle of the century.

### 2.6.3 Heavy rains and floods

As described in Section 1.3.4, heavy rains have the potential to cause flash flooding events in certain parts of Mauritania that result in fatalities, the disruption of livelihoods and damage to infrastructure. Over the last few decades, precipitation for each rainfall event has decreased, meaning that flooding events are becoming less intense. The annual number of consecutive wet days, for example, has shown a slight decrease of 0.02 days/decade on average, from three days in 1950 to two days in 2020 (Figure 57).



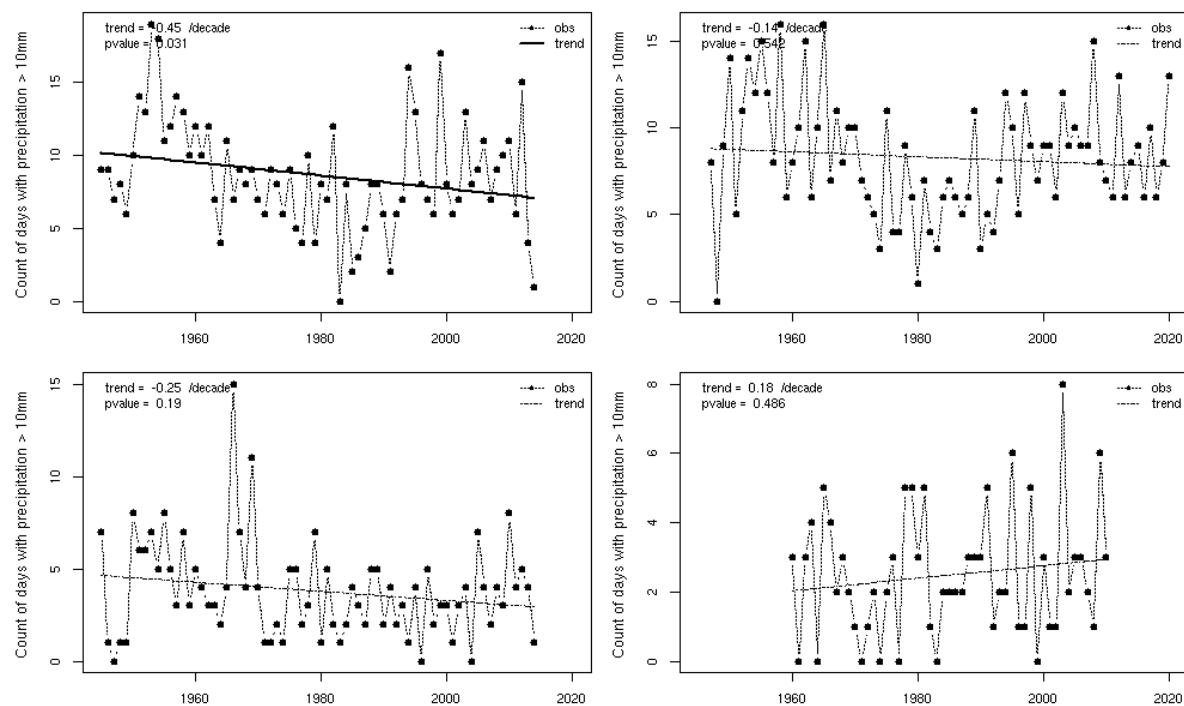
**Figure 57.** Change in the annual largest one-day precipitation amounts (mm) from 1951 to 2020 for Mauritania, indicating yearly values (grey line) and the average trend (solid black line)<sup>667</sup>.

When considering historical trends of heavy rainfall events for the four target hubs, slight decreases have been observed for the annual number of days with rainfall above 10 mm for three of the hubs. These are Nema, Tamcheket and Rachid, where the number of days with heavy rainfall events has declined by 0.5, 0.1 and 0.3 days/decade from 1945 to 2020 (

<sup>666</sup> Appendix 3.

<sup>667</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/trends-variability-historical>.

Figure 58), respectively. In contrast, the number of days with heavy rainfall events of 0.2 days/decade in Aoujeft has increased slightly.

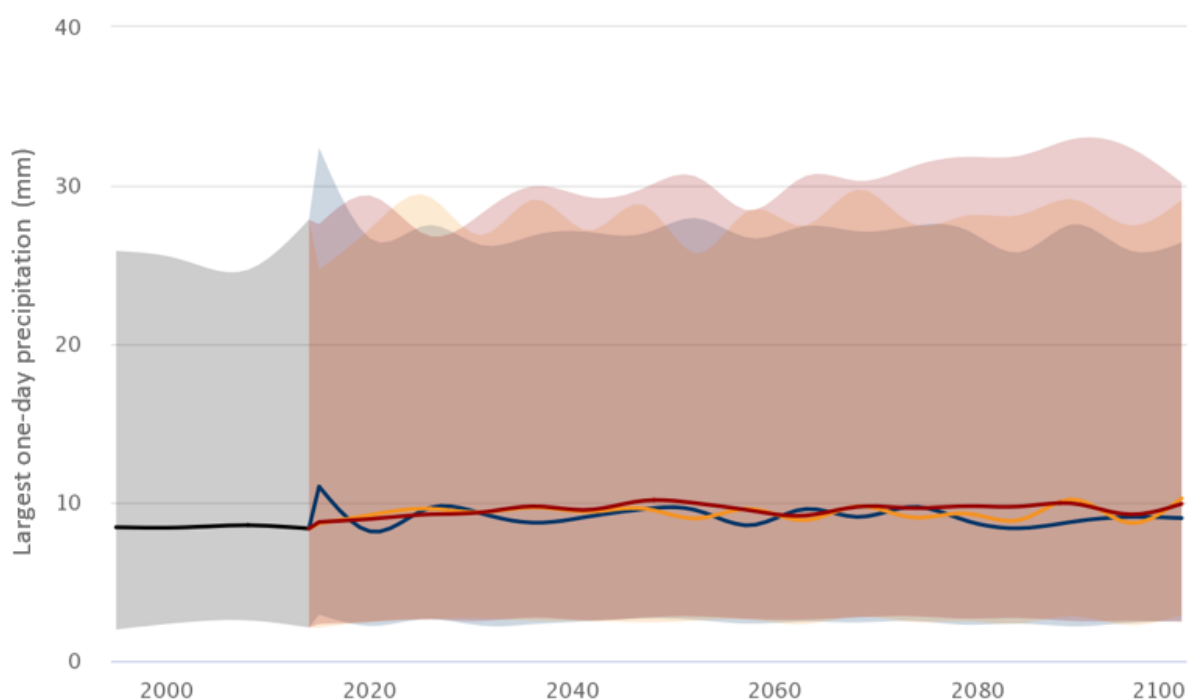


**Figure 58.** Observed change in the number of days with heavy rain (more than 10 mm) for Nema (top left, 1945–2014), Tamcheket (top right, 1946–2020), Rachid (bottom left, 1945–2014) and Aoujeft (bottom right, 1960–2010)<sup>668</sup>.

Under future climate conditions, the number of days with heavy rainfall events will continue to decrease slightly, while the amount of precipitation for the largest rainfall events per year will remain relatively constant. By 2100, Mauritania's annual one-day precipitation will remain similar to 2020 levels (

Figure 59). At the hub level, the number of days with heavy rainfall events will become less frequent by the middle of the century for two of the target hubs. For Nema, the number of days with heavy rain will decrease by three days under RCP8.5 relative to historical values and will display minimal change under an RCP4.5 scenario. Heavy rain events will also become less frequent for Tamcheket, decreasing to 3.4 days by 2050 under RCP8.5 at a rate of 0.8 days/decade. For Rachid and Aoujeft, the number of heavy rain days for RCP4.5 and RCP8.5 is predicted to remain constant relative to historical values.

<sup>668</sup> Appendix 3.



**Figure 59.** Projected change in Mauritania's average annual largest one-day precipitation from 2020 to 2099 using the historical reference period 1995–2014<sup>669</sup>. The median line and 10–90 percentiles for: i) SSP1-2.6 (blue); ii) SSP2-4.5 (yellow); and iii) SSP5-8.6 (red) are provided.

## 2.7 Climate change impacts

### 2.7.1 Impacts on water resources

Mauritania lies almost entirely within the Sahara Desert and is ranked the 4<sup>th</sup> most arid region out of 250 countries and territories globally<sup>670</sup>. As a result, the level of water scarcity within the country is classified as 'high'<sup>671</sup> (Figure 60). Only Mauritania's coastal zones receive adequate seasonal rainfall, and the only perennial river in the country is the Senegal River, which forms the country's southern border (Figure 20). As a result of the uneven distribution of surface water across Mauritania, most of the population depends on groundwater for their water supply. In the face of climate change, however, the rate of groundwater recharge has slowed; consequently, overextraction threatens the long-term sustainability of aquifers and boreholes. In fact, hydrological maps indicate that within the proposed project's target region, only the Tamcheket hub hosts sufficient groundwater resources to support the population in the medium term.

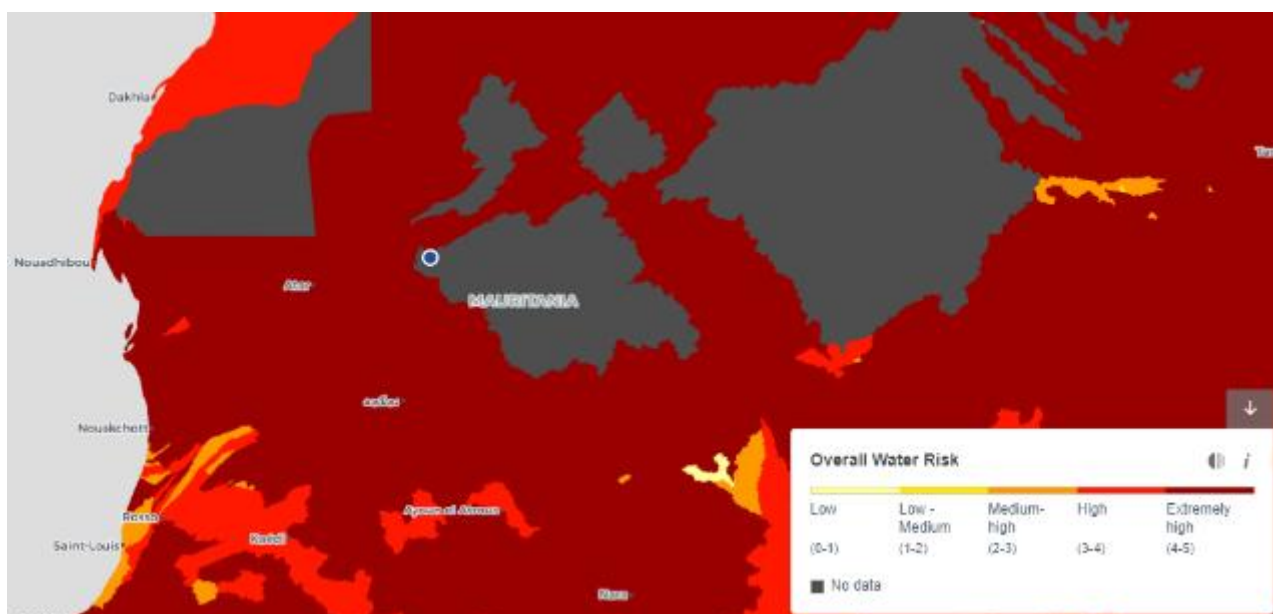
<sup>669</sup> WB. 2022. Climate change knowledge portal: Mauritania. Available at:

<https://climateknowledgeportal.worldbank.org/country/mauritania/climate-data-projections>

<sup>670</sup> World Wildlife Fund (WWF). 2020. Water Risk Filter — Country overview: Mauritania. Available at:

[https://wateractionhub.org/media/files/2020/08/20/Country\\_Profile\\_-\\_2020-08-20T100144.891.pdf](https://wateractionhub.org/media/files/2020/08/20/Country_Profile_-_2020-08-20T100144.891.pdf)

<sup>671</sup> ThinkHazard. 2020. Mauritania — Water scarcity. Available at: <https://thinkhazard.org/en/report/159-mauritania/DG>



**Figure 60.** Overall water risk in Mauritania. Source: Aqueduct Water Risk Atlas

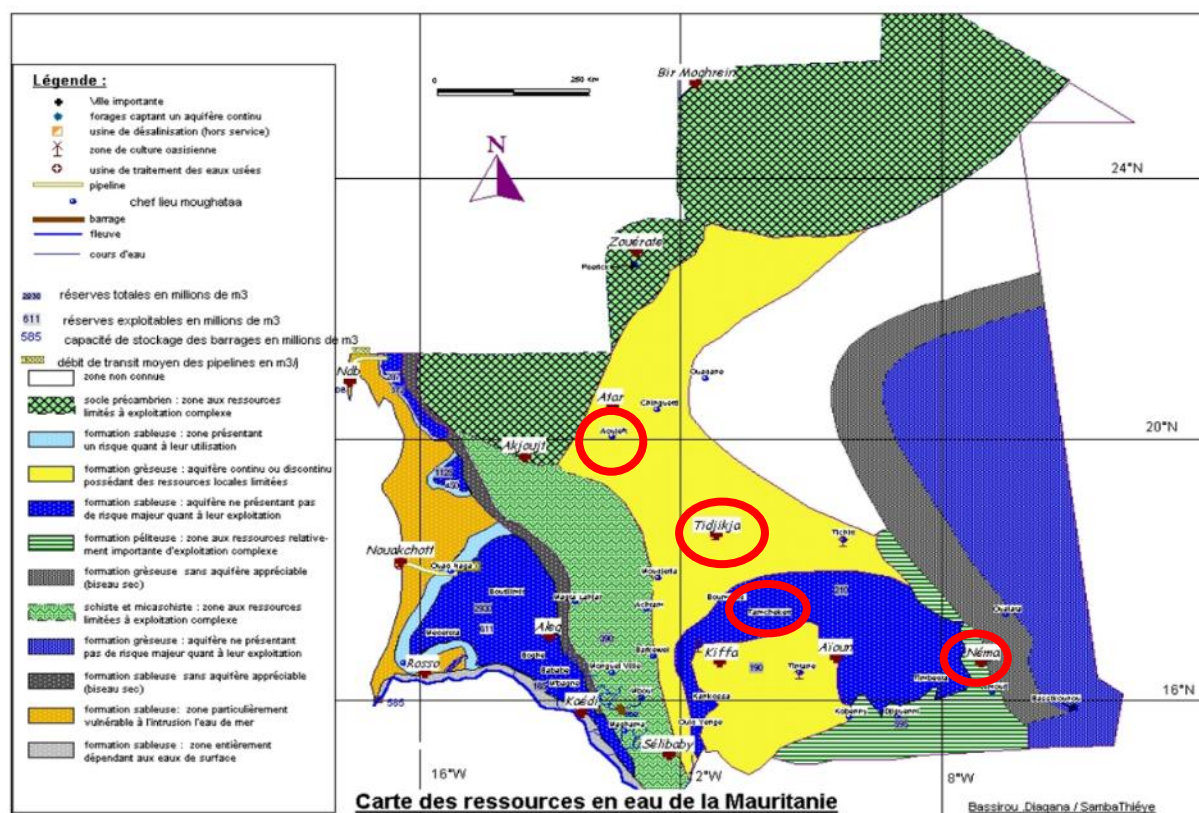
The main environmental challenge currently faced by Mauritania's population is the temporally and spatially erratic character of local rainfall, which has induced recurrent droughts since the 1960s<sup>672</sup>. During the 1970s and 1980s, extended periods of drought led to critical reductions in water resources and vegetation, which considerably increased the rate of land degradation and desertification. This resulted in a loss of arable land and reduced agricultural production, as well as a loss of pastures and livestock depletion<sup>673</sup>. Climate change has induced a general decrease in rainfall of ~10–15% across Mauritania over the last four decades. Additionally, the onset of the wet season has become increasingly delayed over time, such that the dry season has increased in duration. These changes in rainfall regime, together with increases in temperature and potential evaporation, have directly impacted Mauritania's water table and surface water resources, with foreseeable consequences for agriculture, health and the well-being of the population<sup>674</sup>.

<sup>672</sup> AWorRIA/ACTERRA. 2022. Critical climate risks in four regional hubs.

<sup>673</sup> Islamic Republic of Mauritania. 2004. National adaptation programme of action to climate change. Nouakchott, Mauritania.

<sup>674</sup> République Islamique de Mauritanie. 2019. Fourth National Communication.





**Figure 61.** Map indicating the location of groundwater resources in Mauritania<sup>675</sup>. The red circles represent the locations of the four target hubs: Aoujeft, Rachid, Tamcheket and Nema (from north to south).

During field visits by national consultants<sup>676</sup>, stakeholders in Nema reported a decrease in runoff of ~10% from 2000 to 2020. Runoff is a proxy for water availability; decreased runoff reflects regional trends of decreased precipitation and increased evapotranspiration. Increased evapotranspiration has also been linked to a decline in woody and herbaceous plant cover, which not only impacts agricultural production but also has important implications for water infiltration, soil moisture retention and groundwater recharge<sup>677</sup>. Additional vulnerability, exposure and impacts of climate change on water resources in Nema include: i) a drop in piezometric levels<sup>678</sup>; ii) alteration of the wadi flow regime<sup>679</sup>; and iii) a reduction in the storage capacity of small dams, a result of accelerated silting caused by water erosion during intense rainfall events<sup>680</sup>. Lastly, as a consequence of increasing temperatures and reduced annual rainfall, surface waters in the hub have become warmer and less aerated. As a result, the dilution and biodegradation of certain pollutants has been negatively impacted, reducing the quality of available water.

Several ephemeral rivers, streams and *wadis* are at risk of drying up in Tamcheket hub, particularly in the communes of Taletfal (Tahourat), Telmeden, Guelta Touzelat, Arereji, Taymsett and Iriji. Additionally, a number of historic wells have been permanently dry since the 1960s, for example those in the Majhar, Iriji Oum Lemhar, Tegwa, Aïn Ajhaniya, Legreywa, El Mbeydih, Le Mbeyha, Aguemoun and Lebyadh communes.

<sup>675</sup> Bassirou D. 2007. Les ressources en eau en Mauritanie.

<sup>676</sup> Annex 7: Summary of consultations and stakeholder engagement plan

<sup>677</sup> République Islamique de Mauritanie. 2019. Fourth National Communication.

<sup>678</sup> The piezometric level is the level to which groundwater rises under hydrostatic pressure in wells or springs.

<sup>679</sup> Wadis are drainage courses formed by water, distinct from river valleys or gullies in that surface water is intermittent or ephemeral. Wadis are generally dry year-round except after a rain.

<sup>680</sup> Friedel MJ, Finn CA & Horton J. 2012. Synthèse des données hydrologiques.



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Similar observations have been made within the regional hub of Rachid, where several seasonal streams and *gueltas*<sup>681</sup> — including the Telmeden and Touzelat *gueltas* — dried up as a result of accelerated silting prior to 1960. Furthermore, community members in recent stakeholder consultations<sup>682</sup> have reported that an additional five wells have run dry since the onset of recurrent droughts in the late 1960s. There are no obvious reasons for the wells to dry up beyond siltation and drought, which suggests that the loss of these water access points is a consequence of climate change rather than socio-economic factors. Community members within Rachid have further noted that both traditional dry-stone wells and newly established cement wells have been impacted by reduced water availability.

Within the Aoujeft hub, stakeholders informed national consultants<sup>683</sup> that 10 well points have dried up between 1951 and 2020. Three of these well points dried up as a result of silting in the years preceding 1960, and an additional seven water points — in the communes of Oum Chenad, Ten Mour, Timoline, Timitine, Ijichane, Aïn Lebgar and Tiroutène — have disappeared since the onset of recurrent droughts towards the end of the 1960s.

### **Risk of climate change impacts on water resources**

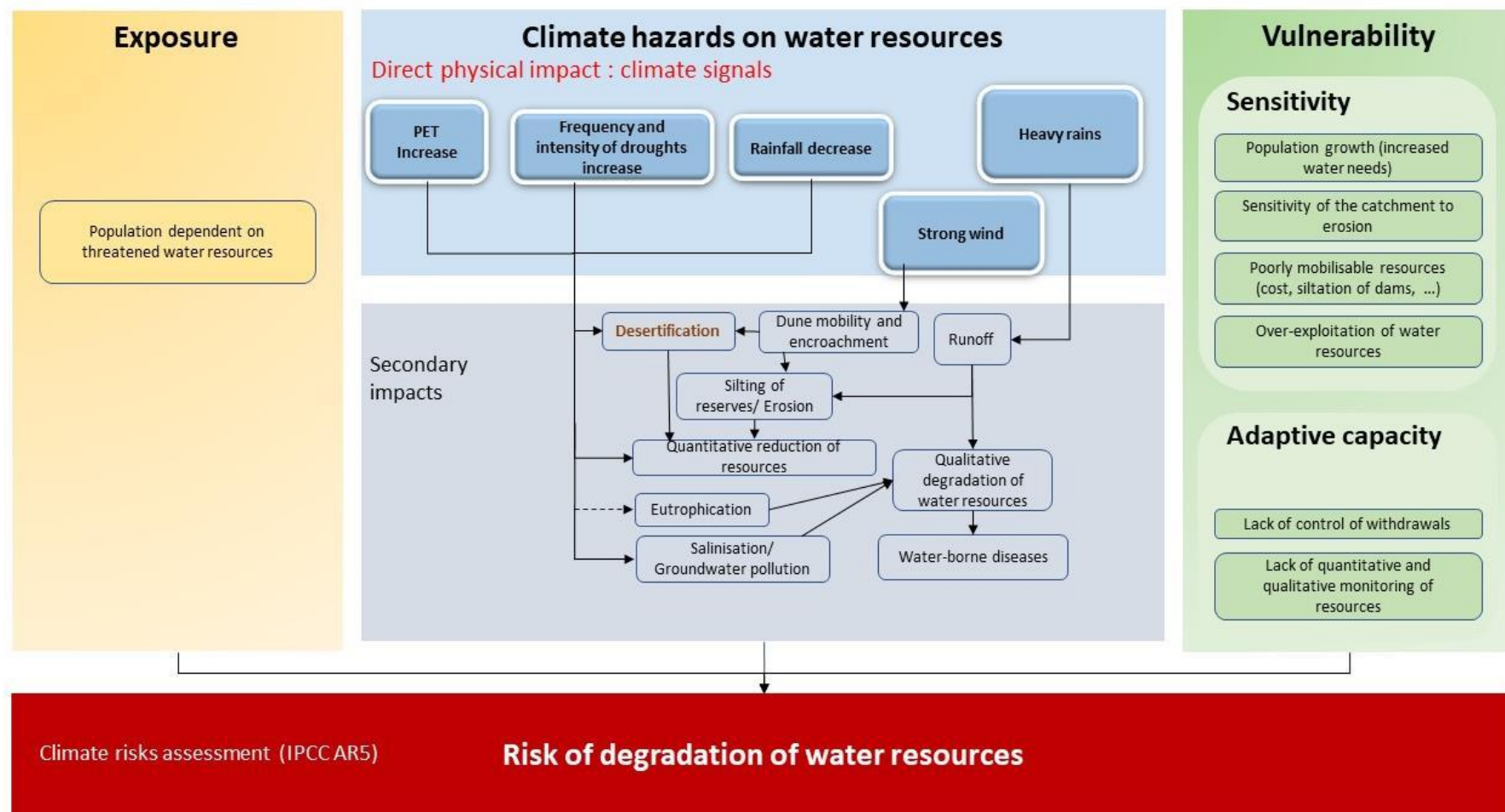
Figure 62 provides a summary of the risk chain that was jointly developed during focus group discussions with national experts to identify risks contributing to water-resources degradation across the proposed project's target region. This risk chain includes identified exposure, vulnerability and climate hazard (direct physical impacts) risks. The secondary impacts were only used by facilitators to guide the discussion on exposure and vulnerability.

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<sup>681</sup> A *guelta* is an ephemeral pocket of water that forms in drainage canals or wadis in the Sahara.

<sup>682</sup> Annex 7: Summary of consultations and stakeholder engagement plan

<sup>683</sup> Annex 7: Summary of consultations and stakeholder engagement plan



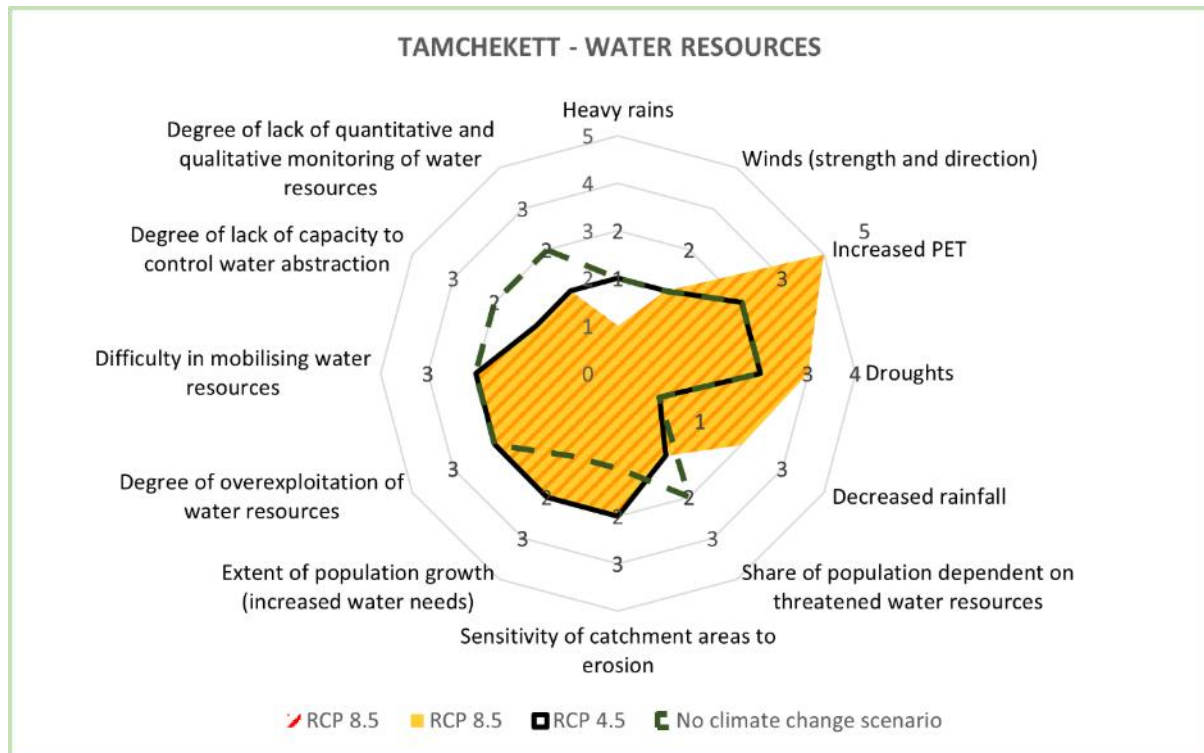
**Figure 62.** Risk chain for the degradation of water resources<sup>684</sup>

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The radar graphs below (Figure 63–Figure 66)<sup>685</sup> display the hub-specific risk scores assigned to each risk component identified in the water resources risk chain (Figure 62). For all radar plots, higher risk scores are associated with greater levels of vulnerability and exposure, as well as more severe climate change impacts. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 2.1).

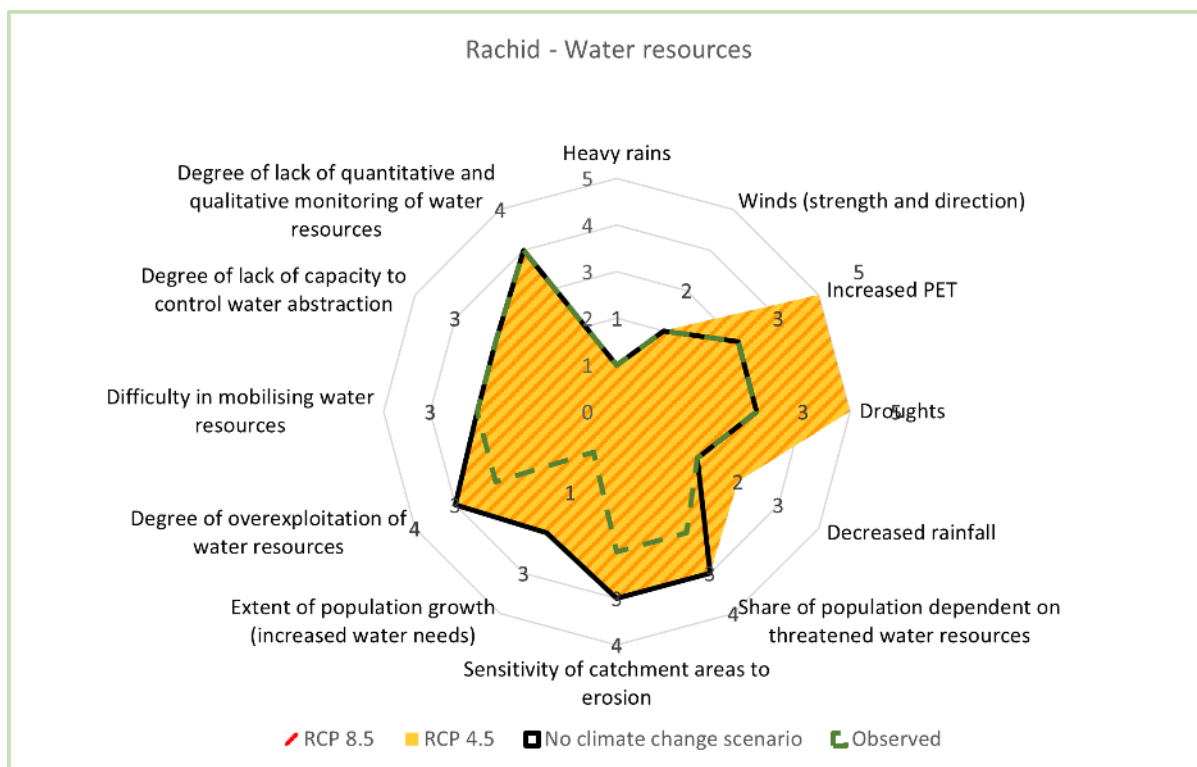
[The figure for Nema was not provided project design partners]

**Figure 63.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on water resources in Nema.

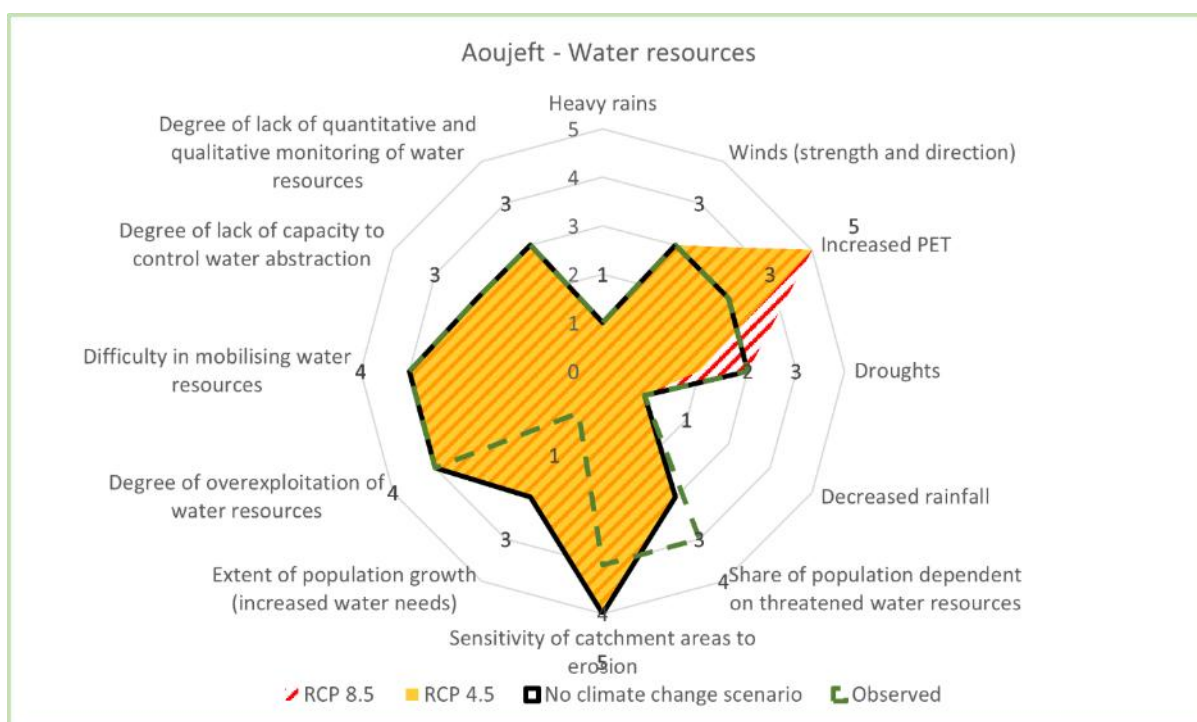


**Figure 64.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on water resources in Tamcheket.

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**Figure 65.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on water resources in Rachid.



**Figure 66.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on water resources in Aoujeft.

The risk scores assigned to climate hazards are generally high across all four hubs — particularly under future climate change scenarios. These high scores reflect the severe impacts of recurrent droughts, increased temperature and increased ETP on the quality and

availability of water resources in the target hubs. Additionally, in Aoujeft and Nema the risk scores for winds — which cause the silting up of surface water bodies — are particularly high.

Although the overall risk of water-resource degradation is relatively high in all four target hubs, the highest risk is observable in Aoujeft, largely as a result of the population's heavy dependence on threatened water sources. The radar graphs also indicate limited adaptive capacity in Aoujeft, Rachid and Tamcheket, a consequence of water and sanitation services within these hubs only recently being administrated by a dedicated government entity. Procedures for regulating and monitoring water use are, therefore, not yet fully developed. In Nema, the management of water resources by a dedicated entity was established earlier; consequently, the risk score for limited capacity is lower. Moreover, by 2050, population growth in all four hubs is expected to be higher than currently observed (2022), regardless of the climate change scenario. As a result, the demand for water is expected to increase, thereby increasing the risk of water-resource degradation in all four hubs<sup>686</sup>.

**Aoujeft:**

High exposure and vulnerability scores have been assigned for the current situation, but exposure is expected to decrease by 2050 as a result of improved services within the hub. Climate change is expected to place moderate stress on water resources.

**Rachid:**

Moderate exposure and vulnerability scores have been assigned for the current situation, but both are expected to increase by 2050 as a result of limited access to unsustainable groundwater resources. As a result of more frequent droughts and increased ETP, climate change will place additional stress on water resources, particularly under RCP8.5.

**Tamcheket:**

Moderate exposure and vulnerability scores have been assigned for the current situation, but overall risk is expected to decrease slightly by 2050 as a result of the implementation of groundwater recharge projects. Climate change will place additional stress on water resources, though, specifically as a result of drought, decreasing rainfall and increased ETP.

**Nema:**

Exposure and vulnerability scores are relatively low for both the current situation and for 2050 owing to ongoing water supply projects and well-established water network management protocols. Climate change is nonetheless expected to add moderate stress to water resources.

provides a further summary of the key risk scores for water resource degradation in each of the target hubs.

**Box 1.** Summary of major risks for water-resource degradation across the proposed project's target region<sup>687</sup>

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<sup>687</sup> Appendix 4

Aoujeft:

High exposure and vulnerability scores have been assigned for the current situation, but exposure is expected to decrease by 2050 as a result of improved services within the hub. Climate change is expected to place moderate stress on water resources.

Rachid:

Moderate exposure and vulnerability scores have been assigned for the current situation, but both are expected to increase by 2050 as a result of limited access to unsustainable groundwater resources. As a result of more frequent droughts and increased ETP, climate change will place additional stress on water resources, particularly under RCP8.5.

Tamcheket:

Moderate exposure and vulnerability scores have been assigned for the current situation, but overall risk is expected to decrease slightly by 2050 as a result of the implementation of groundwater recharge projects. Climate change will place additional stress on water resources, though, specifically as a result of drought, decreasing rainfall and increased ETP.

Nema:

Exposure and vulnerability scores are relatively low for both the current situation and for 2050 owing to ongoing water supply projects and well-established water network management protocols. Climate change is nonetheless expected to add moderate stress to water resources.

## 2.7.2 Impacts on ecosystems and rangelands

Mauritania's Fourth National Communication (2019) reports that 'chronic droughts and human pressure will destroy woody vegetation cover, accentuate desertification, affect biological diversity and reduce pastoral potential, thus provoking a massive rural exodus towards the large urban centres'. Additionally, historical conflicts over access to natural resources — for example, in the Guidimakha wilayah — are likely to intensify and spread as a result of the growing demand for food, fibre and energy and the loss and degradation of productive land. These conflicts are likely to be exacerbated by changing agricultural conditions, increased water shortages, loss of biodiversity, reduced grazing land and poverty<sup>688</sup>.

Climate change and anthropogenic pressure have also negatively impacted biodiversity in Mauritania. A number of indigenous floral and faunal species have already gone extinct within the proposed project's four target hubs (Appendix 4). The loss of these species has, in turn, contributed to the degradation of Mauritania's main agro-silvopastoral ecosystems. The loss of these ecosystems and the services they provide has been a major source of conflict in rural oases — particularly between farmers and herders (transhumant or sedentary herders and sedentary farmers).

Climate change-induced impacts on ecosystems and rangelands have also been observed at the hub level. In Nema, some infrastructure has been completely buried by silting, which has resulted in: i) a rural exodus to larger cities; ii) displacement of populations; and iii) degradation of agricultural areas. Additionally, communities in Nema have noted that droughts in the 1970s and 1980s led to a sharp decline in livestock numbers, with a dramatic acceleration of this decline during the rural exodus and a tendency for the remaining herds to be owned by urban businessmen. Improved rainfall during the 2000s has allowed for the reconstitution of herds kept by local livestock farmers. The last few decades have, however, also been marked by a strong move towards sedentary livestock farming, which has led to: i) the regression of

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<sup>688</sup> République Islamique de Mauritanie. 2019. Fourth National Communication.

nomadic systems; ii) the spatial and temporal reduction of transhumance; and iii) increased competition over pastoral resources<sup>689</sup>.

Tamcheket hub is characterised by hydromorphic sandy-clay soils generally found around ephemeral *wadis* and *tamourts*<sup>690</sup>, where they are clearly dominated by *Vachellia nilotica* (formerly *Vachellia nilotica*) (gum Arabic tree) and *Ziziphus mauritiana* (jujube tree). In some areas, stands of these indigenous tree species are particularly dense and are classified as forests. Remaining forested areas are considered relics, however, as *V. nilotica* and *Z. mauritiana* show no obvious signs of regeneration<sup>691</sup>.

Within Rachid hub, livestock roaming in peri-oasis areas is a major source of conflict, because livestock often damage flood recession crops, which are more vulnerable and difficult to protect than *zeribas*<sup>692</sup>. The impacts of climate hazards on livestock productivity have exacerbated the situation, as recurrent droughts have further degraded rangelands such that pastoral areas and water points have become scarcer and more remote. Limited rangeland availability has increased the distance and duration of transhumance required to maintain a nomadic lifestyle, and many livestock farmers have shifted to a sedentary lifestyle. Peri-urban development and the implementation of breed improvement programmes to address fodder shortages have, in turn, impacted the hub's entire livestock sector — particularly by changing the way in which livestock have historically been raised.

Within Aoujeft hub, the Adrar wilayah is characterised by abundant rangelands and pastures. This region serves as a transit and transhumance zone for herds of small ruminants and camels from several wilayahs in the country. Fodder availability in Adrar is dependent on rainfall and consequently varies from year to year. Transhumance is the main livestock system used in the wilayah, but the peri-urban livestock system has been adopted for certain goat species in the Toumza commune. Additionally, some fodder crops have been introduced under palm trees, and local breeders then sell these crops as supplementary food to farms within urban centres. Based on focus group discussions, oasis livestock raising in Aoujeft has been experiencing several challenges, including: i) observed reductions in woody and herbaceous cover and, consequently, shelter and forage; ii) more frequent miscarriages in livestock when maternal bodies are too weak to carry offspring to term; iii) a decrease in the abundance of the most appetising plant species and, consequently, fodder; iv) a reduction in the period of lactation in livestock; and v) a decrease in community members' food security as a result of reduced livestock productivity. Lastly, during a field visit by national consultants, herders reported that the current (2020) density of trees in nearby oases was lower than before the 1970s drought<sup>693</sup>.

### **Risk of climate change impacts on ecosystems and rangelands**

Figure 67 provides a summary of the risk chain that was jointly developed during focus group discussions with national experts to identify risks contributing to ecosystem and rangeland degradation within the target region. This risk chain describes exposure, climate hazard (direct physical impacts) and vulnerability risks.

<sup>689</sup> Sahara and Sahel Observatory (OSS). 2015. Analyse des processus décisionnels et définition du rôle de la population.

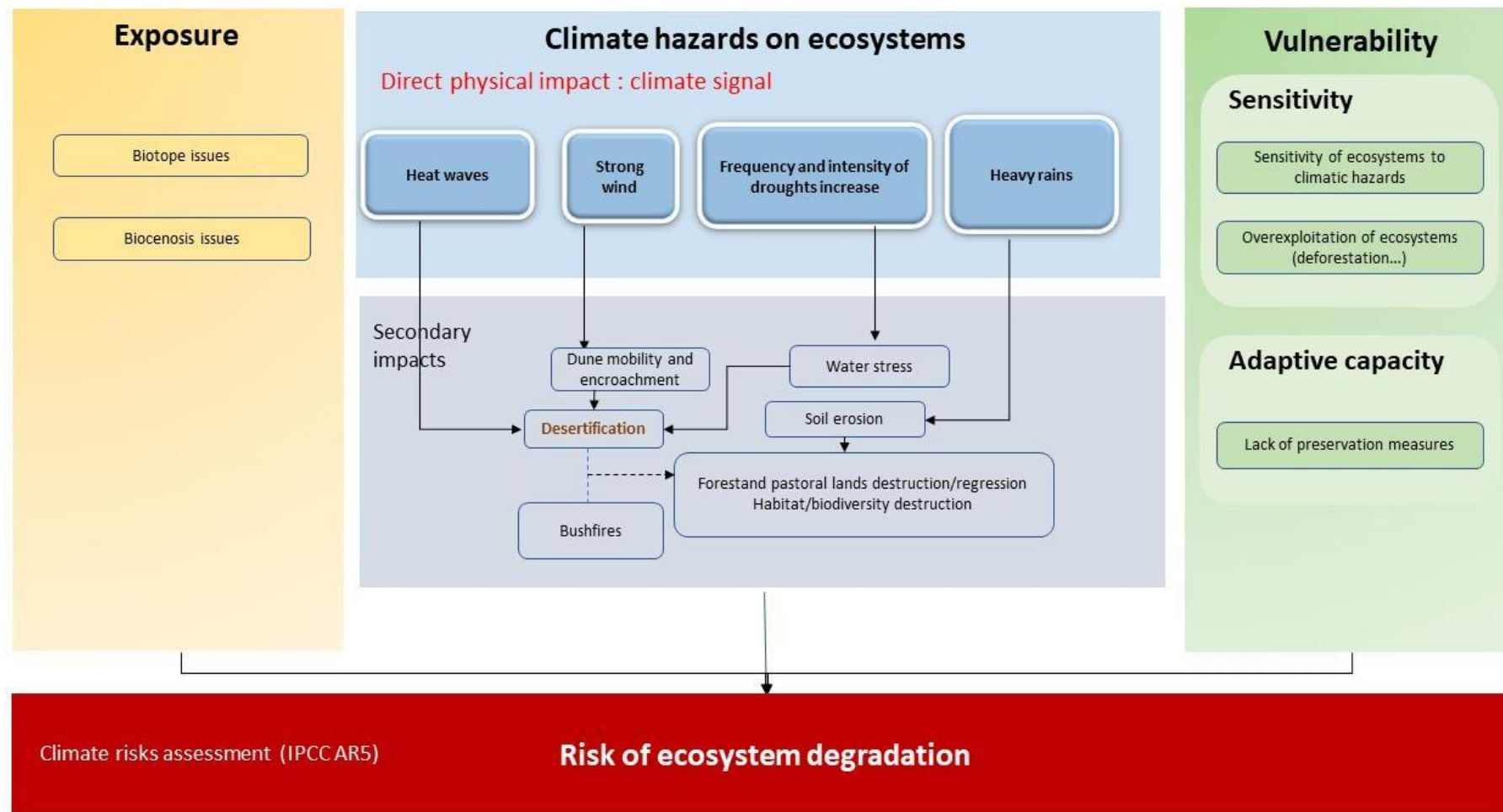
<sup>690</sup> *Tamourts* are closed, forested basins contained in deep depressions and characterised by stands of *Vachellia nilotica* (formerly *Acacia nilotica*).

<sup>691</sup> Appendix 4

<sup>692</sup> Palm grove property unit.

<sup>693</sup> Appendix 4



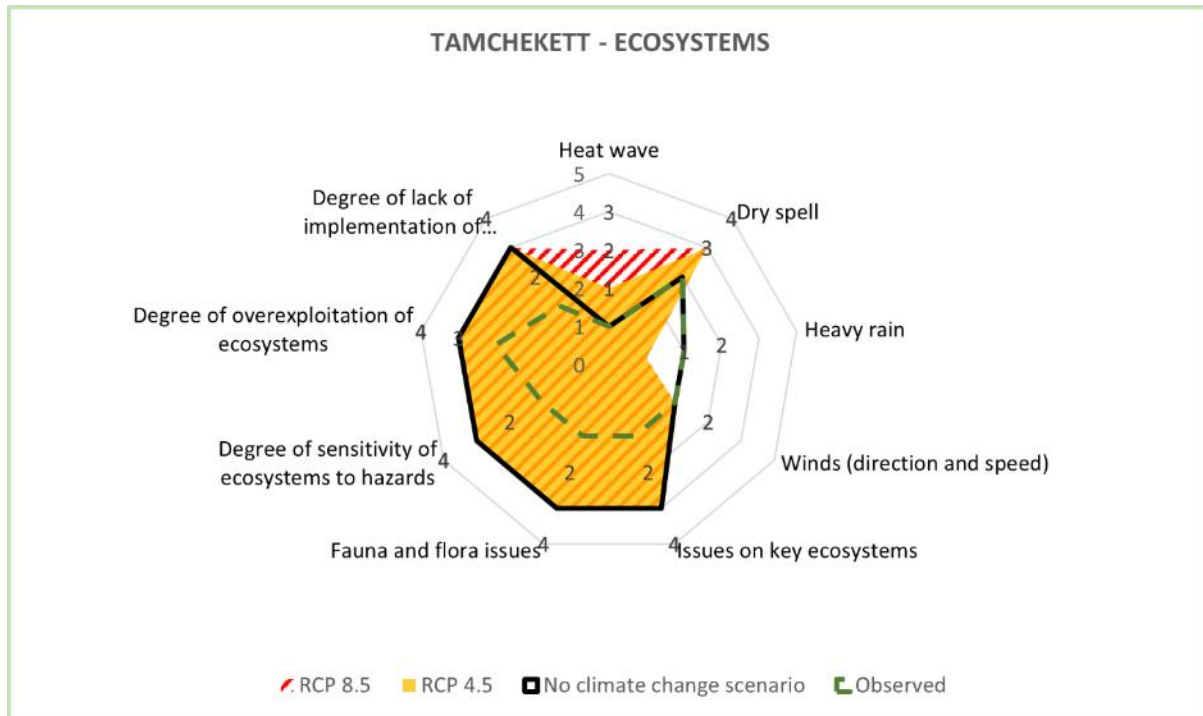


**Figure 67.** Risk chain for ecosystem and rangeland degradation<sup>694</sup>.

<sup>694</sup>Appendix 4

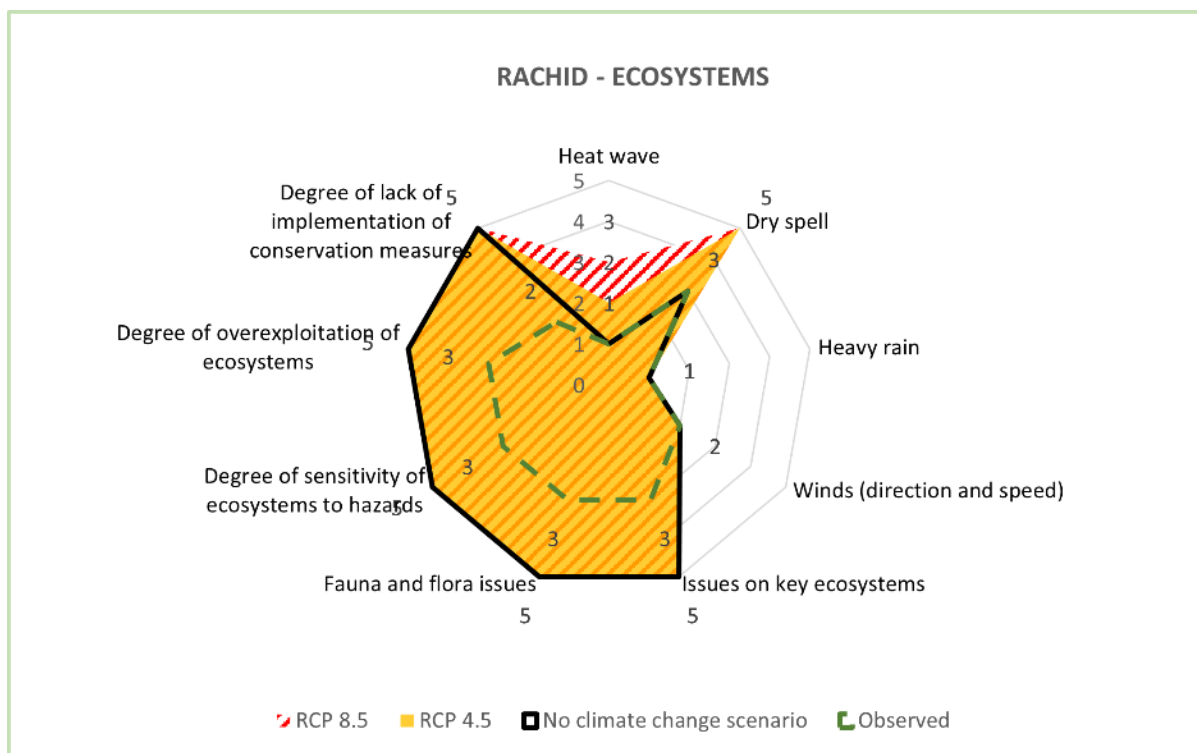


The radar graphs<sup>695</sup> visualise the risk scores obtained for each factor identified in the ecosystem and rangeland degradation risk chains. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 3.1).

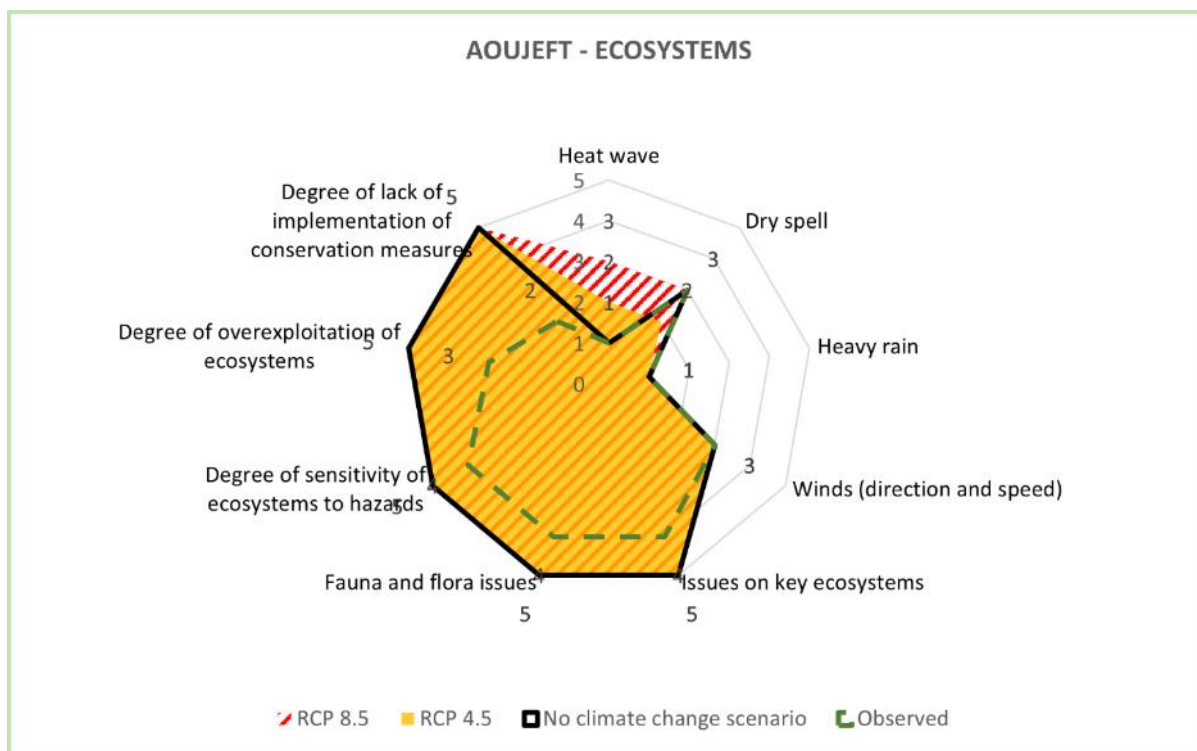


**Figure 68.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on ecosystems in Tamcheket.

<sup>695</sup> Appendix 4



**Figure 69.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on ecosystems in Rachid.



**Figure 70.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on ecosystems in Aoujeft.

The overall risks of ecosystem and rangeland degradation varies at the hub level, but recurrent droughts and silting caused by strong winds have had considerable impacts on ecosystems in all four target hubs. The overall risk of ecosystem and rangeland degradation is highest in Aoujeft as reflected in comparatively high exposure and vulnerability scores. Biotypes within Aoujeft are particularly sensitive to disturbance and have already been negatively impacted by silting caused by strong winds. Moreover, almost all indigenous fauna have disappeared and indigenous flora have been severely degraded. Consequently, Sahelian flora are gradually being replaced by Saharan flora, which severely limits the carrying capacity of pastures for livestock. In contrast, vulnerability and exposure scores are relatively low in Tamcheket and Nema, so the overall risk of ecosystem degradation in these two hubs is lower. In general, local communities are well informed about the risks and impacts of ecosystem degradation, but limited economic means prevent communities from implementing adaptation measures. By 2050, accelerated desertification is projected to result in transformation of the Sahelian climate into a Saharan climate, with subsequent impacts for native biotypes and biodiversity and the ecosystem services (ESSs) they provide<sup>696</sup>. The main findings for each hub are summarised in

**Aoujeft:**

High exposure and vulnerability scores have been assigned for the current situation. Maximum vulnerability and exposure scores are projected by 2050. Climate change increases the risk of ecosystem degradation under the RCP8.5 scenario only.

**Rachid:**

Moderate exposure and vulnerability scores have been assigned for the current situation, but maximum vulnerability and exposure scores are predicted for 2050. Climate change is projected to place additional pressure on ecosystems and rangelands, particularly under the RCP8.5 scenario.

**Tamcheket and Nema:**

Observed exposure and vulnerability scores are relatively low and are projected to remain lower than those for Aoujeft and Rachid in 2050. Climate change is expected to increase pressure on ecosystems under RCP8.5, particularly in Nema. At the 2050 horizon, the overall risk of ecosystem and rangeland degradation in these hubs will be lower than in Rachid and Aoujeft.

**Box 2.** Summary of major risks for ecosystem and rangeland degradation across the proposed project's target regions<sup>697</sup>.

**Aoujeft:**

High exposure and vulnerability scores have been assigned for the current situation. Maximum vulnerability and exposure scores are projected by 2050. Climate change increases the risk of ecosystem degradation under the RCP8.5 scenario only.

**Rachid:**

Moderate exposure and vulnerability scores have been assigned for the current situation, but maximum vulnerability and exposure scores are predicted for 2050. Climate change is projected to place additional pressure on ecosystems and rangelands, particularly under the RCP8.5 scenario.

**Tamcheket and Nema:**

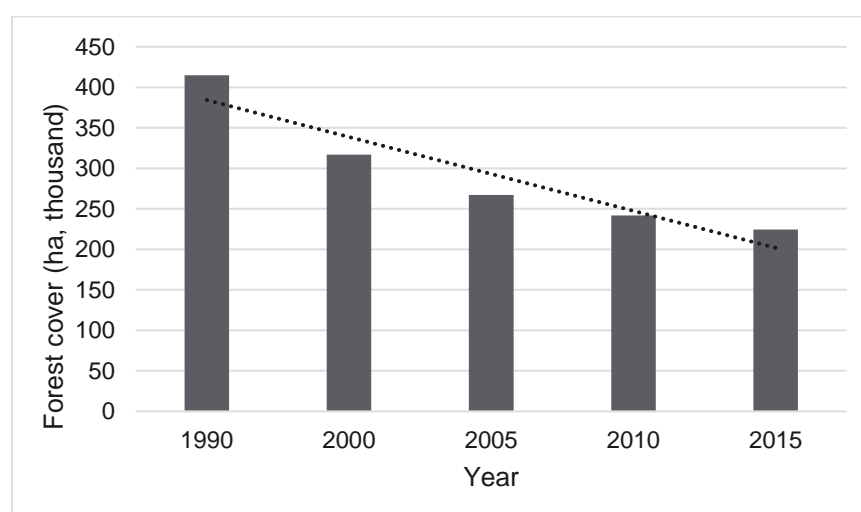
Observed exposure and vulnerability scores are relatively low and are projected to remain lower than those for Aoujeft and Rachid in 2050. Climate change is expected to increase pressure on ecosystems under RCP8.5, particularly in Nema. At the 2050 horizon, the overall risk of ecosystem and rangeland degradation in these hubs will be lower than in Rachid and Aoujeft.

<sup>696</sup> Appendix 4

<sup>697</sup> Appendix 4

### 2.7.3 Impacts on agriculture

An estimated 974,000 Mauritians live in food insecurity, including ~231,000 in severe food insecurity and in urgent need of assistance<sup>698</sup>. Moreover, the World Health Organisation's (WHO) emergency malnutrition threshold (~15%) has been exceeded in six wilayahs — namely, Hodh El Gharbi, Assaba, Gorgol, Brakna, Tagant and Guidimaha. Between 1975 and 2013, the rate of land use change in Mauritania increased by only ~0.3% — from ~0.4% per annum (1975–2000) to ~0.7% per annum (2000–2013). In 2013, less than 1% of the country's surface area was agricultural land, making Mauritania the least cultivated country in West Africa. Additionally, other bioproductive<sup>699</sup> landcover types — including forests, gallery forests<sup>700</sup> and swamp forests — comprise only a small fraction of the country's total land areas (Figure 19)<sup>701</sup>.



**Figure 71.** Area of forest cover in Mauritania<sup>702</sup>.

Climate hazards are expected to result in: i) the loss of both seedlings and harvests; ii) water stress on plants; iii) land degradation and erosion; and iv) extension of the arid zone towards the south of the country. This will exacerbate challenges already faced by farmers, such as the appearance of devastating crop pests. Consequently, food insecurity is projected to intensify within the proposed project's target region, with subsequent impacts on health and the well-being of communities<sup>703</sup>.

Increased rainfall variability is also likely to impact bioproductive natural resources. For example, chronic droughts, together with increased anthropogenic pressure, are expected to accelerate the regression of woody and herbaceous plant covers. This will in turn accentuate desertification and the loss of biodiversity and reduce rangelands' pastoral potential. Already, rainfall irregularity, the limited spatial and temporal distribution of rains and the lengthening of the dry season are the main causes of sowing failure, the abandonment of dry sowing techniques and necessary increases in the number and density of seeds per sowing plot<sup>704</sup>.

<sup>698</sup> WFP. 2015. WFP Mauritania brief.

<sup>699</sup> Bioproductive areas are those which support significant photosynthetic activity and biomass accumulation. Barren areas, with low or dispersed productivity, are ignored.

<sup>700</sup> A gallery forest is one formed as a corridor along rivers or wetlands, projecting into landscapes that are otherwise only sparsely treed, such as savannas, grasslands or deserts.

<sup>701</sup> FAO. 2014. Evaluation des ressources forestières mondiales 2015: Mauritanie.

<sup>702</sup> FAO. 2014. Evaluation des ressources forestières mondiales 2015: Mauritanie.

<sup>703</sup> Appendix 4

<sup>704</sup> Appendix 4

*Diéri* production depends exclusively on rainfall and is, therefore, very uncertain. Average yields for *diéri*<sup>705</sup> crops are around 547 kg/ha, with observed variations depending on the incidence of drought. In water-scarce years, *diéri* yield losses can exceed 70% of total production. Farmers interviewed during field visits by national consultants estimated a 90% loss during drought years and a 30% loss during abnormally hot years. In oasis agricultural systems, the main challenges faced by farmers include the scarcity of water and the difficulty of mobilising it<sup>706</sup>.

Rainfed agriculture is also subject to the adverse impacts of rainfall variability and climate change. Long dry spells during sensitive phases of plant growth — for example, the vegetative and reproductive phases — often result in reduced productivity and the loss of crop yields. Within the proposed project's target regions, agriculture is practiced mainly for subsistence, and existing farming methods are generally rudimentary. Unsuitable climate conditions therefore exacerbate national food insecurity, particularly as access to improved agricultural technologies is limited<sup>707</sup>.

During stakeholder consultations, most farmers also reported a drop in the water table level. In Aoujeft, farmers indicated that groundwater levels have fallen from a depth of ~6 m to a depth of at least 12 m since the 1960s. Lowering of the water table as a result of recurrent droughts and the overexploitation of water resources has led to progressive soil degradation. The quality of water in oases has also deteriorated. Droughts in the 1970s and 1980s, together with unsustainable farming practices, have contributed to the salinisation of groundwater resources. Consequently, there is insufficient freshwater available for palm grove irrigation. This major constraint on agricultural productivity is compounded by silting, which covers large parts of the palm groves; in some instances, the increasing height of sand dunes has completely buried palm trees<sup>708</sup>.

Wind erosion also threatens oasis agriculture. Recurrent droughts have resulted in the gradual disappearance of vegetation cover and a subsequent reduction in soil binding by roots. As a result, fine soil particles are easily uplifted and transported over long distances, leaving coarse sand particles exposed to displacement via strong winds. In recent years, an increase in the intensity of extreme rainfall events has also intensified water erosion within palm groves. Water erosion scours the surface layers of soil that are fertile and conducive to plant growth. Additionally, water erosion during intense rainfall events results in the formation of deep gullies that destabilise watercourse banks<sup>709</sup>.

Additionally, drought conditions and high temperatures have increased the frequency of bushfires, which damage bioproductive ecosystems, rangelands and crops. While increasingly dry weather conditions during droughts and extreme heatwaves favour the spread of bushfires, fires in Mauritania are generally started by humans. Historically, fires have been particularly frequent within the wilayahs of Hodh Chargui (Nema hub) and Hodh El Gharbi (Tamcheket hub). Table 43 summarises the number of fires and the area burnt in these two wilayahs between the years 2016 and 2021<sup>710</sup>.

Wilayahs	Year	Area burnt (km <sup>2</sup> )	No. of fires
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<sup>705</sup> *Diéri* is a geographical term (of Toucouleur origin) designating the non-floodable land of a river valley, as opposed to the *walo*.

<sup>706</sup> Appendix 4

<sup>707</sup> Appendix 4

<sup>708</sup> Appendix 4

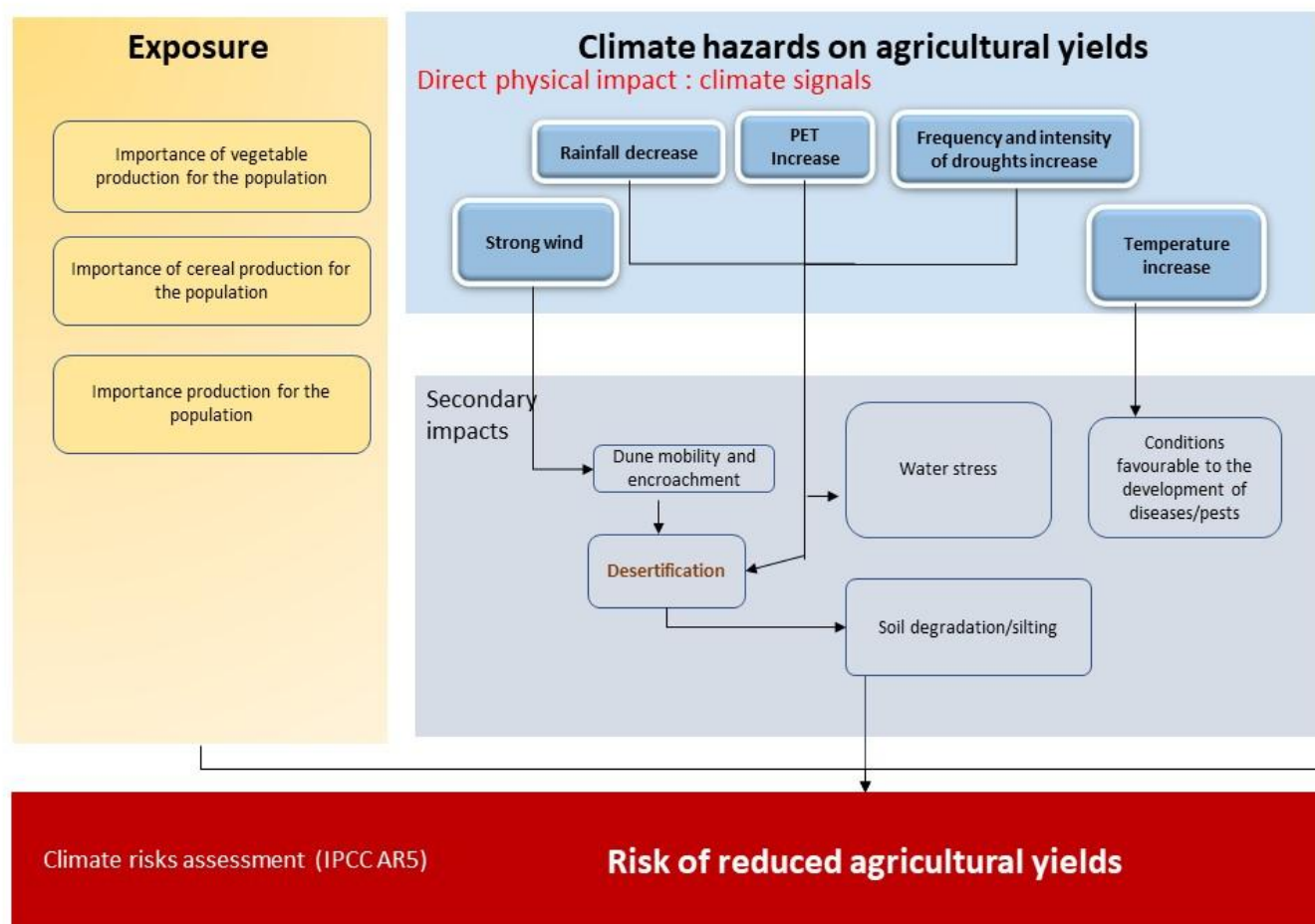
<sup>709</sup> Appendix 4

<sup>710</sup> Appendix 4

<b>Hodh Chargui (Nema)</b>	2016–2017	183.25	20
	2018–2019	657.70	33
	2019–2020	413.29	14
	2020–2021	2,528.78	43
<b>Hodh El Gharbi (Tamcheket)</b>	2016–2017	148.20	10
	2017–2018	12.45	3
	2018–2019	6.49	6

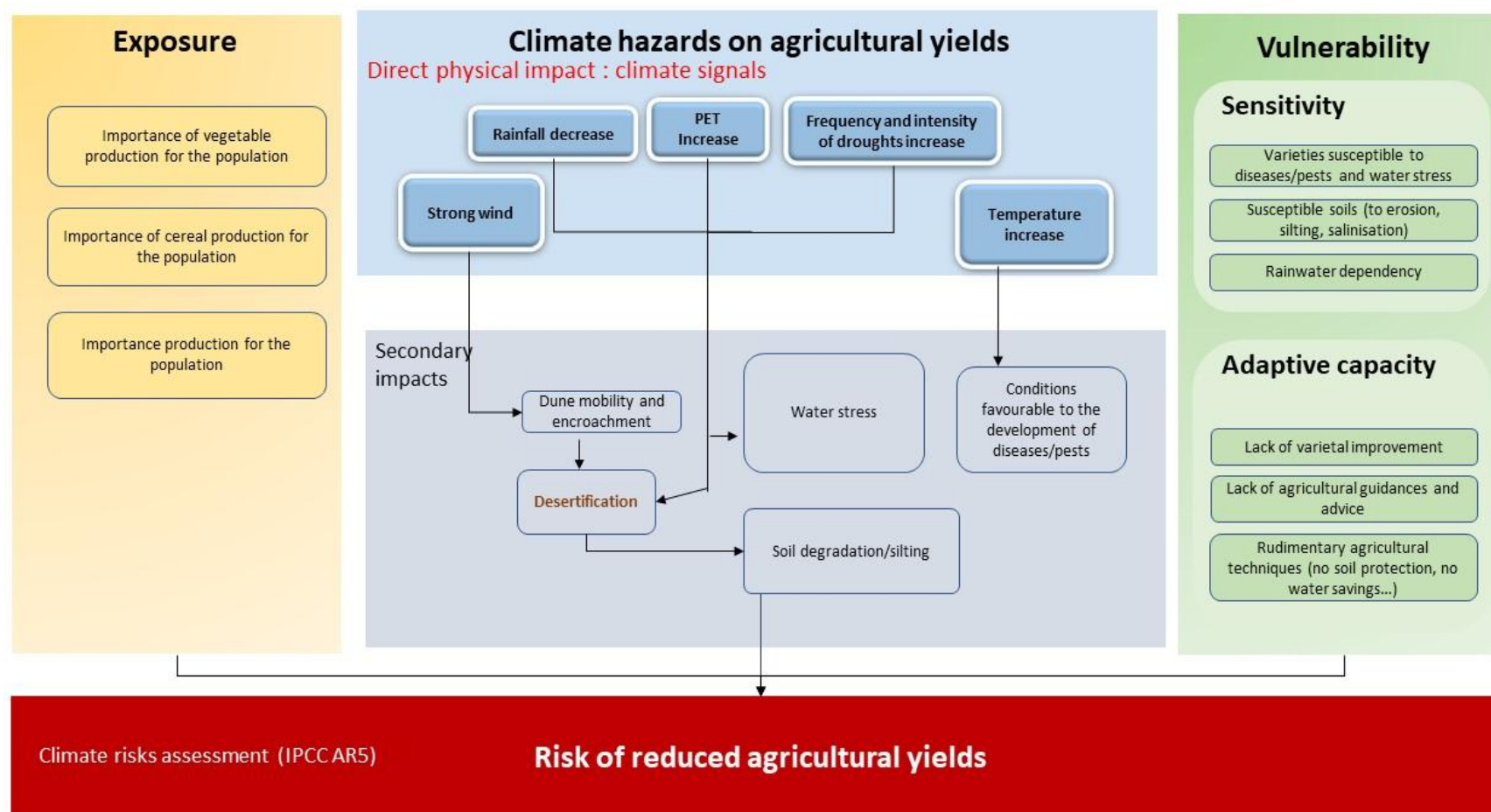
**Table 43.** Total area of burnt land and total number of fires reported between 2016 and 2021 in the hubs of Nema and Tamcheket<sup>711</sup>.

### Risk of climate change impacts on agriculture



(following page) summarises the jointly developed risk chain for reduced agricultural yields. It includes exposure, climate hazard (direct physical impacts) and vulnerability risks identified during focus group discussions with national experts. Secondary impacts were used only to guide discussions on exposure and vulnerability.

<sup>711</sup> Appendix 2z

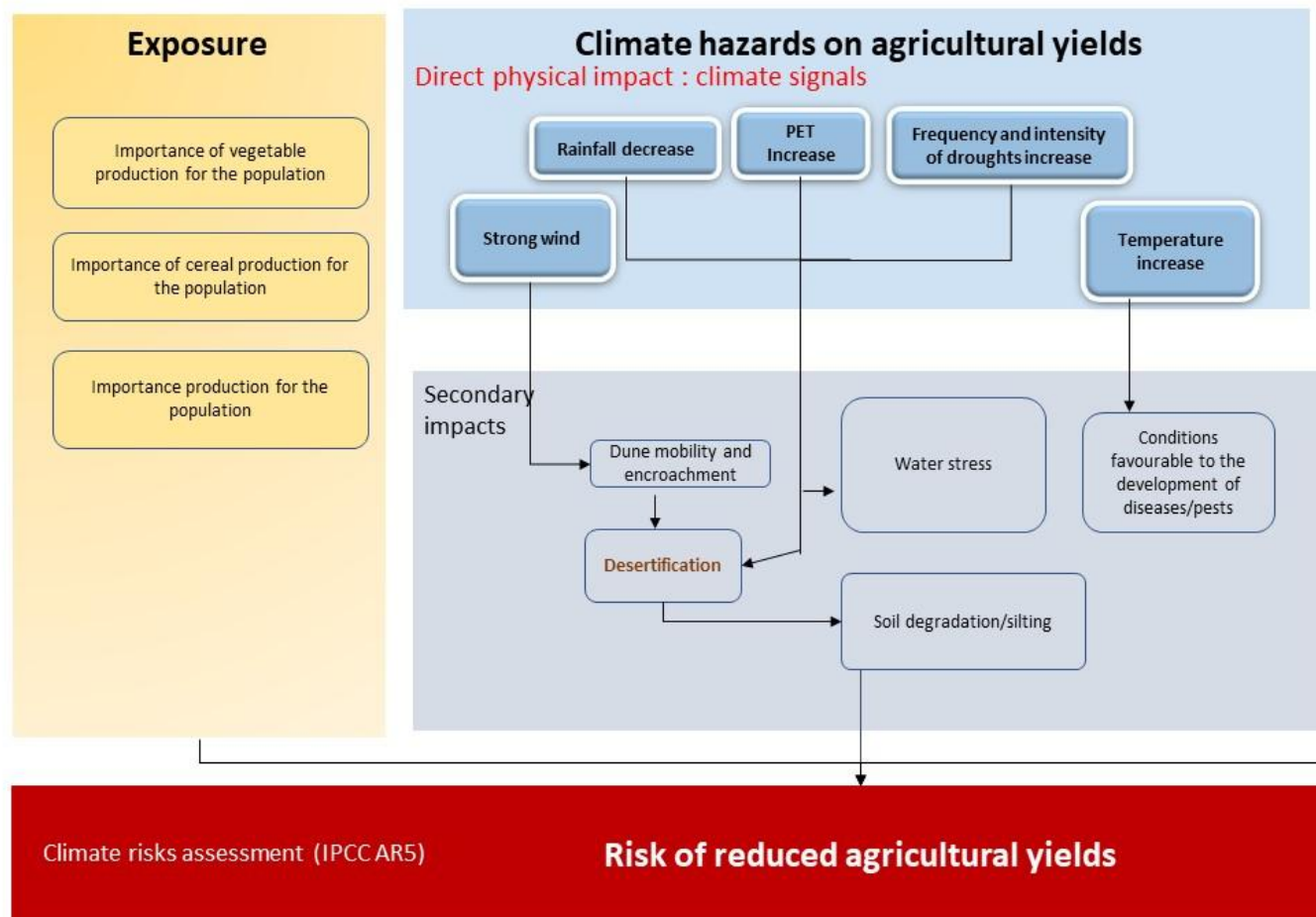


**Figure 72.** Risk chain for vulnerability, exposure and climate change impacts on agriculture<sup>712</sup>.

<sup>712</sup> Appendix 4



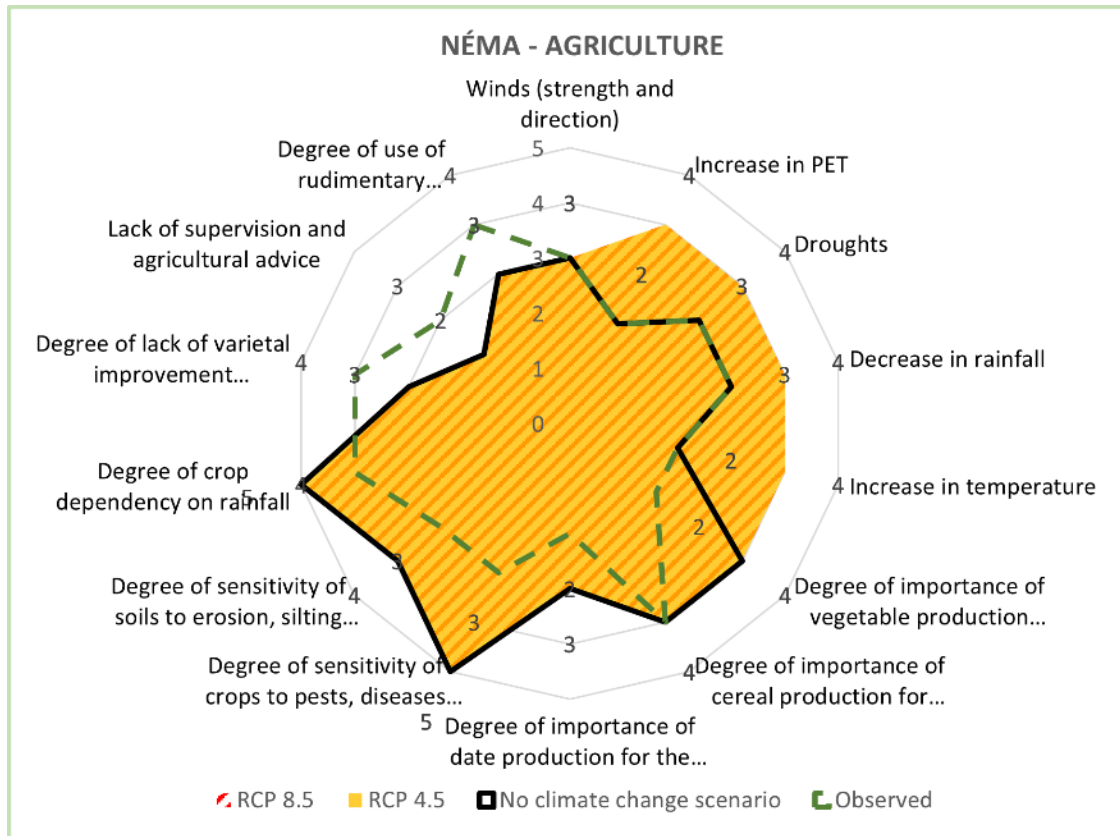
The radar graphs in Figure 73 - 76<sup>713</sup> summarise the risk scores allocated to each risk factor identified in



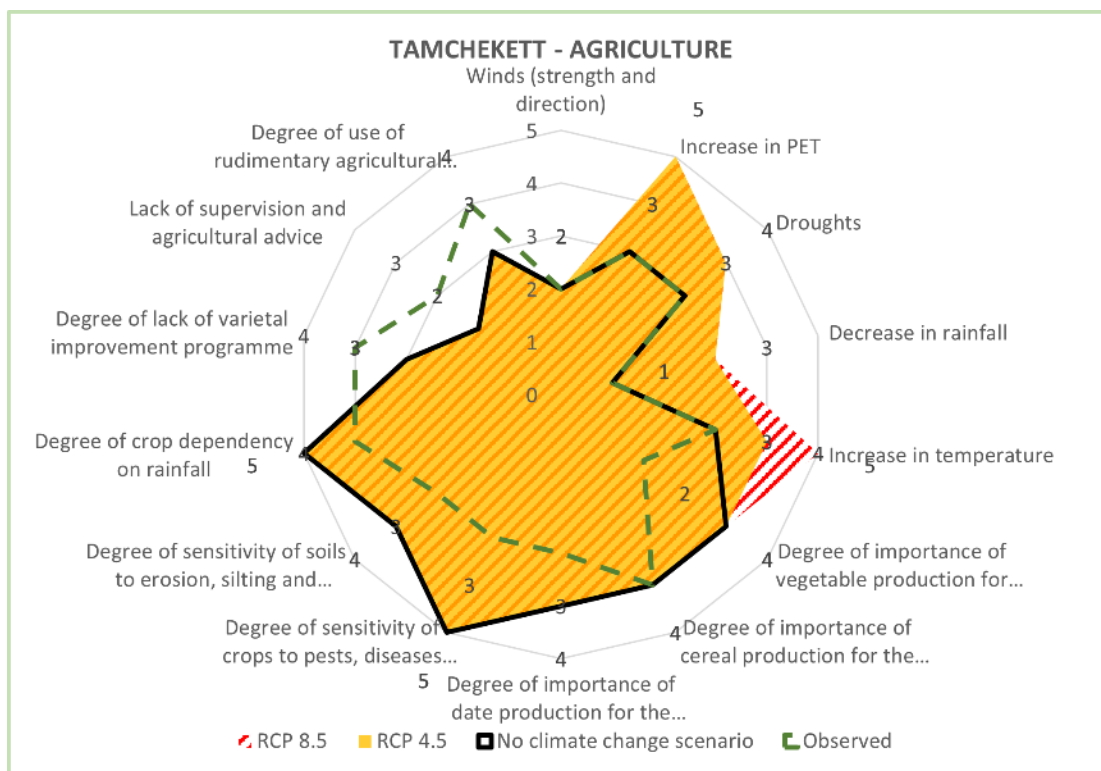
. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 2.1 and Appendix 4).

<sup>713</sup> Appendix 4

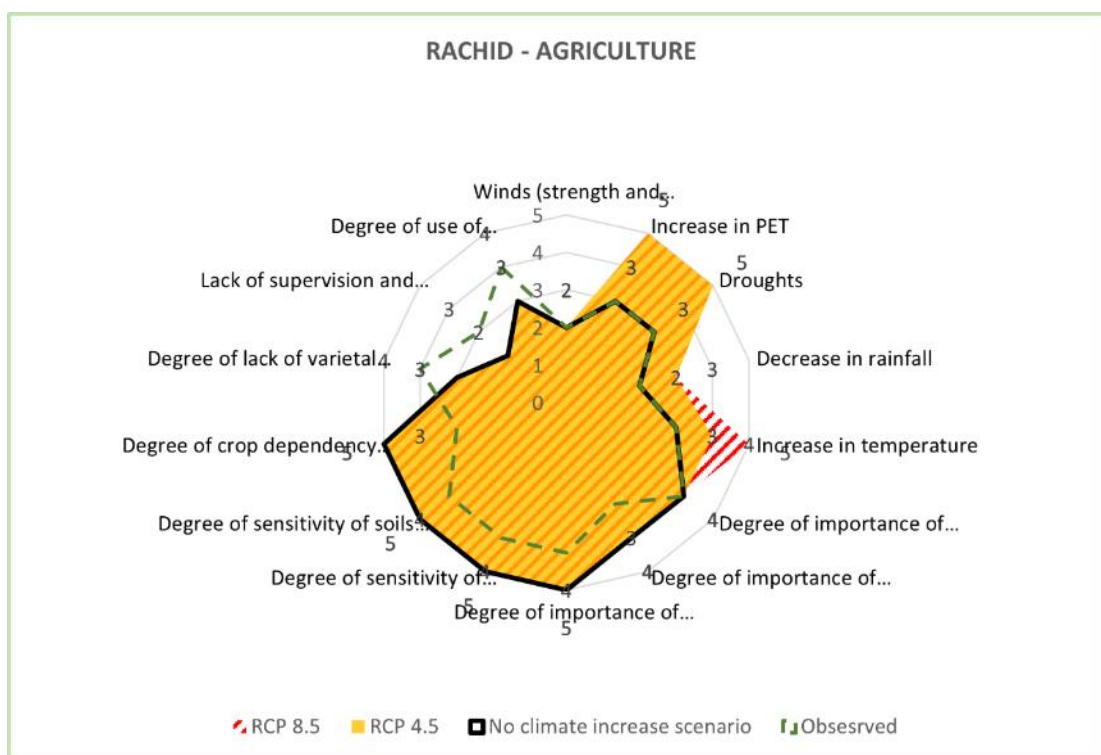




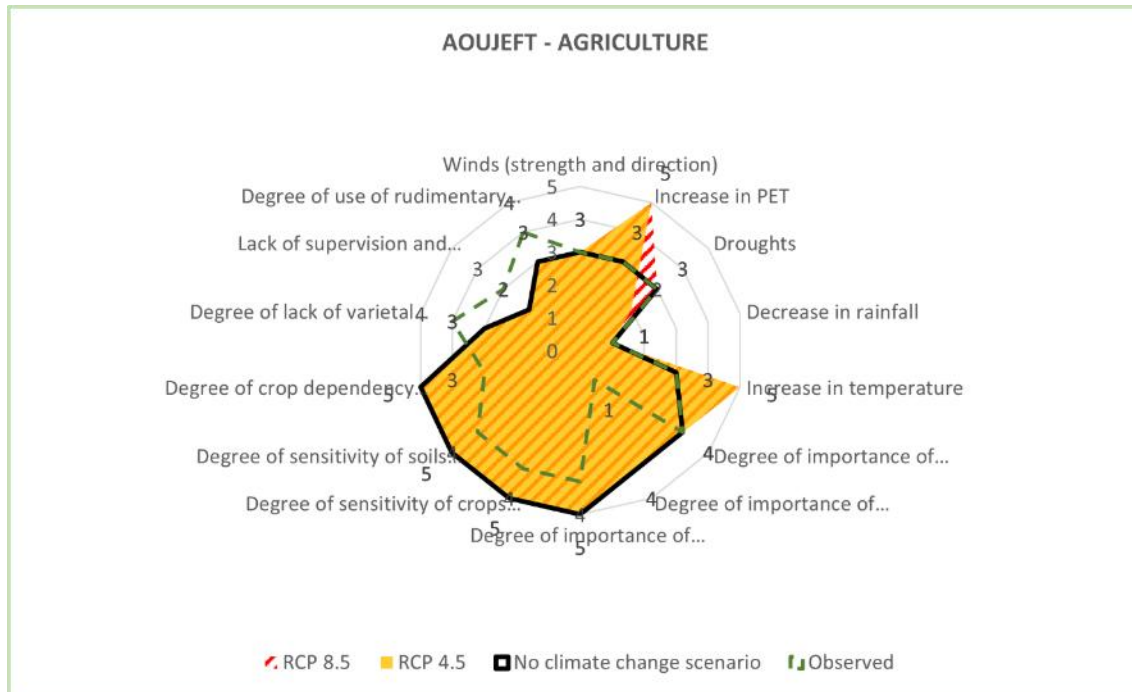
**Figure 72.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on agriculture in Nema.



**Figure 73.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on agriculture in Tamcheket.



**Figure 74.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on agriculture in Rachid.



**Figure 75.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on agriculture in Aoujeft.

Climate-related risk components have been allocated high scores across all four target hubs. These high scores reflect the negative impacts of increasing temperature, increased rates of evapotranspiration (water-balance deficit) and more intense droughts on agricultural yields. Additionally, observed decreases in rainfall within Aoujeft and Nema compound the risk of reduced agricultural yield in these two hubs<sup>714</sup>.

Agriculture is the main economic sector in all four target hubs; consequently, all four regions are particularly exposed to impacts on agricultural yield. Rachid is the most exposed, as a result of high dependence on date palm production, market gardening and cereal crops. The hub of Aoujeft is also highly dependent on palm date production — being the most productive date region countrywide — and market gardening, while Tamcheket is more dependent on cereal crops and, to a lesser extent, phoeniculture<sup>715</sup>.

Vulnerability scores are also high in all four hubs. Aoujeft and Rachid are slightly more vulnerable as a result of: i) the sensitivity of irrigated crops and market gardens to limited water resources; and ii) the sensitivity of their generally bare and dry soil to wind erosion. In contrast, agriculture in Tamcheket and Nema is predominantly rainfed. Food production in these hubs is consequently relatively less sensitive to limited water availability<sup>716</sup>.

Lastly, the adaptive capacity of farmers in all four hubs is limited. A varietal improvement programme has not yet been introduced, existing agricultural practices are fairly rudimentary and supervision by experienced community members is generally limited. The overall risk of reduced agricultural yields is, therefore, high within all four target hubs — but particularly in Rachid and Tamcheket. By 2050, the risk of reduced agricultural yield is projected to increase considerably under both the RCP4.5 and RCP8.5 climate change scenarios<sup>717</sup>.

<sup>714</sup> Appendix 4

<sup>715</sup> Oasis agriculture

<sup>716</sup> Appendix 4

<sup>717</sup> Appendix 4

Exposure, vulnerability and climate hazard risk scores for reduced agricultural production are similar across all four of the proposed project's target hubs.

**Exposure:**

Across all four hubs, exposure scores are high because of communities' heavy dependence on agricultural production for both sustenance and livelihood.

**Vulnerability:**

Within all four hubs, vulnerability scores are high as a result of crops' high sensitivity to climate conditions. Additionally, Aoujeft and Rachid are sensitive to erosion and silting as a result of their inherently dry soil types. Vulnerability is, however, expected to decrease by 2050 following programmes intended to improve agricultural practices and crop varieties.

**Climate change:**

The risk of reduced agricultural yields is expected to increase by 2050 under future climate change scenarios. The impacts of climate change are expected to be particularly important in Rachid, Tamcheket and Nema as a result of increased ETP, extended periods of drought and increased temperatures.

summarises the main findings from the risk analysis for reduced agricultural yields in each of the target hubs.

**Box 3.** Summary of major risks for reduced agricultural yields across the proposed project's target regions.

Exposure, vulnerability and climate hazard risk scores for reduced agricultural production are similar across all four of the proposed project's target hubs.

**Exposure:**

Across all four hubs, exposure scores are high because of communities' heavy dependence on agricultural production for both sustenance and livelihood.

**Vulnerability:**

Within all four hubs, vulnerability scores are high as a result of crops' high sensitivity to climate conditions. Additionally, Aoujeft and Rachid are sensitive to erosion and silting as a result of their inherently dry soil types. Vulnerability is, however, expected to decrease by 2050 following programmes intended to improve agricultural practices and crop varieties.

**Climate change:**

The risk of reduced agricultural yields is expected to increase by 2050 under future climate change scenarios. The impacts of climate change are expected to be particularly important in Rachid, Tamcheket and Nema as a result of increased ETP, extended periods of drought and increased temperatures.

#### 2.7.4 Impacts on livestock production

A shift from pastoral nomadism to sedentism<sup>718</sup> in response to successive droughts has resulted in substantial changes to Mauritania's historically extensive<sup>719</sup> production systems, which have recently diversified to include intensive<sup>720</sup> agricultural management practices<sup>721,722</sup>.

Livestock management in particular has undergone major changes since the 1960s. Intense droughts in the 1970s and 1980s severely impacted livestock farmers in the project's four target hubs, as building up livestock herds is the main strategy for accumulating capital in rural

<sup>718</sup> The practice of living in one place for a long time.

<sup>719</sup> Extensive agriculture utilises large tracts of land, but investment in labour and resources is low.

<sup>720</sup> Intensive farming invests large quantities of resources and labour into small tracts of land to maximise yields.

<sup>721</sup> Ministère du Développement Rural (MDR). 2002.

<sup>722</sup> MDR. 2005.

communities. A major reduction in the availability of water and fodder species resulted in the rural exodus of many livestock farmers, most of whom sold their livestock to urban inhabitants with the investment capital to: i) take advantage of reduced animal prices; and ii) establish sedentary livestock systems near main roads to enable access to fodder supplements and administrative services<sup>723</sup>.

Additionally, new settlements have been established within former wintering grounds in the hubs of Néma and Tamcheket and new water points for livestock have been established along the Road of Hope<sup>724</sup> in the southeast of the country<sup>725</sup>. The deterioration of nomadic herders' living conditions during severe episodes of drought has led to a reduction in the number of pastoral nomads. A shift towards more sedentary lifestyles has been characterised by the appearance of multiple new villages along historical transhumance routes and asphalted roads. Although new methods of peri-urban livestock farming have increased overall livestock production under drought conditions, the shift from transhumance to sedentary farming — particularly of cattle and camels for commercial milk production — has increased pressure on natural resources and accelerated the degradation of natural and agro-ecosystems<sup>726</sup>.

In addition to climate change impacts, non-climatic drivers — urbanisation, population growth, poverty, commercialisation — have induced the following socio-economic impacts on livestock production:

- a shift from pastoral nomadism to transhumance and sedentary livestock farming;
- a change in the ownership of camel herds from rural subsistence farmers to wealthy urban businessmen, for whom camel husbandry provides opportunities for financial investment and prestige;
- the expansion of complementary agricultural and livestock farming, wherein animals exploit not only rangelands close to the farmer's concession, but also crop residues — either directly through grazing or indirectly after cutting and storing yields;
- the development of urban and peri-urban livestock farming systems — particularly using goats, given their ability to digest urban waste and browse ruderal grazing land; and
- the establishment of intensive units (poultry and cattle) and semi-intensive dairy units (cattle and camels).

Over time, pastoral nomadism has evolved towards a sedentary livestock system, with a subsequent reduction in transhumant movements. This has resulted in the overexploitation of grazing and browsing areas that surround settlements. Additionally, confining larger herds to smaller pastures has increased the demand for fodder supplements and veterinary inputs. The commercialisation of camel farming by urban businessmen has also resulted in the overexploitation of natural resources in historically transhumant zones. This has, in turn, caused conflict between sedentary farmers and agropastoral nomads, whose access to land, water and fodder has been reduced. These socio-economic impacts have led to the establishment of a growing number of villages. As a result of the migration of working-age men to urban centres in search of employment, populations within these settlements are mostly comprised of women and children<sup>727</sup>.

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<sup>724</sup> The Road of Hope (Route de l'Espoir) is a 1,200 km-long road connecting Néma to the capital city of Nouakchott.

<sup>725</sup> FAO. 2001. The Road of Hope: control of moving sand dunes in Mauritania. Available at: <https://www.fao.org/3/y2795e/y2795e07.htm>.

<sup>726</sup> OSS. 2015. Mauritanie: Atlas des cartes d'occupation du sol — Projet amélioration de la résilience des populations sahéliennes aux mutations environnementales.

<sup>727</sup> OSS. 2015. Mauritanie: Atlas des cartes d'occupation du sol — Projet amélioration de la résilience des populations sahéliennes aux mutations environnementales.

Climate change impacts on livestock production:

- Rangeland degradation as a result of silting and/or drought — particularly in Nema and Tamcheket hub;
- Reduced milk yields during drought;
- Reduced cattle productivity and increased intervals between births during drought;
- Emergence of new livestock diseases (e.g. Rift Valley fever) and epizootic diseases;
- Declines in the most palatable fodder species, including *Senegalisa senegal* (formerly *Acacia senegal*) and *Commifora africana* — particularly in Rachid hub;
- Drying up of pastoral wells as a result of drought;
- Increased animal mortality during drought.

Non-climate impacts on livestock production:

- Shift from nomadic pastoral systems to sedentary farming, with subsequent reductions in the spatial and temporal transhumance of cattle herds;
- Concentration of livestock around settlements for socioeconomic reasons, including improved market access;
- Increased domestic work for women and children as a result of decreased transhumance and more sedentary lifestyles;
- Increased financial burden on livestock farmers as a result of increased expenses relating to fodder supplements and veterinary inputs.

provides a summary of the main climate change-induced and non-climate impacts on livestock production within the proposed project's target regions<sup>728</sup>.

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**Box 4.** Summary of climate and non-climate impacts on livestock production within the proposed project's target hubs<sup>729</sup>.

Climate change impacts on livestock production:

- Rangeland degradation as a result of silting and/or drought — particularly in Nema and Tamcheket hub;
- Reduced milk yields during drought;
- Reduced cattle productivity and increased intervals between births during drought;
- Emergence of new livestock diseases (e.g. Rift Valley fever) and epizootic diseases;
- Declines in the most palatable fodder species, including *Senegalisa senegal* (formerly *Acacia senegal*) and *Commifora africana* — particularly in Rachid hub;
- Drying up of pastoral wells as a result of drought;
- Increased animal mortality during drought.

Non-climate impacts on livestock production:

- Shift from nomadic pastoral systems to sedentary farming, with subsequent reductions in the spatial and temporal transhumance of cattle herds;
- Concentration of livestock around settlements for socioeconomic reasons, including improved market access;
- Increased domestic work for women and children as a result of decreased transhumance and more sedentary lifestyles;
- Increased financial burden on livestock farmers as a result of increased expenses relating to fodder supplements and veterinary inputs.

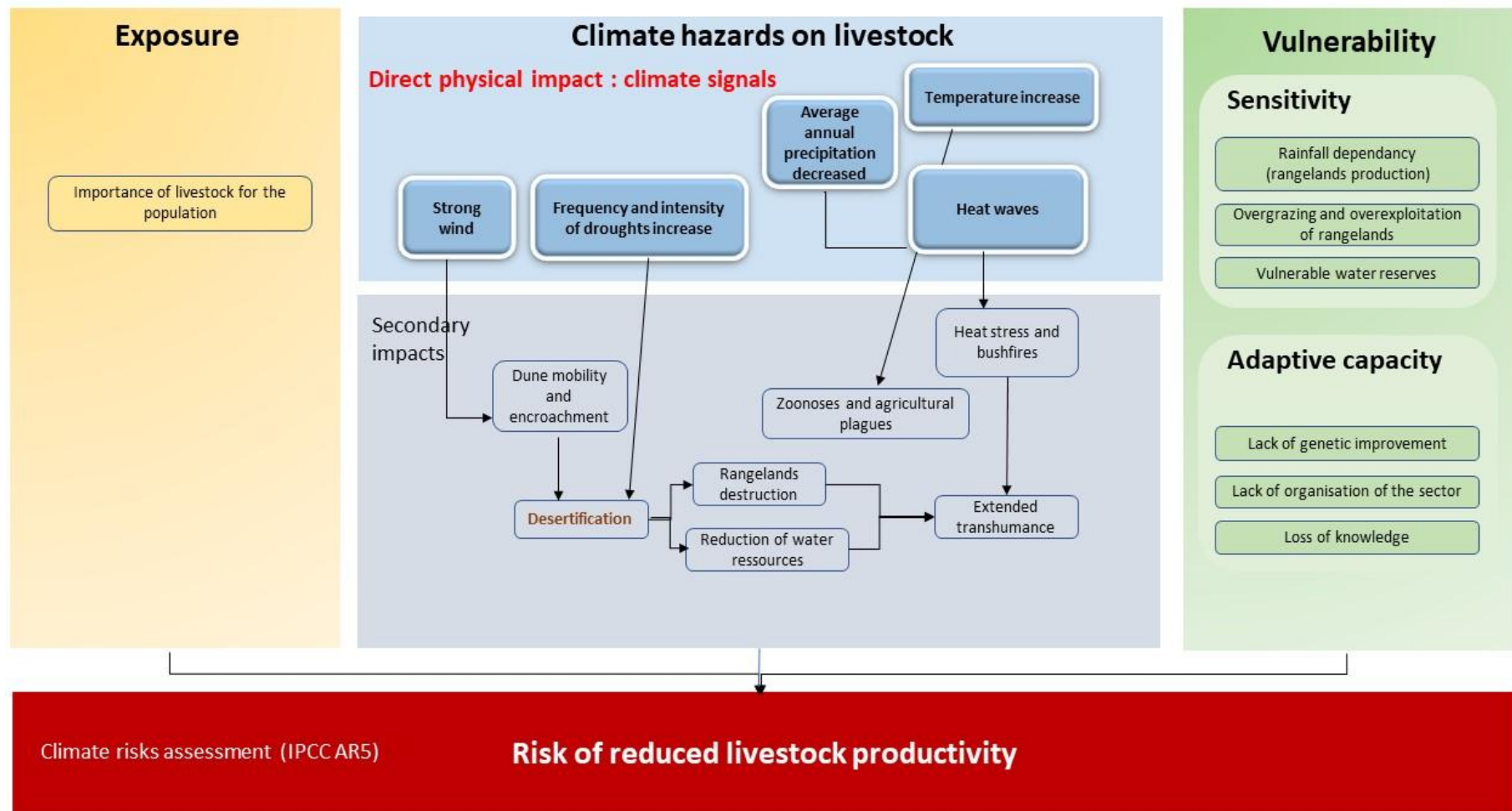
### **Risk of climate change impacts on livestock production**

Figure 76 summarises the jointly developed risk chain for reduced agricultural yields. It includes exposure, climate hazard (direct physical impacts) and vulnerability risks identified during focus group discussions with national experts. Secondary impacts were used only to guide discussions on exposure and vulnerability.

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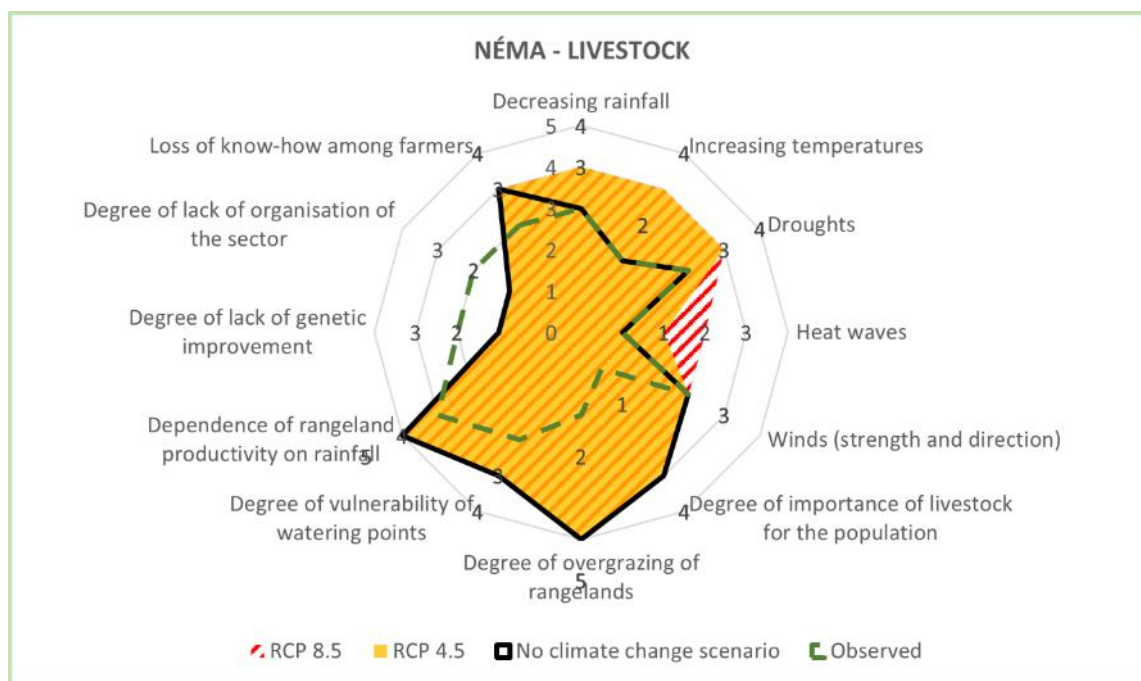




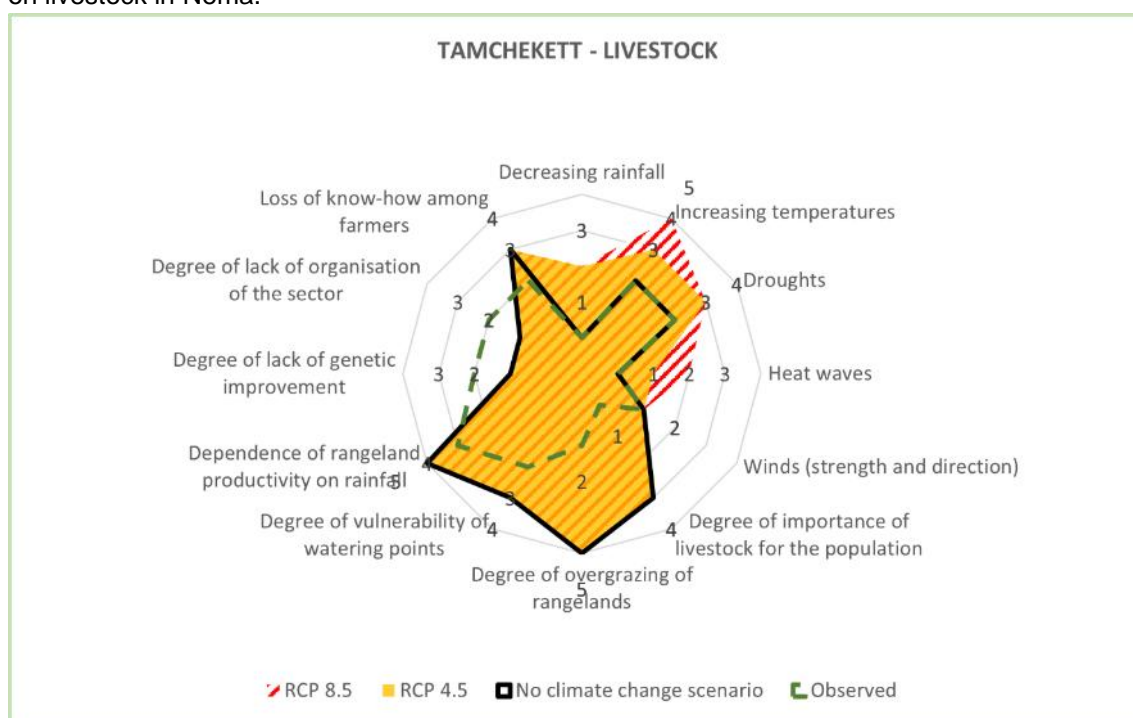
**Figure 76.** Risk chain for vulnerability, exposure and climate change impacts on livestock production.



The radar graphs in Figures 78 - 81<sup>730</sup> summarise the risk scores allocated to each risk factor identified in Figure 76. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 2.1).

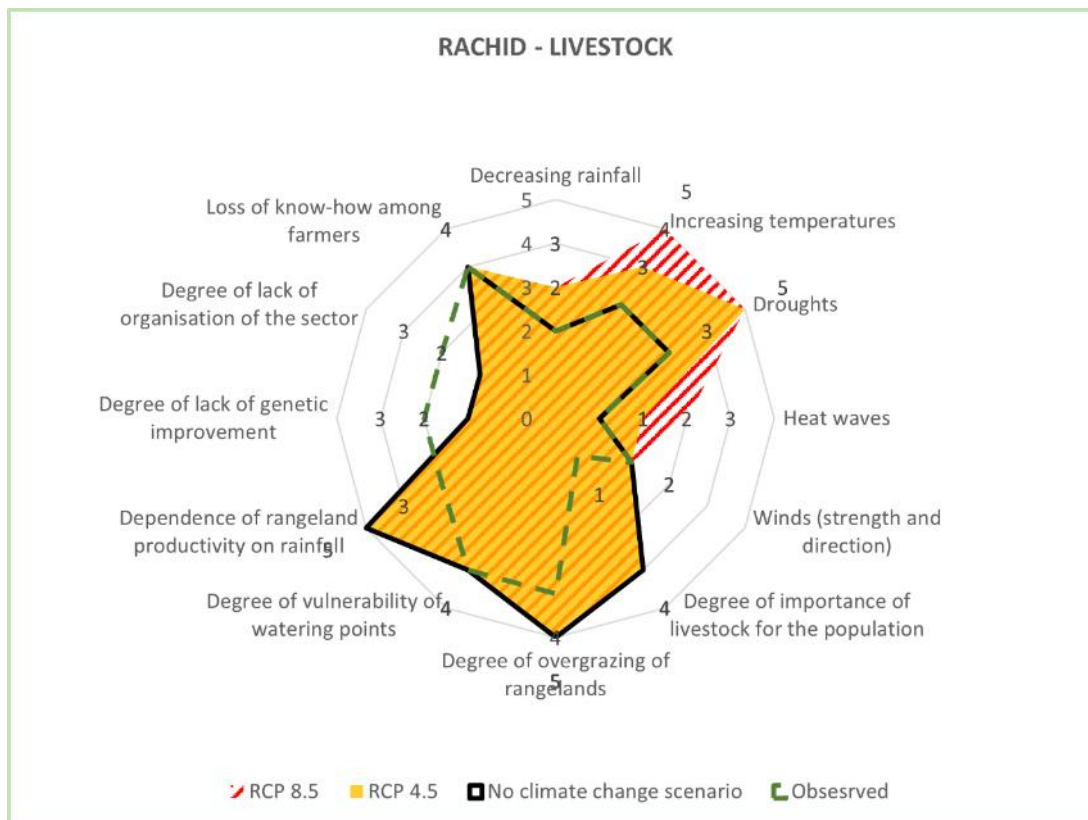


**Figure 77.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on livestock in Nema.

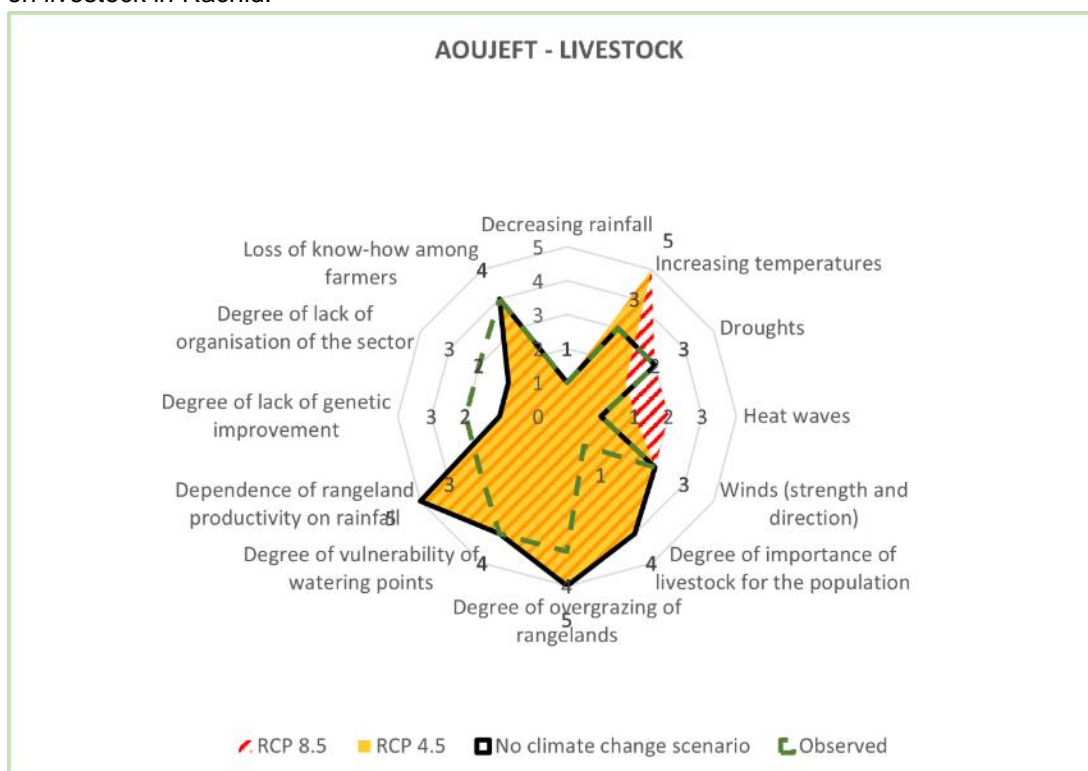


**Figure 78.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on livestock in Tamcheket.

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**Figure 79.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on livestock in Rachid.



**Figure 80.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on livestock in Aoujeft.

Livestock farming is an important economic activity in all four hubs. As a result, all four target regions are highly exposed to the impacts of reduced livestock production. Vulnerability scores are also high across all four hubs, but Aoujeft and Rachid are particularly sensitive to reduced livestock production as a result of overgrazing and the drying up of pastoral water points. In Nema and Tamcheket, livestock farming depends heavily on rainfall, which directly impacts the productivity of rangelands and the availability of fodder. As a result, the climate component of risk is particularly high in these two hubs. Additionally, the risks associated with limited adaptive capacity are high in all four target regions. This is largely the result of: i) delays in the establishment of programmes for the genetic improvement of livestock breeds; ii) limited organisation within the livestock sector; and iii) a severe loss of knowledge among breeders because of the rural exodus, particularly in Aoujeft and Rachid. By 2050, exposure and vulnerability are expected to remain high, and the climate component of risk is predicted to be by up to 64% in Rachid and 70% in Tamcheket under RCP8.5<sup>731</sup>.

Exposure, vulnerability and climate hazard risk scores for reduced agricultural production are similar across all four of the proposed project's target hubs.

**Exposure:**

Across all four hubs, exposure scores are high because of communities' heavy dependence on agricultural production for both sustenance and livelihood.

**Vulnerability:**

Within all four hubs, vulnerability scores are high as a result of crops' high sensitivity to climate conditions. Additionally, Aoujeft and Rachid are sensitive to erosion and silting as a result of their inherently dry soil types. Vulnerability is, however, expected to decrease by 2050 following programmes intended to improve agricultural practices and crop varieties.

**Climate change:**

The risk of reduced agricultural yields is expected to increase by 2050 under future climate change scenarios. The impacts of climate change are expected to be particularly important in Rachid, Tamcheket and Nema as a result of increased ETP, extended periods of drought and increased temperatures.

5 summarises the main findings from the risk analysis for flood impacts in each of the four target hubs.

**Box 5.** Summary of major risks for reduced livestock production across the proposed project's target regions<sup>732</sup>.

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Exposure, vulnerability and climate hazard risk scores for reduced livestock production are similar across all four of the proposed project's target hubs.

**Exposure:**

Across all four hubs, exposure scores are high as a result of populations' heavy dependence on livestock for income generation.

**Vulnerability:**

Vulnerability risk scores are high across all four hubs as a result of: i) overgrazing, particularly in Aoujeft and Rachid; ii) the dependence of rangelands on rainfall; and iii) the loss of farming knowledge among farmers as a result of the rural exodus. However, planned programmes for genetic improvement and better organisation of the sector are expected to reduce vulnerability by 2050.

**Climate hazard:**

Climate change hazard components have been allocated high scores in Rachid, Nema and Tamcheket as a result of increasing temperatures, more severe droughts and more intense heatwaves.

## 2.7.5 Impacts on infrastructure

Silting of both ecosystems and infrastructure — including roads, buildings, wells and palm groves — is a major challenge within the proposed project's four rural-urban hubs. Silting has impacted all production systems in Tamcheket and has reduced the resilience of communities and ecosystems in all four target regions<sup>733</sup>. Table 44 summarises the hub-level impacts of silting identified during focus group discussions with national experts and community members during field visits by national consultants.

**Table 44.** Synthesis of silting impacts identified during focus group discussions with national experts in each of the proposed project's target rural-urban hubs<sup>734</sup>.

Hub	Infrastructure	Degree/intensity of silting	Observed impacts/comments
Nema	Palm grove and wells in Oued Nkhal Agouenit	Completely buried	Rural exodus to larger cities
	Rainfed agriculture in Tichilit Talh	Completely buried	Rural exodus to larger cities
	Wells in Zangra and Bamoir	Completely buried	Displacement of populations
	Oued Tatrart commune	Completely buried	Reduced agricultural land
Tamcheket	Entire city of Tamcheket	Highly threatened by gullying	Urgent measures required
Rachid	Taoujeft commune and wadi	Highly threatened by gullying	Urgent measures required
	Wadi Narzik, Talmedi commune and Tenwarer palm groves	Completely buried	Urgent measures required
	Road network connecting Rachid-Tidjikja and Ain Savra	Very threatened (~60% buried)	Urgent measures required

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<sup>734</sup> Appendix 4

Hub	Infrastructure	Degree/intensity of silting	Observed impacts/comments
	Wadi Rachid, Dakhlet palm groves and wells	Highly threatened	Urgent measures required
	North-western parts of Rachid	Highly threatened	Urgent measures required
	Palm grove Iriji, Fom Dar et Saguia	Highly threatened	Urgent measures required
<b>Aoujeft</b>	Oued Tenmour palm groves	Completely buried	Displacement of populations
	Aoujeft city palm groves	Completely buried	Displacement of populations
	North-eastern parts of the Loudeye palm grove	Completely buried	Displacement of populations
	Atar Aoujeft Rachid road	Very threatened (~70% buried)	Daily mechanical desilting required
	Entire city of Aoujeft	Very threatened	Urgent measures required
	Tenwemed commune and palm grove	Very threatened	Urgent measures required
	Mataa Moulana tenwemed	Very threatened	Urgent measures required
	Ain savra	Very threatened	Urgent measures required

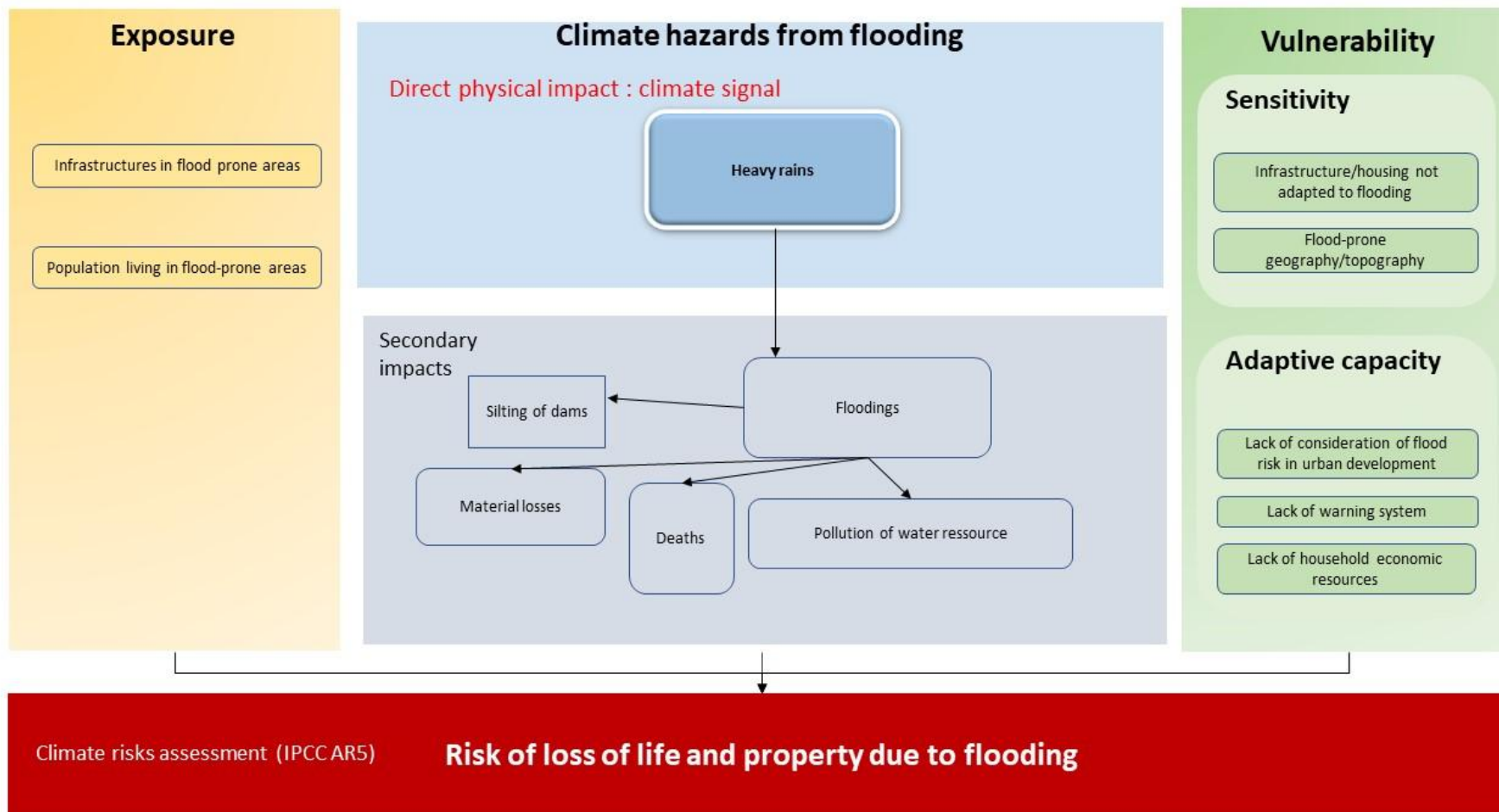
Additionally, silting has exacerbated flooding during intense rainfall events across all four rural-urban hubs. Although flooding events are relatively rare given the context of decreasing annual rainfall and increasing drought intensity across Mauritania, floods within the proposed project's target region often result in: i) the loss of both human and livestock life; ii) damage to palm groves, human settlements, natural ecosystems, agricultural lands and road networks; and iii) a reduction in communities' capacities to produce livestock and agricultural produce for subsistence and income generation. For example, the dam of Toueymirt — located ~10 km south-east of the town of Tamcheket — was severely damaged by flooding in the same year it was built. Consequently, the downstream town of Tintane — located in the wilayah of Hodh El Gharbi — was severely flooded by fast-flowing waters originating from the El Aguer plateau in Tamcheket hub. Extensive damage to agricultural fields, properties and infrastructure was reported following this extreme climate event. These impacts facilitate the expansion of shanty towns<sup>735</sup> and contribute to the rural exodus by reducing the quality of life in rural settlements. The impacts of climate change-induced floods therefore place communities' livelihoods and well-being at risk and accelerate the degradation of important natural resources upon which rural communities are heavily dependent for both sustenance and income generation<sup>736</sup>.

### **Risk of climate change impacts on infrastructure**

Figure 81 represents the jointly developed risk chain for flooding in the proposed project's target regions. This risk chain includes exposure, vulnerability and climate hazard (direct physical impacts) risks identified during focus group discussions facilitated by national consultants in Mauritania. Secondary impacts were used only to guide discussions on exposure and vulnerability.

<sup>735</sup> A deprived area on the outskirts of a town consisting of large numbers of shanty dwellings, or shacks.

<sup>736</sup> Appendix 4

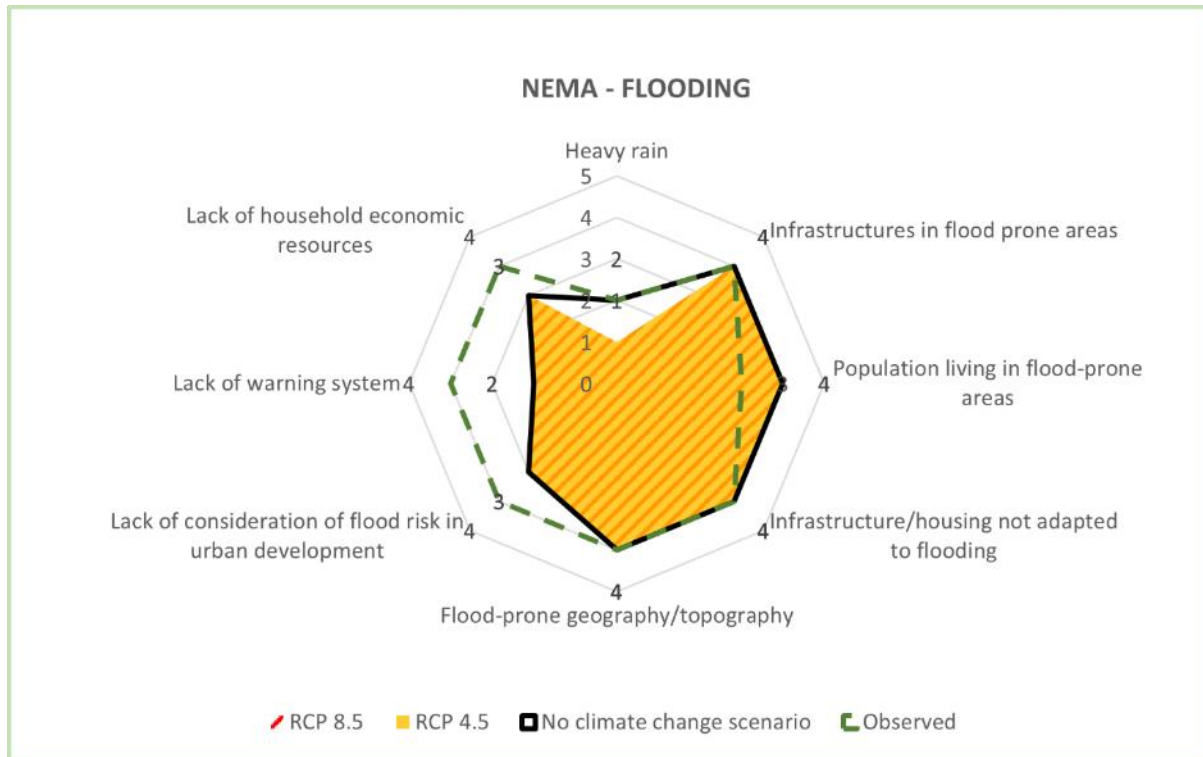


**Figure 81.** Risk chain for vulnerability, exposure and climate change impacts on flooding and damage to infrastructure<sup>737</sup>.

<sup>737</sup> Appendix 4

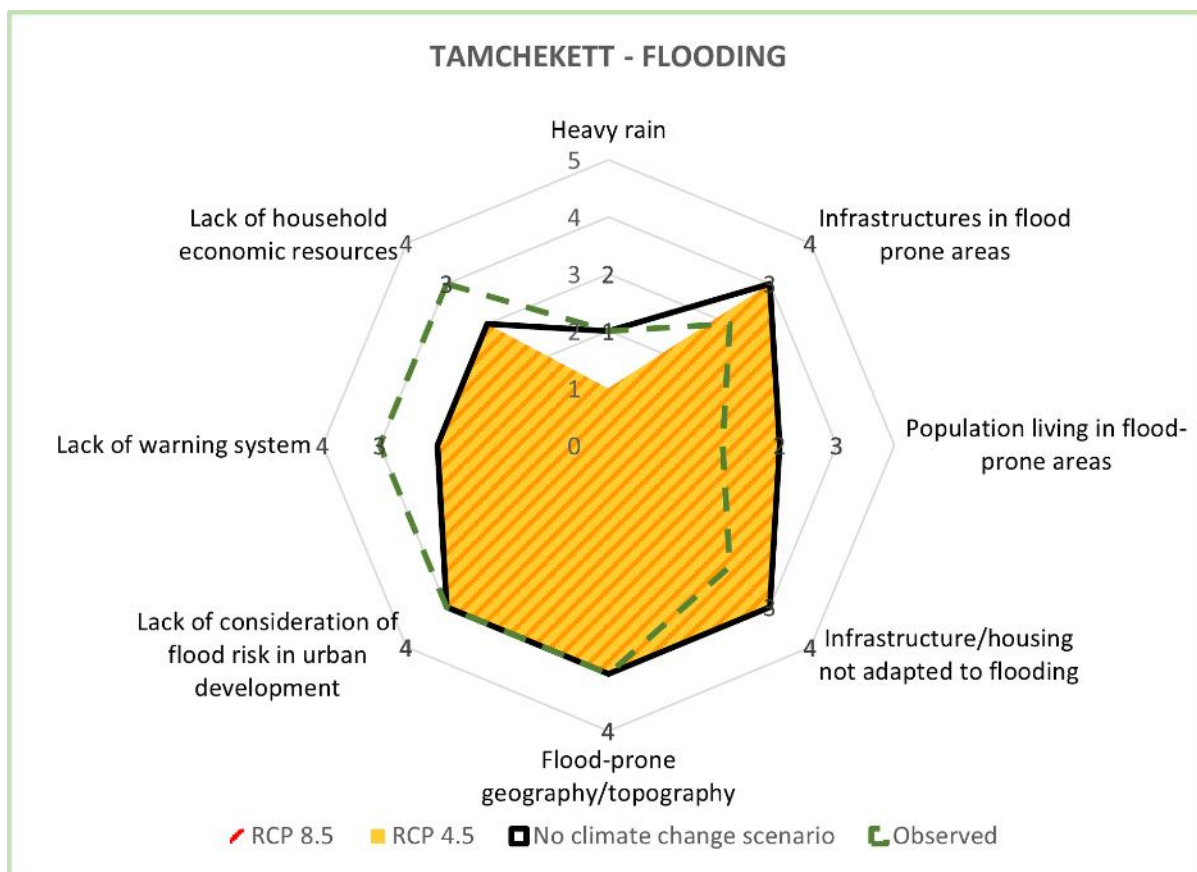


The radar graphs in Figure 83 – Figure 86<sup>738</sup> summarise the risk scores allocated to each risk factor identified in Figure 76. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 2.1).

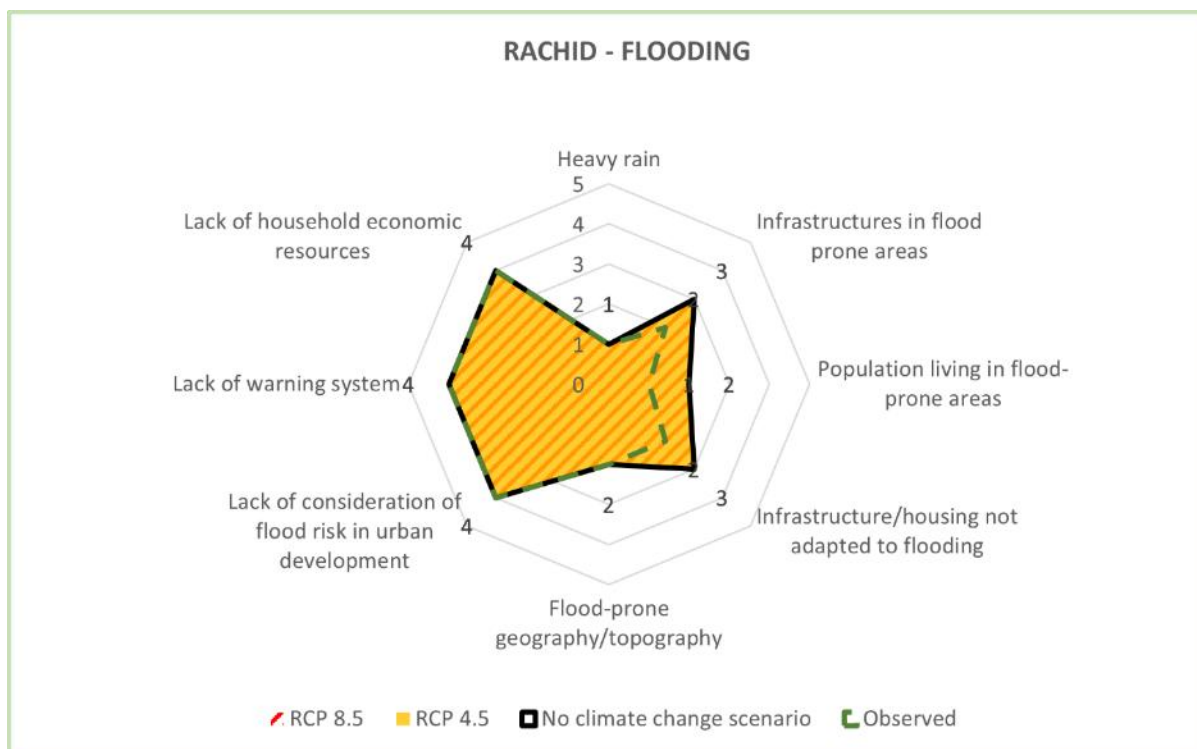


**Figure 82.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on flooding and associated damage to infrastructure in Nema.

<sup>738</sup> Appendix 4

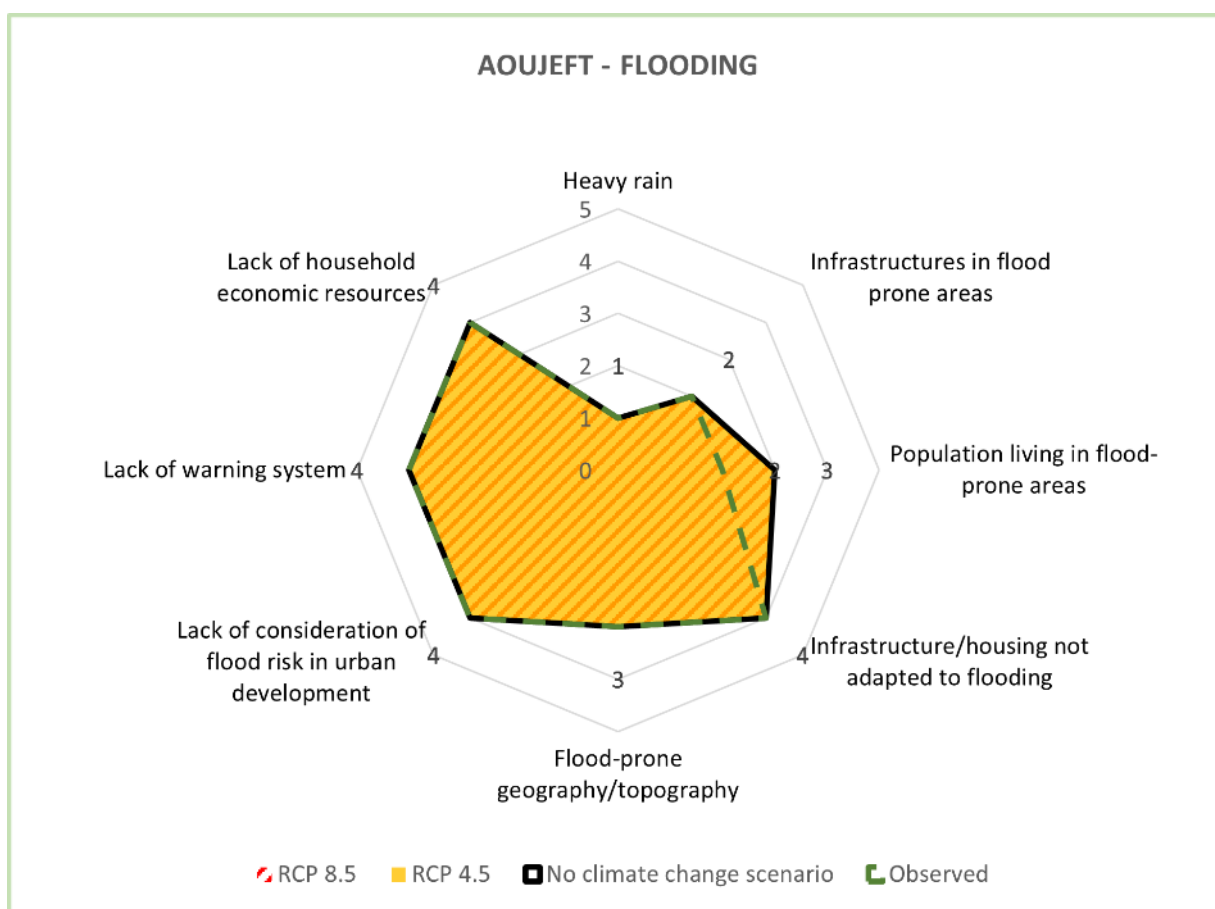


**Figure 83.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on flooding and associated damage to infrastructure in Tamcheket.



**Figure 84.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on flooding and associated damage to infrastructure in Rachid.





**Figure 85.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on flooding and associated damage to infrastructure in Aoujeft.

The current risk of flooding is relatively high in the rural-urban hub of Nema and lower in the other three hubs. The high observed risk in Nema is mostly explained by the hub's high exposure and vulnerability scores, which compound the impacts of climate hazards. Nema hub is particularly vulnerable to flooding as a result of its topography — which is characterised by the convergence of catchment areas and low-lying areas — and poor drainage infrastructure. The hubs of Aoujeft and Tamcheket are also located within regions characterised by the convergence of several watersheds, which increases their vulnerability to flooding<sup>739</sup>.

Although the risk of heavy rainfall is low across all four rural-urban hubs, the climatic component of flood risk is lowest in Aoujeft and Rachid under observed and projected climate change scenarios (RCP4.5 and RCP8.5). Additionally, the vulnerability component of risk is relatively low in Rachid hub, as most infrastructure within the region has been built on elevated ground. As a result, few people in Rachid live within flood-prone areas<sup>740</sup>.

By 2050, projected decreases in the frequency of heavy rainfall events contribute to a decrease in the overall risk of floods across all four hubs. The risk of flooding is expected to decrease by ~50% in Tamcheket and Nema, while in Rachid and Aoujeft the projected risk of flooding is expected to be negligible under the RCP4.5 and RCP8.5 GHG emissions scenarios. The overall flood risk is expected to be highest in Nema hub under all future

<sup>739</sup> Appendix 4

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scenarios, as a large proportion of the hub's population live in flood-prone areas and are therefore very exposed to flood-related impacts<sup>741</sup>. Box 6 provides a summary of the main findings for each of the proposed project's four target hubs.

**Box 6.** Summary of major risks for flood damage across the proposed project's target regions<sup>742</sup>.

**Nema and Tamcheket:**

Both observed and projected exposure and vulnerability scores for Nema are relatively high as a result of: i) the presence of informal settlements within flood-prone areas; and ii) limited flood-defence infrastructure. The climate hazard component of risk currently exacerbates the impacts of flooding on infrastructure, but the climate risk component is projected to decrease by 2050 under the RCP4.5 and RCP8.4 GHG emissions scenarios as a result of fewer heavy rainfall events. The risk scores obtained for Tamcheket are similar to those obtained for Nema, but the population in Tamcheket has lower observed and projected exposure scores as a result of fewer communities living in flood-prone areas.

**Aoujeft and Rachid:**

The overall risk of flooding is lowest in Aoujeft and Rachid. This is mainly explained by low exposure scores, as the topography in these hubs is less conducive to flooding. In Rachid, for example, most infrastructure is positioned on elevated ground above flood levels. Additionally, the incidence of heavy rainfall events is lower in these two hubs than in Tamcheket and Nema.

## 2.7.6 Impacts on health

The impacts of climate change on Mauritania's water and agricultural sectors — including, *inter alia*, decreased water quality and availability and reduced food production — have resulted in increased malnutrition and the accelerated spread of infectious and parasitic diseases, particularly in children below the age of five<sup>743</sup>. Additionally, more frequent and intense heatwaves — particularly within the Tagant and Assaba mountain ranges — have increased the incidences of dehydration and heatstroke. Following the country's first reports of heat stroke-related casualties in 2012, the health sector in Mauritania was selected as a priority sector for addressing climate change impacts. As a result of limited data availability, however, health sector interventions were not incorporated into the Fourth National Communication (2019)<sup>744</sup>.

The 'urban heat island' phenomenon<sup>745</sup> also has negative implications for human health in Mauritania. Grey infrastructure absorbs more heat than natural ecosystems, so as sedentary populations expand and settlements grow, temperatures within the surrounding environment increase. As a result, those engaged in outdoor activities — for example, practitioners of subsistence agriculture — are increasingly exposed to high temperatures, which increase the risk of heat stroke and dehydration. Additionally, ecosystem degradation, together with the expansion of grey infrastructure, has enhanced the albedo effect<sup>746</sup> across North Africa. Increased albedo increases the risk of exposure to ultra-violet rays, which may partly explain the observed increase in skin cancer incidences across Mauritania. The absence of dermatologists and other health professionals in rural health posts does, however, limit the

<sup>741</sup> Appendix 4

<sup>742</sup> Appendix 4

<sup>743</sup> WFP. 2015. WFP Mauritania brief.

<sup>744</sup> République Islamique de Mauritanie, 2019. Fourth National Communication to the UNFCCC.

<sup>745</sup> Urban heat islands occur when cities replace natural land cover with dense concentrations of pavement, buildings and other surfaces that absorb and retain heat.

<sup>746</sup> Albedo is an expression of the ability of surfaces to reflect sunlight (heat from the sun). Light-coloured surfaces return a large part of the sunrays back to the atmosphere (high albedo), while dark surfaces absorb the sunrays (low albedo).

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availability of data to confirm the contribution of climate change to increased cases of skin disease<sup>747,748</sup>.

In addition to the above, ecosystem degradation in Mauritania has been linked to: i) increased incidences of malaria as a result of the proliferation of mosquitoes; ii) high blood pressure in response to increasing temperatures; iii) diseases related to reproductive health; and iv) malnutrition and nutritional anaemia as a result of food deficiencies. Moreover, during an interview with national consultants, the Regional Directorate for Health Action in Tagant reported an increase in the incidence of the following health conditions<sup>749</sup>:

- vector-borne diseases;
- schistosomiasis;
- venereal diseases;
- Rift Valley fever outbreaks;
- dysentery;
- trachoma;
- conjunctivitis; and
- heat stroke.

### **Risk of climate change impacts on livestock production**

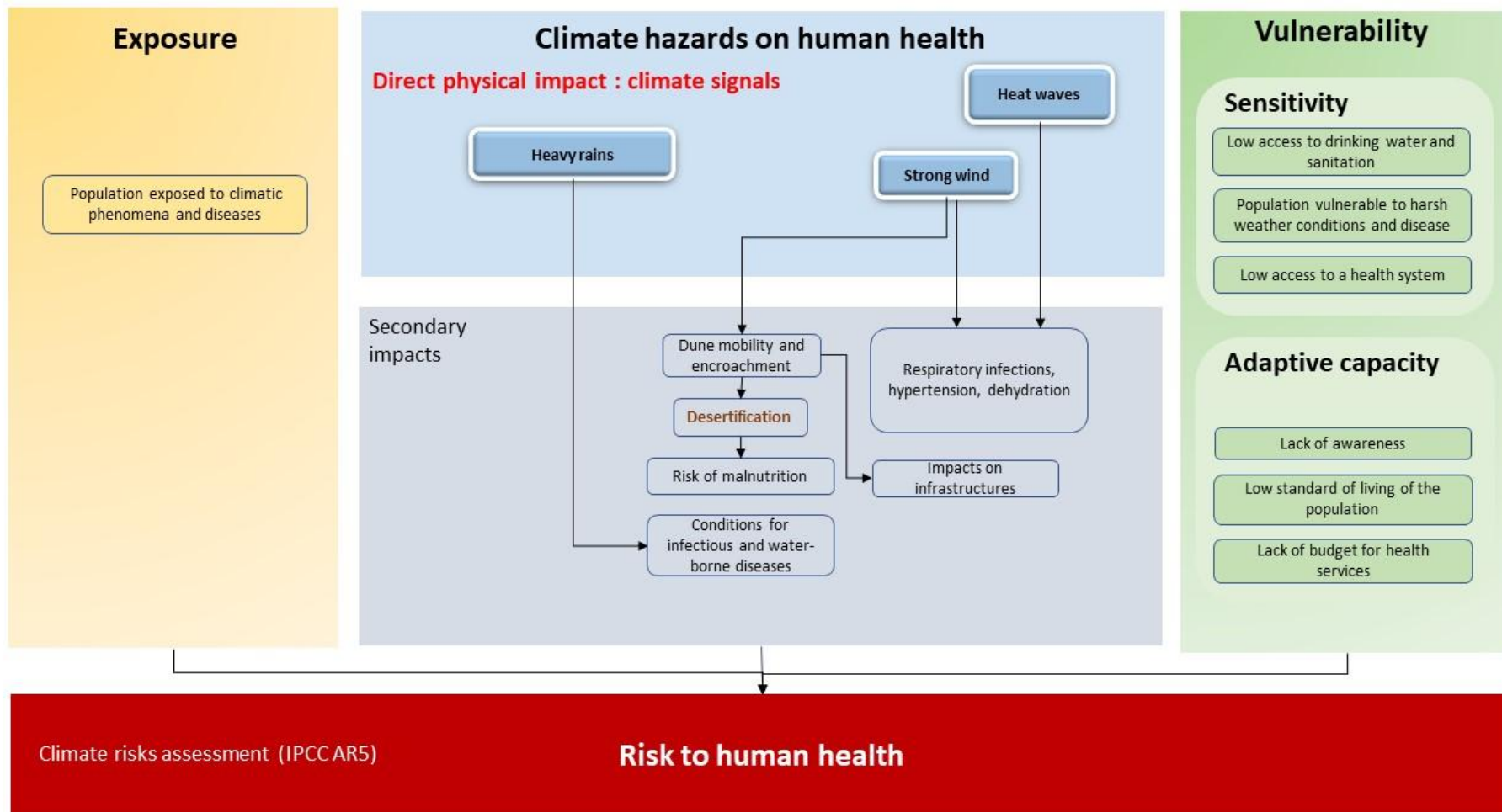
Figure 86 provides a summary of the jointly developed risks chain for impacts on health in the proposed project's target regions. This risk chain includes exposure, vulnerability and climate hazard (direct physical impacts) risks identified during focus group discussions facilitated by national consultants in Mauritania. Secondary impacts were used only to guide discussions on exposure and vulnerability.

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<sup>747</sup> Coates SJ, Enbale W, Davis MDP & Andersen LK. 2020. The effects of climate change on human health in Africa, a dermatologic perspective: a report from the International Society of Dermatology Climate Change Committee. *International Journal of Dermatology*, 59(3): 265–278. DOI: 10.1111/ijd.14759.

<sup>748</sup> Muller SA. 2011. Climate change, dermatology and ecosystem services; trends and trade-offs. *International Journal of Dermatology*, 50(5): 504–507. DOI: 10.1111/j.1365-4632.2011.04929.

<sup>749</sup> Appendix 4



**Figure 86.** Risk chain for vulnerability, exposure and climate change impacts on health<sup>750</sup>.

<sup>750</sup> Appendix 4

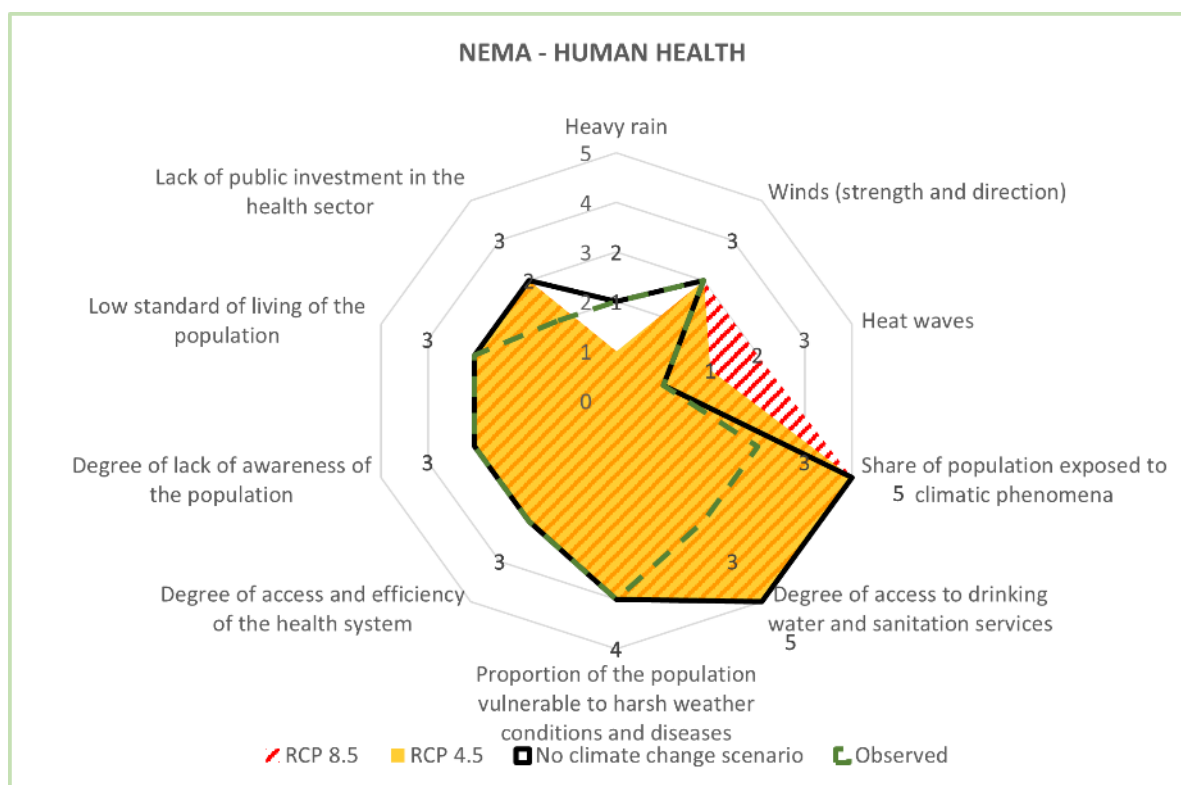
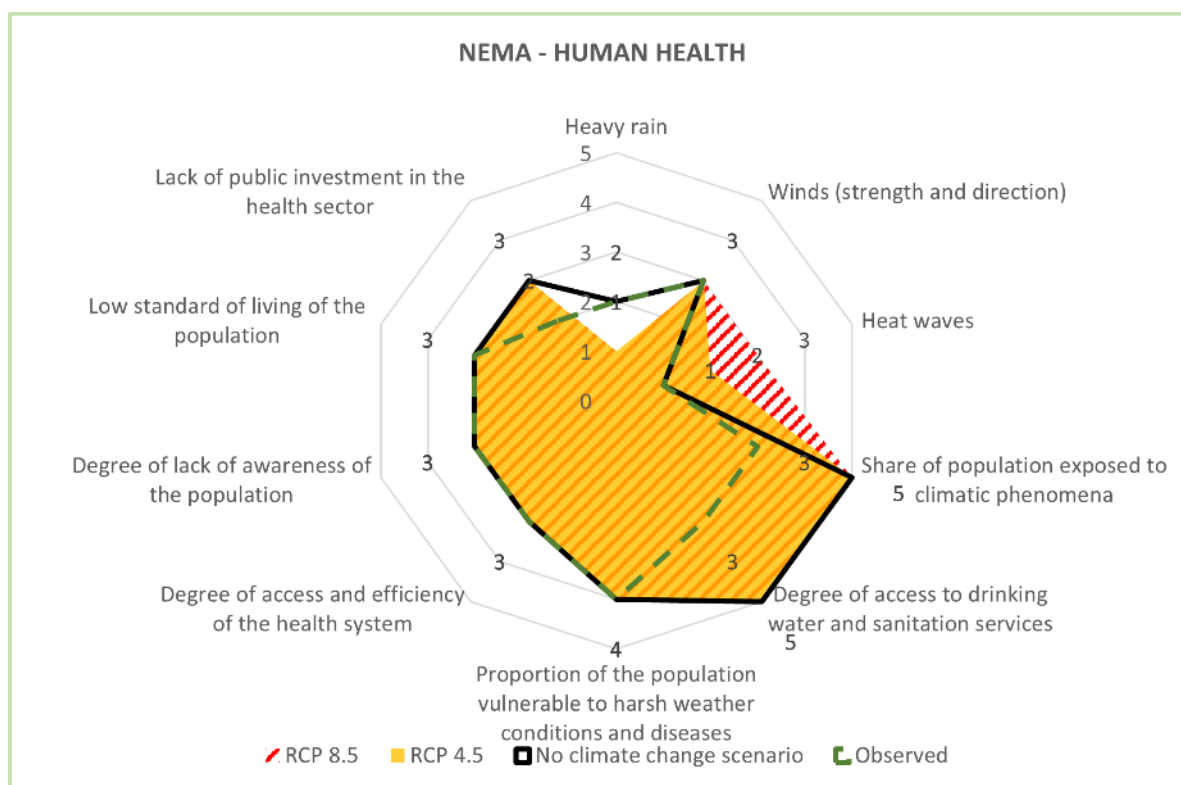
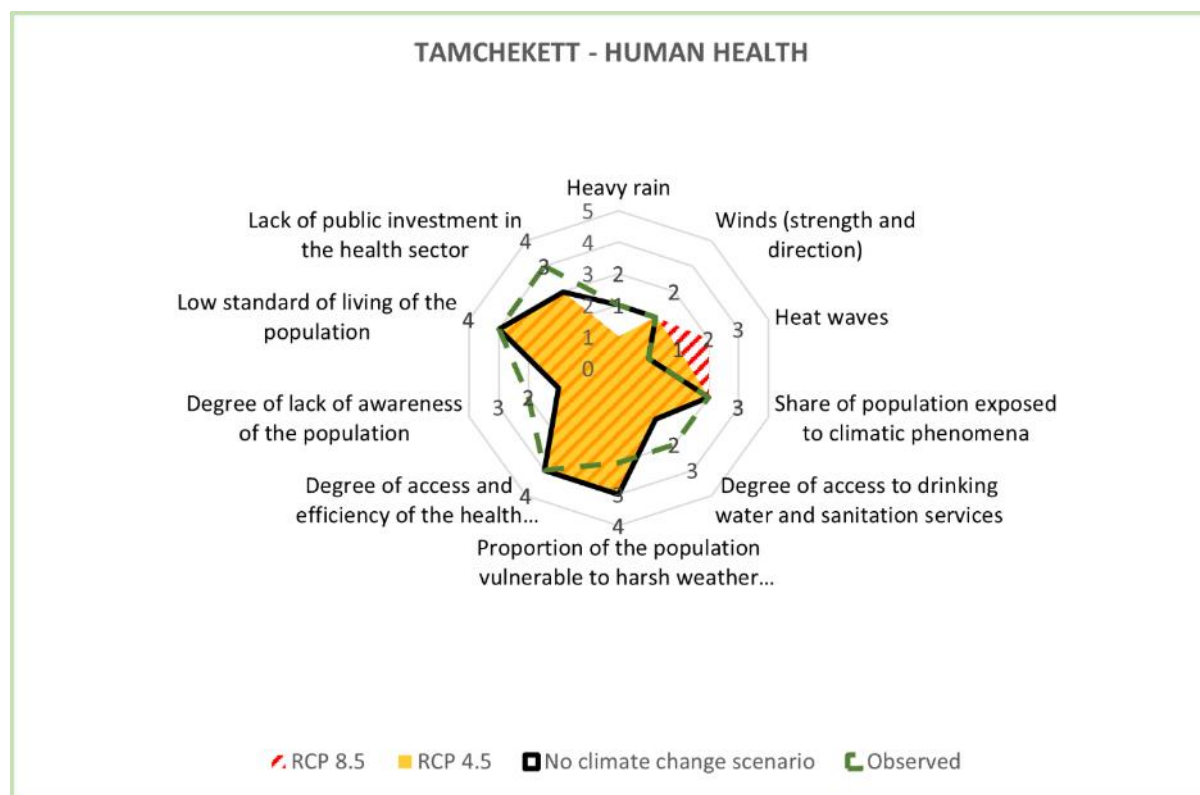


Figure 87–Figure 90<sup>751</sup> summarise the risk scores allocated to each risk factor identified in Figure 76. Observed and projected (2050) risk scores were assigned according to the criteria provided in Table 25 and Table 26, as described in the methodology (Section 2.1).

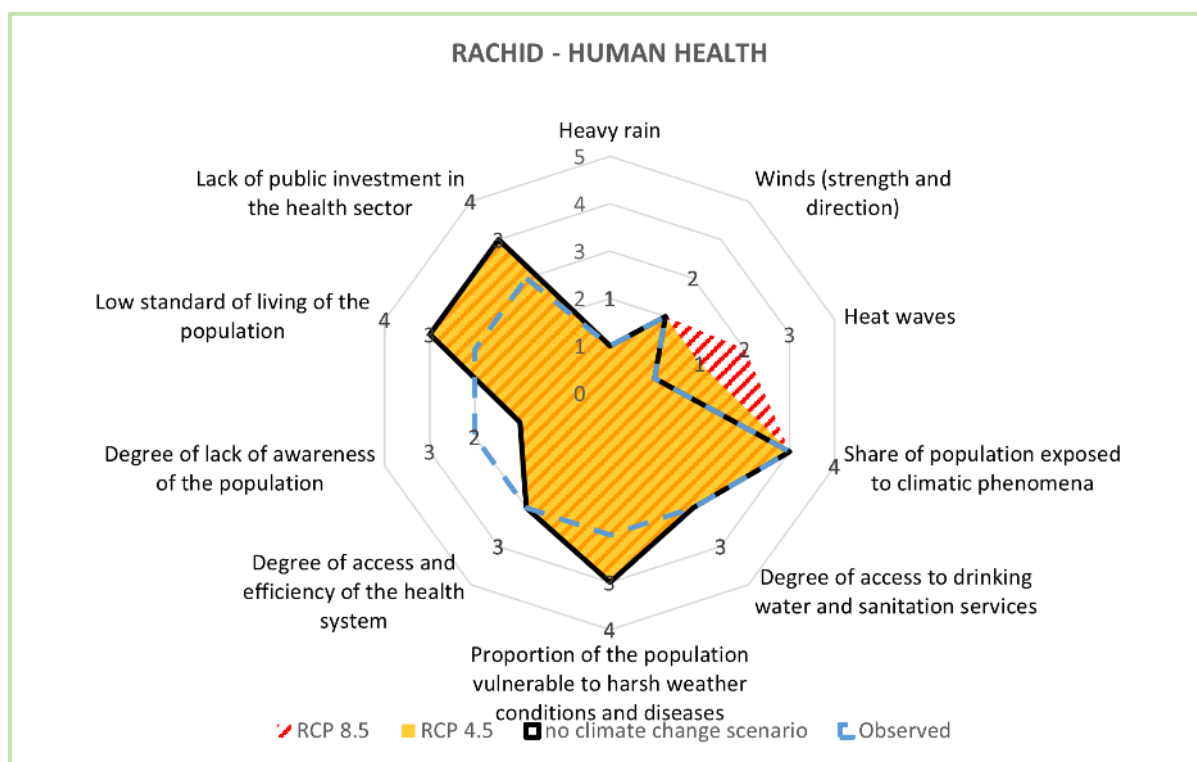


<sup>751</sup> Appendix 4

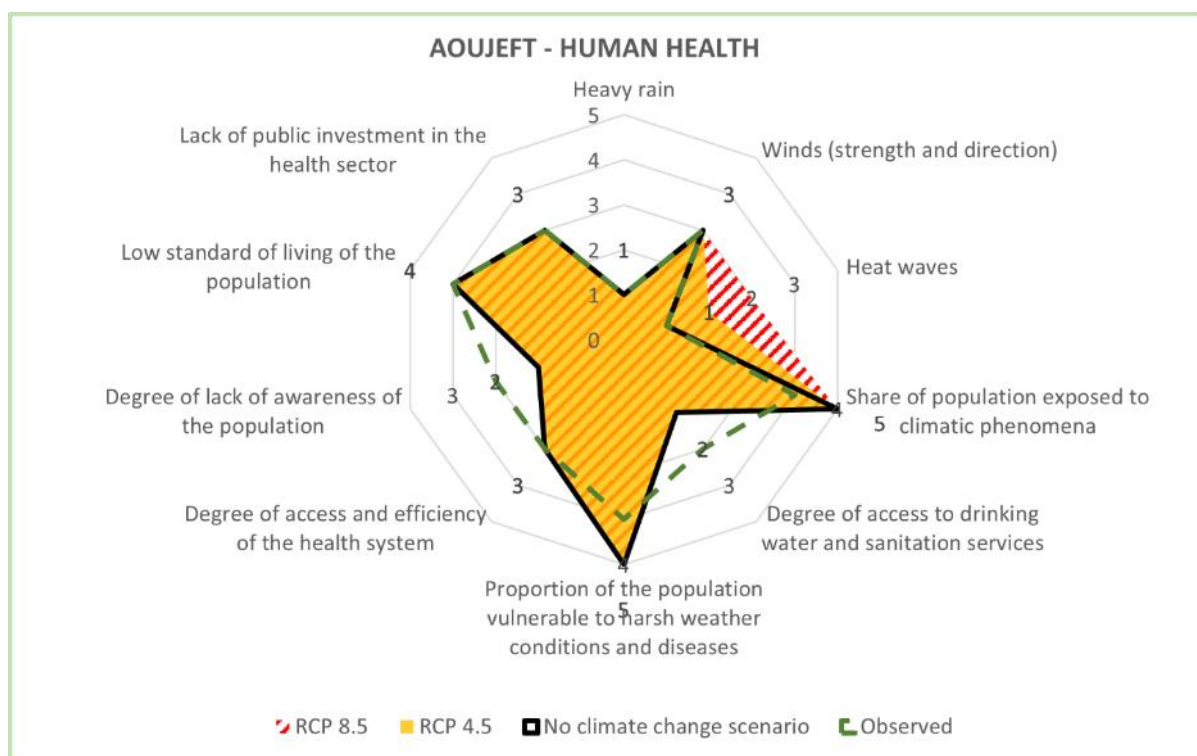
**Figure 87.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on health in Nema.



**Figure 88.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on health in Tamcheket.



**Figure 89.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on health in Rachid.



**Figure 90.** Observed and projected risk scores for vulnerability, exposure and climate change impacts on health in Aoujeft.

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The overall risk of human health impacts is currently moderate in all of the proposed project's target hubs; the highest risk score is in Aoujeft, while the lowest overall risk is in Rachid. The climate component of risk is relatively low in all four hubs. The highest climate risk scores are in Aoujeft and Rachid. These are mostly associated with strong winds, which not only cause respiratory problems as a result of the dispersion of sand and dust particles, but also isolate populations from health centres via the silting up of roads. The observed and projected risk scores for heatwaves are still reasonably low in all hubs, but during stakeholder consultations, local communities expressed concerns over the health implications of extreme heat<sup>752</sup>.

The exposure component of risk is particularly evident in the hubs of Aoujeft and Rachid, where large parts of the population are exposed to inherently harsh weather conditions and extreme climatic events. Vulnerability scores are also extremely high in all of the proposed project's focal hubs, which reflects rural populations' limited access to clean drinking water, sanitation services and healthcare facilities. The populations in Aoujeft and Nema are particularly vulnerable to health impacts: in Aoujeft, the prevalence of climate-related diseases has resulted in high infant mortality rates, while in Nema, high poverty rates (52%) limit the population's access to healthcare. Additionally, access to health posts is particularly difficult for isolated populations in Tamcheket hub. The adaptive capacity of populations within the proposed project's target hubs is further limited by the low standard of living of the population and limited education regarding major health challenges<sup>753</sup>.

By 2050, the expected deterioration of already limited health services in Nema and Aoujeft is projected to considerably increase vulnerability and exposure to health impacts in these hubs. Additionally, by 2050, climate change is projected to increase the risk of health impacts in Aoujeft and Rachid by 20–25% under the RCP4.5 GHG emissions scenario and by 17–50% under the RCP8.5 emissions scenario. In contrast, the climate risk component in Nema and Tamcheket is expected to remain stable under projected climate change scenarios<sup>754</sup>. Box 7 summarises the main findings from the risk analysis for impacts on health in each of the proposed project's target hubs.

**Box 7.** Summary of main risks for impacts on health across the proposed project's target regions<sup>755</sup>.

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**Aoujeft:**

High exposure and vulnerability scores have been allocated for the current situation. Exposure is projected to increase by 2050 as a result of accelerated desertification, which is expected to have negative health implications for the population. Additionally, projected climate change under the RCP4.5 and RCP8.5 emissions scenarios is expected to increase pressure on the healthcare system as a result of expected increases in the incidence of climate-related diseases.

**Rachid:**

High exposure and vulnerability scores have been observed for the current situation. The vulnerability risk component is projected to increase by 2050 as a result of: i) the population's poor standard of living; and ii) the poor quality of healthcare facilities in the region. Projected climate change scenarios increase the risk of health impacts, mainly as a result of anticipated increases in the frequency and intensity of heatwaves.

**Tamcheket:**

Moderate exposure and vulnerability scores have been allocated for the current situation in Tamcheket. By 2050, vulnerability is projected to decrease following the establishment of a new health centre in the hub. Climate change is not expected to considerably increase the risk of health impacts under the RCP4.5 and RCP8.5 GHG emissions scenarios.

**Nema:**

Exposure and vulnerability scores are relatively low for the current situation, but exposure to health impacts is expected to increase by 2050 as a result of the need to travel further distances for transhumance. Under future climate change scenarios, projected climate change is expected to have limited impacts on health.

### 2.7.7 Climate change risk ranking for each hub

The findings of sectoral climate risk analyses for each rural-urban hub are synthesised in the text to follow. The radar graphs in Figure 91–Figure 94 summarise the mean observed and projected (2050) risk scores for each sector under four scenarios: i) the current situation; ii) a future scenario with no climate change; iii) the RCP4.5 future climate change scenario; and iv) the RCP8.5 future climate change scenario. Detailed calculations of the risk scores for each sector are provided in Annex 4.

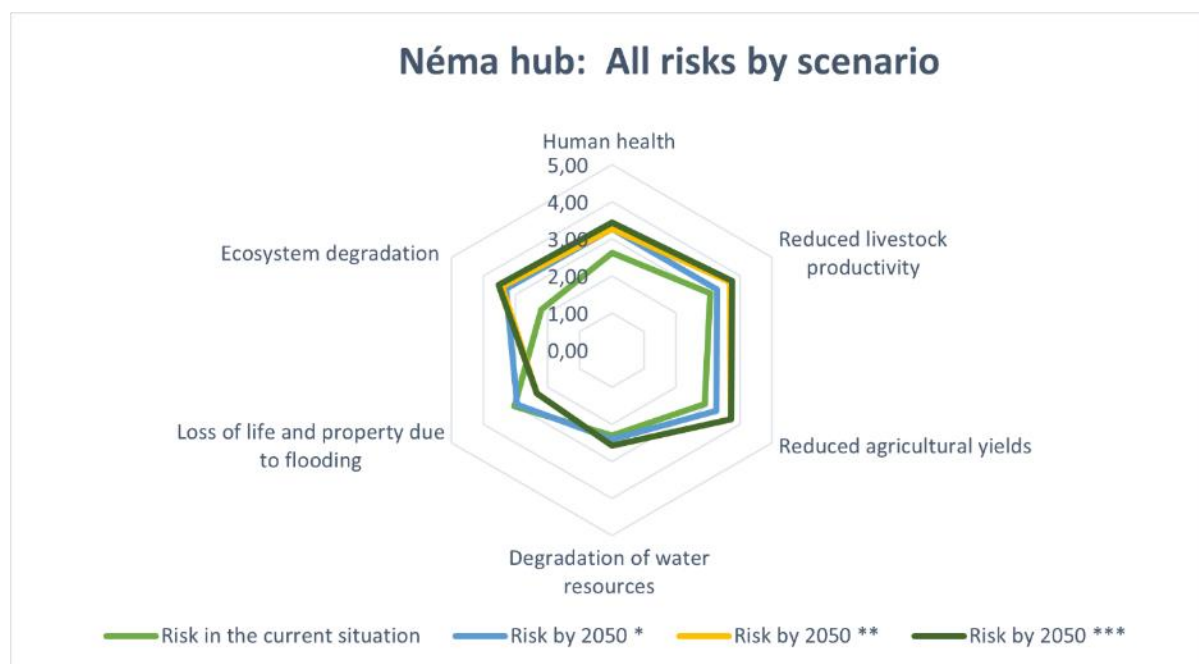
**Nema**

In Nema hub, the highest-ranking climate change risks — for both observed and projected climate scenarios — are associated with reduced agricultural yields and livestock productivity (Figure 91). Additionally, by 2050 the risk of climate change-induced ecosystem degradation is projected to be very high under both the RCP4.5 and RCP8.5 emissions scenarios. The risk of impacts on these sectors is mainly explained by observed and projected increases in evapotranspiration across the region. .

**Table 45** summarises the climate change risk levels associated with each sector in Nema under both observed and projected climate scenarios<sup>756</sup>.

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**Figure 91.** Synthesis of observed and projected (2050) risk levels for climate change impacts on major sectors in Néma hub (\* = no climate change; \*\* = RCP4.5; \*\*\* = RCP8.5)<sup>757</sup>.

**Table 45.** Summary of climate change risk levels associated with major sectors in Nema under observed and projected climate scenarios<sup>758</sup>.

Risk level	Observed	RCP 4.5	RCP 8.5
Very High (require urgent intervention)	Flood damage to infrastructure	Reduced livestock productivity	Reduced livestock productivity
	Reduced livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Reduced agricultural yields	Ecosystem degradation	Ecosystem degradation
High	Human health	Human health	Human health
	Water resources degradation	Water resources degradation	Water resources degradation
Moderate	Ecosystem degradation	Flood damage to infrastructure	Flood damage to infrastructure

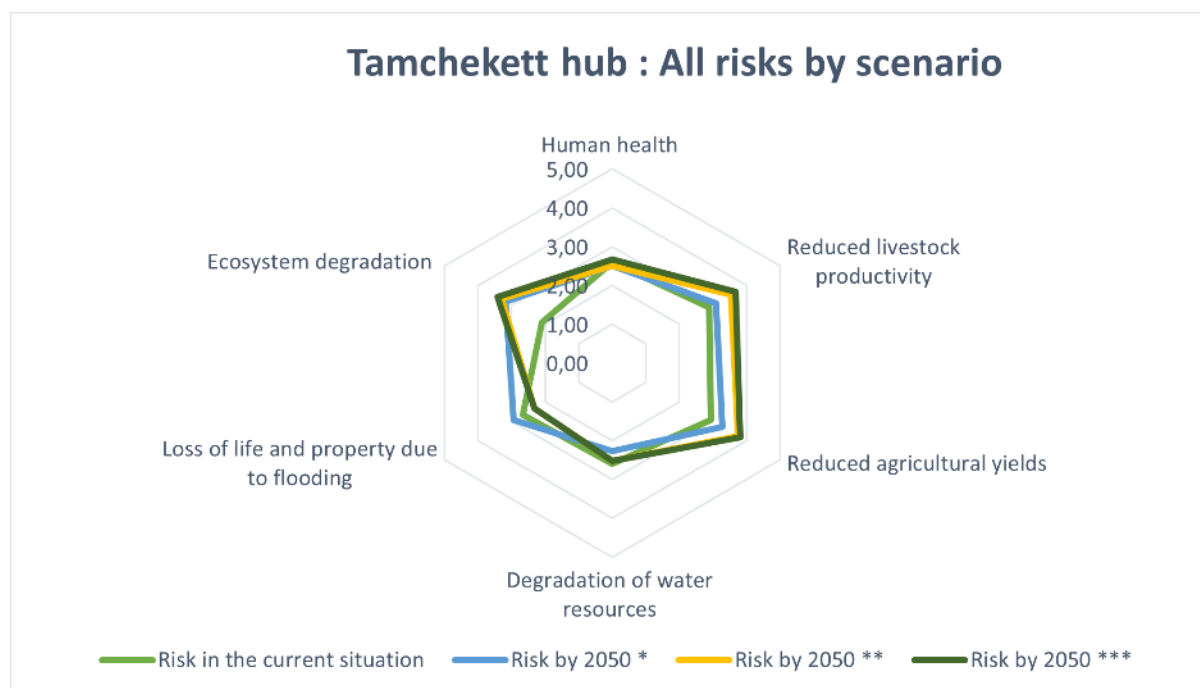
### Tamcheket

In Tamcheket hub, the highest climate change risk levels relate to reduced agricultural yields, reduced livestock productivity and accelerated ecosystem degradation (Figure 92). The particularly high-risk scores associated with these sectors are mainly explained by the projected increases in evapotranspiration under both the RCP4.5 and RCP8.5 GHG emissions scenarios. Table 46 summarises the climate change risk levels associated with each sector in Tamcheket under both observed and projected climate scenarios<sup>759</sup>.

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**Figure 92.** Synthesis of observed and projected (2050) risk levels for climate change impacts on major sectors in Tamchekett hub (\* = no climate change; \*\* = RCP4.5; \*\*\* = RCP8.5)<sup>760</sup>.

**Table 46.** Summary of climate change risk levels associated with major sectors in Tamchekett under observed and projected climate scenarios<sup>761</sup>.

Risk level	Observed	RCP 4.5	RCP 8.5
Very High (require urgent intervention)	Reduced agricultural yields	Reduced livestock productivity	Reduced livestock productivity
	Reduced livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Flood damage to infrastructure	Ecosystem degradation	Ecosystem degradation
High	Human health	Human health	Human health
	Degradation of water resources	Degradation of water resources	Degradation of water resources
Moderate	Ecosystem degradation	Flood damage to infrastructure	Flood damage to infrastructure

### Rachid

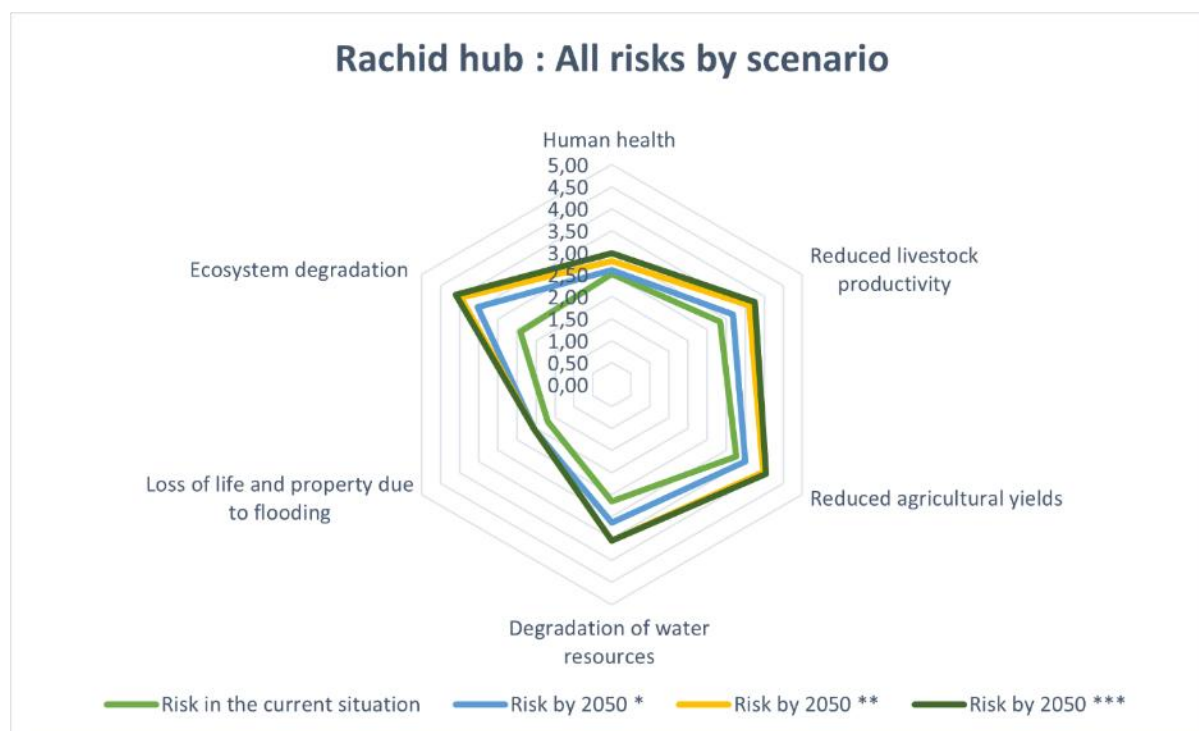
In Rachid hub, the highest climate change risk levels are associated with ecosystem degradation, resource degradation, reduced livestock productivity and reduced agricultural yields (Figure 93). The high-risk scores associated with these sectors are largely explained by projected increases in both evapotranspiration and temperature under future climate change scenarios (RCP4.5 and RCP8.5)<sup>762</sup>. Table 47 summarises the climate change risk levels associated with each sector in Rachid under both observed and projected climate scenarios<sup>763</sup>.

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**Figure 93.** Synthesis of observed and projected (2050) risk levels for climate change impacts on major sectors in Rachid hub (\* = no climate change; \*\* = RCP4.5; \*\*\* = RCP8.5)<sup>764</sup>.

**Table 47.** Summary of climate change risk levels associated with major sectors in Rachid under observed and projected climate scenarios<sup>765</sup>.

Risk level	Observed	RCP 4.5	RCP 8.5
Very High (require urgent intervention)	Reduced agricultural yields	Ecosystem degradation	Ecosystem degradation
	Reduced livestock productivity	Reduced agricultural yields	Reduced agricultural yields
	Degradation of water resources	Degradation of water resources	Degradation of water resources
High	Human health	Reduced livestock productivity	Reduced livestock productivity
	Ecosystem degradation	Human health	Human health
Moderate	Flood damage to infrastructure	Flood damage to infrastructure	Flood damage to infrastructure

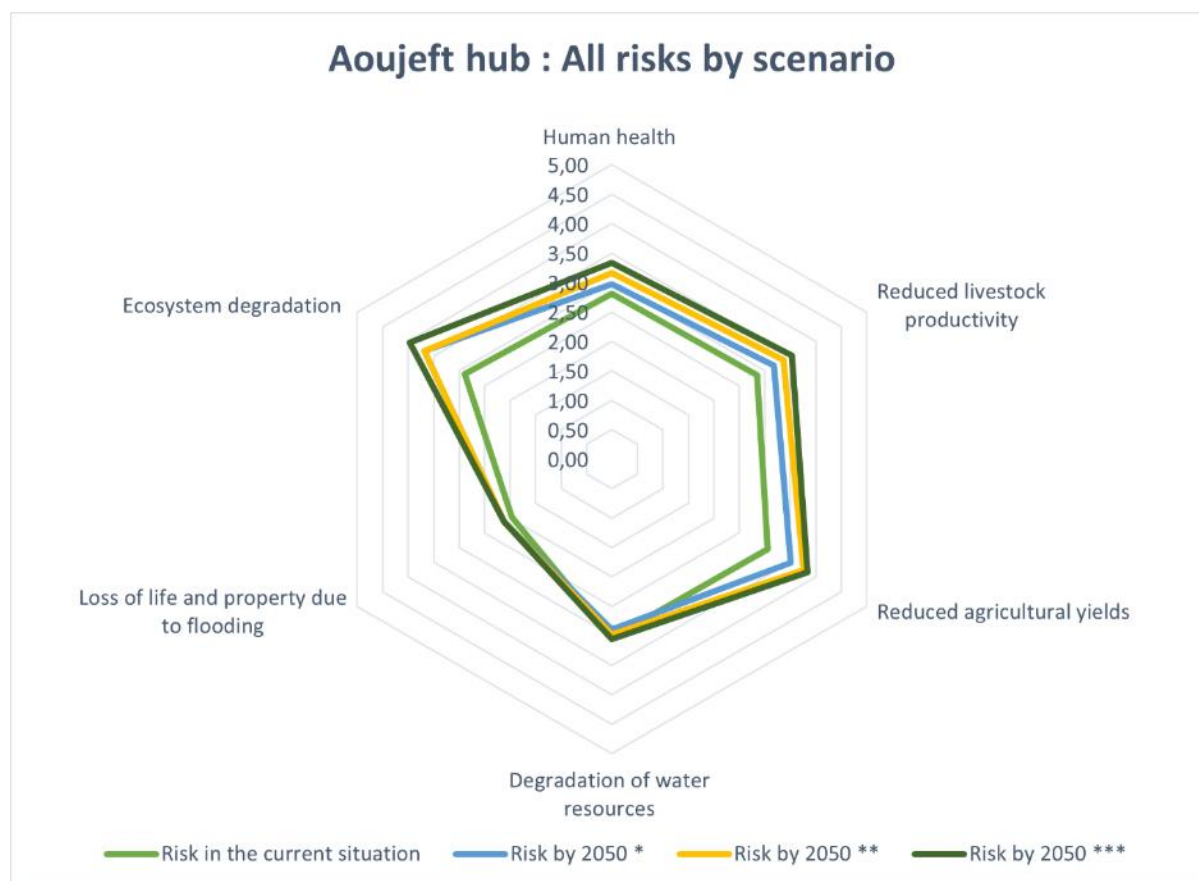
### Aoujeft

In Aoujeft, the highest climate change risk levels are associated with ecosystem degradation, but the risks of reduced agricultural yields and reduced livestock productivity are also high (Figure 94). High-risk scores for this sector are explained by projected increases in the water balance deficit as a result of increasing temperature and evapotranspiration under future climate change scenarios (RCP4.5 and RCP8.5). Table 48 summarises the climate change risk levels associated with each sector in Rachid under both observed and projected climate scenarios<sup>766</sup>.

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<sup>766</sup> Appendix 4



**Figure 94.** Synthesis of observed and projected (2050) risk levels for climate change impacts on major sectors in Aoujeft hub (\* = no climate change; \*\* = RCP4.5; \*\*\* = RCP8.5)<sup>767</sup>.

**Table 48.** Summary of climate change risk levels associated with major sectors in Aoujeft under observed and projected climate scenarios<sup>768</sup>.

Risk level	Observed	RCP 4.5	RCP 8.5
Very High (require intervention) <span style="float: right;">urgent</span>	Reduced agricultural yields	Reduced agricultural yields	Ecosystem degradation
	Degradation of water resources	Ecosystem degradation	Reduced agricultural yields
	Ecosystem degradation	Reduced livestock productivity	Reduced livestock productivity
High	Reduced livestock productivity	Human health	Human health
	Human health	Degradation of water resources	Degradation of water resources
Moderate	Flood damage to infrastructure	Flood damage to infrastructure	Flood damage to infrastructure

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### 3 Institutional and Strategic Framework

The section below describes Mauritania's institutional and strategic framework, within which the governmental and non-governmental bodies relevant to the proposed project operate. This is followed by an overview of the relevant policies in climate change, environment and economic development, and how the project's proposed interventions complement these policies.

#### 3.1 Institutional Framework

The Islamic Republic of Mauritania has been a sovereign state since 1960; its first democratic presidential election was held in 2007. The executive branch of the government comprises the president, elected every five years in an absolute majority vote; a prime minister, appointed by the president; and a cabinet of nominated ministers. The legislative branch comprises the National Assembly, made up of 157 seats elected every five years (there was previously a Senate, but it was abolished after a constitutional referendum in 2017). The government is made up of traditional ministries, special agencies and parastatal companies. The institutions relevant to this project are described below.

##### 3.1.1 Ministry of Environment and Sustainable Development

The Ministry of Environment and Sustainable Development (*Ministère de l'Environnement et du Développement Durable*, MEDD) steers climate-change and sustainable-development policies in Mauritania. It is responsible for developing and implementing the National Sustainable Development Plan (SNEDD), implementing the National Environmental Action Plan (PANE II), developing operational plans, and governing and mobilising financial and material resources for programme implementation. The MEDD has developed sector-specific plans and programmes for desertification and climate change, biodiversity, wetland conservation and coastal ordinance, as introduced in section 1.2 below. The MEDD acts as the country's focal point for the United Nations Framework Convention on Climate Change (UNFCCC). Within the MEDD, the Coordination Cell for the National Climate Change Programme (*Cellule de Coordination du Programme National sur le Changement Climatique*, CCPNCC) was established to coordinate and implement climate-change programmes in the country as well as reporting, such as the National Communications III. The MEDD and the CCPNCC consult directly with different ministries and departments to advance such programmes.

The MEDD is comprised of the following technical directorates:

- Directorate of Planning, Coordination and Statistics;
- Directorate of Regulations and Multilateral Agreements;
- Directorate of Evaluation and Environmental Control;
- Directorate of Protection and Restoration of Species and Landscapes;
- Directorate of Climate and Green Economy; and
- Directorate of Administrative and Financial Affairs.

##### 3.1.2 Ministry of Water and Sanitation

This ministry (*Ministère de l'Hydraulique et de l'Assainissement*, MHA) is responsible for the political and technical supervision of several public institutions, including the National Company of Boreholes and Wells (*Société Nationale des Forages et Puits*, SNFP), the National Rural Water Agency (*Office National des Services d'Eau en Milieu Rural*, ONSER) and the National Water Resource Centre (*Centre National des Ressources en Eau*, CNRE).

The SNFP was established with staff and equipment from MHA's Water directorate, and is responsible for borehole and well construction<sup>769</sup>, as well as the underpinning hydrogeological and geophysical studies.

ONSER is a government agency that controls about half the country's rural piped-water systems, managing operations, maintenance or, in some areas, subcontracting out that management to third parties. The systems under ONSER's direct operation have had sub-optimal outcomes for multiple reasons. For example, water tariffs for rural areas have not been updated since 2002, leading to a disparity between past and current water prices and creating challenges for budgeting and planning. ONSER also requires a sufficient asset-management system, or system-adequate management and monitoring tools, structured objectives, planning or budgeting<sup>770</sup>. It responds to day-to-day operations and maintenance needs on an ad-hoc basis. However, there are a few cases of subcontracted rural water networks under the oversight of the Multisector Regulatory Authority (*Autorité de Régulation, ARE*), which have shown positive management results<sup>771</sup>.

CNRE is responsible for the development and monitoring of water resources nationwide. However, it has been unable to fulfil its mandate because of limited financial and technical resources. Its operational budget decreased by ~60% between 2005–2016, undermining its operational capacity<sup>772</sup>. The agency is funded by budget subsidies, with some additional revenue coming from fees for water abstraction and borehole-siting services. As a result of its lack of resources, CNRE is unable to collect groundwater data and has insufficient resources to update its databases regularly and to disseminate information.

The MHA is comprised of four directorates:

- hydraulics;
- hydrologies and dams;
- sanitation; and
- administrative and financial affairs.

### 3.1.3 Ministry of Agriculture and Rural Development

The *Ministère de l'Agriculture et du Développement Rural* (MADR) designs, executes, monitors and evaluates government policies related to agricultural and rural development. The department is made up of three field officers, six technical advisors, an internal inspection cell, a land property cell, a communications cell and the Minister's secretary. It offers technical supervision to the following institutions: i) the National Centre for Agronomic Research and Agricultural Development (*Centre Nationale de Recherche Agronomique et de Développement Agricole*, CNRADA); ii) the National School of Agricultural Training and Extension (*École Nationale de Formation et de Vulgarisation Agricole*, ENFVA); iii) the National Centre for Locust Control (*Centre Nationale de Lutte Anticridienne*, CNLA); the M'Pourié Farm; iv) the National Company for Rural Development (*Société Nationale pour le Développement Rural*, SONADER), which provides extension and advisory services primarily in irrigated agriculture areas; v) the National Company for Agricultural Development and Works (*Société Nationale des Aménagements Agricoles et Travaux*, SNAAT); and vi) the National Company for Sugar and Derivatives (*Compagnie Mauritanienne de Sucre et Dérivées*, COMASUD).

### 3.1.4 Ministry of Livestock

The *Ministère d'Élevage* (ME) is responsible for the conception, execution, monitoring and evaluation of governmental policies on livestock development, including programmes, legislation and

<sup>769</sup> AMCOW. 2010. Water supply and sanitation in Mauritania: Turning finance into services for 2015 and beyond.

<sup>770</sup> WB. 2020. Project appraisal for the water and sanitation sectoral project in the Islamic Republic of Mauritania. Report No PAD3377.

<sup>771</sup> WB. 2020. Project appraisal for the water and sanitation sectoral project in the Islamic Republic of Mauritania. Report No PAD3377.

<sup>772</sup> WB. 2020. Project appraisal for the water and sanitation sectoral project in the Islamic Republic of Mauritania. Report No PAD3377.



regulations<sup>773</sup>. The ministry is also the technical supervisor of the following organisations: i) the National Office of Research and Development of Livestock and Pastoralism (*Office National de Recherches et de Développement de l'Élevage et du Pastoralisme*, ONARDEP); ii) the Mauritanian Company of Livestock Products (*Société Mauritanienne des Produits d'Élevage*, MPE); iii) the Mauritanian Company of Dairy Products (*Société Mauritanienne de Produits Laitiers*, SMPL); and iv) the Nouakchott Abattoir Company (*Société des Abattoirs de Nouakchott*, SAN).

The ME is comprised of a cabinet, a secretariat and four technical directorates:

- Directorate of Strategy, Cooperation and Monitoring and Evaluation;
- Directorate of Veterinarian Services;
- Directorate of Animal Breeds Development; and
- Directorate of Administrative and Financial Affairs.

### 3.1.5 Ministry of Social Affairs, Children and Family

The *Ministère des Affaires Sociales, de l'Enfance et de la Famille* (MASEF) ensures social protection of vulnerable groups, including women and minors<sup>774</sup>. It operates social-protection programmes, including offering social assistance via unconditional cash transfers and health subsidies. The institutional body is also responsible for developing social-protection policy, programme design and implementation. This includes the following: i) developing and implementing a National Social Protection Policy; ii) developing legislation on women's and children's rights; iii) expanding educational and care facilities for young children; iv) supervising programme quality and teacher training; v) implementing women-led programmes for poor families; vi) promoting family stability through family education and parenting programmes; vii) designing and implementing a national gender strategy; viii) ensuring gender equity is considered in national development strategy; ix) promoting women's entrepreneurship; x) developing women's microfinance; and xi) promoting women's legal status and their inclusion in decision-making and their contribution to overall country development.

The MASEF is comprised of five technical and three operational directorates:

- Directorate of Social Work and National Solidarity;
- Directorate of Disabilities;
- Directorate of Family, Women's Promotion and Gender;
- Directorate of Childhood;
- Directorate of Studies, Cooperation and Monitoring;
- Directorate of Financial Affairs;
- Directorate of Information; and
- Directorate of Human Resources.

### 3.1.6 Ministry of Economic Affairs and Development

The *Ministère des Affaires Economiques et du Développement* (MAED) is responsible for designing, coordinating, implementing and monitoring the government's economic and social policy, including financing agreements and relationships with development partners and international financial institutions<sup>775</sup>. The ministry participates in the elaboration and monitoring of international policies and strategies for the region, ensuring their adequacy with the orientations of the national inequality and poverty reduction policies that are in place. The ministry also formulates public-investment and

<sup>773</sup> Government of Mauritania (GoM). 2021. Journal officiel de la République Islamique de Mauritanie. Available at: <https://www.msgg.gov.mr/sites/default/files/2021-10/J.O.%201491F%20DU%2015.08.2021.pdf>. Accessed on 25 July 2022.

<sup>774</sup> MASEF website. Available at: <https://www.masef.gov.mr/>. Accessed on 25 July 2022.

<sup>775</sup> GoM. 2021. Décret 028-2021. Available at: <https://www.economie.gov.mr/IMG/pdf/organigramme2021-2.pdf>. Accessed on 25 July 2022.



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private-sector development programmes. Together with the Ministry of Finance, MAED contributes to the implementation of general and sectoral policies and the reformulation of the parapublic sector. In addition, MAED supervises the National Agency of Statistics and Demographic and Economic Analysis (*Agence Nationale de la Statistique et de l'Analyse Démographique et Économique*, ANSADE) and the Investment Promotion Agency (*Agence de Promotion des Investissements en Mauritanie*, APIM).

The MAED is comprised of the cabinet, the secretariat, and five technical directorates, namely the:

- Directorate for Development Strategies and Policies (*Direction Générale des Stratégies et Politiques de Développement*, DGSP);
- Directorate for Financing and Economic Cooperation (*Direction Générale des Financement et de la Coopération Economique*, DGFCE);
- Directorate for Public-Private Partnerships (*Direction Générale des Partenariats Public-Privé*, DGPPP);
- Directorate of Monitoring, Evaluation and Reforms (*Direction Générale de l'Evaluation, du Suivi et des Réformes*, DGESE); and
- Directorate of Administration and Finances (*Direction des Affaires Administratives et Financières*, DAAF).

#### 3.1.7 Ministry of Housing, Urbanism and Regional Planning

The *Ministère de l'Habitat, de l'Urbanisme et de l'Aménagement du Territoire* (MUAT) is structured around four programmatic areas: i) urban planning and development, including equitable access to property; ii) regional development and land reform; iii) public buildings and equipment; and iv) governance, monitoring and evaluation.

The MUAT is comprised of four technical departments:

- regional works and land reform;
- public buildings and equipment;
- housing and urbanism studies; and
- programmes and cooperation.

#### 3.1.8 Ministry of Interior and Decentralisation

The *Ministère de l'Interieur et de la Décentralisation* (MID) is focused on the decentralisation of governance, a principle established by law in Mauritania in 1986. Under this principle, regions and wilayahs have political and financial autonomy. Institutional consultation mechanisms have been established at the regional and municipal levels to enhance local development. The main bodies are the Regional Poverty Reduction Committees (CRLPs), Regional Development Committees (CRDs) and thematic committees such as Regional Health Committees (CRSs). The main mechanism at municipal level is the Citizen Consultation Committee (CCC), which has a clear allocation of responsibilities. In practice, however, governance remains centralised and local counties are under the authority of national ministries, and regional consultation mechanisms still require legal and financial frameworks to operate fully.

### 3.2 *Administrative regions*

Mauritania is divided into 12 administrative regions or wilayahs, each subdivided into departments or *moughataas* (Section 1.1). The four hubs relevant to this project are made up of a town surrounded by an 80 km radius. These are the Aoujeft, Rachid, Tamcheket and Nema hubs:

- Aoujeft Hub is centred around Aoujeft town and is in the homonymous *moughataa* of the Adrar wilayah. The hub is composed of the agricultural-urban commune of Aoujeft and the rural communes of Maeden, N'Teirguent, El Medah and Tenmewend.
- Rachid Hub is centred around Rachid town and is in the Tidjikja *moughataa*, in the Tagant wilayah. The hub is composed of the communes of El Wahat, Tidjikja and Tensigh, with the latter two comprising agricultural-urban districts.
- Tamcheket Hub is centred around Tamcheket town and is the homonymous *moughataa*, in the Hodh El Gharbi wilayah. This hub is composed of Tamchaket, El Mabrouk, Radhi, Gueate-Teidoume and Sava communes.
- Nema Hub is based in the town of Nema in the homonymous *moughataa*, the capital of the Hodh Chargui wilayah. The hub is composed of ten communes, namely Nema, Achemmim, Jreif, Bangou, Hassi Etila, Oum Avnadech, El Mabrouk, Beribava, Noual and Agoueinit<sup>776</sup>.

### 3.3 Non-governmental organisations

International non-governmental organisations (NGOs) have actively assisted rural Mauritania, particularly in climate change impact-related events such as food shortages, prolonged droughts and locust crises. Subject to the availability of funds, some national NGOs are active in agricultural and rural community development, women's participation in development and natural resource management<sup>777</sup>. For example, Globe provides extension services in rain-fed areas, the American-Mauritanian Association for Social and Economic Development (AMADES), *Actions pour le Developpement Durable en Mauritanie* (ADM), *Association Internationale des Femmes Francophone* (AIFF), *Organisation Mauritanienne pour l'Encadrement et le Developpement* (OMED) and the UK-based Rainbow Development in Africa<sup>778</sup>. These NGO's operations are not necessarily focused on arid areas of the country, rather on rain-fed regions. An informal federation of NGOs in Mauritania also exists, comprising about a dozen organisations. Donor-funded programmes work together with grassroots associations, such as the Union for Women's Cooperatives, the Union of Agricultural Cooperatives and pastoral cooperative associations. These associations are based in Nouakchott, implying a national outreach.

### 3.4 National policies and strategic framework

Several strategic frameworks have been developed in Mauritania that address the challenges of climate change vulnerability and desertification. These climate change, environmental and economic development policies are discussed in

<sup>776</sup> Appendix 4

<sup>777</sup> Devdir. 2008. Directory of development organization – country finder: Mauritania. Available at: [https://www.ecoi.net/en/file/local/1171339/1222\\_1199887569\\_mauritania.pdf](https://www.ecoi.net/en/file/local/1171339/1222_1199887569_mauritania.pdf). Accessed on 26 July 2022.

<sup>778</sup> G-Fras website. [online] Available at: <https://www.g-fras.org> Accessed on 26 July 2022.

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**Table 49** below, which provides a broad assessment of existing gaps, how the relevant policy or framework aligns with the proposed project, as well as opportunities to bolster existing frameworks.

**Table 49.** National policies and strategic frameworks that align with the objectives of the proposed project, including a broad assessment of existing gaps and opportunities for project intervention.

Policy	Policy description, gaps assessment and relevance to the proposed project
Climate change policies	
<i>National Adaptation Programme of Action to Climate Change (2004)</i>	<p>The National Adaptation Programme of Action to Climate Change (NAPA-Rim)<sup>779</sup> acknowledges the severity of climate change and the need for international support to adapt to impacts, given Mauritania's least-developed country (LDC) status. The NAPA-Rim was drafted by the former Department of the Environment, and highlights desertification and the associated consequences as the most notable impact of climate change in Mauritania. Several other impacts are also listed and include, <i>inter alia</i>, increasing water scarcity, lowered water tables, reduced fish stocks and sea-level rise in coastal areas.</p> <p>The NAPA-Rim notes that, in the past, pastoralism has been undermined as a strategy for adapting to climate variability when, in fact, it offers many benefits. Promoting pastoralism and nomadism should, therefore, be a critical consideration in future plans that aim to improve country adaptation. Other adaptation priorities in the NAPA-Rim include: i) investing in water-saving techniques and technology; ii) restoring small dykes and wetlands; and iii) promoting integrated land management.</p> <p>The proposed project aligns with the NAPA-Rim in that both recognise that desertification is the most considerable climate change impact in the country. The Policy includes the implications of desertification in different sectors, such as livestock, agriculture and oases economies. Some identified adaptation options in the Policy are also recommended in the proposed GCF project, such as stabilising dunes, strengthening nomadism, promoting oasis economies, and improving water monitoring and use. The Policy addresses the need to prioritise institutional mechanisms for nature conservation and climate change adaptation. In addition, it acknowledges that the GoM does not have the financial capacity to implement climate change-adaptation projects, identifying the need for tapping into international funding mechanisms. However, its proposed adaptation options and projects do not include land use planning at the regional level, only in Nouakchott, nor does the Policy address gender.</p> <p>The proposed GCF project is superseded by the National Adaptation Plan (NAP), which is described below.</p>
<i>National Adaptation Plan</i>	<p>Mauritania's NAP is currently under development. The government is receiving readiness and preparatory support from the GCF to capacitate local institutions, which will aid the NAP's development.</p> <p>The proposed GCF project will complement the ongoing NAP efforts through its proposed activities, discussed in Section B.3. of the Funding Proposal.</p>
<i>National Communication on Climate Change IV (2019)</i>	<p>The National Communication on Climate Change IV emphasises Mauritania's heightened vulnerability to climate change<sup>780</sup>. Impacts highlighted in this communication include: i) projections that water availability will decrease by 15%; ii) the expansion of the Sahara Desert toward the south of the country; and iii) desert encroachment into agricultural land. These impacts are expected to negatively affect agricultural yield, and food and water security in the country.</p> <p>The proposed project will complement recommendations stipulated in the National Communications on Climate Change IV. Proposed efforts that align are discussed in Section B.3. of the Funding Proposal and include measures to strengthen natural resource management and governance and increase gender inclusion.</p>

<sup>779</sup> GoM. 2004. National Adaptation Programme of Action to Climate Change. Available at: <https://unfccc.int/resource/docs/napa/mau01e.pdf> Accessed on 27 August 2022.

<sup>780</sup> GoM. National Communication on Climate Change IV. Available at: <https://unfccc.int/documents/200088> Accessed on 30 August 2022.

<p><i>Nationally Determined Contributions (2021)</i></p>	<p>The Nationally Determined Contributions (NDCs) delineate Mauritania's adaptation needs<sup>781</sup>. The impacts of climate change on water availability, agriculture and livestock are discussed in the document. It also provides an overview of the identified priority sectors for adaptation, which include nature conservation, agropastoral systems and fisheries.</p> <p>The activities proposed by the project will advance the NDCs through the implementation of sustainable livestock-breeding practices, reforestation interventions and strengthened institutional capacity, with a strong focus on improving the adaptation capacity of rural communities along the Sahara-Sahelian border. Interventions that aim to decrease the impact of desertification in these communities will contribute toward the adaptation goals stipulated in the NDC document. The climate adaptation interventions proposed by the project have been designed in line with the land-use planning, gender responsiveness, institutional requirements and financial needs described in the NDC.</p>
<p><i>Environment and conservation policies</i></p>	
<p><i>National Action Plan against Desertification in Mauritania (National Plan Against Desertification in Mauritania; 2002)</i></p>	<p>The <i>Programme d'Action National de Lutte Contre la Desertification en Mauritanie</i> 2022 (PAN-LCD) highlights the multifaceted nature of desertification. With this foundational understanding, it aims to ensure that the challenges around desertification are incorporated into a sustainable, national development plan that encompasses technical, socioeconomic, judicial and institutional facets.</p> <p>The PAN-LCD has resulted in the formulation of several sustainable development programmes and created awareness of the role that socioeconomic-development objectives play in addressing desertification. In addition, the Plan defines the regulatory and institutional frameworks to combat desertification in Mauritania, including potential internal and external funding streams. The proposed GCF project aligns with the PAN-LCD in that it also acknowledges the multifaceted nature of desertification. Similar to the recommendations in the PAN-LCD, it proposes that strategies to combat desertification be incorporated across different plans, policies and government bodies.</p> <p>Several gaps are identified in the PAN-LCD. These include the need for: i) an operational land-use planning authority, <i>the Schéma National d'Aménagement du Territoire</i> (SNAT), to coordinate local development plans; and ii) coordination with United Nations conventions, such as climate change (UNFCCC) and biodiversity (CBD), and institutional actions to mainstream desertification. Gaps in the PAN-LCD itself include gender equity being incorporated in planning mechanisms.</p> <p>Upon its completion, the NAP (discussed above) will supersede the PAN-LCD.</p>
<p><i>Political Declaration of the Environment and Sustainable Development (2011)</i></p>	<p>The <i>Déclaration de Politique d'Environnement et de Développement Durable</i> (PDEDD) is centred around addressing poverty, state transparency and the conservation of natural resources<sup>782</sup>. The following national priorities are stated within the document: i) promoting sectoral reforms based on the development of human, material and financial resources; ii) establishing Good Environmental Governance (<i>Bonne Gouvernance Environnementale</i>), which is a framework for planning, implementing, monitoring and evaluating national interventions; iii) abiding by international conventions on climate change adaptation and biodiversity conservation; iv) promoting renewable energy; v) engaging with international, national and regional mechanisms for the research, education and dissemination of sustainable management; and vi) improving urban management.</p>

<sup>781</sup> GoM. 2021. Contribution Déterminée Nationale Actualisée (CDN) 2021–2030. Available at:

[https://unfccc.int/sites/default/files/NDC/2022-06/CDN-actualis%C3%A9%202021\\_%20Mauritania.pdf](https://unfccc.int/sites/default/files/NDC/2022-06/CDN-actualis%C3%A9%202021_%20Mauritania.pdf) Accessed on 30 August 2022.

<sup>782</sup> GoM. 2011. Déclaration de Politique d'Environnement et de Développement Durable. Available at: <https://aires-marines.ugar.ca/27/1/DPEDDRIM.pdf> Accessed on 27 August 2022.

	<p>These priorities will be achieved through the reinforcement of institutional capacity in environmental management, integrated resource management and the implementation of international conventions on climate, such as the UNFCCC and the Kyoto Protocol.</p> <p>Although comprehensive, the PDEDD has several gaps, including the absence of land-use planning and gender considerations. In addition, there is no mention of financing sources for the proposed international reforms — despite the identification of ratified international convention for financing. A full review of the PDEDD will be conducted under the proposed GCF project, identifying necessary measures to integrate land use planning and gender considerations into the project design.</p> <p>The proposed GCF project aligns with PDEDD's objectives of improving institutional capacity and governance for environmental management and sustainable development. The PDEDD also includes climate change considerations in its narrative. For example, one PDEDD action is to implement international conventions, such as climate change, biodiversity and desertification. It is also acknowledged that institutional capacity needs to be strengthened to implement environmental and sustainable development goals.</p>
<i>National Action Plan for the Environment II (2012–2016)</i>	<p>The <i>Plan d'Action Nationale pour l'Environnement II</i> (PANE II) was elaborated to create a framework that supports all environmental policies<sup>783</sup>. The objective of the plan includes the development of best practices for environmental conservation and natural resource management. Climate change is recognised as a threat to livelihoods and food security, particularly in rural settings, with the mainstreaming of sustainable development and environmental affairs proposed to address this challenge.</p> <p>PANE II is subdivided into seven sub-programmes: i) environmental evaluation and regulation; ii) sustainable management of natural resources; iii) conservation, restoration and management of biodiversity; iv) prevention of extreme weather events; v) adaptation to climate change; vi) information, education and communication of environmental affairs; and vii) institutional reforms. Through PANE II, the MEDD becomes an independent institution to implement environmental management practices across sectors.</p> <p>The proposed GCF project complements PANE II's objective of mainstreaming natural resource management and reinforcing institutions and governance. In addition, PANE includes a governance apparatus for environmental conservation, climate change and natural resource management. It contains information regarding the existing legislation on natural resource management, which is discussed as uncoordinated in the absence of clearly-defined roles and responsibilities of relevant institutions. The conflicting framework hinders effective natural resource management and the implementation of land-use planning and environmental protection interventions.</p> <p>The proposed GCF project will not review the PANE II under activity 1.1.1 as the Policy has been superseded by the National Strategy and Plan of Action for the Environment and Sustainable Development (SNEDD; discussed below).</p>
<i>National Strategy and Plan of Action for the Environment and Sustainable Development (2017–</i>	<p>The <i>Stratégie Nationale de l'Environnement et du Développement Durable</i> (SNEDD) supersedes PANE II. It provides a strategic foundation for integrating environmental, climate and sustainable development goals into other sectoral</p>

<sup>783</sup> GoM. 2012. Plan d'Action National pour l'Environnement 2012-2016 (PANE II). Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC146663> Accessed on 27 August 2022.

<p>2030) and National Action Plan for Environment Sustainable Development (PANEDD).</p>	<p>policy frameworks<sup>784</sup>. The implementation of SNEDD through the National Action Plan for Environment and Sustainable Development (PANEDD), is part of the wider national institutional framework for development policies.</p> <p>SNEDD and accompanying PANEDD underpin the GoM's coordination mechanisms for monitoring environmental challenges. The initiative is divided into four strategic components: i) integrated environmental governance adapted to challenges; ii) integrated and sustainable management of natural resources and terrestrial biodiversity; iii) sustainable management of the marine and coastal environment; and iv) strengthened prevention and management of pollution and anthropogenic threats. PANEDD operationalises the necessary actions for each of these four strategies, including the relevant implementing institution, financing plan and a monitoring and evaluation plan.</p> <p>The SNEDD includes gender considerations in the proposed institutional reforms for integrated environmental management and suggests women-only positions in the organisations involved in the implementation of the PANEDD. It also includes measures to improve environmental governance in the context of climate change and baseline challenges, including partnerships between institutions, financing streams, and institutional reform. Financing mechanisms for the implementation of various actions are considered.</p> <p>The proposed GCF project aligns with the SNEDD and PANEDD through shared goals of strengthening land-use management and institutional governance, both of which address climate change impacts. Notably, climate change is mainstreamed into the SNEDD plan, with desertification considered a priority. In addition, local and decentralised natural resource management is recognised within land-use planning considerations. These considerations are not, however, included in the PANEDD, with land-use planning activities largely absent. Under activity 1.1.1 the proposed GCF project will complement the SNEDD with a review to advance land-use planning considerations.</p>
<p>National Biodiversity Strategy and Plan of Action (2011–2020)</p>	<p>The <i>Strategie et Plan d'Action National de la Biodiversité</i><sup>785</sup> is aligned with the Convention on Biological Diversity. The Strategy's primary goals include the conservation of wetlands, coastal ecosystems and forests through the long-term maintenance of ecosystem functions. These functions include their capacity to adapt to environmental change, particularly desertification and climate change. The Strategy describes six major focal areas: i) creating the desire to act on behalf of biodiversity; ii) preserving life and its ability to evolve; iii) investing in biodiversity conservation; iv) assuring the sustainable and equitable use of biodiversity; v) assuring policy coherence and the effectiveness of actions; and vi) developing, sharing and using knowledge<sup>786</sup>. National targets and accompanying actions, indicators and implementation costs have been established to support these goals.</p> <p>Within the abovementioned framework, the Strategy includes measures to ensure the sustainable management of rangelands and reduced pressure on pastoral and forest resources. In addition to ensuring the structural integrity of ecosystems, this Strategy contributes to Mauritania's poverty-reduction efforts and also explicitly addresses the inclusion of women and pastoralists in biodiversity management and governance participation.</p>

<sup>784</sup> GoM. 2017. Available at: <https://www.fao.org/faolex/results/details/es/c/LEX-FAOC175844/#:~:text=Sp%C3%A9cifiquement%2C%20la%20SNEDD%20vise%20%C3%A0,%C3%A9cosyst%C3%A9miques%20et%20des%20ressources%20naturelles>. Accessed on 27 August 2022.

<sup>785</sup> GoM. 2011. *Stratégie et Plan D'action National de la Biodiversité 2011-2020*. Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC160741/>. Accessed on 27 August 2022.

<sup>786</sup> GoM. 2014. *Strategie nationale de conservation des zones humides*. Available at: <https://rim-rural.org/2019/10/01/snczh-strategie-nationale-de-conservation-des-zones-humides-en-mauritanie/>. Accessed on 27 August 2022.



	<p>Several gaps are highlighted in the Strategy. These include limited coordination between multiple agencies involved in biodiversity conservation and an outdated institutional and administrative framework for coordinating biodiversity actions. In addition, the inclusion of women and pastoralists in biodiversity management is limited to only one of the Strategy's activities. Climate change considerations, monitoring mechanisms and a detailed overview of financing sources are also absent from the Strategy. Under activity 1.1.1, the proposed GCF project will present a review of the Strategy to include climate change and gender considerations and further expand financing sources to strengthen the National Biodiversity Strategy and Plan of Action.</p> <p>The proposed GCF project aligns with the National Biodiversity Strategy through the promotion of nature-based solutions that support biodiversity conservation, alternative natural resource-based sustainable livelihoods and sustainable livestock practices. Similar to the proposed project, the Strategy recommends addressing desertification to bolster biodiversity. A national land-use plan (SNAT) is also suggested to address the challenge of rural migration to urban centres.</p>
National Strategy for Wetland Conservation (2014)	<p>The <i>Strategie Nationale de Conservation des Zones Humides</i> highlights the urgency of wetland conservation in Mauritania, with emphasis on their value, uniqueness and fragility<sup>787</sup>. The goal of the Strategy is to outline the approach to conservation restoration and sustainable management of wetland ecosystems. Locally, wetland systems are referred to as, <i>inter alia</i>, <i>tamourts</i>, <i>gâats</i>, <i>oueds</i>, <i>tichillits</i>, oases and <i>sebkhas</i> (Section 1.5.3) and include perennial, semi-permanent or temporary water bodies.</p> <p>Several principles for wetland management are described in the Strategy and include: i) participatory management; ii) transparency, equity and social justice; iii) shared responsibility for the environment; iv) decentralisation of decision-making; v) precautionary and preventative measures; and vi) the coordination of synergies. Its objectives are to: i) implement a wetland governance system; ii) implement a legal framework specific to wetlands; iii) preserve and restore wetlands; iv) regulate access to wetland resources; v) maintain and improve the state of wetlands; vi) improve watershed management; vii) develop sustainable agricultural and animal husbandry practices in wetlands; viii) implement the strategy of wetland management; ix) strengthen institutional and human capacity; x) strengthen technical and scientific capacity; xi) promote sustainable exploration practices of natural resources; xii) develop income-generating activities compatible with the sustainable management of wetlands; and xiii) implement a financing mechanism.</p> <p>The proposed project aligns with the Wetland Conservation National Strategy in its approach to strengthening community management of natural resources, including wetlands. The Strategy establishes governance principles for the wetland conservation plan, such as decentralised decision-making, and aims to implement a governance system for wetland conservation, and also reinforces existing institutional capacities. It also incorporates an overview of national and international financing sources, although the specific amounts required to operationalise interventions are not disclosed.</p> <p>Several gaps are present in the National Strategy for Wetland Conservation. First, good wetland management is described as a suitable method for preventing and addressing the challenge of desertification. However, the Strategy only refers to climate change projects and policies in Mauritania without including climate change scenarios in its design. Moreover, the Strategy does not disclose land-use planning activities for wetland conservation under the action plan despite being</p>

<sup>787</sup> GoM. 2014. *Strategie Nationale de Conservation des Zones Humides*. Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC177461/#:~:text=Il%20s'agit%20pour%20la,les%20zones%20humides%2C%20soutenir%20la> Accessed on 27 August 2022.



	<p>informed by existing land-use policies. Finally, the Strategy does not include gender considerations in its plans. Given these gaps, the proposed GCF project will review the National Strategy of Wetland Conservation to include climate change, gender and land-use planning considerations under Activity 1.1.1.</p>
<p><i>Great Green Wall Implementation Strategy and Plan of Action (2009)</i></p>	<p>Albeit not a national policy, Mauritania is included in the Great Green Wall (GGW) Implementation Strategy and Plan of Action. The GGW is a project implemented across 22 countries in the Sahel that aims to regenerate land along the southern and northern border of the Sahara Desert, where annual rainfall is below 400 mm. In particular, the GGW strengthens the implementation of national action plans to address desertification, targeting sustainable development and poverty reduction in the desert margin south of the Sahara.</p> <p>The MEDD is responsible for the implementation of the GGW in Mauritania. These activities are expected to: i) help slow soil erosion; ii) restructure degraded soil; iii) revive, develop and diversify agriculture and stock breeding; iv) restore biodiversity; v) increase forest coverage; vi) control water resources; and vii) reverse rural migration. Over 550 ha have been seeded and 225 ha of dunes have been fixed under the project<sup>788</sup>.</p> <p>The proposed GCF project is aligned with the Great Green Wall interventions of dune fixation and reforestation and will advance its efforts through the activities proposed for implementation in the four regional hubs.</p>
<p><i>Economic development and livelihood policies</i></p>	
<p><i>National Plan for Rural Women (2009–2012)</i></p>	<p>The <i>Plan d'Action National pour la Femme Rural</i> is spearheaded by the Ministry of Social Affairs, Childhood and Family (<i>Ministère des Affaires Sociales, de l'Enfance et de la Famille</i>)<sup>789</sup>. This National Plan forms part of the long-term plan to address poverty in the country, deriving from the Strategy Framework Against Poverty (CSLP). Within this plan, it is recognised that women experience worse socioeconomic conditions than men. These disparities include susceptibility to poverty, abandonment, insufficient access to basic services, exclusion from development plans, and the deprivation of political, economic and social rights.</p> <p>The National Plan for Rural Women has the following six primary objectives: i) promoting women's rights through mass communication and popularisation; ii) improving rural women's health; iii) strengthening women's access to education; iv) developing infrastructure; v) promoting the employment of women through, <i>inter alia</i>, professional training and credit access; and vi) strengthening the institutional capacity of the institutions responsible for rural women.</p> <p>Similar to the Plan's inclusion of women in rural development, the proposed GCF project incorporates gender-responsive activities in its design. One of the objectives of the Plan is to strengthen institutional capacity, including a coordination and monitoring plan for the rural woman, a legislative review, the creation of a National Centre of Rural Women Studies, the institutionalisation of district-level councils for gender-related challenges, and the support of organisations for rural women. The Plan also includes national financing sources.</p> <p>The Plan is limited in that it does not include climate change or land-use planning considerations in its design, despite the presence of proposed reforestation interventions. The Plan is also relatively outdated.</p>

<sup>788</sup> MEDD website. Available at: <http://www.environnement.gov.mr/fr/index.php/features/le-medd-en-chiffres>. Accessed on 29 August 2022.

<sup>789</sup> GoM. 2008. Plan d'Action pour la Femme Rural. Available at: <https://www.ilo.org/dyn/natlex/docs/MONOGRAPH/96687/114335/F1693895911/MRT-96687.pdf>. Accessed on 27 August 2022.

	The proposed GCF project will offer a review to update the rural women policy for gender equality development in Mauritania and include climate change considerations under Activity 1.1.1.
<i>Strategic Framework Against Poverty III (2011–2015)</i>	The <i>Cadre Stratégique de Lutte contre la Pauvreté III</i> (CSLP III) directs poverty-reducing policy towards interdependent and decentralised sectorial policies to spur economic growth <sup>790</sup> . The CSLP III instils country ownership in addressing poverty through national institutions and processes. It is structured around four strategic pillars: i) macroeconomic stabilisation; ii) the inclusion of the poorest in economic growth; iii) human capital development and access to essential services; and iv) governance improvements and institutional-capacity strengthening. This Framework was superseded by the National Strategy for Accelerated Growth and Shared Prosperity II (SCAPP II), described below.
<i>National Accelerated Growth and Shared Prosperity Strategy II (2016–2030)</i>	<p>The <i>Stratégie Nationale de Croissance Accélérée et de Prospérité Partagée II</i> (SCAPP II) is a national development plan aligned with the 2030 Agenda for Sustainable Development<sup>791</sup>. SCAPP II is composed of three axes. The first axis promotes strong, durable and inclusive economic growth through economic diversification and transformation, developing the infrastructure that supports economic growth and a competitive private sector. The second axis addresses human capital development by increasing access to basic social services, such as quality education and professional training, health and nutrition, and employment. The third axis is the reinforcement of governance across all dimensions. SCAPP II recognises the dual importance of ecosystem conservation and restoration to support Mauritania's development and capacity to adapt to climate change.</p> <p>The SCAPP's third objective is to strengthen all governance systems appropriate to economic development and growth. It also includes cost implications of the suggested programmes and quantifies the necessary co-financing amounts, but not financing partners.</p> <p>The proposed GCF project recommends an ecosystem-based approach (EbA) to address climate change adaptation. This approach is supported by the Strategy, which describes EbA as critical in strengthening the country's resilience to climate change. Climate change considerations also underpin the Strategy's strategic plan, which translates into climate-resilience elements for each sectoral objective. In addition, the Strategy includes land-use planning to strengthen and solidify decentralisation, proposing a regional approach. Gender considerations are integrated into the SCAPP II, which includes gender-disaggregated indicators in its diagnostic section and gender objectives in its vision section. The Strategy also addresses gender inclusion under two of its directive sub-programmes, namely: i) improving the resilience of the most vulnerable groups; and ii) improving women's citizen participation, which encompasses national, regional and community-level governance structures.</p>
<i>Development Strategy for the Rural Sector, Horizon 2025 (2012)</i>	The <i>Stratégie de Développement du Secteur Rural</i> (SDSR) <sup>792</sup> was developed together with SCAPP II. It establishes the framework for the development of agropastoralism in Mauritania. The SDSR aims to: i) implement infrastructures adapted to rural settings; ii) foster innovation and development through research,

<sup>790</sup> GoM. 2011. *Cadre Stratégique de Lutte contre la Pauvreté 2011–2015*. <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC145913/#:~:text=S'agissant%20de%20la%20r%C3%A9duction,p%C3%AAche%20artisanale%20c%C3%B4ti%C3%A8re%20et%20continentale>. Accessed on 27 August 2022.

<sup>791</sup> GoM. 2016. Available at: <https://www.fao.org/faolex/results/details/fr/c/LEX-FAOC190616/#:~:text=La%20Strat%C3%A9gie%20nationale%20de%20croissance,de%20soutien%20%C3%A0%20la%20croissance%20>. Accessed on 27 August 2022.

<sup>792</sup> GoM. 2013. *Stratégie de Développement du Secteur Rural* (SDSR) Available at: <https://rim-rural.org/2021/02/16/strategie-de-developpement-du-secteur-rural-sdsr-horizon-2025/>. Accessed on 27 August 2022.

	<p>education and professional training and the inclusion of actors in the value chain; iii) ensure sufficient financing adapted to the country's context; and iv) support commercial services by strengthening the appropriate government departments. The Strategy further aims to promote the inclusion of the youth and women in rural economies. It identifies the need to create public-private partnerships and foster the conditions to attract investment, and also delineates the need to develop and implement the Law for Agropastoral Orientation. The National Agricultural Development Plan offers an actionable plan for the SDSR.</p> <p>The proposed project and SDSR's objectives are aligned in that both aim to develop agriculture and pastoralism through a natural resource-management approach. Regarding rural development governance, the Strategy recognises the importance of participatory and co-management approaches to natural resource management and planning. It also aims to adapt the institutional and judicial framework to enhance rural development further. The SDSR recognises the limited financial contribution of the banking system to the rural and agricultural sectors in its diagnosis. It further details the financing needs for each sectoral Policy objective (livestock, agriculture, rural development, natural resource management and institutional framework strengthening).</p> <p>The SDSR acknowledges the uncertainty of climate change effects and impacts and Mauritania's exacerbated vulnerability to climate change. However, it does not include climate-resilience objectives or results, nor does it describe the implication of desertification on rural development. Moreover, the SDSR does not mention the stark difference between arid landscapes and the Senegal River Valley in the logical framework's objectives and expected results. In addition, the Strategy does not have any land-use planning objectives or outcomes. The proposed GCF project will review the SDSR to include climate change and regional considerations under Activity 1.1.1.</p>
<p><i>National Agricultural Development Plan (2015–2025)</i></p>	<p>The <i>Plan National de Développement Agricole</i> (PNDA)<sup>793</sup> follows the 2012 SDSR and the Law of Agropastoral Orientation (<i>Loi d'Orientation Agropastorale</i>). It is aligned with CSLP and the National Strategy for Food Security (<i>Stratégie Nationale de Sécurité Alimentaire</i>, SNSA). The goals of the PNDA are to: i) promote the intensification and diversification of agricultural products to meet national needs; ii) promote agricultural competitiveness; iii) promote the sustainable and participatory management of natural resources; and iv) increase the operationalisation of the structures that support the agricultural sector. Its action points are structured around local development, natural resource management, and adaptation of the institutional and judicial framework and its supporting structures, namely infrastructure, research, rural councils and financing rural-sector development.</p> <p>The proposed GCF project's approach to local development, natural resource management and institutional strengthening aligns with the PNDA, which is underpinned by climate considerations. For example, climate resilience forms a critical element of the PNDA's first objective, which aims to promote climate-resilient rural and peri-urban economies. Desertification is also acknowledged as a considerable challenge. The PNDA also includes a proposal to create an environmental hazards fund for rainfed agricultural producers. This fund will be used to support food security in vulnerable communities. The absence of long-term climate models does, however, create a gap in this component.</p> <p>The PNDA is informed by the existing land-use planning framework and considers different objectives for oases, and arid and irrigated agricultural zones. Its sub-programme 3.1 includes directorial land access and redistribution plans to</p>

<sup>793</sup> GoM. 2015. Plan National de Développement Agricole. Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC175842/> Accessed on 27 August 2022.

	<p>improve agricultural land use, protection and rehabilitation. Women's employment forms one of the PNDA's pillars, and women's associations are included in the stakeholder list of the PNDA's steering committee. Gender considerations also appear to be incorporated in the PNDA's action plan's objectives.</p> <p>The PNDA includes the institutional strengthening of i) agricultural support systems provided by the Ministry of Agriculture, <i>inter alia</i>, research and development, extension services, training; and of ii) producers' associations and organisations. In addition, it presents the costs associated with the proposed programmes and potential financing partners, including its alignment with ongoing, internationally funded projects. Under Activity 1.1.1, the proposed GCF will review the PNDA and its integration with the other policies, <i>inter alia</i>, the SDSR, the SNEDD or SNADEA.</p>
<i>National Water and Sanitation Policy and Strategy (2016–2030)</i>	<p>The objective of the <i>Stratégie Nationale pour un Accès Durable à l'Eau et l'Assainissement</i> (SNADEA)<sup>794</sup> contributes to Mauritania's sustainable development framework, recognising the political priority of the water sector and its strategic importance to the success of other sectors, such as agricultural development. It recommends appropriate solutions to water-related problems to prevent water scarcity from becoming a limiting factor to economic and social development. The SNADEA is based on an assessment of the country's water inventory. Its strategy is divided into five themes: i) extending the knowledge on monitoring and protecting water resources; ii) improving access to drinking water; iii) improving access to water for agriculture and livestock; iv) improving access to sanitation and hygiene; and v) improving governance of the water sector. The SNADEA further breaks down each theme into recommended programmes and projects, including the appropriate executing agency, institutional partners, project components and outcomes, indicators and implementation budgets. The sectoral objectives in SNADEA 2016–2030 are incorporated into the SCAPP II, introduced above.</p> <p>The proposed GCF project aligns with the Policy's objective of expanding knowledge on, monitoring and protecting water resources. The SNADEA recognises the impacts of climate change on water availability and use. It also incorporates climate change scenarios and their implications on rainfall patterns and includes climate resilience in its programme's objective.</p> <p>Despite the acknowledgement of climate change impacts, desertification is not distinctly mentioned in the Strategy. In addition to climate change considerations, the SNADEA's fifth theme focuses on strengthening the water and sanitation sector's governance apparatus and identifies the institutional partners necessary for implementing the proposed programmes. The SNADEA's strategy includes foreseen costs for programme implementation and potential financing sources. However, while the Strategy acknowledges the role of the water and sanitation sector in addressing women's vulnerability, it does not detail any gender-specific objectives or gender-responsive activities. The SNADEA is also absent of land-use planning considerations. Under Activity 1.1.1, the proposed GCF project will review the SNADEA to integrate water cycles into land-use planning for sustainable water management and gender considerations.</p>
<i>National Livestock Development Plan (2018–2025)</i>	<p>The <i>Plan National de Développement d'Élevage</i> (PNDE) is structured around five pillars: i) supporting and securing traditional pastoral livelihoods, ii) developing livestock breeds for productivity and competitiveness; iii) improving animal health care; iv) strengthening research and development capacity; and v) strengthening the institutional framework and capacity<sup>795</sup>. Each pillar is supported by programme</p>

<sup>794</sup> GoM. 2016. *Stratégie Nationale pour un Accès Durable à l'Eau et l'Assainissement*. Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC190613/>. Accessed on 27 August 2022.

<sup>795</sup> GoM. 2017. *Plan National de Développement d'Élevage*. Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC190618/>. Accessed on 27 August 2022.

	<p>and sub-programme guidelines. For example, the development of a sustainable management system for water resources. The PNDE is to be enacted by a Steering Committee composed of different actors, representatives of the livestock sector and relevant government agencies. The Steering Committee is also responsible for the implementation of monitoring and evaluation.</p> <p>The proposed GCF project's approach to traditional pastoral livelihoods is aligned with the PNDE's goal of developing the livestock sector. The PNDE acknowledges the impacts of climate change on the livestock sector but does not explicitly use climate change scenarios to inform it. It does, however, include an assessment of climate change impacts on the livestock sector. Desertification is addressed in the PNDE as a climate change impact, while pastoralism is recognised as an adaptive strategy that should be reinforced. The PNDE also aims to strengthen governance and institutions under its fifth pillar and includes cost estimates and co-financing needs for each proposed programme.</p> <p>The PNDE incorporates land-use planning considerations in its approach to natural resource management as a condition for strengthening agropastoral livelihoods. However, it does anticipate land-use planning specific activities or objectives. The PNDE also includes gender-specific objectives and activities relating to employment and livelihoods. Despite these gender-specific activities, other activities in the Plan do not have gender considerations clarified. Given the seeming policy gaps, the proposed GCF project will review the PNDE to include gender and land-use planning considerations under Activity 1.1.1.</p>
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## 4 Past and ongoing projects and initiatives

### 4.1 Non-climate change

#### 4.1.1 Country-specific

##### **Integrated Management of Protected Areas in the Arid Regions of Mauritania (IMPADRA) (2021–ongoing; GEF, ~USD20 million)<sup>796</sup>**

This regional project is currently funded by the Global Environment Facility (GEF) and is executed in-country by Ministry of Environment and Sustainable Development (MEDD). The IMPADRA project supports biodiverse conservation efforts to generate global environmental benefits by creating and improving the management effectiveness of a new protected area in Mauritania. The global benefits associated with this project are to enhance the conservation of key species in the arid wilayah of Adrar through: i) the creation and sustainable management of a new protected area (200,000 ha) and ii) the sustainable land management in production systems in 50,000 ha adjacent to the new protected area. The project consists of three components to achieve the objective, namely: i) establish a new protected area in Adrar wilayah; ii) establish financial sustainability mechanisms for sustainable and effective management of the protected area and adjacent landscape; and iii) ensure knowledge management and gender mainstreaming.

Addressing baseline concerns, the IMPADRA project proposes a variety of interventions that address institutional and policy gaps, financial sustainability, livelihoods and knowledge products to support lesson sharing and awareness-raising and to inform strategic conservation decisions in arid zones beyond the target region. It builds on current efforts by the Government of Mauritania (GoM) to establish the necessary institutional structures and capacity to warrant effectiveness in their management. To achieve the outlined objective, the project promotes alternative income-generating activities linked to community-based biodiversity enterprises and supports the implementation of sustainable natural resource management practices. In doing so, the IMPADRA project aims to design and implement measures that accomplish several benefits through the conservation of biodiversity, the safeguarding and improvement of ecosystem services (ESSs) and the well-being of people dependent on them for their livelihoods.

The proposed project will complement and build on the best practices and lessons learned from the IMPADRA project by promoting the adoption of diversified livelihoods that support the sustainable use of natural resources. In addition, the proposed project will contribute to the strengthening of knowledge management systems and awareness-raising and will inform strategic conservation decision-making in arid zones in Mauritania within local and national institutions. By producing policy briefs that promote the inclusion of climate change and gender responsiveness in policies, the proposed project will also complement work that addresses institutional and policy gaps associated with climate change.

##### **Sustainable Management of Natural Resources, Communal Equipment and the Organization of Rural Producers Project (PROGRES) (2020–ongoing; IFAD, USD39.7 million)<sup>797</sup>**

This six-year project is funded by the International Fund for Agricultural Development (IFAD) and targets six southern wilayahs in Mauritania: Assaba, Brakna, Gorgol, Guidimakha, Hodh El Gharbi and Hodh Charghui. PROGRES is the first project designed under IFAD's Country Strategic Opportunities Programme for Mauritania (COSOP, 2018–2024) and is closely aligned with Government goals for the agricultural sector and rural development. The project's theory of change focuses on achieving a rural transformation built on citizen engagement and the sustainable management of natural resources, and it places poor rural communities at the forefront of the sector's

<sup>796</sup> GEF. 2021. Management of Protected Areas in the Arid Regions of Mauritania (IMPADRA). Available at: <https://www.thegef.org/projects-operations/projects/10586>

<sup>797</sup> International Fund for Agricultural Development (IFAD). 2019. Sustainable management of natural resources, communal equipment and the organization of rural producers project. Available at: <https://www.ifad.org/en/web/operations/-/project/2000001878>.



development. PROGRES will work to regenerate degraded ecosystems through the restoration of abandoned farming areas and pastoral areas and to promote climate-resilient agriculture in the six target regions. The project's development objective is to empower the rural poor's sustainable access to natural resources and collective amenities. To achieve this, the project is divided into three components, summarised below.

- Sustainable management of water and soil: To preserve natural resources used as productive agropastoral capital, PROGRES will rehabilitate 9,500 ha of farmland — including dam rehabilitation and the development of ponds and pastoral corridors — using production techniques adapted to ecosystems. Agricultural capacity will be developed using the farmer field schools approach. Under this component, management committees, which will be established for each site, and local farmers' organisations will benefit from natural resource management capacity-building to increase their resilience to climate change.
- Equipment for the support of local development: The project will strengthen the planning and management capacities of nearly 700 local structures and facilitate access to basic socio-economic services by financing 260 public infrastructure sub-projects for, *inter alia*, drinking water, vaccination parks, slaughterhouses and shops.
- Project management and evaluation: The framework of the programme approach<sup>798</sup> adopted for the Mauritania profile will be implemented when executing this component. This approach will create closer synergies with ongoing projects in the implementation of the COSOP strategic objectives by merging project human, logistical and financial resources at both the national and regional levels.

The proposed project will draw on the applied regenerative approaches and make use of the management committees established at the shared intervention site of Hodh El Gharbi. Lessons learned and best practices for the target site will be extracted from PROGRES' monitoring and evaluation plans during its interim evaluation in 2023 to ensure that the proposed project continues to grow and adapt. Best practices relating to citizen engagement and the sustainable management of natural resources identified during the implementation of PROGRES will be applied to the proposed project.

**Mauritania Sectoral Water and Sanitation Project (PSEA) (2020–2026); World Bank (WB), USD49 million)<sup>799</sup>**

The G5 Sahel formulated the Emergency Development Programme (EDP), which launches quick-impact emergency projects in the Sahel region; PSEA is an emergency project under this programme. This WB project is intended to increase access to improved water supply and sanitation services in five wilayahs: Gorgol, Assaba, Guidimakha, Hodh El Gharbi and Hodh Chargui. The project also seeks to strengthen the operational and monitoring performance of the water and sanitation sector institutions. Furthermore, it supports the operationalisation of Pillar I of the EDP: fostering the living conditions of border populations by improving basic public services, in particular access to water and sanitation. PSEA will increase access to improved water supply by constructing and rehabilitating water supply networks, latrines and handwashing facilities in public centres in the five implementation regions. This infrastructure will be complemented by awareness-raising campaigns around water, sanitation and hygiene and will strengthen the capacity and performance sector institutions.

The proposed project seeks to build synergies with PSEA. Where PSEA addresses baseline water management concerns, the proposed project will address climate additionality concerns by strengthening sustainable access to water resources and introducing climate-resilient demand management practices. The proposed project will build on the strengthened capacity by

<sup>798</sup> The establishment of a country programme was jointly initiated by the Government and IFAD with the aim of improving effectiveness and efficiency in the allocation of resources. The end result was the establishment of a certain number of shared functions provided by a pool of experts and a pooling of resources and logistics.

<sup>799</sup> Alliance Sahel. 2021. Emergency development programme. Available at: [https://www.alliance-sahel.org/wp-content/uploads/2020/05/6-Factsheet-PDU\\_MR\\_BM\\_PSEA\\_Sep2021-EN.pdf](https://www.alliance-sahel.org/wp-content/uploads/2020/05/6-Factsheet-PDU_MR_BM_PSEA_Sep2021-EN.pdf).

mainstreaming climate change adaptation and natural resource management into the policies, plans and strategies, supported by local and national institutions. The proposed project will complement the objectives of this project by improving the availability of clean water to local communities in northern Mauritania, primarily through rainwater harvesting techniques.

**Access to drinking water and sanitation in the two Hodh regions of Mauritania (G5-2H) (2019–2024); AFD, USD12.3 million)<sup>800</sup>**

This project is an emergency project under the G5 Sahel's EDP. More specifically, this five-year project is part of the ongoing programme Drinking Water and Sanitation in Five Wilayahs in Mauritania, funded by the French Agency for Development (AFD) and the European Union (EU). It aims to address baseline water and sanitation problems, including the implementation of drinking water and sanitation infrastructure in the Hodh Chargui and Hodh El Gharbi wilayahs. An emergency component allows for the rehabilitation of existing drinking water infrastructure. In funding this project, the AFD addresses the EDP's Pillar I. Mauritania's Ministry of Water and Sanitation (MHA) oversees project implementation, which is currently underway. The three project objectives are summarised below.

- Provide 74 localities — 42 in Hodh Chargui and 32 in Hodh El Gharbi — with drinking water to benefit 60,000 people.
- End open defecation in 400 localities by building 157 public latrines in schools and health centres to benefit 170,000 people.
- Strengthen the institutional design of semi-urban water supply services and overall capacities of the sector.

The proposed project, which shares the two target sites, will build on the interventions of this project by strengthening the capacity of local, regional and national institutions to implement climate-resilient water resources and demand-management practices. The combined effort of the two projects will contribute to ensuring the sustainability of drinking water supplies in Hodh Chargui and Hodh El Gharbi.

**Expanding the national water supply network (2022–ongoing; Mauritanian Government and Islamic Development Bank, USD40 million)<sup>801</sup>**

This project is being implemented on a national level and aims to rehabilitate and extend the running water supply network in the capital, Nouakchott, to ensure better water distribution in the city. A modern distribution network will be set up as part of the project. Overall, the project aims to install 900 km of pipe and make 60,000 connections to households, free of charge. Two pumping stations will be built to the east of the city and a 5,000 m<sup>3</sup> reservoir will be constructed to improve the rate of access to drinking water.

This project is evidence of GoM's recognition of concerns around drinking water and water supply and its implementation of the changes necessary to improve service delivery. The proposed project will learn from the best practices of this project and will inform the water resource management practices (Output 2.2).

<sup>800</sup> Alliance Sahel. 2020. Emergency development programme. Available at: <https://www.alliance-sahel.org/wp-content/uploads/2020/04/Factsheet-PDU-MR-AFD-G5-2H-EN-VF.pdf>.

<sup>801</sup> Feukeng, L. 2019. Mauritania: Government wants to expand water supply network. Available at: <https://www.afrik21.africa/en/mauritania-government-wants-to-expand-water-supply-network/>.



## 4.2 Climate-change related

### 4.2.1 Regional

#### **Mauritania Sustainable Landscape Management Project under the Sahel and West Africa Program (2015–2021; GEF, ~USD24 million)<sup>802</sup>**

This project was funded by the GEF's Least Developed Countries Fund (LDCF), with the MEDD as the implementing agency. It is one of 12 investments that fall under the GEF/WB Sahel and West Africa Programme (SAWAP). SAWAP's objective is to develop sustainable land and water management in targeted landscapes and in climate vulnerable areas in West African and Sahelian countries. Through the programme, the WB supports countries to tackle land degradation and desertification in the Sahel and Sahara, boost food security and support communities to adapt to climate change. In alignment with the SAWAP programme, the objective of this project was to strengthen sustainable landscape management (SLM) in targeted productive ecosystems in the regions of Trarza, Brakna and Gorgol in Mauritania. To achieve this objective and fulfil SAWAP's goals, the project consisted of three components, summarised below.

- Component 1: SLM knowledge, governance and partnerships. This included strengthening the SLM knowledge base among national and local government agencies, local communities, non-profit organisations and the private sector. Governance systems were improved and more effective partnerships were created to support the development of the gum Arabic sector in Mauritania.
- Component 2: SLM practice. The primary intended outcome of this component was to strengthen management of gum Arabic-producing landscapes in the country and to augment integration of SLM considerations into local development planning in the regions of Trarza, Brakna and Gorgol. This included implementing SLM practices in pilot sites that improved vegetation cover and fodder availability, enhancing investments in communities' livelihoods and strengthening MEDD's capacity in SLM.
- Component 3: Project management. The outcome of this component was to ensure that the management of the project was carried out efficiently and effectively. Despite some delays in the implementation of investments, the project met its objectives within the initial time frame and budget.

The overall efficacy of the project was rated substantial, as its activities strengthened the SLM of gum Arabic-producing ecosystems in Trarza, Brakna and Gorgol. The objective and indicators of targeted outcomes of the project were substantially achieved, reaching or exceeding their target values. Best practices and lessons learned from this project will be used by the proposed project, including practices that formulate local development plans integrating SLM, SLM practices that improve vegetation cover and fodder availability, enhanced investments in communities' livelihoods and strengthened MEDD capacity in SLM. The proposed project will also utilise best practices from the SAWAP project on how to engage communities in an adaptive process that delivers results in the short term while enabling communities to adopt proactive adaptation measures in the long term.

#### **The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in seven Sahelian countries of the Great Green Wall (GGW) (2021– ongoing; GCF USD143 million)<sup>803</sup>**

This multi-country programme was coordinated by IFAD and is funded by the Green Climate Fund (GCF), IFAD, African Development Bank (AfDB) Group, African Risk Capacity and World Food Programme (WFP). With a six-year implementation period and a total lifespan of 20 years, this cross-cutting regional programme is intended to impact smallholder farming in seven West African countries: Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and Gambia. As the first proposal developed

<sup>802</sup> WB. 2015. Mauritania Sustainable Landscape Management Project under the SAWAP.

<sup>803</sup> GCF. 2021. The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW).

within the framework of the future GCF umbrella programme GGW, the objective of this programme is to build, strengthen and upscale the resilience and adaptive capacity of smallholder farmers and rural communities of seven Sahelian least-developed countries (LDCs) to climate change, using an integrated climate risk management approach. This approach combines climate risk preparedness with climate risk reduction and climate risk transfer. To achieve this, the regional programme outlined three mutually reinforcing outcomes, summarised below.

- Climate risk preparedness: Strengthened climate weather information to support decision-making and planning in agroforestry and livestock, agricultural insurance products and services and capacity development for farmers, government and the private sector.
- Climate risk reduction: Strengthened climate-resilient, smart agroforestry and pastoral value changes, powered by reliable and affordable renewable energy sources. Among other activities in the value chains, the programme will contribute to reducing greenhouse gas (GHG) emissions from energy use within agricultural value chains by adopting renewable energy technologies (RETs) for water mobilisation and to power processing and packaging.
- Climate risk transfer (micro and sovereign risk transfer mechanism): To enhance resilience building, reduced obstacles such as financial market products and high premiums to enable governments and smallholder farmers to access agricultural insurance.

The programme is enhancing or strengthening an enabling environment in Mauritania, and the proposed project will contribute to this environment by further strengthening and supporting climate awareness and its integration in policies. In alignment with Outcome 3 of the programme, which will provide support for policy and resilience planning at national and local levels, the proposed project will replicate and build on the best practices and lessons learned from the programme's implementation in Mauritania. The proposed project will also build on the institutional structures and capacities enhanced by the programme to promote the awareness of sustainable land and water management practices within local communities. The regional programme will equip farmers with best available technologies for adaptation and mitigation, to be implemented through agricultural insurance schemes. This will be complemented by the proposed project, which will incorporate these sustainable technologies when encouraging communities to adopt diversified livelihoods that support the sustainable use of natural resources.

#### 4.2.2 Country-specific

##### **Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania (2017–ongoing; GEF, USD13.5 million)<sup>804</sup>**

This four-and-a-half year project began in 2017 and is expected to end in 2022; it is primarily implemented by MEDD. The objective of the project is to reduce the climate change vulnerability of communities living in the Sahelian Acacia Savanna rangelands of Mauritania through the implementation of ecosystem-based adaptation (EbA) measures. Two approaches are used to achieve the project's objective: i) strengthening the institutional and technical capacity of government sectors to plan for adaptation and promote the implementation of best adaptation practices throughout the country; and ii) developing an innovative system for the sustainable management of natural resources to guide rural communities to adopt sustainable, climate-resilient livelihoods. The three main elements of this project are outlined below.

- Strengthen capacity at national and local level of government and non-government institutions to adapt to climate change using EbA interventions.
- Integrate EbA into relevant legislation, policies and strategies at all levels of government to adapt to climate change.
- Implement EbA interventions and activities that will mainstream the use of climate-resilient, multi-use and indigenous plant species for the restoration and revegetation of degraded ecosystems in the Sahelian Acacia Savanna rangelands. The restoration of degraded ecosystems will increase

<sup>804</sup> GEF. 2017. Development of an Improved and Innovative Management System for Sustainable Climate-resilient Livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

the generation of valuable ESSs such as water infiltration, soil stabilisation and fodder production. The creation of green firebreaks, an EbA intervention, will also be piloted through this project. This will increase knowledge of best adaptation practices in Mauritania and decrease the vulnerability of local communities to the effects of climate change such as droughts and bushfires.

Though the management project targets different locations to those of the proposed project, it is of particular relevance to the implementation of Output 1.1, Output 2.1 and Output 2.2. The proposed project will learn from and use the best practices of the management project to strengthen the capacity of government and non-government institutions to adapt to climate change using EbA interventions.

### **Enhancing Resilience of Communities to the Adverse Effects of Climate Change on Food Security in Mauritania (PARSACC) (2014–2018; Adaptation Fund, USD7.8 million)<sup>805</sup>**

Funded by the Adaptation Fund (AF), the WFP implemented a four-year project in Mauritania to address food insecurity in the country. The main objective of the project was to enhance environmental governance through ecological monitoring, the management and sharing of climate change knowledge and the mobilisation and involvement of communities to adapt to climate change and build resilient, food-secure livelihoods. These activities aligned with the Government's decentralisation plan and the national adaptation and environmental protection strategies at the local level. PARSACC also supported Government technical staff and local non-governmental organisations (NGOs) to access, analyse and use climate-related information in combination with food security, livelihood and vulnerability data. Communities were supported as participative local prioritisation processes were facilitated and communities were assisted to formulate and sustainably implement their own adaptation plans. The overarching goal of PARSACC was to enhance vulnerable communities' resilience to the effects of climate change on food security. This goal was achieved through a two-stage strategy. First, institutional and technical capacity for well-informed, participative and community-owned adaptation planning and natural resource management planning was established and strengthened (Component 1). Second, communities were mobilised to invest in resilience and climate change adaptation (Components 2 and 3). The three components are summarised below.

- Support technical services and the communities they serve to: i) better understand climate risks, their impact on livelihoods and food security; and ii) facilitate participatory, decentralised adaptation planning.
- Design and implement concrete adaptation measures identified through community adaptation planning that combat desertification and land degradation.
- Design and implement concrete adaptation measures identified through community adaptation planning that diversify and strengthen the livelihoods of the most vulnerable population.

Overlaps between the proposed project and closed PARSACC include, *inter alia*: i) common target sites; ii) strengthening of institutional capacity; and iii) natural resource management planning for communities. Of the eight PARSACC-targeted wilayahs, the proposed project will operate in Tagant, Hodh El Gharbi and Hodh Chargui. Given the common project areas, the proposed project will learn from PARSACC's best practices and will build on the institutional capacity and adaptation plans implemented. PARSACC carried out its participatory process successfully, and the proposed project will adopt those methods. Additionally, the programming tools that were introduced helped strengthen the social cohesion of the targeted communities and raised awareness at various levels about environmental concerns at both a local and regional scale. The proposed project will adopt and build upon the successes of the project and learn from its shortcomings to improve proposed project implementation and sustainability.

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<sup>805</sup> Adaptation Fund (AF). N.d. Enhancing resilience of communities to the adverse effects of climate change on food security in Mauritania. Available at: <https://www.adaptation-fund.org/projects-document-view/?URL=https://pubdocs/en/566581532334876030/14-Proposal-for-Mauritania-WFP-full.pdf>.

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**Climate change adaptation and livelihoods in three arid regions of Mauritania (2021–2024; GEF, USD18,136,584)<sup>806</sup>**

This four-year project is implemented by MEDD and funded by GEF's LDCF. The overall objective of this LDCF project is to increase the local and regional adaptive capacity of the populations of three arid wilayahs (Adrar, Inchiri and Trarza) by strengthening local and regional institutional capacities and improving access to innovation, technical know-how and knowledge. This will facilitate the introduction of EbA approaches to bolster the functions of desert, oasis and wadi ecosystems such that they can better contribute to the resilience of local populations to the impacts of climate change. This will be achieved through the four outcomes of the project described below.

- Stakeholders demonstrate increased technical and institutional capacity for climate change adaptation — particularly EbA — in the arid ecosystems of Adrar, Inchiri and Trarza.
- Sustainable access to and efficient use of water for increased drought resilience of local communities and ecosystems in the three wilayahs is enhanced. Activities under this outcome include the acquisition and implementation of water supply, storage and harvesting systems and the implementation of soil protection and restoration interventions to enhance groundwater recharge through increased water infiltration and to protect areas within the site from flooding, soil erosion and riverbank erosion.
- Protection, productivity and diversification of livelihoods are enhanced through EbA and small-scale infrastructure interventions to increase climate resilience in the wilayahs of Adrar, Inchiri and Trarza. This includes EbA interventions to protect vulnerable communities and ecosystems from dune migration, wind and heat and to provide forage for non-timber forest products.
- Stakeholders demonstrate strengthened knowledge and action-oriented attitudes about climate change and adaptation approaches — particularly EbA.

The proposed project will learn from and improve upon the EbA interventions implemented during the LDCF project, including the EbA interventions implemented for dune stabilisation in different target sites. The LDCF project analyses of biological and mechanical dune stabilisation technique suitability and adaptability to environment will be used by the proposed project to inform the most appropriate dune stabilisation approaches for the four sites. Best practices and lessons learned from the LDCF project will be used by the proposed project, including practices of adaptation training that target government institutions and civil organisations, technical and water management training for local representatives and the acquisition and implementation of rainwater harvesting systems.

**PASK-II Support for the adaptation of agricultural production systems vulnerable to climate change (2015–2019; IFAD and GEF, ~USD10 million)<sup>807</sup>**

The Poverty Reduction Project in Aftout South and Karakoro (PASK) II, which ended its second phase in 2019, was a four-year project funded by the GEF LDCF. The project was developed to increase the resilience of rural communities to growing water deficits and the loss of productivity of plant and animal production systems caused by climate change. Four specific objectives were identified to accomplish the overall objective: i) adapt the agricultural production systems vulnerable to climate change; ii) strengthen the resilience of the livestock farming systems to climate change; iii) improve the efficiency of water management systems and their adaptation to climate change; and iv) strengthen the adaptation capacities of the production systems in the rural areas to the impacts of climate change. To complete these objectives, the project consisted of five components, summarised below.

- Minimise the risk of reduced productivity and agricultural production as a result of the impact of climate change.
- Improve the resilience of livestock farming and animal production systems in oasis and semi-arid areas.

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<sup>806</sup> GEF. 2021. Climate change adaptation and livelihood in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<sup>807</sup> GEF. 2017. Poverty Reduction Project in Aftout South and Karakoro - Phase II. Available at: <https://www.ifad.org/en/web/operations/-/project/1100001577>

- Increase the efficiency of the irrigation and water management systems.
- Strengthen the adaptation capacities of the rural production systems to the impacts of climate change.
- Project management.

The proposed project will draw on the best practices and lessons learned about climate-resilient livestock management and climate-smart crop agriculture. This will include practices on increased production of green forage and capacity to secure livestock feeding during drought periods, the promotion of livestock cropping integration, the irrigated production of forage and improved animal feeding on natural rangelands and from local bio-agricultural products. The GEF project practices that support climate-resilient crop agriculture, such as sustainable land management and techniques that recognise the value of effective traditional cropping practices, will also inform the proposed project activities under Outputs 2.1 and 2.2.

### **Strengthening Mauritania's national capacity for transparency and ambitious climate reporting (2022–2025; GEF ~USD1.2 million)<sup>808</sup>**

This three-year project will be implemented by the United Nations Environmental Programme (UNEP) and MEDD and is focused on fostering enabling conditions that mainstream mitigation concerns into sustainable development strategies through capacity building initiatives for transparency. The main project objective is to strengthen Mauritania's capacities in climate transparency, according to the Enhanced Transparency Framework (ETF) under the Paris Agreement, and thereby achieve its sustainable low-carbon development goals. The project comprises two components: i) strengthening Mauritania's capacity to collect and process climate change data into useful information for policymaking and reporting to the United Nations Framework Convention on Climate Change (UNFCCC); and ii) monitoring and evaluation. Expected outcomes of the project include improving Mauritania's monitoring, reporting and verification system and improving its institutional capacity to comply with the ETF. To achieve the project objective and expected outcomes, the project is comprised of three outputs, described below.

- Strengthen national institutions to coordinate, manage and report transparently on implemented climate change activities.
- Provide technical support, training and tools to the country to submit transparent, consistent, comparable, complete and accurate GHG inventories.
- Provide technical support, training and tools to the country to track Nationally Determined Contributions (NDCs) for mitigation, adaptation and support needed and received.

The proposed project will replicate and learn from the best practices of the GEF project and complement it by strengthening the institutional and technical capacity of the national institutions to coordinate, manage and transparently report on implemented climate change activities. In addition, the improved national capacity and technical support provided by this project will enable more favourable circumstances for Output 1.1. The project will enable the country to track the success of its NDCs and thereby demonstrate the potential benefit of the proposed project.

<sup>808</sup> GEF. 2021. Strengthening Mauritania's national capacity for transparency and ambitious climate Reporting. Available at: <https://www.thegef.org/projects-operations/projects/10428>

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Table 50 shows the summary of planned and ongoing initiatives in Mauritania, as well as proposed complementarity achieved by the current GCF project.



**Table 50.** Summary of planned and ongoing initiatives in Mauritania, as well as proposed complementarity achieved by the current GCF project.

Project details	Project description	Complementarity achieved by the proposed GCF project
<p><b>Project:</b> <i>Integrated Management of Protected Areas in the Arid Regions of Mauritania (IMPADRA)</i><sup>809</sup></p> <p>(Concept approved in 2021; Project Document currently under development)</p> <p><b>Fund:</b> Global Environment Facility (~US\$20 million)</p> <p><b>Implementing Agency:</b> United Nations Environment Programme (UNEP)</p> <p><b>Executing Agency:</b> Ministry of the Environment and Sustainable Development (MEDD)</p>	<p>The IMPADRA project seeks to enhance biodiversity conservation and the generation of global environmental benefits in the wilayahs of Adrar. The project comprises three objectives, namely: i) establish a new 200,000 ha protected area in the Adrar wilayah (Component 1); ii) establish financial sustainability mechanisms for sustainable and effective management of the protected area and 50,000 ha of adjacent landscape (Component 2); and iii) strengthen knowledge management and gender mainstreaming (Component 3).</p>	<p>Shared focus on Adrar wilayah</p> <p>The proposed GCF project will upscale plans for a new protected area under Component 1 of the IMPADRA project by establishing fenced-off buffer zones, or conservation areas, within Aoujeft hub. Planting protective treelines and restoring ecosystems within these buffer zones will synergistically contribute to biodiversity conservation and biological dune fixation.</p> <p>The proposed GCF project will complement Component 2 of the IMPADRA project by: i) establishing an on-granting mechanism to support the uptake of sustainable livelihoods in the target region; and ii) promoting climate-smart agricultural and livestock practices, which will reduce anthropogenic pressure on fragile oasis ecosystems in this hub.</p> <p>The proposed GCF project will build on IMPADRA's efforts to strengthen climate knowledge management systems and gender mainstreaming under Component 3 by: i) establishing commune-level coordination platforms to facilitate knowledge-sharing, natural resource management, sustainable land-use planning and the implementation of EbA activities; ii) preparing policy briefs for the integration of climate considerations and gender-responsiveness into commune-level restoration plans; and iii) training stakeholders in Adrar to use existing climate knowledge platforms established under the National Adaptation Plan (NAP) process.</p>
<p><b>Project:</b> <i>Sustainable Management of Natural Resources, Communal Equipment and the Organisation of Rural Producers Project (PROGRES) (2020–2026)</i><sup>810</sup></p> <p><b>Fund:</b> International Fund for Agricultural Development (IFAD) (US\$39.7 million)</p>	<p>The PROGRES project works to regenerate degraded ecosystems and promote climate-resilient agriculture in six wilayahs across southern Mauritania: Assaba, Brakna, Gorgol, Guidimakha, Hodh El Gharbi and Hodh Charghi. The project has committed to restoring 9,500 ha of degraded farmland using water- and soil conservation techniques, dam rehabilitation, pond development and the creation of</p>	<p>Shared focus on Hodh El Gharbi and Hodh Charghi wilayah</p> <p>The proposed GCF project will upscale ecosystem rehabilitation efforts undertaken by the PROGRES project in Hodh El Gharbi and Hodh Chargui by: i) establishing buffer zones for biological dune-fixation and ecosystem restoration in Tamcheket and Nema; ii) facilitating the uptake of climate-smart agricultural practices in these regions, to reduce pressure on natural ecosystems; and iii) investing in water resource-</p>

<sup>809</sup> GEF. 2021. Integrated Management of Protected Areas in the Arid Regions of Mauritania (IMPADRA). Available at: <https://www.thegef.org/projects-operations/projects/10586>

<sup>810</sup> IFAD. 2019. Sustainable management of natural resources, communal equipment and the organization of rural producers project. Available at: <https://www.ifad.org/en/web/operations/-/project/2000001878>



<p><b>Executing Entity:</b> Ministry of Rural Development (MDR<sup>811</sup>)</p>	<p>pastoral corridors. The project's main objectives include: i) the restoration of abandoned farming areas and pastoral areas; and ii) improving rural and impoverished communities' access to natural resources and collective amenities.</p>	<p>management infrastructure (sand dams, gabions, stone bunds, clay dikes) to reduce excessive runoff during extreme rainfall events and thereby improve water and soil conservation.</p> <p>The establishment of commune-level coordination committees under the proposed GCF project will ensure that best practices and lessons learned from the PROGRES project are employed in the two Hodhs (Tamcheket and Nema hubs) and replicated in the more northern wilayahs of Adrar (Aoujeft hub) and Tagant (Rachid hub).</p>
<p><b>Project:</b> <i>The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in seven Sahelian countries of the Great Green Wall (GGW) (2021–ongoing)</i><sup>812</sup></p> <p><b>Fund:</b> GCF (US\$143 million)</p> <p><b>Accredited Entity:</b> IFAD</p> <p><b>National Executing Entity(ies):</b> Ministry of Finance; Ministry of Agriculture</p>	<p>This cross-cutting regional programme intends to build, strengthen and upscale the climate resilience and adaptive capacity of smallholder farmers in seven Sahelian Least Developed Countries (LDCs) West African countries: Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and Gambia. The GGW programme uses an integrated climate-risk management approach, which combines climate-risk preparedness with climate-risk reduction and climate-risk transfer.</p> <p>In Mauritania, the project is centred around six strategic pillars. The six pillars are: i) enhancement of food security via sustainable management of production systems; ii) promotion of good governance and local development; iii) generation of income through the development of additional activities; iv) support for research and management of knowledge; v) capacity building for all involved stakeholders; and vi) overseeing coordination and conducting regular monitoring and evaluation. The project operates in Trarza, Brakna, Tagant, Assaba, Hodh El Gharbi and Hodh Chargui wilayas.</p>	<p>Shared focus in Hodh Charghi, Hodh El Gharbi and Tagant wilayah.</p> <p>The proposed project will contribute to pillar i) of the GGW project in Mauritania by promoting the adoption of climate-smart agricultural techniques and sustainable livestock management practices, to both increase food security and reduce pressure on natural landscapes.</p> <p>The establishment of commune-level technical committees (CTCs) under the proposed GCF project will contribute to pillars ii) and v) and vi) of the GGW project in Mauritania, which focus on governance, capacity-building and coordination for monitoring and evaluation.</p> <p>The development of sustainable livelihood opportunities within the target hubs of Aoujeft, Rachid, Tamcheket and Nema will upscale GGW efforts to support income generation through the development of additional activities (pillar iii).</p> <p>The proposed GCF project will support objective iv) of the GGW project by facilitating the two-way flow of knowledge (top-down and bottom-up) between national stakeholders, regional stakeholders and local beneficiaries in the hubs of Aoujeft, Rachid, Tamcheket and Nema. CTCs established under the project will be responsible for collecting and disseminating project-specific best practices and lessons learned for climate change adaptation between stakeholders at all levels, using the existing knowledge management platform developed under the NAP. The types of information shared will include, <i>inter alia</i>, strategies for integrated climate risk management, data pertaining to the impacts</p>

<sup>811</sup> Ministère du Développement Rural

<sup>812</sup> GCF. 2021. FP162: The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW). Available at: <https://www.greenclimate.fund/project/fp162>

		of climate change on landscapes and communities within the target hubs, market studies and business cases for sustainable livelihood opportunities, and plans for the climate-resilient management of natural resources.
<p><b>Project:</b> <i>Climate change adaptation and livelihoods in three arid regions of Mauritania (2021–2024)</i><sup>813</sup></p> <p><b>Fund:</b> GEF (US\$18,186,584)</p> <p><b>Implementing Agency:</b> UNEP</p> <p><b>Executing Agency:</b> MEDD</p>	<p>The overall objective of this LDCF project is to increase the local and regional adaptive capacity of the populations of three arid wilayahs (Adrar, Inchiri and Trarza) by strengthening local and regional institutional capacities and improving access to innovation, technical know-how and knowledge. The project comprises four components: i) institutional and technical capacity development for the planning and implementation of climate change adaptation in arid ecosystems; ii) sustainable access to and efficient use of water; iii) protection, productivity and diversification of local livelihoods; and iv) knowledge for action on climate change and EbA in arid ecosystems.</p>	<p>Shared focus in Adrar wilaya</p> <p>The proposed GCF project will contribute to improving knowledge management in the target regions by disseminating publications and strategies generated by the ongoing GEF project to end-users in Aoujeft, Rachid, Tamcheket and Nema, using existing knowledge management systems developed under the NAP. This will be conducted by commune-level CTCs within each hub.</p> <p>Additionally, AGPO members capacitated under the GEF project will be represented in commune-level CTCs established under the proposed project to ensure effective coordination between the two projects in Adrar.</p> <p>The proposed project will complement efforts undertaken by the GEF project to enhance the functioning of desert, oasis and <i>wadi</i> ecosystems. This will be achieved by upscaling the installation of physical structures and EbA measures for controlling sand encroachment in Adrar (additional 400 ha) and replicating these methods in the wilayah of Tagant, Hodh El Gharbi and Hodh Chargui.</p> <p>The current project will also upscale efforts to install efficient water provisioning and distribution systems in Adrar by providing target communes with rainwater harvesting and drip irrigation kits and constructing additional boreholes and sand dams, equipped with solar-powered pumps. The installation of these systems will be replicated in the Tagant, Hodh El Gharbi and Hodh Chargui wilayahs.</p> <p>Local livelihoods developed under the ongoing GEF project — for example, via the establishment poultry farms and nurseries — will be upscaled under the proposed project and replicated in the remaining three target hubs.</p>
<p><b>Project:</b> <i>Strengthening Mauritania's national capacity for transparency</i></p>	<p>This project, implemented by UNEP and the MEDD, is focused on creating an enabling</p>	<p>The proposed GCF project will use best practices and lessons learned from the ongoing GEF project to develop monitoring</p>

<sup>813</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<p><i>and ambitious climate reporting (2022–2025)</i></p> <p><b>Fund:</b> GEF (US\$1,37 million)</p> <p><b>Implementing Agency:</b> UNEP</p> <p><b>Executing Agency:</b> MEDD</p>	<p>environment for mainstreaming climate change mitigation into sustainable development strategies.</p> <p>The project comprises two components: i) strengthening Mauritania's capacity to collect and process climate change data to inform policymaking and improve reporting to the United Nations Framework Convention on Climate Change (UNFCCC); and ii) strengthening M&amp;E efforts in Mauritania.</p>	<p>and reporting mechanisms that improve the traceability and risk management of funds channelled from government budgets and sustainable natural resource-based livelihoods towards upscaling climate change adaptation and EbA interventions.</p>
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## 5 Best practices and lessons learned

The International Finance Corporation identifies five priority sectors that, when conditions are favourable, could strategically enhance climate-change adaptation, namely: i) policies; ii) institutional arrangements; iii) data and information; iv) communication, technology and knowledge; and v) economic incentives<sup>814</sup>. All five areas are covered in this proposed project's suggested interventions for combatting climate-change desertification in Mauritania. The proposed interventions have been designed in accordance with regional and international best practices, as well as lessons learned from past and ongoing initiatives to ensure that the maximum benefit is achieved. These best practices and lessons learned are detailed in Sections 5.1–0 below.

### 5.1 Establishing an enabling environment for climate change adaptation

An enabling environment is essential to the success of a climate-change project's adaption goals. In many instances, projects and programmes implementing ecosystem-based adaptation (EbA) interventions — including, *inter alia*, sustainable land management and ecosystem restoration — have failed to produce lasting impacts. This is often because local institutions have limited capacity to enforce climate change-related regulations<sup>815</sup>. Therefore, establishing or strengthening institutions and regulatory frameworks to promote sustained investment in climate-change adaptation is central to the success of the proposed project.

In 2015, the investment environment in Mauritania was described as '[an] insufficiently enabling business environment characterised by administrative barriers and legal and judicial issues'<sup>816</sup>. Moreover, the National Adaptation Plan (NAP) for Mauritania was only initiated in April 2015 and has not progressed much since then. Currently, there is no long-term national strategy to ensure the consistency, complementarity, and coordination of climate change-adaptation projects in the country<sup>817</sup>. This has limited the integration of climate-change adaptation into development planning, resulting in adaptation projects being designed and implemented largely in an *ad hoc* manner. Furthermore, although climate change influences a range of economic sectors, mitigating the effects of climate change is still considered the sole responsibility of the Ministry of the Environment and Sustainable Development (MEDD). The current policies, strategies, and plans in the environmental sector — including water, livestock husbandry and agriculture — do not include practices for adaptation to climate change, nor for EbA<sup>818</sup>.

In line with these observations, several past and ongoing projects in the country have incorporated components for increasing the capacity of local, regional, and national institutions, as well as communities, to plan and implement climate change adaptation interventions. Best practices and lessons learned are discussed in the sections below. This pertains to: i) strengthening technical and institutional capacity; and ii) mainstreaming climate considerations into plans, policies and strategies.

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<sup>814</sup> International Finance Corporation. 2013. Enabling environment for private sector adaptation. Available at: <https://documents1.worldbank.org/curated/en/734691487221282291/pdf/112808-WP-Enabling-Environment-for-Private-Sector-Adaptation-PUBLIC.pdf>.

<sup>816</sup> Bertelsmann Stiftung (BTI). 2022. Mauritania Country Report 2022. Available at: <https://bti-project.org/en/reports/country-report/MRT>

<sup>817</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>.

<sup>818</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

### 5.1.1 Best practices

Several initiatives have recently been implemented to enhance cross-sectoral coordination of planning and monitoring interventions for Mauritania's environmental and sustainable development. For example, in 2006, Regional Delegations for Environment and Sustainable Development (DREDDs by their French acronyms<sup>819</sup>) were established in each wilayah to lead and coordinate the MEDD's interventions at provincial level. DREDDs are also responsible for ensuring that these interventions are aligned with existing environmental policies, strategies, and plans. In 2012, Mauritania's prime minister established the National Council for the Environment and Sustainable Development (CNEDD<sup>820</sup> by its French acronym) and corresponding Regional Councils for Environment and Sustainable Development (CREDDs<sup>821</sup> by its French acronym) in each wilayah to promote communication and coordination and support the implementation of field activities under the National Action Plan for Environment and Sustainable Development (PANEDD by its French acronym)<sup>822</sup>. In 2014, focal points for climate change were designated within most of the ministries of the Government of Mauritania (GoM)<sup>823</sup>.

At the local level, several approaches to community governance have been employed. Firstly, Local Development Associations have been established to grow existing income-generating activities that are dependent on natural resources — for example, through the establishment of butcheries and shops and the development of small-scale agricultural plots. Secondly, Pastoral Associations have been established to promote animal health, the use of migratory routes and food availability for livestock. Thirdly, Associations for Natural Resources (AGLCs<sup>824</sup>) have been established to support the sustainable management of natural resources<sup>825</sup>.

Before establishing new coordination frameworks, it is best practice to take stock of the existing institutions within a target region. Each institution's structure and achievements should be analysed, as well as its level of gender equity in decision-making processes. This will identify gaps where policy revisions are required<sup>826</sup>. All coordination bodies, policies and strategies established under the proposed project should complement the already-existing structures.

In line with this best practice, the Green Climate Fund's (GCF) '*NAP readiness proposal* (2016)' has committed to conducting a gap analysis and capacity assessment of the existing institutional framework in Mauritania. This process will assess strengths and weaknesses regarding existing capacities and resources to effectively engage in the NAP process. In addition, the NAP readiness and preparatory-support process will build capacity of the relevant government institutions' policy-makers, decision-makers, and technical staff by providing tailored training on: i) the current climate vulnerability of each sector; ii) recommended revisions to current policies and institutions to ensure climate change is taken into account rigorously, using the best available evidence; and iii) a standardised approach to implementing the NAP process. To leverage existing resources, trained government staff will support with establishing and training hub-level coordination committees within the four target rural-urban hubs (Activity 1.1.1), as well as with drafting gender- and climate-change responsive policy briefs (Activity 1.1.1). Wherever feasible, coordination committees will build on existing institutions established under other climate change-adaptation projects in the region,

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<sup>819</sup> Délégation Régionale de l'Environnement et du Développement Durable

<sup>820</sup> Conseil National Environnement et Développement Durable

<sup>821</sup> Conseil Régional Environnement et Développement Durable

<sup>822</sup> <https://www.iowater.org/avancementdenosprojets/mauritania-national-action-plan-nature-and-environment-pane>

<sup>823</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

<sup>824</sup> Association de Gestion Locale Collective des ressources naturelles. Located mainly in Hodh El Gharbi.

<sup>825</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

<sup>826</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

including the World Food Programme (WFP) and Global Environment Facility (GEF) projects described below.

The 2014–2019, the WFP project '*Enhancing resilience of communities to the adverse effects of climate change on Food Security in Mauritania*' (PARSACC; Table 51) successfully strengthened target communities' organisational and management capacities<sup>827</sup> through: i) the establishment of village management committees; ii) training committee representatives on management tools; iii) training community members on equipment maintenance; iv) supplying the MEDD with office equipment and a means of transport; and v) improving processes for collecting and using strategic information and data, planning and developing reports<sup>828</sup>.

Similarly, the ongoing GEF project '*Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania*' (2016) seeks to strengthen technical and institutional capacity at the national, provincial and local levels by: i) developing a national strategy to inform climate change-adaptation planning and advance the NAP process; ii) organising training events to facilitate the implementation of appropriate adaptation measures; iii) establishing new AGLCs where needed; and iv) training existing AGLC management committees on the use of EbA for managing natural resources sustainably<sup>829</sup>. At the community level, institutional capacity for sustainable development planning will be built through developing or revising, as required, Communal Development Plans (CDPs) that promote adaptation interventions, including EbA, as best practices for managing natural resources<sup>830</sup>.

The ongoing GEF project '*Climate change adaptation and livelihoods in three arid regions of Mauritania*' (2018) aims to strengthen institutional and technical capacity in the Adrar, Trarza and Inchiri wilayahs by: i) conducting climate change-vulnerability assessments; ii) identifying appropriate adaptation options; iii) developing community-level Climate Action Plans (CAPs), with a specific focus on gender; and iv) training community members and institutions on the implementation of identified climate change interventions<sup>831</sup>. The CAPs developed under this project will make provision to establish community-level committees that will coordinate with regional government structures, including DREDDs, the Ministry of Livestock (ME), the Ministry of Agriculture and the Ministry of Water and Sanitation (MHA). These committees will also support the implementation of climate change-adaptation interventions in each community. Wherever feasible, existing institutional structures — for example, existing AGLCs<sup>832</sup> — will be further strengthened to fulfil the role of these community-level coordination committees.

National consultants in Mauritania have recommended that the DREDDs and their internal consulting teams fulfil the role of hub-level coordination and technical committees in each of the proposed project's four target hubs – Aoujeft, Rachid, Tamcheket and Nema. To facilitate knowledge-sharing between regional- and local-level stakeholders, it is further recommended that commune-level technical committees (CTCs) be established in each of the twelve communes targeted by the project, since the commune is the smallest administrative unit in Mauritania. This will improve coordination between local and regional authorities, civil society-organisations, regional committees and community members. A list of potential representatives of these CTCs has been provided (Table

<sup>827</sup> Capacity building of more than 303 executives and technicians from MEDD, DREDD, journalists and NGOs involved and nearly 26,910 representatives of communities and populations

<sup>828</sup> WFP. 2019. Final evaluation report: Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

<sup>829</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>.

<sup>830</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

<sup>831</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<sup>832</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

52)<sup>833</sup>. Based on best practices drawn from past projects, it is recommended that CTCs meet at least every quarter to: i) ensure climate change adaptation is integrated into commune-level plans and policies; and ii) support the implementation of adaptation interventions by village-level project management teams<sup>834</sup>. Accordingly, the proposed project will incorporate quarterly meetings into each CTC's guidance framework (Sub-activity 1.1.1.2).

A participatory approach has been identified as best practice for developing national strategies and policy briefs that incorporate multisectoral experience and evidence for measures that buffer communities against extreme events. Under the proposed GCF project, relevant government sectors will be invited to participate in proposing revisions to existing national laws, strategies and plans, to: i) integrate climate change adaptation into regulatory frameworks; ii) promote the implementation of best adaptation practices, including EbA; and iii) incorporate gender considerations into existing legislation<sup>835</sup>. Wherever feasible, policy briefs established under the proposed project will build on existing national strategies, CDPs and CAPs generated under past and ongoing projects.

The above-mentioned projects also recognise the importance of providing government staff and other relevant stakeholders — including DREDDs, CREDDs, community-based organisations (CBOs) and AGLCs in target wilayahs — with training to: i) analyse and revise existing development strategies, to ensure climate change concerns and gender equity are incorporated into existing legislation; and ii) implement revised strategies and plans that incorporate climate change and gender considerations.

In accordance with these best practices, policy briefs developed under Activity 1.1.1 of the proposed GCF project will be based on a participatory approach. Training programmes will be developed under Sub-activity 1.1.1.2 to: i) provide members of cross-sectoral coordination committees with targeted, solution-based training on sustainable natural resource management and strategic land-use planning to improve the climate resilience of targeted communities; and ii) train policy- and decision-makers on the inclusion of climate change considerations and gender-responsiveness in natural resource management and land-use planning into policies, plans and strategies.

Past and ongoing initiatives have also incorporated gender considerations into both technical and institutional capacity-building interventions. The development of a gender action plan (GAP) encompassing proposed capacity-building activities is considered an international best practice and is necessary to guarantee that Mauritanian men and women benefit from adaptation interventions to the same degree. The development of a GAP under the proposed GCF project will promote gender equity during the project decision-making process, for example, by appointing women as members of hub-level coordination committees and designing planning processes that facilitate input from women<sup>836</sup>.

Lastly, a best practice for strengthening national ownership of strategic development plans in Mauritania is to translate them into appropriate languages to facilitate dissemination and uptake of knowledge. Accordingly, policy briefs developed under the proposed project will be translated (from English) into Arabic and/or French before being presented to relevant government ministries and departments.

Evaluation of the past and ongoing projects above suggests that the mechanisms for consultation and coordination (i.e., within, and between, communities as well as across institutions, at the local, regional and national level) are essential for: i) the creation of an enabling environment; and ii) ensuring that project interventions are aligned with existing strategies for reducing the impacts of

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<sup>833</sup> Appendix 6

<sup>834</sup> Islamic Republic of Mauritania. 2014. Oasis Sustainable Development Program (PDDO) supervisory report.

<sup>835</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<sup>836</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>



desertification. In accordance with the best practices outlined above, the development of climate change- and gender-responsive policy briefs and regulatory frameworks under Output 1.1 (Activity 1.1.1) of the proposed project will be based on a participatory approach. This will build on existing national strategies, CDPs and CAPs, developed under past and ongoing projects. Moreover, guidelines, workshops and training programmes will be established to train policy- and decision-makers, local community members, government representatives and coordination committees established under the proposed project on sustainable natural resources management (SNRM) and strategic land-use planning.

### 5.1.2 Lessons learned

Lessons learned from past projects suggest that political instability complicates the policy environment and weakens national ownership, for example, by increasing the likelihood of *coups*, regime reversals and government collapse, with potential disruptions to project implementation. It is, therefore, essential to engage with government ministries — including the MEDD, the Ministry of Economic Affairs and Finance (MAED), the Ministry of Rural Development and the Ministry of Agriculture — to mobilise political support for mainstreaming climate change and gender into legislation<sup>837</sup>. The proposed project will build on this lesson by ensuring that all relevant government ministries are consulted early in the project timeline<sup>838</sup>.

Past projects have also identified the need for upscaling successful technical and institutional capacity-building interventions. Under the PARSACC (2014–2019) project, training programmes and workshops aimed at strengthening the technical capacity of project staff, government institutions and local communities reached more than 11 thousand households and 303 managers and technicians at different levels — including journalists, representatives of non-governmental organisations (NGOs), CBOs and MEDD. Despite this, the awareness and training of local populations remains insufficient in light of the number of villages impacted by climate change (85 villages and more than 120,000 households)<sup>839</sup>. To maximise the potential impact of capacity-building initiatives implemented under the proposed GCF project, training programmes and workshops must be easily upscaled following the completion of the project. Additionally, although PARSACC facilitated the formation of direct partnership links between 85 Village Management Committees (CGVs<sup>840</sup>), 41 cooperatives, 16 NGOs and 9 regional radios — for improved awareness, communication, and coordination across local, regional, and national levels — these partnerships remain fragile in the absence of consolidation action<sup>841</sup>. Therefore, the development of effective training programmes and clear guidance frameworks is needed to support the long-term sustainability of coordination committees established under Output 1.1 of the proposed project.

Policy reviews conducted in past projects have founded that although EbA and SNRM have emerged as effective solutions for climate change adaptation, existing sectoral policies, plans and strategies in Mauritania focus mainly on economic growth and development, rather than climate change adaptation. As a result, there is generally limited funding available for climate change adaptation, and where environmental policies and frameworks do exist, their implementation is rarely prioritised. For example, although DREDDs were established in 2006 to lead and coordinate the MEDD's interventions at the provincial level, these regulatory bodies do not yet have the official premises,

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<sup>837</sup> UNEP. 2015. Mauritania. Available at:

[https://www.unpei.org/files/sites/default/files/country\\_factsheets/mauritania\\_country\\_factsheet\\_june\\_2015.pdf](https://www.unpei.org/files/sites/default/files/country_factsheets/mauritania_country_factsheet_june_2015.pdf).

<sup>838</sup> UNEP. 2015. Mauritania. Available at:

[https://www.unpei.org/files/sites/default/files/country\\_factsheets/mauritania\\_country\\_factsheet\\_june\\_2015.pdf](https://www.unpei.org/files/sites/default/files/country_factsheets/mauritania_country_factsheet_june_2015.pdf).

<sup>839</sup> WFP. 2019. Final evaluation report: Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

<sup>840</sup> Comité de Gestion Villageois

<sup>841</sup> WFP. 2019. Final evaluation report: Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

vehicles, human resource capacity, or technical knowledge needed to implement these measures<sup>842</sup>. Based on this observation, lessons learned from past projects suggest that climate change adaptation and socio-economic development cannot be achieved independently of one another. To address this challenge, awareness raising campaigns and training sessions targeting decision-makers and policymakers will be introduced under Activity 1.1.1 of the proposed project to facilitate the inclusion of climate change considerations and gender-responsiveness into natural resource management and land-use planning policies, plans and strategies.

Lastly, although past projects have recorded positive outcomes related to gender without having developed a GAP, lessons learned indicate that having one ensures a higher rate of positive outcomes<sup>843</sup>. This may be, in part, because it ensures that a high percentage of women benefit from technical and institutional training. For example, in a previous project titled '*Mauritania sustainable landscape management project under the Sahel and West Africa Program (SAWAP)*' (2015–2021; Table 51) efforts to include gender mainstreaming were intentionally incorporated into most activities from the onset of the project, and, as a result, more than 50% of women benefited from this project's diverse income-generating activities.

**Table 51.** Lessons learned and best practices from baseline investments in the target region and how these will be incorporated into the proposed project design.

Past project	Lessons learned and best practices	Project approach
<i>Mauritania Sustainable Landscape Management Project under the Sahel and West Africa Program (SAWAP)</i> (2015–2021) <sup>844</sup>	Land-use planning and sustainable natural resources management must be conducted using an integrated and iterative approach, to account for the dynamic nature of landscape processes and ensure that interventions evolve as the pressures on natural resources change.	<ul style="list-style-type: none"> <li>Establish coordination platforms to facilitate the integration of adaptation interventions into legal frameworks.</li> <li>Collect, analyse and disseminate project-relevant best practices and lessons learned to local, regional and national stakeholders through the existing knowledge management platform.</li> </ul>
	High-quality seedlings and starter kits should be provided to nurseries to create a sustainable agro-silvopastoral production cycle.	<ul style="list-style-type: none"> <li>Supply climate-resilient seed varieties to local cooperatives and train communities on methods for developing community-managed seed banks.</li> <li>Supply and distribute irrigation and water-harvesting materials required for adopting climate-resilient horticultural practices.</li> </ul>
	To secure financial resources for project development and implementation, appropriate strategies should be developed.	<ul style="list-style-type: none"> <li>Establish a sustainable flow-of-funds mechanism within the existing district government's fiscal space to channel funds towards scaling investment in EbA.</li> <li>Formalise a flow-of-funds mechanism to direct funds generated via PES schemes towards reinvestment into adaptation.</li> </ul>
	Available financial and human resources must be effectively managed to ensure the efficient and cost-effective implementation of project interventions.	<ul style="list-style-type: none"> <li>Develop an on-granting mechanism to regulate access to GCF funding for the adoption of climate-smart technologies.</li> <li>Develop an exhaustive M&amp;E plan to ensure that project targets are being met timeously and investments are generating tangible benefits.</li> </ul>
	Regular M&E of climate-adaptive interventions must be undertaken to ensure that the most effective and appropriate solutions are being	<ul style="list-style-type: none"> <li>Collect data regularly in accordance with the project's M&amp;E plan to ensure that project targets are being met and benefits are being accrued over time.</li> </ul>

<sup>842</sup> WFP. 2019. Final evaluation report: Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

<sup>843</sup> WB. 2021. Mauritania sustainable landscape management project under the Sahel and West Africa Programme: Terminal evaluation. Available at: <https://documents1.worldbank.org/curated/en/825511629388966252/pdf/Mauritania-Sustainable-Landscape-Management-Project.pdf>

<sup>844</sup> World Bank. 2015. Mauritania Sustainable Landscape Management Project under the SAWAP.

	implemented under future conditions of climate change.	<ul style="list-style-type: none"> <li>Analyse and disseminate project-relevant best practices and lessons learned through the existing knowledge platform developed under the NAP.</li> </ul>
	To promote participatory monitoring and adaptive management, information must be widely accessible and not controlled by any single stakeholder.	<ul style="list-style-type: none"> <li>Collect national and regional best practices for adaptation to climate change-induced droughts and desertification.</li> <li>Develop methodologies for the effective dissemination and use of climate knowledge in rural Mauritania.</li> <li>Disseminate relevant knowledge on climate change and adaptation strategies to relevant stakeholders in an audience-appropriate manner, using existing knowledge management platforms.</li> </ul>
<i>Enhancing Resilience of Communities to the Adverse Effects of Climate Change on Food Security in Mauritania (PARSACC) (2014–2018)</i> <sup>845,846</sup>	Regularly engaging with stakeholders in an equitable manner is necessary to ensure that adaptation benefits and natural resource management are responsive to the needs of the target groups. This, in turn, encourages buy-in from national- and local-level decision-makers, which will contribute to the sustainability of proposed adaptation interventions in the long term.	<ul style="list-style-type: none"> <li>Facilitate information and knowledge sharing between national consultants, government stakeholders and local community members within the four target hubs, using coordination platforms established under the proposed project.</li> <li>Establish community-level decision-making groups in the target communes (within the project's four hubs).</li> <li>Co-develop site-specific restoration plans with members of community-level decision-making groups.</li> </ul>
	Integrated natural resource planning and management must be linked to Mauritania's overall sustainable development strategy and public administration framework.	<ul style="list-style-type: none"> <li>Establish coordination platforms to facilitate collaboration between stakeholders at all levels and ensure that interventions introduced under the proposed project are well aligned with — and integrated into — Mauritania's national strategies.</li> </ul>
	Traditional knowledge must be incorporated into training material for farmers and local communities on climate-resilient agricultural practices and land and water resources management strategies.	<ul style="list-style-type: none"> <li>Engage with local communities to identify strategic sites for protective treelines within priority communes.</li> <li>Establish community-based agricultural and livestock cooperatives to facilitate the adoption of climate-smart livestock management practices that incorporate traditional knowledge.</li> </ul>
	Inter-sectoral participation is key for developing local adaptation to climate change action plans.	<ul style="list-style-type: none"> <li>Coordination mechanism established under the project will ensure close collaboration between different sectoral institutions at the wilayah-, hub- and commune- levels.</li> </ul>
	Future projects/programmes should be designed to focus on smaller areas. Introducing more cross-cutting activities on a smaller scale will build real resilience to climate change.	<ul style="list-style-type: none"> <li>The proposed project will use a hub-centred approach, rather than a wilayah-centred approach, with each hub covering a total area of 80–85 km<sup>2</sup>.</li> <li>On-the-ground interventions will be implemented at the commune-level and will only target the most vulnerable communes in each hub. Communes are the smallest administrative division in Mauritania.</li> </ul>

<sup>845</sup> Saadani Y & Selmane ML. 2019. Project for Enhancing Community Resilience and Food Security to Adverse Effects of Climate Change in Mauritania (PARSACC): Final Project Evaluation. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

<sup>846</sup> United Nations World Food Programme. 2017. Enhancing Resilience of Communities to the Adverse effects of Climate Change on Food Security in Mauritania: Project Performance Report. Available at: <https://pubdocs.worldbank.org/en/243511532334900726/14-For-Website-First-PPR-for-AF-Project-in-Mauritania.xlsx>

	Future projects/programmes should run over more than four years to maximise efficiency.	<ul style="list-style-type: none"> <li>The proposed project will have an implementation period of six years.</li> </ul>
<i>Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania (2017–2022)</i> <sup>847</sup>	The formalisation of organisations and associations established under climate change projects and programmes often takes longer than anticipated and leads to delays in the implementation of other project activities.	<ul style="list-style-type: none"> <li>Under a new national law, community-based organisations and associations can be officially established via announcement, rather than via the Ministry of the Interior. The project will enlist this approach when establishing community coordination structures.</li> </ul>
	A comprehensive adaptation knowledge-sharing strategy is being developed under the NAP process. To avoid duplication of effort, climate change adaptation projects in Mauritania should make use of existing NAP knowledge management systems.	<ul style="list-style-type: none"> <li>The proposed project will train beneficiaries and stakeholders to make use of the existing knowledge management platform developed under the NAP.</li> </ul>
	The integration of EbA into local-level development strategies requires regular review cycles.	<ul style="list-style-type: none"> <li>The development of commune-level restoration plans under the proposed project will incorporate regular review cycles for obtaining stakeholder feedback, with immovable deadlines. If deadlines are not met, plans will be finalised according to advice provided by DREDD representatives and a National Consultant (ecologist)</li> </ul>

<sup>847</sup> GEF. 2022. Development of an Improved and Innovative Management System for Sustainable Climate-resilient Livelihoods in Mauritania: Project Implementation Report (Final Year). Available at: [https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/fba8c925-df7c-e811-8124-3863bb2e1360/PIR/ProjectImplementationReportPIR\\_GEFCCA5580MauritaniaPIR2022.docx](https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/fba8c925-df7c-e811-8124-3863bb2e1360/PIR/ProjectImplementationReportPIR_GEFCCA5580MauritaniaPIR2022.docx)

**Table 52.** Proposed structure and composition of commune-level technical committees (CTCs) in each of the proposed project's four target hubs.

Hub	Wilayah	Commune	Composition of CTC			
			Local authority	Civil society representatives	Regional committee representatives	Community representatives
Aoujeft	Adrar	Aoujeft	Mayor	Participatory Oasis Management Association (AGPO) Moughataa Breeders' Associations	Director of Adrar DREDD	One representative per village
		El Medah	Mayor			
		Elmaeden	Mayor			
		N'Teirguent	Mayor			
		El Ain	Mayor			
Rachid	Tagant	Tidjikja	Mayor	AGPO Moughataa Breeders' Associations Moughataa Cooperatives Unions Moughataa Farmers' Associations	Director of Tagant DREDD	One representative per village
		El Wahat	Mayor			
		Tensigh	Mayor			
Tamcheket	Hodh El Gharbi	Tamchaket	Mayor	Moughataa Breeders' Associations Moughataa Cooperatives Unions Moughataa Farmers' Associations	Director of Hodh El Gharbi DREDD	One representative per village
		Essava	Mayor			
		Guaet Teidouma	Mayor			
		El Mabrouk	Mayor			

Hub	Wilayah	Commune	Composition of CTC			
			Local authority	Civil society representatives	Regional committee representatives	Community representatives
Nema	Hodh Chargui	Néma	Mayor	Moughataa Breeders' Associations Moughataa Cooperatives Unions Moughataa Farmers' Associations	Director of Hodh Chargui DREDD	One representative per village
		Jraif	Mayor			
		Oum Avnadech	Mayor			
		Oualata	Mayor			
		N'Beiket Lahwach	Mayor			

## 5.2 Knowledge management and monitoring systems

Effective knowledge management (KM) — including the generation, collection, storage, and dissemination of information — is essential for maximising the success of adaptation initiatives. Access to detailed, current information regarding advances in climate change adaptation helps ensure that resources are invested in strategies with demonstrated success, rather than short-term recourse. Additionally, effective KM systems for the collection and analysis of meteorological data are important for improving the accuracy of climate model projections, which inform the design and implementation of appropriate climate change adaptation interventions<sup>848</sup>.

Although Mauritania has documented the experience, knowledge and best practices learned through various adaptation projects in recent years — including projects funded by the Least Developed Countries Fund (LDCF), GEF and the Adaptation Fund (AF) under the umbrella of the National Adaptation Programme of Action to Climate Change (NAPA-Rim) — these projects have tended to focus on immediate socio-economic and environmental concerns, with concomitant adaptation interventions that are short-term and project-based. As a result, the monitoring and evaluation (M&E) of adaptation projects in the medium- to long-term, and on a national and local scale is currently limited. Additionally, not all governmental institutions and departments have the technical capacity to collect, analyse and disseminate data that are needed for review processes. There is, therefore, a need for capacity-building in terms of the dissemination of monitoring best practices at the national, wilayah and local levels via an effective KM system<sup>849</sup>.

In line with these observations, several past and ongoing projects have introduced measures to improve the status of KM systems in Mauritania. Both international and national best practices and lessons learned are discussed below. These relate to: i) the establishment of KM platforms and ii) the development of a comprehensive knowledge base.

### 5.2.1 Best practices

In 2016, the AF developed a '*Knowledge Management Strategy and Action Plan*' to enhance recipient countries' knowledge of measures for reducing climate change vulnerability and increasing adaptive capacity. The best practices outlined in this action plan suggest that the first step for establishing a KM system is to determine the key types of knowledge assets to be captured and shared. Some examples of knowledge types include, *inter alia*: i) best practices and lessons learned; ii) technical knowledge; iii) administrative knowledge; and iv) institutional knowledge. Ideally, countries should identify knowledge gaps in the early stages of project implementation<sup>850</sup>.

Next, a clear process must be established to determine: i) when data should be captured; ii) how data should be captured; and iii) who will be responsible for capturing data. Once all relevant data have been captured, appropriate techniques for information dissemination, to both experts and the public, must be selected. Examples of activities for knowledge sharing include, for example, webinars, workshops, and the distribution of material (such as pamphlets, videos, infographics, podcasts, case studies and field studies) to relevant stakeholders<sup>851</sup>. An important best practice for knowledge dissemination is to consider the home language and literacy rate of the target audience. In general, literacy rates within rural areas of Mauritania are low (Section 0). The tailoring of existing KM systems under the proposed GCF project (Activity 1.1.1) will ensure that context and situational knowledge is

<sup>848</sup> AF. 2016. Knowledge management strategy and action plan. Available at: <https://www.adaptation-fund.org/wp-content/uploads/2017/09/KM-strategy-action-plan.pdf>

<sup>849</sup> GCF. 2018. NAP readiness proposal. Available at: <https://www.greenclimate.fund/sites/default/files/document/readiness-proposals-mauritania-unep-adaptation-planning.pdf>

<sup>850</sup> AF. 2016. Knowledge management strategy and action plan. Available at: <https://www.adaptation-fund.org/wp-content/uploads/2017/09/KM-strategy-action-plan.pdf>

<sup>851</sup> AF. 2016. Knowledge management strategy and action plan. Available at: <https://www.adaptation-fund.org/wp-content/uploads/2017/09/KM-strategy-action-plan.pdf>



disseminated to target communities in an accessible format. Additionally, to increase ownership of KM systems, academic documents informing decision-making will be translated into Arabic and/or French<sup>852</sup>.

Once an effective KM platform has been established and appropriate knowledge-sharing activities have been selected, partnerships for collaborative data collection and the exchange of information should be established with Civil Society Organizations, multilateral institutions<sup>853</sup> (e.g., United Nations Development Programme (UNDP), United Nations Environmental Programme (UNEP), World Bank (WB)), research institutions and other funders — particularly those which are also generating knowledge on a regular basis. Additionally, to assist recipient countries in carrying out project-specific KM activities, the AF Knowledge Management Strategy and Action Plan recommends that the following steps be taken: i) optimise existing KM toolkits to improve collaboration and further promote KM capture on projects; ii) roll out newly established KM systems via readiness workshops; and iii) develop a project-specific webpage to enable the dissemination of relevant information among beneficiaries, partners and other institutions working on adaptation<sup>854</sup>. Accordingly, several past and ongoing projects have incorporated these best practices into the design of interventions aimed at strengthening or establishing, as needed, effective KM systems in Mauritania.

The past GEF-funded project titled '*Building core capacity for the implementation, monitoring and reporting of Multilateral Environmental Agreements (MEAs) and relevant Sustainable Development Goals (SDGs) in Mauritania*' (2018–2022), has achieved an excellent baseline for the environmental information and the KM in the context of MEAs and SDGs. This was achieved through undertaking several baseline studies to identify existing knowledge gaps, which resulted in the production of reports to guide the design of and implementation of a suite of project activities for improving KM, monitoring, and reporting<sup>855</sup>.

The successful implementation of KM-related activities under this GEF project resulted in the production of the following deliverables, products, and outputs:

- a stocktaking and analytic mapping exercise report for current environmental information systems, data flows and environmental statistics related to the MEAs & SDGs (including the existing databases and GIS-based systems and knowledge products managed by relevant ministries and public bodies);
- an analysis study report on the technical and institutional capacity gaps and needs of the knowledge management platform developed under the National Adaptation Plan (NAP) in terms of its capacity to take leadership as the national specialised agency on environmental data, information, and assessment — particularly those related with arid and semi-arid zones;
- a report on data sharing for the formulation of an Environmental Information Charter or Agreement on streamlining environmental data collection and sharing, to be signed by key ministries and agencies involved in the collection, management, analysis, research, or consumption of environmental data;
- an analysis report, with comprehensive guidelines and consultative recommendations for the review of MEA and SDG decision-making processes and mechanisms in relation with mainstreaming environmental information in Mauritania;
- an analysis study report reviewing all existing environmental data, information KM databases, information systems and collaborative mechanisms in use by MEA focal points and stakeholders — particularly those related to monitoring or reporting processes and the implementation of MEAs and SDGs; and lastly,

<sup>852</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>853</sup> AF. 2016. Knowledge management strategy and action plan. Available at: <https://www.adaptation-fund.org/wp-content/uploads/2017/09/KM-strategy-action-plan.pdf>

<sup>854</sup> AF. 2016. Knowledge management strategy and action plan. Available at: <https://www.adaptation-fund.org/wp-content/uploads/2017/09/KM-strategy-action-plan.pdf>

<sup>855</sup> UNEP. 2020. Project implementation review: Mauritania CCCD project. Available at: <https://open.unep.org/project/GEF-9747>

- a design framework for an online environmental database and KM system that facilitates the implementation and reporting of MEAs and promotes collaborations between MEA focal points, NGOs and relevant ministries and agencies<sup>856</sup>.

The analysis study reports produced by the abovementioned GEF project have been used to guide the establishment of an effective KM system under the NAP development process — to aid the integration of climate change knowledge into new and existing policies, programmes, and activities within all relevant sectors, and at all levels of governance, in Mauritania.

The MEDD previously hosted a KM platform for information dissemination at the national, provincial, and local levels. The information stored on this platform included: i) protocols developed for centralised, long-term data collection and analysis, to measure the costs and benefits of adaptation practices; ii) documentation of the implementation of adaptation interventions, including EbA; and iii) best adaptation practices identified under past projects — including the PARSACC project<sup>857</sup>. However, the now-discontinued CNOEZA system did not host climate information and had limited capacity to reach end-users is limited. As a result, Mauritania's National Strategy for Environment and Sustainable Development (SNEDD; 2017–2021) outlines the need to operationalise a new information system within the MEDD and the NAP readiness proposal submitted to the GCF in 2018 has committed to achieving this object<sup>858</sup>.

Through Mauritania's proposed GCF-funded '*NAP Readiness and Preparatory Support*' programme, sustainable climate information systems to inform climate change adaptation will be established, along with a long-term operation and maintenance plan. Climate change research and systematic observation of the environment are carried out by three main research institutions in Mauritania, namely: i) the National Meteorological Office; ii) the National Institute of Public Health Research; and iii) the Mauritanian Institute of Oceanographic Research and Fisheries. However, the limited availability of qualified staff and operational equipment — including climate observation stations and hydrometeorological stations — hinders the effective generation of climate data. For example, Mauritania's observation network is comprised of only 14 meteorological observation stations and two weather observation stations,<sup>859</sup> and monitoring of the upper air observations in the troposphere has not been undertaken in the country since 1993<sup>860</sup>. As a result of limited technical and human capacity to model, monitor, forecast and disseminate climate change impacts, climate related decision making generally relies on stakeholder perception and field observations in Mauritania<sup>861</sup>.

To address these challenges, interventions incorporated into the NAP readiness proposal for the establishment of a climate information system include:

- conducting a gap analysis and needs assessment for a fully operational and sustainable information system in Mauritania, including a capacity assessment of the newly established NAP;
- enhancing climate change knowledge and information management systems to ensure information reaches the end users including local/rural communities in Mauritania;
- developing and maintaining a database to compile and centralize climate change information;
- developing a coordination mechanism for improving access to and sharing of data (including data collection and analysis);

<sup>856</sup> UNEP. 2020. Project implementation review: Mauritania CCCD project. Available at: [https://projects.unep.org/docs/gef/documents/PIRs/PIR%20FY2020/Batch%201%20CCCD/9747\\_FY20\\_PIR\\_UNEP\\_Mauritania\\_BuildingCoreCapacityforImplementationMonitoringandReportingofMEA.DOCX](https://projects.unep.org/docs/gef/documents/PIRs/PIR%20FY2020/Batch%201%20CCCD/9747_FY20_PIR_UNEP_Mauritania_BuildingCoreCapacityforImplementationMonitoringandReportingofMEA.DOCX)

<sup>857</sup> WFP. 2019. Final evaluation report: Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania. Available at: <https://pubdocs.worldbank.org/en/748471589219402020/14-Mauritania-PARSACC-final-evaluation-EN.pdf>

<sup>858</sup> GCF. 2018. NAP readiness proposal. Available at: <https://www.greenclimate.fund/sites/default/files/document/readiness-proposals-mauritania-unep-adaptation-planning.pdf>

<sup>859</sup> MEDD. 2014. Executive Summary: Third National Communication.

<sup>860</sup> MEDD. 2014. Executive Summary: Third National Communication.

<sup>861</sup> GCF. 2016. NAP readiness and preparatory support proposal for Mauritania. Available at: <https://www.greenclimate.fund/sites/default/files/document/readiness-proposals-mauritania-unep-adaptation-planning.pdf>

- providing staff from Mauritania's Meteorological Agency, MEDD and other relevant ministries and departments with training on the following key themes: i) using climate monitoring equipment; ii) using multiple sources of climate data for developing climate scenarios; iii) developing impact scenarios and modelling; and iv) improving the database archives; and
- developing and implementing a strategy for the operation and maintenance of the climate information management system.

Once an operational climate KM platform has been established, a stocktaking exercise will be conducted to identify gaps in information available at national and sectoral level. The gaps identified will be bridged by conducting complementary climate change risk and vulnerability analyses.

As a best practice, all data — including best practices and lessons learned — generated under the proposed GCF project for increasing resilience to climate change-induced desertification in Aoujeft, Rachid, Tamcheket and Nema will feed into existing KM platforms developed under the NAP. To achieve this, relevant members of local, regional, and national decision-making bodies will be trained on the use of existing KM tools (Sub-activity 1.1.1.3). Additionally, to bridge gaps information gaps identified in the NAP readiness and preparatory support process, a comprehensive knowledge base will be developed under the proposed project (Activity 1.1.1), to facilitate upscaling and adaptive implementation of interventions relating to sustainable natural resource management and strategic land-use planning within the desert landscapes of Mauritania.

### 5.2.2 Lessons learned

Lessons learned from past projects have found that one of the biggest challenges related to KM in developing countries is that most knowledge is experiential and is 'in people's heads' rather than documented on paper for official use. As a result, accumulated knowledge regarding best practices for climate change adaptation is at risk of being lost when local community members, experts and authorities retire or pass away<sup>862</sup>. Accordingly, under the proposed GCF project, a framework will be developed to guide the collection and preservation of information and the use of the KM tools in the long-term (Sub-activity 1.1.1.2).

Additionally, lessons learned from past and ongoing projects have identified the need to make KM systems accessible to even the most under-resourced communities<sup>863</sup>. Communities in rural Mauritania rarely have access to internet; therefore, obtaining information from centralised KM platforms presents a major challenge. Consequently, mechanisms for the regular dissemination of updated information — in formats that are tailored to the level of understanding of the target audience — are needed to ensure that target communities remain informed about advances in climate change adaptation (Activity 1.1.1).

Lastly, an important lesson learned from past and ongoing climate services projects is that climate information is inherently uncertain. While improved climate information services enable improved access to climate forecasts, awareness raising is needed to ensure that end-users are made aware of the limitations of forecasting when making decisions. For example, seasonal forecasts are typically presented as probabilistic, which presents an obstacle to end-users who need to translate model projections into sectoral management decisions. With a clear effort to engage end-users in improving their understanding of uncertainty in climate forecasts, it may be that climate services are more impactful<sup>864</sup>. As such, under the proposed GCF project, relevant members of local, regional, and

<sup>862</sup> AF. 2019. Knowledge management: An ingredient for better climate adaptation. Available at: <https://www.adaptation-fund.org/knowledge-management-an-ingredient-for-better-climate-adaptation/>

<sup>863</sup> AF. 2019. Knowledge management: An ingredient for better climate adaptation. Available at: <https://www.adaptation-fund.org/knowledge-management-an-ingredient-for-better-climate-adaptation/>

<sup>864</sup> CCAFS Program Management Unit. 2021. Impactful climate services: what are the lessons learned? Available at: <https://ccafs.cgiar.org/news/impactful-climate-services-what-are-lessons-learned>

national decision-making bodies will be trained on concepts of uncertainty and the most appropriate application of tailored climate information outputs (Sub-activity 1.1.1.2).

### 5.3 Payment for ecosystem services and sustainable, alternative livelihoods (PES)

The term ‘payment for ecosystem services’ (PES) is used to describe schemes in which the beneficiaries or users of ecosystem services (ESS) provide payment to the stewards of associated ecosystems. In practice, PES often involves a series of payments to land or other natural resource managers in return for a guaranteed flow of ESSs, or the enhancement of services over-and-above what would otherwise be provided in the absence of payment. The basic idea behind PES is that those who provide ESSs, like any other service, should be paid for doing so. PES therefore provides an opportunity to put a price on previously un-priced ESSs including, *inter alia*: climate regulation, water quality regulation and the provision of habitat for wildlife<sup>865</sup>.

By establishing a flow of funds in return for the provision of ecosystem goods and services, PES schemes have the potential to facilitate continued investment in the operation and maintenance of EbA solutions and sustainable, diversified livelihoods. Best practices and lessons learned for the establishment of PES schemes are discussed below.

#### 5.3.1 Best practices

The design and implementation of a PES scheme or alternative natural-resource based livelihood activity can be divided into four broad phases: i) identifying a saleable ESS or income-generating activity and prospective buyers and sellers; ii) establishing PES scheme principles and resolving technical issues; iii) negotiating and implementing payment agreements based on valuation of ESSs; and iv) monitoring, evaluating, and reviewing implementation<sup>866</sup>.

The first phase involves a preliminary gap analysis to evaluate existing prospects for establishing a PES scheme or alternative livelihood activity within the proposed target region. This is generally achieved via a stocktaking exercise, to identify: i) saleable ESSs; and ii) potential to increase the supply of these ESS<sup>867</sup>. National consultants in Mauritania have identified several saleable ESS within the proposed GCF project’s four target rural-urban hubs (Table 52). To supplement this list, a comprehensive asset register of all ESS within the target region will be developed under the proposed project.

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<sup>865</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>866</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>867</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

**Table 53.** Identified prospects for the establishment and upscaling of PES schemes within the proposed project's target regions<sup>868</sup>

Activity	Ecosystem service	Potential source of payment	Description of PES scheme
<b>Establishment of community-managed protected areas:</b> Select a site impacted by desertification and fence it off with wire mesh, to protect it against animal intrusion and human exploitation, and enable the regeneration of natural vegetation	Provision of ecosystem goods	Mowing	Collection of straw or grass that grows in the protected area for building or other uses. A small once-off fee must be paid each time someone wants to collect straw from the conservation site.
		Collection of dead wood	Collection of dead wood from trees and shrubs grown on the protected site to be used as fuelwood. Communities must pay a fixed amount in advance to allow the collection of dead wood for a specified period.
		Sustainable harvest of timber products (living wood)	Once natural vegetation has regenerated, the limited harvest of living branches as timber for building will be allowed. Community members will need to pay to harvest living wood and supervision will be provided to ensure that quotas are not exceeded, and sustainable methods are used.
		Seed collection	Once vegetation has been sufficiently regenerated, community members can collect and sell seeds from the protected area, for example, to nurseries. Income generated from the sale of seeds can then be deposited into the site management committee's cash register and invested in maintaining the conservation area in the long-term.
		Collection of non-timber forest products	Ecosystem regeneration in Mauritania has, in some instances, resulted in the re-establishment of non-woody fruit trees — for example, ' <i>jujube</i> ', whose products are consumable and exploited to produce jujube juice. The community can collect and sell these non-timber products to generate income, to be re-invested in the upkeep of conservation areas.

<sup>868</sup> Appendix 6

		Recreational sites for tourists	Rehabilitate historical sites and recreational areas for tourists and derive income from small entry fees paid by visitors.
<b>Establishment of community water points:</b> Drill boreholes equipped with solar pumping	Water provision	Demand management fee	Established water points, whether used for domestic needs or for market gardening, will be subject to payment according to the quantity used.  The price per cubic meter of water, can or barrel will be set lower than for urban areas because of cost-savings generated via solar pumping. The income generated through regulatory payments will be put towards maintaining solar equipment.
<b>Construction of dykes:</b> Reduce the water flow rate within a <i>wadi</i> or stream by backfilling the water course with compacted earth, to improve infiltration and improve soil moisture content	Flood regulation Groundwater recharge	Maintenance/protection fee	Management fee to be paid by farmers exploiting flooded areas. Management fee can be paid in kind (cereals or legumes) at the time of harvest.
<b>Construct stone bunds/gabion ('slowdown threshold'):</b> The thresholds are built upstream of date farms and promote water retention on farms.	Flood regulation	Maintenance/protection fee	Beneficiaries must pay a very small royalty fee to authorities for the flood protection services provided. Gabions generally require little maintenance.

Under the proposed GCF project, the most feasible ESS, sustainable alternative livelihoods and small-scale PES schemes outlined in Table 53 will be formalised and incorporated into relevant legislature in each of the target communes within the four target hubs (Activity 2.2.3). Additionally, a mechanism for the flow of funds from PES schemes and agricultural-based livelihoods towards the maintenance and scaling of interventions aimed at restoring ecosystem functioning in the target communes will be established.

The second phase in developing and implementing a PES scheme or alternative natural resource-based livelihood involves establishing the principles that will underpin the scheme and resolving technical challenges. Prospective buyers and sellers may need to invest considerable time and effort into building sound working relationships and crafting a mutually beneficial deal. Table 54 (below) outlines some of the key principles that need to be determined before establishing a PES scheme<sup>869</sup>.

**Table 54.** Establishing PES scheme principles<sup>870</sup>

Principle	Example(s)
Ecosystem service(s)	Water quality, climate regulation, habitat for wildlife, landscape aesthetics
Buyer(s)	Community members, private company, government agency, NGO
Seller(s)	Farmer, private landowner, private company, government agency
Intermediary (where applicable)	Environmental NGO, multilateral institution (e.g., UNEP)
Key knowledge providers	Research institutions, government ministries
Geographical scale	Catchment, commune, village
Contractual period	Ten years, 15 years, in perpetuity
Agreed interventions	Buffer sites, hedgerows, tree planting, waste storage, fencing
Measures to minimise trade-offs	Monitoring and evaluation framework (who, how, when?)
Type of payment approach	Input- or output-based payments? Uniform or differentiated payments? Series of payments or once-off payments?

Additionally, several technical challenges need to be addressed before developing and implementing a PES scheme or agricultural-based livelihood activity. Firstly, a baseline analysis needs to be conducted to determine the level of ESS provision that would reasonably have been expected in the absence of payment. At a minimum, sellers should be expected to comply with existing regulatory requirements. Secondly, land ownership and property rights need to be considered. Different parties may have interests in the same area of land, and all may need to be engaged by scheme proponents. In some instances, it may be difficult to identify the land ownership rights. Thirdly, a risk assessment needs to be undertaken to explore possible unintended consequences. Table 55 provides examples of questions that might be asked in a risk assessment, as well examples of mitigation measures that could be reflected in scheme design<sup>871</sup>.

<sup>869</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>870</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>871</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)



**Table 55.** Examples of risk factors and potential mitigation measures to incorporate into the design of PES schemes<sup>872</sup>.

<b>Risk factor</b>	<b>Potential mitigation measure</b>
Is there a risk that increasing the provision of an ecosystem service (ESS) in one area will lead to pressure on ESS elsewhere (leakage)? (For example, is there a risk that farming on adjacent land might be intensified to compensate for reduced output in the area covered by the PES scheme?)	Ensure that arrangements for monitoring extend beyond the geographic boundaries of the PES scheme to assess the magnitude of any leakage and consider any potential conditions of contract that might be introduced to minimise leakage.
Is there a risk that land or resources management will increase the level of a particular ESS at the expenses of others (leading to trade-offs in service provision)?	The PES scheme should incorporate environmental safeguards to minimise the risk of trade-offs.
Is there a risk that the interventions will be too short-lived to deliver the necessary ESS benefits being paid for?	The scheme should incorporate safeguards to ensure the permanence of the interventions where possible. For example, project landowners must commit to a permanent land-use change. Permanence be encouraged through including measures which, from a seller's perspective, are 'worth doing anyway' (for example, to save on utility costs).
Is there a risk of creating perverse incentives (for example, creating a temptation on the part of land managers to plant non-native tree species which sequester carbon at a faster rate than indigenous species)?	The scheme should incorporate measures to minimise the risk of creating perverse incentives, for example guidelines on the way in which ESS outcomes should be achieved and maintained.
Is there a risk that the land or resource management interventions proposed will fail to yield the anticipated ESS leading to diminished confidence on the part of buyers?	Primary research should be undertaken to demonstrate the links between management interventions and ESS outcomes. Demonstration plots should be used to determine whether management interventions introduced under PES schemes do, in fact, increase the supply of ESS.
Is there a risk that changes in external factors (for example, rising commodity prices) might undermine the scheme?	Adaptive management should be incorporated into PES schemes to accommodate external changes. Reasonably foreseeable external changes should be reflected in the baseline that will be used to gauge additionality.
Is there any risk of chance events such as fires or the arrival of invasive species which might undermine the agreed interventions?	If the risk of interventions being undermined is high, insurance should be considered as part of the scheme. For example, project landowner(s) must demonstrate their commitment to permanence by replanting or undertaking compensatory planting should ESS areas be lost as a result of wind, fire, pests, diseases or development.

In accordance with the best practices outlined above, formalisation of existing PES schemes and agricultural-based livelihoods under the proposed GCF project will ensure that all key principles for the establishment of diversified income-generating activities are in place and all technical aspects — including baseline and risk analyses — have been addressed (Activity 2.3.2).

The third phase in the PES and livelihood development process involves negotiating and implementing the PES agreement. Sellers and buyers will need to negotiate and agree on the nature,

<sup>872</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

level and timing of ESS payments and draw up necessary contracts to enforce the conditions agreed upon. The negotiation of ESS payment fees should be based on a valuation of ESS<sup>873</sup>.

ESS valuations should incorporate calculations of the following<sup>874</sup>:

- sellers' opportunity costs — for example, the impact of proposed PES schemes on earnings from returns forgone (e.g., from agricultural production), both now and in the future (to account for projected changes in commodity prices);
- the start-up and ongoing maintenance costs required to deliver agreed interventions, particularly for 'asset-building' schemes which focus on restoring an area's ESSs;
- transaction costs — for example, the costs of establishing the baseline, training, developing a monitoring framework and providing third party assurance;
- the costs of alternative scenarios — for example, for improved drinking water quality, the cost of building a water treatment plant should be calculated and compared with the baseline scenario in which water is filtered by natural processes; and lastly,
- the degree of competition in both supply and demand of ESS (buyers will tend to seek the lowest-cost suppliers of services).

Accordingly, the development of a standardised method for valuating ESSs — particularly those relating to increased water infiltration and dune stabilisation — under the proposed GCF project (Activity 2.1.1) will incorporate the above-mentioned factors.

The fourth phase in the development of a PES scheme involves monitoring, evaluating, and reviewing the performance of the PES scheme considering its original objectives. Regular monitoring and evaluation ensure that: i) ESS outcomes are being delivered; ii) investments in management interventions are in fact enhancing ESSs; iii) adverse trade-offs are not taking place between valuable ESSs; and iv) relevant regulatory requirements are being complied with<sup>875</sup>. In line with this best practice, a monitoring and evaluation mechanism will be designed under the proposed GCF project to ensure the effective long-term management and adaptive flow of funds from PES schemes based on lessons learned from project implementation.

### 5.3.2 Lessons learned

Since the 1990s, PES schemes have increasingly been introduced by developing countries. Despite the increasing number of PES projects, however, there is a paucity of rigorous studies analysing their effectiveness and impacts on communities making and receiving the ESS payments<sup>876</sup>.

To partially address this shortage of lessons learned, an analysis of the Mexican PES programme for hydrological services titled '*Payments for hydrological environmental services (P-SAH) programme*', initiated in 2003, has been assessed for the purposes of extracting various lessons from the political process that led to the program as well as the impact of the ESS payments on recipient communities<sup>877</sup>.

The first important lesson for policy designers involved in the establishment of PES schemes is the need to establish clear objectives and criteria before promotional activities take place. Participants in the early phases of the Mexican programme have emphasised the importance of forming an advisory

<sup>873</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>874</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>875</sup> URS. 2010. Payments for ecosystem services: A best practice guide. Available at: [https://www.researchgate.net/publication/259639317\\_Payments\\_for\\_Ecosystem\\_Services\\_A\\_Best\\_Practice\\_Guide](https://www.researchgate.net/publication/259639317_Payments_for_Ecosystem_Services_A_Best_Practice_Guide)

<sup>876</sup> Alix-Garcia J, de Janvry A, Sadoulet E & Torres JM. 2009. Lessons learned from Mexico's Payment for Environmental Services Program. Available at: <https://are.berkeley.edu/~esadoulet/papers/LessonsPES.pdf>

<sup>877</sup> Alix-Garcia J, de Janvry A, Sadoulet E & Torres JM. 2009. Lessons learned from Mexico's Payment for Environmental Services Program. Available at: <https://are.berkeley.edu/~esadoulet/papers/LessonsPES.pdf>

group that included both national and international experts to guide the policy design process. A combination of expertise from outside the country and experts aware of the realities of implementing programs in Mexico accelerated the design of the PES scheme and allowed recommendations to be made quickly and effectively<sup>878</sup>.

Another important lesson learned from the P-SAH project is that communities must be given sufficient incentives to reduce extractive activities in favour of conservation. This requires that ESS payments be high enough to compensate for the loss of resource extraction, agriculture, or cattle grazing by ESS stewards and sellers. One way to determine the magnitude of payment design is to use an auction process to induce potential participants to reveal the minimum payment community members would accept in exchange for conservation on their properties. Alternatively, rigorous contingent valuation studies can be conducted in areas targeted by the project. These considerations should be incorporated into the development of a standardised method for the valuation of ESSs under the proposed GCF project<sup>879</sup>.

Another important lesson learned from the P-SAH project is that PES contracts should incorporate commitments to conserving the entire ecosystem as opposed to just the proportion of land being paid for. To avoid the movement of productive activities from PES hectares to other, previously unexploited, ecosystems within the target region, it is very important that contracts for payments specify that there should be no change in the entire intact area. This does not imply that payments should be given for all hectares of natural resources within the target wilayah, but rather that PES contracts should eliminate the possibility of land degradation being reallocated from one site to another<sup>880</sup>.

Additional lessons learned on PES in the Mauritanian context can be drawn from the BACoMaB<sup>881</sup> Trust Fund, which was established in partnership with the GoM and European Union (EU) to facilitate the establishment of a PES scheme for the effective management of marine protected areas in Mauritania<sup>882</sup>.

Lessons drawn from the experience of an established trust fund for marine ESSs in Mauritania highlight the importance of the following key themes: i) making the economic case for ESSs to build commitments ensuring sustainable finance; ii) lobbying and consensus building for establishing a shared understanding of the benefits ESS provide to local community members; and iii) developing financially and institutionally sustainable funding mechanisms<sup>883</sup>.

These lessons learned will be incorporated into interventions aimed at creating an enabling environment for continued investment in the operation and maintenance of EbA and sustainable, diversified livelihoods, and as introduced in the proposed project under Output 2.

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<sup>878</sup> Alix-Garcia J, de Janvry A, Sadoulet E & Torres JM. 2009. Lessons learned from Mexico's Payment for Environmental Services Program. Available at: <https://are.berkeley.edu/~esadoulet/papers/LessonsPES.pdf>

<sup>879</sup> Alix-Garcia J, de Janvry A, Sadoulet E & Torres JM. 2009. Lessons learned from Mexico's Payment for Environmental Services Program. Available at: <https://are.berkeley.edu/~esadoulet/papers/LessonsPES.pdf>

<sup>880</sup> Alix-Garcia J, de Janvry A, Sadoulet E & Torres JM. 2009. Lessons learned from Mexico's Payment for Environmental Services Program. Available at: <https://are.berkeley.edu/~esadoulet/papers/LessonsPES.pdf>

<sup>881</sup> Fonds Fiduciaire du Banc d'Arguin et de la Biodiversité Côtière et Marine

<sup>882</sup> OECD. 2018. Sustainable financing for marine ecosystem services in Mauritania and Guinea-Bissau. Available at: <https://www.oecd.org/countries/mauritania/Policy-Paper-Sustainable-financing-for-marine-ecosystem-services-in-Mauritania-Guinea-Bissau.pdf>

<sup>883</sup> OECD. 2018. Sustainable financing for marine ecosystem services in Mauritania and Guinea-Bissau. Available at: <https://www.oecd.org/countries/mauritania/Policy-Paper-Sustainable-financing-for-marine-ecosystem-services-in-Mauritania-Guinea-Bissau.pdf>

#### 5.4 Dune fixation and control of sand encroachment

The impacts of climate change-induced desertification in Mauritania include a reduction in the amount of arable land, grazing land, forests, and water resources because of sand inundation. Various studies have found that mobile sand dunes cover approximately two-thirds of the country's land area. Sand encroachment occurs when sand grains are carried by winds and deposited along water courses and on cultivated or uncultivated land. As sand dunes are mobilised in this way, they bury villages, roads, oases, crops, market gardens, irrigation channels and dams in their path (Figure 95). This results in major damage to infrastructure and socioeconomic costs.



**Figure 95.** Image supplied by the national consultant to illustrate the extent and impact of sand inundation within the proposed project's target region.

For this reason, interventions aimed at fixing sand dunes and reducing the impacts of sand encroachment are needed within the proposed project's target rural-urban hubs. These hubs are all located along the boundary between the Sahel and southward-expanding Sahara Desert. Best practices and lessons learned from past and ongoing projects aimed at slowing the rate of sand encroachment are discussed below.

##### 5.4.1 Best practices

Under the United Nations Convention to Combat Desertification (UNCCD), best practices for combatting desertification and reducing sand encroachment in arid environments include: i) preventing or reducing land degradation; ii) rehabilitating already degraded land; and iii) reclaiming land which has already undergone desertification<sup>884</sup>.

The state of soils and natural vegetation are important determinants of desertification rates. Intact vegetation preserves the cohesion soil surface layers, binds particles, and resists the avalanche effect<sup>885</sup>. For these reasons, the presence of vegetation cover is considered the best protection against the negative effects of wind. Since vegetation is generally sparse, stunted or absent in arid

<sup>884</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>885</sup> The process that occurs when falling sand, set in motion by wind, causes the displacement of a larger quantity of sand particles. The more intense the initial displacement is, the greater the number of particles set in motion, until a maximum or saturation point is reached, where the quantity of sand lost from one point on a sand dune is equal to the quantity gained further along the transport route.

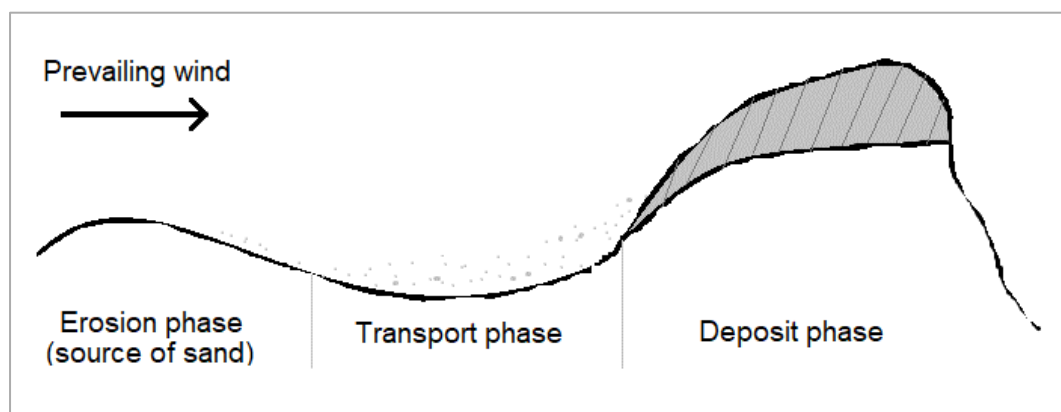
environments, the Sahara and Sahel regions (in Mauritania) are particularly exposed to the negative impacts of wind. Moreover, the unsustainable exploitation of plants — via harvesting and livestock foraging — has exacerbated soil degradation and increased the exposure of sand particles to wind action<sup>886</sup>.

Wind erosion is particularly prevalent in soils that have:

- mobile, dry and finely crushed in texture;
- high ratio of sand to clay;
- a uniform soil surface with no natural or artificial obstacles;
- sparse plant cover; and
- a large area exposed in the direction of the prevailing wind.

Additionally, poor farming practices (e.g., clearing of large areas), unsustainable livestock management (overgrazing and trampling) and the over-exploitation of forest resources increase the susceptibility of soils to wind erosion<sup>887</sup>.

When a site is threatened by sand encroachment, sources of erosion, transport routes and sand-accumulation sectors must be carefully identified (Figure 96).



**Figure 96.** Phases of sand encroachment<sup>888</sup>.

Appropriate interventions can be designed to mitigate sand encroachment in each phase: i) control the source of sand (erosion phase) — for example, by stabilizing sand dunes, preventing land degradation and restoring degraded ecosystems; ii) redirect the route of sand (transport phase) — for example, by establishing protective infrastructure and green belts that provide buffer zones; and iii) reclaim areas that have already been sanded over (deposit phase) — for example, by hand-desilting habitats and infrastructure that have been subjected to sand inundation.

Sanded-over zones must be surveyed and mapped, with precise geographical coordinates, to determine the direction of sand encroachment and identify potential sites of sand deposition. In 1990, all sanded-over sites Mauritania were surveyed and recorded on a general map as part of the GoM's 'Multisectoral Desertification Control Programme' (PMLCD). These data are available from the Directorate of Nature Protection of the MEDD.<sup>889</sup>

## Dune fixation techniques

### *Mechanical dune stabilisation*

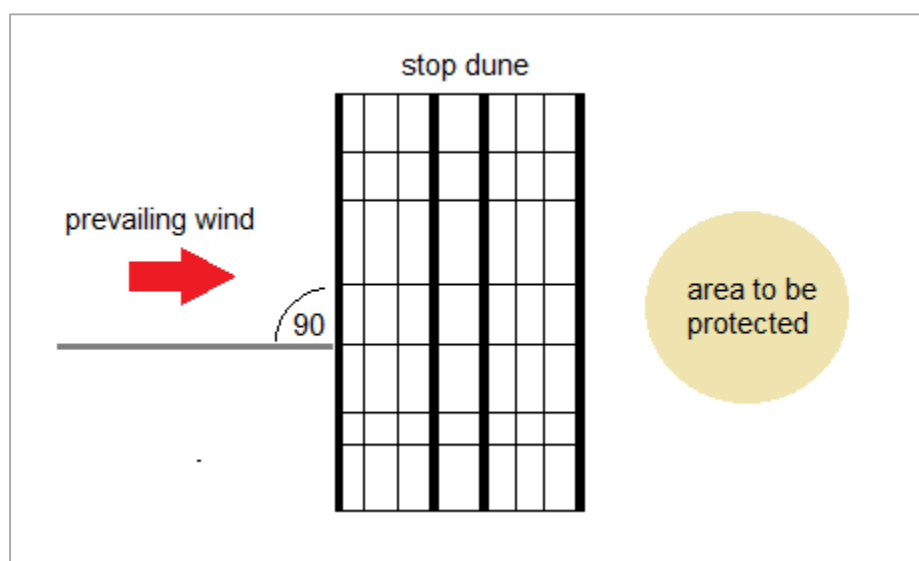
<sup>886</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>887</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>888</sup> FAO. 1988. Manuel de fixation des dunes. FAO Conservation Guide No. 18. Rome.

<sup>889</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

Past and ongoing projects have halted or slowed the movement of sand by erecting fences (1–1.5 m high) as obstacles to block the movement of sand and facilitate the build-up of artificial sand dunes. There are two distinct techniques for establishing artificial dunes, distinguished by the positioning of fences in relation to the direction of the prevailing wind. ‘Stop dunes’ or ‘check dunes’ are the most used artificial dunes for preventing the advancement of sand. ‘Check dunes’ are established by erecting fences directly perpendicular to the prevailing wind (Figure 97). To account for winds originating from other directions, ‘check dunes’ typically incorporate a grid of stop lines, between successive fences, with each element in the grid acting as barrier against which sand is deposited. Open spaces within the grid are gradually filled up as sand becomes trapped in between the fence lines<sup>890</sup>. National consultants have provided photographic evidence for the successful implementation of this dune fixation technique within the proposed project’s target region (Figure 98).



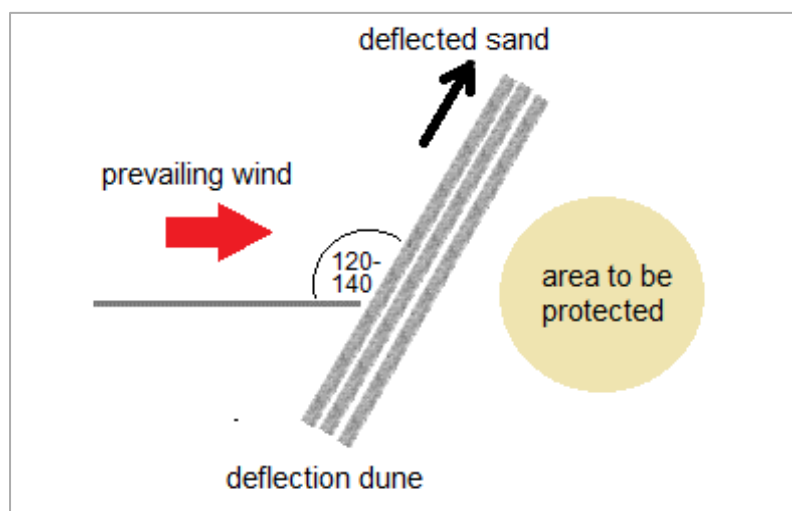
**Figure 97.** Stop dunes (or ‘check dunes’) are erected perpendicular to the direction of the prevailing wind to prevent the advancement of sand.

<sup>890</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>



**Figure 98.** Check dunes have been successfully erected within the proposed project's target region to prevent the advancement of sand <sup>891</sup>.

In contrast, 'deflection dunes' divert advancing sand in a direction other than that of the prevailing wind. These artificial dunes are formed by erecting fences at an angle of 120–140 degrees relative to the direction of the prevailing wind (Figure 99).



**Figure 99.** Deflection dunes are erected at an angle relative to the direction of the prevailing wind to prevent the advancement of sand.

In Mauritania, fences for mechanical dune fixation are typically constructed via wattling<sup>892</sup> (*clayonnage*). Within the proposed project's target regions, the materials used for wattling include dead palm fronds (Figure 101), dead *Euphorbia* stalks, and branches and twigs from mature stands of suitable tree species (Figure 100) — for example, *Prosopis juliflora*, *Balanites aegyptiaca* and various *Vachellia* (formerly *Acacia*) (Figure 102). Straw from crop species such as millet, sorghum, and rice, as well as other, naturally leafy vegetation, such as *Panicum turgidum*, have also been used<sup>893</sup>. As a best practice, materials used for wattling must be harvested in a sustainable manner, so as not to endanger forest tree species, compromise natural resources, or cause damage to existing agricultural stands.

<sup>891</sup> Image supplied by National Consultant.

<sup>892</sup> A construction of poles intertwined with twigs, reeds, or branches, used for walls, fences, and roofs.

<sup>893</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>





**Figure 100.** Physical barriers around agricultural plots to reduce sand inundation in the village of Ain Savra.



**Figure 101.** Wattling (*clayonnage*) constructed using bundles of dead date palm fronds<sup>894</sup>.

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<sup>894</sup> Image supplied by national consultants





**Figure 102.** Wattling (clayonnage) constructed using twigs and branches from stands of locally available tree species within the proposed project's target region<sup>895</sup>.

Once proposed fence lines have been marked out with stakes, plant matter is set in a trench to form upright hedges. For maximum effectiveness, wattling must be 30–40% permeable to the wind, such that wind speed is curbed and sand builds up without causing wind turbulence on the slip face of the building dune<sup>896</sup>. The recommended grid size for check dunes is 20 m x 20 m and wattling materials should be buried at least 30 cm deep as a foundation<sup>897</sup>. Fences must be regularly maintained and raised when sand reaches a level 10–15 cm from their upper edge. Fences are repeatedly raised until the artificial dune attains a balanced shape, which signals that the dune is stable and fixed. Under the proposed GCF project, interventions for mechanical dune fixation within the rural-urban hubs of Aoujeft, Rachid, Tamcheket and Nema will be designed and implemented in accordance with the abovementioned best practices (Activity 2.1.1).

#### *Mulching and protective screening*

This dune stabilisation technique involves uniformly covering an existing sand dune with a natural mulch or artificial protective screen (or fabric), to prevent saltation and wind erosion. Natural mulch can be made from straw, bark, branches, or *Euphorbia* stalks, whereas protective screens can be made from plastic film, hessian, acrylic fibre, or mesh. Mineral oils, including asphalt, heavy oil and crude oil, can also be used to fix moving sand in place. These materials, however, are particularly costly and evidence for their long-term effectiveness in stabilising sand is limited<sup>898</sup>.

#### *Biological dune fixation*

Once mobile sand dunes have been mechanically stabilised, they can be actively fixed in place by establishing green belts<sup>899</sup> and treelines —this increases vegetation cover and is widely considered the most effective form of soil protection against wind erosion<sup>900</sup>.

#### Selecting species for biological dune fixation

Sand dunes present a challenging environment for the establishment and growth of all plant species. Therefore, species selected for dune fixation activities in Mauritania must be well adapted to the environment and the depth of residual moisture in the underlying soil substrate<sup>901</sup>. The preferred choice of plant species for biological dune fixation is dependent on site-specific climatic and ecological

<sup>895</sup> Image supplied by national consultants

<sup>896</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>897</sup> Appendix 6

<sup>898</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>899</sup> Ould Safi M, Megharbi A & Haddouche D. 2018. Caractérisation des bandes vertes de la lutte contre l'envahissement du sable dans la région de Gouara au sud-ouest de l'Algérie. *Int J Ecol Dev*, 33(4):1–9.

<sup>900</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>901</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

conditions; however, as a best practice, preference should always be given to indigenous woody and grassy species over non-indigenous species.

The species selection for the proposed project will be based on several criteria. These criteria have been identified through the findings of past projects and include the following factors: i) the ability to grow in a nutrient-poor environment, and potential to tolerate extreme fluctuations in diurnal temperature; ii) the possession of a tap-root system to effectively penetrate deeper layers of soil moisture and thereby offset the effects of drought; iii) adaptation to strong, hot, dry winds and their abrasive action on leaves and stems; iv) rapid growth and the ability to regenerate easily following disturbance; and v) the ability to improve the state of dune soil<sup>902</sup>. The main species for achieving biological dune fixation in Mauritania are summarised in Table 56 (below).

**Table 56.** Summary of main species used for biological dune fixation in Mauritania<sup>903</sup>

Site specifics for biological dune fixation	Preferred choice of plant species
Very mobile strip dunes	<ul style="list-style-type: none"> <li>• <i>Prosopis juliflora</i></li> <li>• <i>Aristida pungens</i></li> </ul>
Sand departure zones/deflation zones that are susceptible to scouring by wind	<ul style="list-style-type: none"> <li>• <i>Leptadenia pyrotechnica</i></li> <li>• <i>Aristida pungens</i></li> <li>• <i>Panicum turgidum</i></li> </ul>
Relatively stable intermediate zones	Slow-growing woody species, including: <ul style="list-style-type: none"> <li>• <i>Vachelia raddiana</i></li> <li>• <i>Senegalia senegal</i></li> <li>• <i>Balanites aegyptiaca</i></li> <li>• <i>Euphorbia balsamifera</i></li> <li>• <i>Persica salvadora</i></li> </ul>

#### Methodology for planting tree species

The ideal time for tree planting is when the soil has sufficient moisture to satisfy the needs of seedlings during the first few months of growth. Sufficient soil moisture not only improves the efficiency of planting, since soil is more malleable, but also provides seedlings with sufficient water to rapidly extend their rooting system – and this improves their chances of survival during initial periods of drought or flooding. In line with this observation, it is considered best practice to plant seedlings a few days after good rain, when new and residual soil moisture meet<sup>904</sup>. Accordingly, under the proposed GCF project, planting, and restocking activities (Activity 2.1.1) should be undertaken as soon as the first rains fall at the start of the wet season (early in July).

Determining the target tree density is also important for the tree-planting process. The preferred target density varies with slope and types of plant species used. Therefore, under the proposed project, planting densities will need to be modified to accommodate the carrying capacity of target sites and species. Planting density is commonly determined by equating the number of seedlings or cuttings per hectare with the average annual rainfall in millimetres. For example, in a region with annual rainfall of 200 mm, it is advised to plant 200 woody seedlings and 200 perennial grass seedlings<sup>905</sup> per hectare. Lower annual rainfall requires greater spacing along and between treelines, to prevent interspecific competition for water and subsequently, exhaustion of the soil's water reserves. Moreover, selected planting densities must be contributed to slowing wind speeds and preventing wind erosion<sup>906</sup>. These planting guidelines and best practices will be applied during tree-planting activities implemented under the proposed GCF project (Activity 2.1.1).

<sup>902</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>903</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>904</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>905</sup>

<sup>906</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

The main drivers of reduced seedling growth and failed establishment are drought, floods, high runoff, fire, strong winds and livestock intrusion. It is, therefore, essential that seedlings and cuttings are protected from these risks in the first two–three years of establishment. This can be achieved by: i) planting seedlings above floodplains and livestock paths; ii) establishing a network of windbreaks; and iii) implementing integrated grazing management (agro-silvopasture<sup>907</sup>) systems where fencing is cost-prohibitive<sup>908</sup>. Additionally, in lower rainfall areas, the low inherent soil moisture it is necessary to completely removal invasive plant species and weeds, which may compete with tree seedlings, for both soil and water resources. For the proposed project, the site-specific baseline conditions (in Aoujeft, Rachid, Tamcheket and Nema) will determine the extent to which these best practices are utilised, as it applies for both the establishment and management of treelines as well as for the ecosystem restoration sites (Activity 2.1.1).

### Community-managed conservation areas

Within arid and semi-arid environments, intact vegetation and biological dune fixation installations are highly sensitive to disturbance. Therefore, effective protection — particularly from livestock browsing — is required to prevent land degradation and associated sand encroachment. Past initiatives, including the GEF-funded project titled ‘*Project for the restoration/reforestation of degraded lands in Tembara, Male commune, moughataa d’Aleg, wilayah Brakna*’ (2016), have successfully protected afforested and reforested areas from exploitative human activities and livestock browsing by: i) fencing off intervention sites (Figure 103); and ii) posting permanent guards at these sites<sup>909</sup>. As a best practice, these guards should be recruited from villages near the areas requiring protection, to provide employment opportunities to local community members. The stewardship of community-managed conservation areas can be further incentivised by planting multi-use species, with the potential to provide sustainable income-generating opportunities (sustainably sourced fuelwood, building material, seed, and fodder) to local community members, within these protected areas<sup>910</sup>. The proposed project will adopt these best practices under Activity 2.1.1.



**Figure 103.** The fenced-off conservation area established in Male commune, in eastern Mauritania<sup>911</sup>.

<sup>907</sup> Agro-silvopastoral systems are land-use practices in which trees and crops are integrated into livestock production

<sup>908</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>909</sup> FAO. 2020. Action against desertification. Available at: <http://www.fao.org/documents/card/en/c/ca6932en/>.

<sup>909</sup> GEF Small Grants Programme. 2016. Projet de restauration/reboisement des terres dégradées de Tembara, commune de Male, moughataa d’Aleg, wilaya du brakna

<sup>910</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>911</sup> Image provided by national consultant

## Rehabilitation of degraded areas

The overexploitation of forest resources and the subsequent loss of vegetation cover increases the susceptibility of sand to wind erosion. This is because vegetation protects soil from wind erosion, by both binding soil particles, and improving infiltration of water from rainfall. Degraded ecosystems (often lacking vegetation) are, therefore, a major source of loose sand, which becomes mobilised during the sand encroachment process<sup>912</sup>. To limit this source of sand and prevent further silting within the proposed project's target regions, degraded landscapes must be actively rehabilitated via the reforestation of indigenous and multi-use plant species. Past projects have found that: i) developing natural resource management plans; ii) training communities to restore ecosystems with climate-resilient and multi-use species; iii) implementing and training communities in sustainable income-generating activities; and iv) building institutional capacity are all important for the rehabilitation of degraded ecosystems and the associated restoration of ESS that contribute to dune stabilisation and water infiltration<sup>913</sup>.

The best practices when planting trees for biological dune fixation, discussed above, should also be applied when re-planting indigenous vegetation. Additionally, national consultants have identified animal 'collar re-seeding' as an effective technique for dispersing the seeds of indigenous tree species within rangelands, to rehabilitate ecosystems that have been degraded by livestock foraging. This method involves: i) attaching a seed-containing pouch to livestock via a collar; and ii) piercing the pouch to enable seeds to fall through while the animal moves across rangelands in search of forage. In this way, forest seeds can be easily dispersed and trampled into the soil by moving animals, to facilitate the regeneration of over-exploited vegetation cover<sup>914</sup>.

These best practices will be replicated under the proposed project, to facilitate the rehabilitation of degraded landscapes (Activity 2.1.1) (the exact number of hectares to be rehabilitated will be determined once a map has been generated by national consultants). Additionally, the best practices for tree-planting and protected areas management identified above will be incorporated into landscape rehabilitation activities.

### 5.4.2 Lessons learned

An important lesson learned from past projects is that the introduction of non-indigenous species for biological dune fixation can negatively impact indigenous species and agricultural crop varieties; therefore, careful risk analyses and cost-benefit analyses should be conducted when selecting species for interventions targeting sand encroachment.

The tree species *Prosopis juliflora* is a fast-growing woody tree species native to the coastal regions of Latin America, Central America, Mexico, and the West Indies. It is cultivated throughout the tropics and adapts very well to dry zones because of its extended tap-root system. Its root system is very deep, sometimes reaching a depth of ~50 m, while its lateral roots grow very close to the surface and extended up to ~20 m from the trunk. The species tolerates high temperatures, low rainfall and saline soils and is, therefore, well-adapted to climate conditions in the Sahel and Sahara Desert. Currently, *P. juliflora* is the only woody species to have demonstrated success in fixing sand dunes in Mauritania<sup>915</sup>.

As a result of its ecophysiological adaptations, *P. juliflora* has an ability to access and absorb moisture in the soil. This favourable adaptation increases its capacity to produce new roots and shoots and

<sup>912</sup> FAO. 1988. Manuel de fixation des dunes. FAO Conservation Guide No. 18. Rome.

<sup>913</sup> Ould Safi M, Megharbi A & Haddouche D. 2018. Caractérisation des bandes vertes de la lutte contre l'envahissement du sable dans la région de Gouara au sud-ouest de l'Algérie. *Int J Ecol Dev*, 33(4):1–9.

<sup>914</sup> Appendix 6

<sup>915</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

outcompete surrounding plants in its environment. If not carefully monitored and properly managed, *P. juliflora* can easily become invasive — particularly in sandy zones where the water table is close to the surface. Moreover, if planted too densely, *P. juliflora* limits the growth of the grassy understorey, as a result of: i) its spreading root system outcompeting indigenous species for water uptake; and ii) its canopy preventing sufficient light from reaching ground cover<sup>916</sup>. Within the proposed project's target regions, national consultants and community members have reported that the introduction of *Prosopis* has negatively impacted local agricultural species in oases, palm groves and market gardens<sup>917</sup>. Accordingly, to prevent maladaptation, rigorous risk and cost-benefit analyses should be undertaken to ensure that species selected for biological dune fixation (under Activity 2.1.1) have positive rather than negative long-term impacts.

Another important lesson learned from past projects is that the successful establishment of tree lines and green belts in arid environments is highly dependent on water availability. Effective stewardship by local community members undoubtedly increases the chances of seedling survival. This includes, for example, the establishment of fences around conservation areas and guarding intervention sites. Nevertheless, an even more crucial determinant of tree seedling success are the local climatic factors and associated extreme events. For example, despite adequate protection against browsing and trampling by livestock, the Saharan green belt shown in Figure 104 (Algeria) failed to establish as a result of limited water availability. To prevent this outcome under the proposed project, contingency measures should be put in place to ensure the survival of planted seedlings during extreme climatic events (droughts, floods, extreme winds). Drip irrigation<sup>918</sup> has since been recognized as an effective technique for irrigating Saharan crops and green belts in Algeria during periods of drought<sup>919</sup>. The proposed project will incorporate these lessons learned into the design of all tree-planting activities (Activity 2.1.1) to ensure the survival of seedlings under extreme climate conditions.



**Figure 104.** An unsuccessful greenbelt resulting from limited water availability<sup>920</sup>.

## 5.5 Adoption of improved or diversified livelihoods

<sup>916</sup> FAO. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>917</sup> Appendix 6

<sup>918</sup> Drip irrigation involves placing tubing with emitters on the ground along side the plants. The emitters slowly drip water into the soil at the root zone. Because moisture levels are kept at an optimal range, plant productivity and quality improve.

<sup>919</sup> Ould Safi M, Megharbi A & Haddouche D. 2018. Caractérisation des bandes vertes de la lutte contre l'envahissement du sable dans la région de Gouara au sud-ouest de l'Algérie. *Int J Ecol Dev*, 33(4):1–9.

<sup>920</sup> Boulghobra N, Hadri T & Bouhana M. 2014. Using Landsat imagery for monitoring the spatiotemporal evolution of sanding in dryland, the case of In-Salah in the Tidikelt (southern Algerian Sahara). *Geographia Technica*, 9(5):1-9.

Climate change-induced environmental degradation limits livelihood opportunities that depend on natural resources. In rural Mauritania, local communities' livelihoods depend heavily on agriculture and animal husbandry: two of the economic sectors most vulnerable to climate change impacts<sup>921</sup>. Climate-smart agricultural technologies, sustainable livestock management practices and the adoption of alternative sustainable livelihoods are, therefore, important for climate change adaptation, with co-benefits of poverty reduction and increased food security<sup>922</sup>.

### 5.5.1 Best practices

#### **Climate-smart agriculture**

Climate-smart agriculture (CSA) is an integrated approach to managing agricultural landscapes — including croplands, pastures and forests — that addresses the interlinked challenges of food security and accelerating climate change. CSA aims to simultaneously achieve three outcomes: i) increased agricultural productivity and food security; ii) enhanced resilience to climate change; and iii) reduced emissions<sup>923</sup>.

In 2020, the WB compiled a country profile outlining best practices for CSA in Mali, which shares a border with Mauritania and is characterised by a similar arid environment. To counter the threat of climate change-induced desertification and improve crop production in Mali, several climate-smart practices have been prioritised, including:

- the use of improved varieties that are drought-tolerant and fast-growing;
- drip irrigation;
- composting — to increase soil fertility;
- fertiliser microdosing<sup>924</sup>;
- urea deep placement<sup>925</sup>; and
- soil and water conservation<sup>926</sup>.

Farmer-managed natural regeneration (FMNR)<sup>927</sup>, particularly in the context of reducing desertification, has also become increasingly common. Generally, forestry and agroforestry have been promoted, with stands of *Senegalia senegal* (formerly *Acacia senegal*) commonly planted for the extraction of gum Arabic — a food additive used in a wide variety of products produced globally, including soft drinks. Additionally, academic research has found evidence that drip irrigation and *zai* pits<sup>928</sup> (Figure 105) have favourable impact potential across all three CSA pillars (i.e., productivity, resilience, and emissions)<sup>929</sup>. In 2014, a terminal evaluation of the WB-supported program titled '*The West Africa Agricultural Productivity Program*', found that ~175,000 farmers who had used at least one of the abovementioned CSA technologies experienced an average increase in agricultural yield and income of ~30% and ~34%, respectively<sup>930</sup>.

<sup>921</sup> Schlenker W & Lobell DB. 2010. Robust negative impacts of climate change on African agriculture. *Environ. Res. Lett.* 5: 14010. DOI:10.1088/1748-9326/5/1/014010.

<sup>922</sup> Safriel U & Adeel Z. 2008. Development paths of drylands: Thresholds and sustainability. *Sustain. Sci.* 3: 117–123. DOI:10.1007/s11625-007-0038-5.

<sup>923</sup> WB. 2021. Climate-smart agriculture. Available at: <https://www.worldbank.org/en/topic/climate-smart-agriculture>

<sup>924</sup> The application of small, affordable quantities of fertiliser with the seed at planting time, or as top dressing 3–4 weeks after shoot emergence.

<sup>925</sup> Fertiliser application technology that involves placing a nutrient-dense briquette under the soil surface, either by hand or with an applicator, to stimulate crop growth and productivity

<sup>926</sup> WB Group. 2020. Climate-smart agriculture in Mali. Available at: [https://cgspage.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile\\_feb21.pdf?sequence=3&isAllowed=y](https://cgspage.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile_feb21.pdf?sequence=3&isAllowed=y)

<sup>927</sup> A set of practices used by farmers to encourage the growth of native trees on agricultural land; FMNR is reported to deliver a number of positive impacts, including soil fertility improvement and the provision of fodder for livestock

<sup>928</sup> *Zai* pits are 20–30cm-wide depressions in which the seeds of crops species are planted. These small basins improve rainfall and runoff capture. When available, crop residue, mulch or manure is added to every pit to increase soil fertility and help vegetation grow in the first phases.

<sup>929</sup> Andrieu N, *et al.* 2017. Prioritizing investments for climate-smart agriculture: lessons learned from Mali. *Agricultural Systems*, 154: 13–24.

<sup>930</sup> WB. 2014. The West Africa Agricultural Productivity Program: a major boost for agriculture in Mali. WB: Washington, DC. Available at: <http://www.worldbank.org>





**Figure 105.** The construction of zai pits for improved rainfall and runoff capture<sup>931</sup>.

Since Mali and Mauritania are both Sahelian countries characterised by hot, arid environments, CSA technologies with demonstrated success in Mali are expected to yield similar results in Mauritania. Accordingly, the best practices for CSA in Mali, identified above, will be incorporated into the design of CSA interventions to be introduced or strengthened within the proposed project's target communes (Activity 2.3.1).

Additional CSA best practices identified by national consultants in Mauritania include: i) the reestablishment and upscaling of phoeniculture (oasis agriculture) — which is conventionally carried out predominantly by women; ii) the integration of crop farming, forestry and livestock husbandry (agro-silvopasture); iii) the construction of earthen dykes within which cereal crops can be established (low-water agriculture) — to leverage seasonal runoff; and iv) the establishment of market gardens supplied with solar irrigation kits<sup>932,933</sup>. Therefore, the integration of these best practices into CSA activities designed under the proposed project (Activity 2.3.1) will be a priority.

### **Climate-resilient livestock management**

Several past and ongoing climate change adaptation projects, both nationally and internationally, have introduced interventions aimed at reducing the impact of livestock farming on natural resources and increasing the resilience of livestock-dependent livelihoods to the impacts of climate change.

Since 2015, the WB-supported project titled '*Regional Sahel Pastoralism Support Project*' has been assisting pastoralists in six Sahel countries — Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal — to adopt climate-resilient livestock management practices. Under this project, livestock productivity and resilience to climate change in Mauritania have been increased through, *inter alia*:

- the establishment of 25 veterinary care units to increase animal health;
- the improvement of climate-resilient breeds (gene pools);

<sup>931</sup> Histories of Geographical Knowledge. 2015. Technological advancements within the regeneration of the Sahel. Available at: <https://historiesofgeography.wordpress.com/2013/02/15/84/>

<sup>932</sup> Appendix 6

<sup>933</sup> Appendix 5

- the development of an animal health manual for field veterinary agents;
- the construction of 118 water points along strategic pastoral routes; and
- the rehabilitation or construction of nine markets, to improve market access for the sale of livestock produce<sup>934</sup>.

Additionally, in the neighbouring country of Mali — characterised by similar environmental conditions to those in Mauritania — climate-smart fodder production, feed supplementation and herd mobility are among the main CSA-related practices used by agro-pastoralists. Cattle fattening, through stall feeding and animal housing has also been promoted in the country, and has potential to increase livestock productivity, farmer incomes and resilience to climate hazards, while simultaneously allowing for the capture of manure for use in biogas digesters or in crop and vegetable fields<sup>935</sup>.

Past projects in Mauritania have also used ‘set-aside’ practices<sup>936</sup> to rehabilitate degraded ecosystems and rangelands. These practices involve: i) developing rotation systems for setting aside pasture; ii) methods of re-seeding where vegetation has been degraded by intense foraging by livestock; and iii) establishing protection systems to protect intact and rehabilitated areas from animal encroachment — for example, by erecting fences and demarcating specific livestock paths and corridors to be traversed by transhumant pastoralists.

Accordingly, the abovementioned best practices from past and ongoing projects will be replicated in the design of the proposed project, to facilitate the adoption of climate-resilient and sustainable livestock management practices by farmers within the target communes (Activity 2.3.1).

### **Alternative livelihoods**

Past projects have found that opportunities for income generation are essential for ensuring community involvement from the start of the project. In addition to diversifying communities’ livelihoods in the short term, climate-smart alternative livelihoods increase the resilience of the communities through the provision of alternative income streams and SNRM practices in the long term<sup>937</sup>.

#### *Type of diverse livelihoods*

Climate-resilient livelihood opportunities and income-generating activities carried out by other projects are listed below.

- Agribusiness development: This has been accomplished by introducing improved planting material (such as seedlings), providing training in crop-specific production and building sustainable supply chains, including storage, transport and processing facilities<sup>938</sup>. By enabling market access, including access to international markets through product advertising, the project contributes to increased trade and rural income in the target regions. Past projects have selected crops that are in high demand globally and perform well in the targeted areas, such as coffee, cassava and black pepper, to ensure the success of the local farmers.
- Vegetable gardens/market gardening: This has been accomplished by setting up vegetable gardens with fences, horticultural equipment and a variety of seeds, enabling community members to improve and diversify vegetable production for family consumption and increase family income from the sale of produce on the market. In addition to family consumption and generated income, market gardening cooperatives have reinvested part of their profits to finance

<sup>934</sup> WB Group. 2022. Implementation completion and results report for the Regional Sahel Pastoralism Support Project. Available at: <https://documents1.worldbank.org/curated/en/174961655387862183/pdf/Western-and-Central-Africa-Regional-Sahel-Pastoralism-Support-Project.pdf>

<sup>935</sup> WB Group. 2020. Climate-smart agriculture in Mali. Available at: [https://cgspage.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile\\_feb21.pdf?sequence=3&isAllowed=y](https://cgspage.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile_feb21.pdf?sequence=3&isAllowed=y)

<sup>936</sup> The practice of taking specific fields out of production or putting them in rotation

<sup>937</sup> WB. 2021. Mauritania sustainable landscape management project under the SAWAP.

<sup>938</sup> NCBA. 2017. East Timor agribusiness development project.



new income-generating activities, such as community shops<sup>939</sup>. This is evidence that market gardening improves food security, generates livelihoods and improves quality of life for communities. Best practices and lessons learned for market gardening are described below.

- Selling of non-timber forestry products: Past projects have provided the material necessary for growing, harvesting, maintaining, transforming and marketing the selected agropastoral products and non-timber forestry products. Best practices incorporated the generation of non-timber forestry products on plots that are set-aside or will allow for sustainable harvesting by allocating a percentage of the restored forestry area to be harvested by community members. Harvesting during the dry season has increased sources of income for local communities in drought periods. Community members have received training sessions on the best use, maintenance and sale of non-timber forestry products.
- Nurseries: Community members — particularly women, who may not own land large enough to benefit from agroforestry and climate-smart livestock management activities — can take advantage of free seedlings to start nurseries. Women can develop their own nurseries, where fragile seedlings can be raised into mature, locally acclimated seedlings that can be sold for cash to eager crop farmers in the target and surrounding regions<sup>940</sup>. Past projects have made seedlings, climate-resilient crop training and business skills training available to community members to promote sustainable income-generating activities. Trees grown in nurseries can then be used to supply reforestation and land rehabilitation activities. Some nurseries have already been established within the proposed project's target regions (Figure 106 and Figure 107); therefore, opportunities for upscaling exist.



**Figure 106.** Nursery established within the proposed project's target region<sup>941</sup>.

<sup>939</sup> AF. 2019. Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania.

<sup>940</sup> NCBA. 2017. East Timor agribusiness development project.

<sup>941</sup> Image supplied by national consultant



**Figure 107.** Nursery within the proposed project's target region<sup>942</sup>.

- Beekeeping (apiculture): Past projects have promoted beekeeping and provided full beehives with rises, beekeeping equipment necessary to ensure proper management of the apiary (combinations, smokers, knives, extractors, reopeners, beehives, wax-embossing machines, etc.) and provided training for community members in the management and operation of apiaries. Success has been limited as a result of the specific knowledge and techniques required for apiaries<sup>943</sup>. Given this lesson, related trainings on the management and operation of apiaries should be frequent (biannual) instead of once-off.
- Community shops: Initial funding and infrastructure to start up community shops has contributed to job creation and income resources for the poor. Furthermore, guaranteed access to everyday products reduced the need for communities (particularly women) to travel to other communities, providing savings in time and transport costs.

All of the activities above have particularly targeted women and the youth to improve the income of these beneficiaries and increase their food security, while also promoting the sustainable use of natural resources. In accordance with this best practice, the proposed project will target women and other vulnerable groups when introducing new income-generating activities (Table 57 and Table 58).

Sustainable income-generating activities promote the sustainable management of natural resources. This is done by providing training to community members on how to: i) restore degraded land; ii) sustainably source vegetable produce; iii) manage tree nurseries on reserved land; iv) sustainably source non-timber forestry products. The proposed project will implement such income-generating activities to promote the sustainable use of natural resources (Activity 2.3.1).

<sup>942</sup> Image supplied by national consultant

<sup>943</sup> AF. 2019. Project for enhancing community resilience and food security to adverse effects of climate change in Mauritania.

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In addition to the alternative livelihoods above, national consultants have provided a list of potential diversified livelihood opportunities specific to the proposed project's target region. Table 59 provides a summary of the diversified alternative livelihoods that national consultants have identified.

**Table 57.** The number of direct beneficiaries across the four target hubs<sup>944</sup>

Direct beneficiaries				
Hub	Target commune	Men	Women	Total
Aoujeft	Aoujeft	2,615	2,747	5,362
	Elmaeden	1,750	1,727	3,477
	Ain Savra <sup>945</sup>	1,072	939	2,011
	El Medah	1,751	1,651	3,402
<b>Total Aoujeft</b>		<b>7,188</b>	<b>7,064</b>	<b>14,252</b>
Rachid	Tidjikja	8,880	10,506	19,386
	El Wahat	4,265	4,230	8,495
<b>Total Rachid</b>		<b>13,145</b>	<b>14,736</b>	<b>27,881</b>
Tamcheket	El Mabrouk	1,495	1,535	3,030
	Guaet Teidouma	4,942	6,050	10,992
<b>Total Tamcheket</b>		<b>6,437</b>	<b>7,585</b>	<b>14,022</b>
Nema	Jreif	2,707	3,324	6,031
	Nwal	2,704	2,905	5,609
	Oualata	2,362	2,420	4,782
	N'Beiket Lahwach	6334	6318	12652
<b>Total Nema</b>		<b>14,107</b>	<b>14,967</b>	<b>29,074</b>
<b>Grand total</b>		<b>40,877</b>	<b>44,352</b>	<b>85,229</b>

**Table 58.** The number of indirect beneficiaries across the four target hubs

Beneficiaries in non-target communes				
Hub	Commune	Men	Women	Total
Aoujeft	N'Teirguent	796	840	1,636
<b>Total Aoujeft</b>		<b>796</b>	<b>840</b>	<b>1,636</b>
Rachid	Tensigh <sup>946</sup>	3,186	3,595	6,781
<b>Total Rachid</b>		<b>3,186</b>	<b>3,595</b>	<b>6,781</b>
Tamcheket	Tamchaket	2,264	2,732	4,996
	Radhi	4,509	5,222	9,731
	Sava	6,947	8,240	15,187
<b>Total Tamcheket</b>		<b>13,720</b>	<b>16,194</b>	<b>29,914</b>
Nema	Agoueinit	4,203	5,116	9,319
	Achemmim	1,555	1,743	3,298
	Biribava	2,716	3,258	5,974
	Bangou	6,108	7,564	13,672

<sup>944</sup> National Agency for Statistics and Analysis of Economic Data (ANSADE) of Mauritania/2023 General Population and Housing Census (see ANSADE website).

<sup>945</sup> Ministère des Affaires Economiques et du Développement (MAED) & Office National de la Statistique. 2013. Recensement Général de la Population et de l'Habitat (RGPH 2013). Available at: [http://www.dgct.mr/wp-content/uploads/2016/06/Populations-2013-brochure-RGPH\\_Final-4-aou.pdf](http://www.dgct.mr/wp-content/uploads/2016/06/Populations-2013-brochure-RGPH_Final-4-aou.pdf)

<sup>946</sup> Ministère des Affaires Economiques et du Développement (MAED) & Office National de la Statistique. 2013. Recensement Général de la Population et de l'Habitat (RGPH 2013). Available at: [http://www.dgct.mr/wp-content/uploads/2016/06/Populations-2013-brochure-RGPH\\_Final-4-aou.pdf](http://www.dgct.mr/wp-content/uploads/2016/06/Populations-2013-brochure-RGPH_Final-4-aou.pdf)

	El Mabrouk	3,201	3,715	6,916
	Oum Avnadech	11,820	13,239	25,059
	Néma	15,951	19,091	35,042
	Hassi Etila	3,263	4,134	7,397
<b>Total Nema</b>		<b>48,817</b>	<b>57,860</b>	<b>106,677</b>
<b>Grand total</b>		<b>66,519</b>	<b>78,489</b>	<b>145,009</b>

**Table 59.** Summary of potential alternative livelihoods within the proposed project's target regions, as identified by national consultants<sup>947</sup>.

Alternative livelihood activity	Description
Market gardening (small-scale fruit and vegetable production)	Areas equipped with a borehole, water tower, solar pumping kit and cisterns to produce fruits and vegetables, both for resale and home consumption.
Animal fattening (fattening of small ruminants for resale)	Provide a group of farmers with capital to: i) buy small ruminants at a good price during the lean season; ii) obtain livestock feed; and iii) sell livestock to butchers for a profit.
Butcherries	The establishment of butcherries for the sale of meat to households for consumption will complement animal fattening by developing the market for livestock products.
Poultry farming	Poultry farming requires less land than other forms of livestock farming. Chickens can be kept for resale or home consumption, as well as egg production.
Depot for sale of domestic gas	This activity has the potential to provide households with an energy source other than firewood.
Establishment of village shops	The establishment of village shops — to be run by women's cooperatives — will not only provide income generating opportunities for local women, but also provide community members with basic necessities and improve access to products in areas where the private sector is not present as a result of limited demand.
Production of livestock feed from date nuts	Date nuts can be crushed and ground down to produce nutritious livestock feed. A small amount of capital and nut crusher are needed to initiate this activity.
Drying fruit and vegetables (preservation of consumables)	The drying of fruits and vegetables is conventionally carried out by women, to preserve agricultural produce and increase food security during the lean season. This activity could be upscaled via the provision of solar-powered dryers.
Drying red meat ( <i>tichtar</i> )	Conventionally, nomadic communities dried meat by spreading it out on the ground and exposing it to the sun. This activity can be upscaled through the provision of solar-powered dryers, which will simultaneously make the operation healthier and more hygienic. Dried meat is then cut into small pieces, or <i>tichtars</i> , and sold for human consumption. This practice provides communities with a valuable source of protein when fresh meat is not available; therefore, the demand for this product is high.
Collection and sale of non-timber forest products	Non-timber forest products, for example, the <i>jujube</i> fruit, can be collected from protected areas for a small fee and sold for a profit.
Establish pastoral water points to re-establish transhumant lifestyle (boreholes with solar pumps)	Using solar pumps and water towers, pastoral water points can be established along historical transhumance routes, to improve herders' access to water and promote the re-establishment of transhumant livestock practices.
Sewing production unit	Women's cooperatives can sew traditional African <i>kikoi</i> s to sell to households for profit.
Bakery for bread production using gas ovens	Many households struggle to find fuelwood and the use of wood as a fuel for cooking harms the environment. To avoid these challenges, households can be equipped with gas ovens, or more efficient cookstoves, to enable them to bake bread without harming the environment. The sale of the bread using gas ovens/cookstoves will constitute an income-generating activity.
Transport (community carts)	'Community carts' (horse-, ox-, or donkey-drawn carts) provide a means of transport in rural areas — for example, for transporting trees to be planted in protected areas, water for agriculture and nurseries, and stones for the construction of stone bunds. This transport can be used by individuals for a small fee, to generate income and maintain the condition of animals.

<sup>947</sup> Appendix 6

### *Market gardening*

Market gardening is the small-scale production of fruits and vegetables, such as cash crops, frequently sold locally to other community members, at local markets and at international markets when accessible. It is an income-generating activity that supports the sustainable use of natural resources while diversifying communities' livelihoods. Best practices to support market gardening include the selection of producers and agronomist supervisors, the provision of initial and continued technical support, and enabling market access. A participatory approach should be taken to select producers that fit the suggested criteria. This may include: i) owning a concession (*zriba*); ii) being a farmer; and iii) implementing resource-use techniques that are sustainable. The progress of market gardening is, in large part, the result of effective supervision systems. The decisions made by experienced community leaders have contributed to the diversification of fruit and vegetable production, an increase in market gardening areas, improved yields, and an acceptance of natural resource management practices. These practices have been reflected in the improved date palm techniques of the International Fund for Agricultural Development (IFAD)-supported project titled '*Oasis Sustainable Development Program*'<sup>948</sup>.

Past projects report that best practices include: i) providing support in the form of technical demonstrations and ii) training producers in how to increase market gardening areas and yields, diversify production, and adopt natural resource management techniques. The combination of these best practices resulted in new knowledge for producers and the induced effect of other producers observing and applying the new techniques. For example, the Oasis Sustainable Development Program reported that 1,084 producers were supervised directly by farmer leaders, but ~3,250 producers benefitted from the induced effects<sup>949</sup>. Given this effectiveness, the proposed project will: i) select agronomist supervisors to support producers; ii) provide support in the form of technical demonstrations; and iii) host training for producers in the abovementioned topics (Activity 2.3.1).

### 5.5.2 Lessons learned

#### **Climate-smart agriculture**

A lesson learned from the implementation of CSA adaptation solutions in Mali — which neighbours Mauritania and is characterised by similar socio-economic and climate conditions, — is that although effective, the types of CSA practices adopted by local communities generally respond to short-term needs rather than long-term sustainability goals. For example, in the region of Segou, there are considerable differences in the observed and potential adoption rates of the most common CSA technologies and practices — including the use of drought-tolerant crop varieties, micro-dosing, the use of organic manure, intercropping, contour farming, FMNR and agroforestry. The most-adopted technology is the use of organic manure (89% of farmers), while the least-adopted is the practice of intercropping (21% of farmers), which requires relatively more time and effort to establish<sup>950</sup>. This implies that community members are more prepared to adopt CSA solutions that can be achieved in the short-term, than solutions with a high impact potential in the long-term. CSA adaptation options such as seed priming and fertilisation, which require low initial cost and labour inputs, are most preferred by farmers<sup>951</sup>.

Some of the challenges contributing to the limited adoption of long-term CSA practices in Mali include, *inter alia*: i) limited access to relevant knowledge about the practices; ii) poor

<sup>948</sup> Islamic Republic of Mauritania. 2014. Oasis Sustainable Development Program (PDDO) supervisory report.

<sup>949</sup> Islamic Republic of Mauritania. 2014. Oasis Sustainable Development Program (PDDO) supervisory report.

<sup>950</sup> WB Group. 2020. Climate-smart agriculture in Mali. Available at:

[https://cgspace.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile\\_feb21.pdf?sequence=3&isAllowed=y](https://cgspace.cgiar.org/bitstream/handle/10568/111457/MALI%20CSA%20Profile_feb21.pdf?sequence=3&isAllowed=y)

<sup>951</sup> WB Group. 2020. Climate-smart agriculture in Mali.



organisation of associated value chains; and iii) limited financial capacity to invest in the initial change from one farming method to another. Land tenure is also an important factor limiting the adoption of more permanent CSA strategies — for example, agroforestry, drip irrigation and investment in hard infrastructure<sup>952</sup>. Based on the lessons learned above, interventions aimed at facilitating the uptake of CSA practices in Mauritania under the proposed project (Activity 2.3.1) will ensure that: i) knowledge on CSA methods is efficiently disseminated among rural farmers; ii) value chains for CSA products are developed, to ensure that sustainable farming translates into tangible benefits for local community members; iii) financial support is provided to farmers wanting to adopt CSA practices; and iv) land tenure discrepancies are resolved — to limit conflict between landowners, as well as between livestock and non-livestock keepers.

### **Climate-resilient livestock management**

As in the case of CSA strategies, lessons learned from past projects suggest that although climate-resilient livestock management practices have demonstrated success in the long-term, rural farmers often have limited financial capacity to invest in the initial shift to climate-resilient strategies — including, *inter alia*, the purchase of improved livestock breeds and supplementary feed during the lean season.

For example, under the IFAD project titled '*Increasing food security and farming system resilience in East Africa through wide-scale adoption of climate-smart agricultural practices*' (2017), the adoption of improved livestock feed baskets in Lushoto, Tanzania, was expected to increase milk yields, reduce poverty levels, improve food security, and contribute to greenhouse gas (GHG) reduction — particularly if complemented by the purchase of dairy cows as opposed to local cattle breeds<sup>953</sup>. However, additional costs related to the purchase of improved breeds threatened to exhaust many rural farmers' financial resources; therefore, few farmers adopted this strategy. Providing an improved breed of dairy cow at zero purchase cost increased the predicted adoption rate of supplementary feeding by ~30% when compared with the introduction improved feeding only<sup>954</sup>. Under the proposed project, subsidising the purchase of selected livestock breeds and easing liquidity constraints (by increasing rural communities' access to credit), may provide incentives for the adoption of climate-resilient livestock management practices (Activity 2.3.1).

### **Alternative livelihoods**

With support from the United Nations High Commissioner for Refugees (UNHCR) and the United Nations (UN) in Mauritania, the past project titled '*UNHCR's Livelihoods Programme in Mauritania*' (2017–2019) introduced a strategy to strengthen livelihoods for both host and refugee communities in the *moughataa* of Bassikounou. The livelihoods strategy developed under this project is based on a value chain analysis and focused primarily on rural populations. The strategy has identified several important priorities, including the strengthening of local value chains related to livestock, dairy production, leather goods and Arabic gum. Additionally, sewing, dressmaking and small-scale agriculture (fruit and vegetable production) have been identified as important sectors in the region, along with micro-enterprises targeting women and the youth. Since the introduction of this strategy, UNHCR Mauritania and other development partners have begun the implementation of five key livelihoods and income generating activities (IGAs) in the region: i) market gardens, ii) artisanal

<sup>952</sup> Mathys E, Murphy E & Woldt M. 2015. USAID Office of Food for Peace Food Security Desk Review for Mali, FY2015–FY2019. Washington, DC: FHI 360/FANTA.

<sup>953</sup> Shikuku KM, Valdivia RO, Paul BK, Mwongera C, Winowiecki L, Läderach P, Herrero M & Silvestri S. 2016. Prioritizing climate-smart livestock technologies in rural Tanzania: A minimum data approach. *Agricultural Systems*, 151:149–152. DOI: 10.1016/j.agsy.2016.06.004

<sup>954</sup> Shikuku KM, Valdivia RO, Paul BK, Mwongera C, Winowiecki L, Läderach P, Herrero M & Silvestri S. 2016. Prioritizing climate-smart livestock technologies in rural Tanzania: A minimum data approach. *Agricultural Systems*, 151:149–152. DOI: 10.1016/j.agsy.2016.06.004

crafts (leather, ironwork, textile dyeing); iii) livestock sales; iv) milk production and sale; and iv) the establishment of small businesses and women's cooperatives.

Terminal evaluation of the abovementioned project found that overall, the small-scale UNHCR livelihood activities introduced in Mauritania have not significantly improved income generation or economic inclusion for refugees and host communities. However, livelihood activities do appear to support improved food security in participating households. The most successful alternative livelihood activities included: i) small businesses established for the production and sale of dry meat, which generated sufficient demand to sell all produce; and ii) market gardening, in which all 800 target households participated. Women in small-scale commercial activities benefitted from access to lower-priced food for their families and borrowing food when needed. Additionally, support to artisanal craftspeople boosted production. Marketing support is, however, lacking, and, therefore, value chains for this livelihood need to be developed. The worst-performing income-generating activities were associated with animal husbandry. In particular, animal husbandry was constrained by poor animal shelter conditions and the need to outsource herding. Based on these lessons learned, the introduction of diversified IGAs within the proposed project's target region (Activity 2.3.1) will be informed by rigorous value chain analyses and supported by market access development (Sub-activity 2.3.1.6). Financial support and training will be provided to households adopting diversified livestock-related IGAs — for example, poultry farming and dairy production — to eliminate constraints relating to herding and animal care identified above. However, based on their demonstrated success, horticultural IGAs — for example market gardens and nurseries — will be prioritised under the proposed project (Activity 2.3.1).

Although market gardening was successfully implemented under the abovementioned UNHCR project (2017/2019), a decrease in market gardening areas has been observed as a result of the flooding of some plots in the rainy seasons. Climate-resilient drought- and flood-resistant crops are important in such cases, and the proposed project will promote these by: i) supplying improved seedlings to local communities; and ii) providing training on the planting and farming of these for agriculture.

Lastly, under the ongoing '*Oasis Sustainable Development Programme*' (2016), supported by IFAD, regional divisions of the Union of AGPOs oversaw the organisation and diversification of livelihoods, while the economic interest group — set up by producers under the AGPOs — was responsible for ensuring the conservation, processing, and sale of oasis agricultural products under favourable conditions, including seed supply and the regulation of production flow on urban markets<sup>955</sup>. This arrangement produced positive outcomes in terms of seed supply and the regulation of production flow. Lessons learned from this project indicate the importance of identifying the responsibilities of all stakeholders involved to avoid discrepancies that hinder the project's success. Accordingly, the proposed GCF project will provide initial support to communities for the uptake of diversified livelihoods by: i) incorporating coordination mechanisms into the design of IGA interventions; and ii) strengthening community members' capacity through the provision of training and engagement workshops, to identify the roles and responsibilities of involved stakeholders (Activity 2.3.1).

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<sup>955</sup> Islamic Republic of Mauritania. 2014. Oasis Sustainable Development Program (PDDO) supervisory report.

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## 5.6 Water resources and demand management

In Mauritania, the risk of water insecurity under future climate change scenarios is high as a result of: i) projected increases in the variability of runoff and river flows; ii) increased temperatures, with associated increases in evaporation and decreases in runoff; iii) increased competition over limited water resources; and iv) limited water infrastructure. Additionally, Mauritania's southern areas are classified as 'high risk' for river flooding and flash flooding because of more intense extreme rainfall events and reduced water infiltration<sup>956</sup>.

Water resources and demand management is, therefore, essential for rural communities in Mauritania that are subjected to intensifying water supply concerns because of climate change and the overexploitation of existing water resources. Integrated water resources management techniques — including the restoration of degraded watersheds, water demand management strategies and the installation of infrastructure for flood prevention and increased infiltration — are important methods for building the resilience of rural communities to climate change. Past projects have used different methods to address this, and their best practices and lessons learned are explored below.

### 5.6.1 Best practices

As in most of North Africa, surface water is used as a primary water source in Mauritania (Section 1.4.1). However, available surface water is far below the demand for potable water. Moreover, water quality is jeopardised because of limited sanitation infrastructure, pollution and potential salt intrusion in groundwater. Moreover, a major decrease in the flow of the Senegal River has forced local communities to abandon traditional flooding agriculture in the river valley and migrate towards the capital, Nouakchott. Managing water demand to ensure the supply of adequate potable water is, therefore, one of the priorities for socio-economic development in Mauritania<sup>957</sup>.

### **Quantifying water resources**

Aquifers, which lie beneath Mauritania's arid soil surface, are an important source of fresh water (Section 1.4.1). However, little is known about the country's aquifers and making use of them requires diligent water resource planning. In 2007, the International Atomic Energy Agency (IAEA) commenced its first technical cooperation project, titled '*Use of Isotope Hydrology Techniques for the Study of the Trarza's Aquifer and Discontinued Aquifers in Southern Mauritania*', to characterise and inform the management of one of the country's major aquifers: the Trarza aquifer. The purpose of this project was to improve available information on water resources in the region, and thereby improve the ability to make sound decisions on where and how to extract water efficiently<sup>958</sup>. As a best practice, similar hydrological studies should be incorporated into the design of the proposed project (Activity 2.2.2), to quantify and map both groundwater and surface water resources in the four target hubs, as well as the interconnectivity of aquifers and key recharge areas.

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<sup>956</sup> WB. 2021. Climate Change Knowledge Portal — Mauritania. Available at: <https://climateknowledgeportal.worldbank.org/country/mauritania/vulnerability>

<sup>957</sup> International Atomic Energy Agency. 2011. Isotope Hydrology helps to Ensure Sustainable Water Management in Mauritania. Available at: <https://www.iaea.org/newscenter/news/isotope-hydrology-helps-to-ensure-sustainable-water-management-in-mauritania>

<sup>958</sup> International Atomic Energy Agency. 2011. Isotope Hydrology helps to Ensure Sustainable Water Management in Mauritania. Available at: <https://www.iaea.org/newscenter/news/isotope-hydrology-helps-to-ensure-sustainable-water-management-in-mauritania>

## Demand management

Once the quality and quantity of water available for exploitation has been characterised within the proposed target region, water demand should be carefully managed to improve the balance between demand and supply and prevent sudden decreases in availability<sup>959</sup>. Irrigated agriculture consumes more than 75% of water resource use in most Middle Eastern and North African (MENA) countries, including those located in the Sahel. This emphasises the need for improved water demand management and improved irrigation efficiency within the agricultural sector. The use of modern irrigation techniques — for example, drip irrigation, micro-sprinklers and other water-saving devices — has become widespread in some of the Sahel countries and has resulted in substantial water savings<sup>960</sup>. Extensive water savings have also been realised through careful implementation of a variety of on-farm irrigation management practices — including, *inter alia*: i) planting drought-tolerant crop species; ii) irrigation scheduling<sup>961</sup>; iii) mulching; *zai* pits; and half-moons<sup>962</sup> — which limit the need for regular irrigation<sup>963</sup>.

Demand management is, however, not limited to on-farm measures and practices. Past projects in the Sahel have identified the importance of appropriate water conservation policies and awareness raising campaigns emphasising the need to conserve water. Moreover, reduction in municipal water-use losses, installation of water-saving devices in homes, enforcement of water conservation laws, pricing policies, water use monitoring (for example, of community well points) and conservation incentives are all considered best practices for increasing the availability of freshwater resources<sup>964</sup>. Accordingly, under the proposed project, participatory community-level vulnerability assessments will be conducted to determine 'water availability and access, to identify: i) opportunities for reducing water demand; and ii) gaps where increased water supply is needed (Activity 2.2.2). Moreover, to address the need for appropriate water conservation policies and awareness raising campaigns, water-user groups (WUG) will be established and trained on: i) water supply and demand management; and ii) raising awareness about the impacts of climate-change and land use practices on water resources (Activity 2.2.2).

## Water resources management

In addition to water demand management strategies, adaptation interventions aimed at reducing runoff, increasing water infiltration, promoting aquifer recharge, and improving access to water are needed. These are necessary to: i) increase resilience to climate-change induced droughts; and ii) reduce flood risks during extreme rainfall events. To achieve these objectives, past and ongoing projects have employed several techniques for managing groundwater and surface water resources<sup>965</sup>.

Rainwater harvesting (RWH) systems and cisterns have been recognised by the GoM as a feasible option for improving access to water and sanitation. In the city of Nouakchott, this has offered a reduction in flood impacts as a co-benefit<sup>966</sup>. RWH systems are roof-to-tap systems

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<sup>959</sup> Brooks DB, Rached E & Saade E. 1997. Management of water demand in Africa and the Middle East. International Development Research Centre: Ottawa.

<sup>960</sup> Brooks DB, Rached E & Saade E. 1997. Management of water demand in Africa and the Middle East. International Development Research Centre: Ottawa.

<sup>961</sup> Smart water management is not just about how water is delivered but also when, how often, and how much. To avoid under- or overwatering their crops, farmers carefully monitor the weather forecast, as well as soil and plant moisture, and adapt their irrigation schedule to the current conditions.

<sup>962</sup> Half-moon trenches dug on gentle slopes with the removed soil placed downslope.

<sup>963</sup> Centre for Urban Education about Sustainable Agriculture. 2014. 10 Ways farmers are saving water. Available at: <https://cuesa.org/article/10-ways-farmers-are-saving-water>

<sup>964</sup> Brooks DB, Rached E & Saade E. 1997. Management of water demand in Africa and the Middle East. International Development Research Centre: Ottawa.

<sup>965</sup> Milagros JC. 2007. Rainwater harvesting systems for communities in developing countries. Available at:

<sup>966</sup> Belhassan K. 2022. Water Scarcity Management in the Maghreb Region. Available at: <https://www.intechopen.com/online-first/80984>

that collect rainwater or condensation from rooftops and divert it via pipes into a storage tank with a tap outlet. The advantages of installing RWH systems include:

- reduced reliance on groundwater resources and variable surface waters;
- avoidance of surface-water pollutants;
- cost-effectiveness;
- potential for upscaling by training local community members to build, operate and maintain a RWH system;
- quantity of water harvested is unaffected by terrain, geology, or infrastructure management schemes; and
- delivery of water directly to the household, which relieves women and children from the burden of travelling long distances to find water, which, in turn, saves time and energy.

In addition to RWH systems, national consultants have recommended that raised water towers be constructed, to serve as a storage and distribution point for water pumped from boreholes<sup>967</sup>. Accordingly, under the proposed project, RWH systems, water towers and communal cisterns will be installed to increase water availability in target communes, particularly during prolonged drought periods (Activity 2.2.2).

Previous projects identified an integrated watershed approach to better managing groundwater and surface water resources. The WFP, Food and Agriculture Organisation (FAO), and IFAD are currently piloting an integrated watershed approach in the Sahel, based on a comprehensive understanding of the characteristics of the territory (plateau, slopes, and lowland) and how these interact with one another. The installation of infrastructure for controlling water flow — including the construction of dykes<sup>968</sup>, check dams<sup>969</sup> and gabions<sup>970</sup> — has been implemented in each territory to reduce the flow rate of runoff, increase water infiltration and prevent erosion<sup>971</sup>.

Under the GEF-funded project titled '*Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania*' (2016–2020), EbA and restorative techniques have been identified as best practice for stabilising soil, reducing runoff and improving infiltration for groundwater recharge. This includes, for example, the planting of trees and shrubs in 150 ha of degraded watersheds and the establishment of contour lines<sup>972</sup> for sloping agriculture. Species that may be considered for planted during EbA activities include: *Senegalia senegal*, *Vachellia tortilis*, *Balanites aegyptiaca* and *Ziziphus mauritania*<sup>973</sup>.

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<sup>967</sup> Appendix 6

<sup>968</sup> A dyke is a barrier used to regulate or hold back water from a river.

<sup>969</sup> A check dam is a small dam constructed across a drainage ditch, swale, or channel to lower the velocity of flow.

<sup>970</sup> A gabion is semi permeable barrier, made of boulders in a mesh of steel wires and anchored to the stream bank, to slow but not stop, the flow of storm water in a small watercourse so to favour water infiltration to groundwater and help prevent soil erosion.

<sup>971</sup> Cooper R. 2018. Natural Resources Management Strategies in the Sahel. Available at: [https://assets.publishing.service.gov.uk/media/5c6acc2340f0b61a196aa83a/453\\_Sahel\\_Natural\\_Resources\\_Management.pdf](https://assets.publishing.service.gov.uk/media/5c6acc2340f0b61a196aa83a/453_Sahel_Natural_Resources_Management.pdf)

<sup>972</sup> With contour lines, crop rows are oriented perpendicular to or across the slope of the land to reduce downhill soil erosion by wind and water.

<sup>973</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

Lastly, stone bunds, gabions and earthen dykes have been identified by stakeholders and national consultants as effective ‘slowdown thresholds’ for regulating the flow of runoff and recharging groundwater within the proposed project’s target regions<sup>974</sup>. Stone bunds are small-scale structures positioned along the contours of steep dunes and slopes to: i) prevent occasional heavy rains from washing away soil; and ii) retain water for long enough that it soaks into underlying soil (Figure 108 and Figure 109). Clay dykes (raised beds) are typically constructed along the banks of watercourses, parallel to the flow of water, to prevent overflow during extreme rainfall events and flash floods (Figure 110 and Figure 111). In areas with limited clay — for example, the wilayahs of Adrar and Tagant — stone gabions may be constructed along the banks of watercourses instead (Figure 112 and Figure 113)<sup>975</sup>. In accordance with these best practices, the proposed project will incorporate the implementation of both physical structures and EbA interventions (Activity 2.2.2) for improved aquifer recharge, to reduce flood risks, and also increase water availability and accessibility.



**Figure 108.** Stone bunds constructed within the proposed project’s target region<sup>976</sup>.

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<sup>974</sup> Appendix 6

<sup>975</sup> Appendix 6

<sup>976</sup> Image provided by national consultants



**Figure 109.** Water retention by stone bunds within the proposed project's target regions<sup>977</sup>.



**Figure 110.** Clay dyke constructed along a water course within the proposed project's target region<sup>978</sup>.

<sup>977</sup> Image provided by national consultants

<sup>978</sup> Image provided by national consultants





**Figure 111.** Clay dyke constructed within the proposed project's target region<sup>979</sup>.



**Figure 112.** Stone gabion constructed in parallel with a watercourse within the proposed project's target region<sup>980</sup>.

<sup>979</sup> Image provided by national consultants

<sup>980</sup> Image provided by national consultants



**Figure 113.** Stone gabions constructed to stabilise the banks of a water course and reduce the risk of flooding within the proposed project's target region<sup>981</sup>.

### Groundwater dams

Groundwater dams are hydraulic structures — either of artificial or natural origin — that impede the flow of groundwater and stores it in aquifers<sup>982</sup>. In areas with arid and semi-arid climates, groundwater dams have proven to be an effective technique to store water for all-year round use<sup>983</sup>. Water and soil conservation is important in arid regions; therefore finding successful mechanisms for storing water during rainy seasons, which can be used during dry seasons, is crucial for local communities that rely on this natural resource<sup>984</sup> and to support urban or agricultural development<sup>985</sup>. The resilience of ecosystems and local communities can breakdown when a tipping point in land degradation has been reached — causing cascading effects such as water scarcity and degraded soils<sup>986</sup>. If implemented correctly, groundwater dams can be a potential solution to these challenges. Sustainable water management is critical because climate change has intensified water stress and local communities in drier regions are expected to experience increased water shortages<sup>987</sup>.

Several water harvesting techniques are being used to adapt to water insecurity induced by climate change<sup>988</sup>, with groundwater dams being one such technique. The concept of groundwater dams is not novel as it has been practiced and used by ancient civilisations as far back as 2,000 years ago<sup>989</sup>, however, with the plethora of water-related challenges being experienced by inhabitants of drier regions, this effective technique has gained more attention

<sup>981</sup> Image provided by national consultants

<sup>982</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.

<sup>983</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. *Ground Water*, 24(4): 497-506.

<sup>984</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>985</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.

<sup>986</sup> WFP. 2022. Tackling hunger at its root. Available: <https://docs.wfp.org/api/documents/WFP-0000139477/download/>

<sup>987</sup> Ritchie H., Eisma JA. & Parker A. 2021. Sand dams as a potential Solution to Rural Water Security in Drylands: Existing research and Future Opportunities. *Front. Water*, 3: 1-18.

<sup>988</sup> Ritchie H., Eisma JA. & Parker A. 2021. Sand dams as a potential Solution to Rural Water Security in Drylands: Existing research and Future Opportunities. *Front. Water*, 3: 1-18.

<sup>989</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. *Ground Water*, 24(4): 497-506.

in recent years. Groundwater dams have been constructed in a number of regions around the globe — most notably in Africa, India and Brazil<sup>990</sup>.

They are usually utilised in areas with fluctuating groundwater flows, which are usually attributed to a considerable increase in flows after rainfall periods, and the low flows that are typical during dry seasons<sup>991</sup>. In an effort to generate supplementary water resources, the 1992 Rio Conference regarded the development and use of subsurface dams as a primary goal in their Agenda 21 plan<sup>992</sup>. Moreover, the United Nations Convention to Combat Desertification (UNCCD) in 1994, recommended the use of groundwater dams as a suitable method in semi-arid and arid areas for the economic storage of water<sup>993</sup>.

#### *Types of groundwater dams*

There are two types of groundwater dams: (i) subsurface or underground dams and (ii) sand storage dams. A subsurface dam, seen in

Figure 114 below, is built in situ — in the subsurface — and works by intercepting the natural groundwater flow from an aquifer and reduces variation in the groundwater table situated upstream of the dam with the purpose of storing this water underground<sup>994,995</sup>. Subsurface dams are constructed in two phases. Firstly, a trench is excavated across a valley or riverbed up to the point at which an impervious layer of bedrock is reached, at a suitable site. Secondly, an impermeable barrier or wall is built — using easily accessible construction materials such as stone masonry, clay, bricks reinforced concrete, tarred-felt, corrugated iron, PVC sheets, sheets of steel, or the use of an injected screen — in the trench that acts as a barrier prohibiting the flow of water underground<sup>996,997</sup>. The materials used to construct the impermeable barrier or wall are shown in Figure 115. The typical dam height for this structure is 2–6 m; however, a subsurface dam in Brazil was built at a height of 110 m<sup>998</sup>.

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<sup>990</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>991</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>992</sup> Onder H. & Yilmaz M. 2005. Underground Dams. *European Water*, 11/12: 35-45.

<sup>993</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.

<sup>994</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.

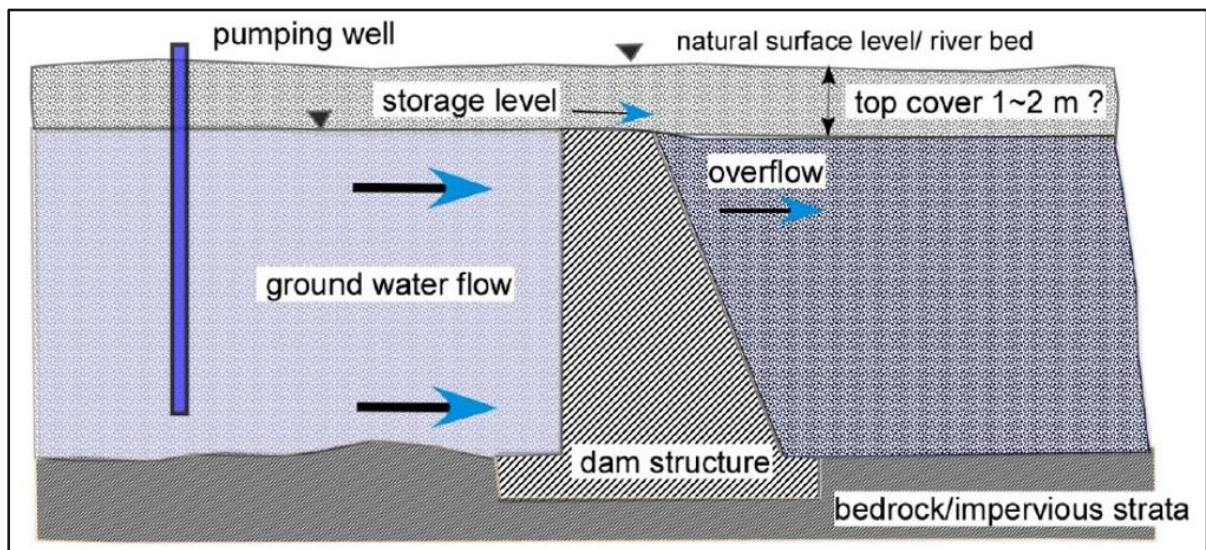
<sup>995</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>996</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.

<sup>997</sup> Du Preez D. 2018. Feasibility and Geotechnical Design of Subsurface Dams in Dry Ephemeral Rivers for the Augmentation of Shallow Groundwater Supply. Unpublished master's thesis. Stellenbosch: Stellenbosch University.

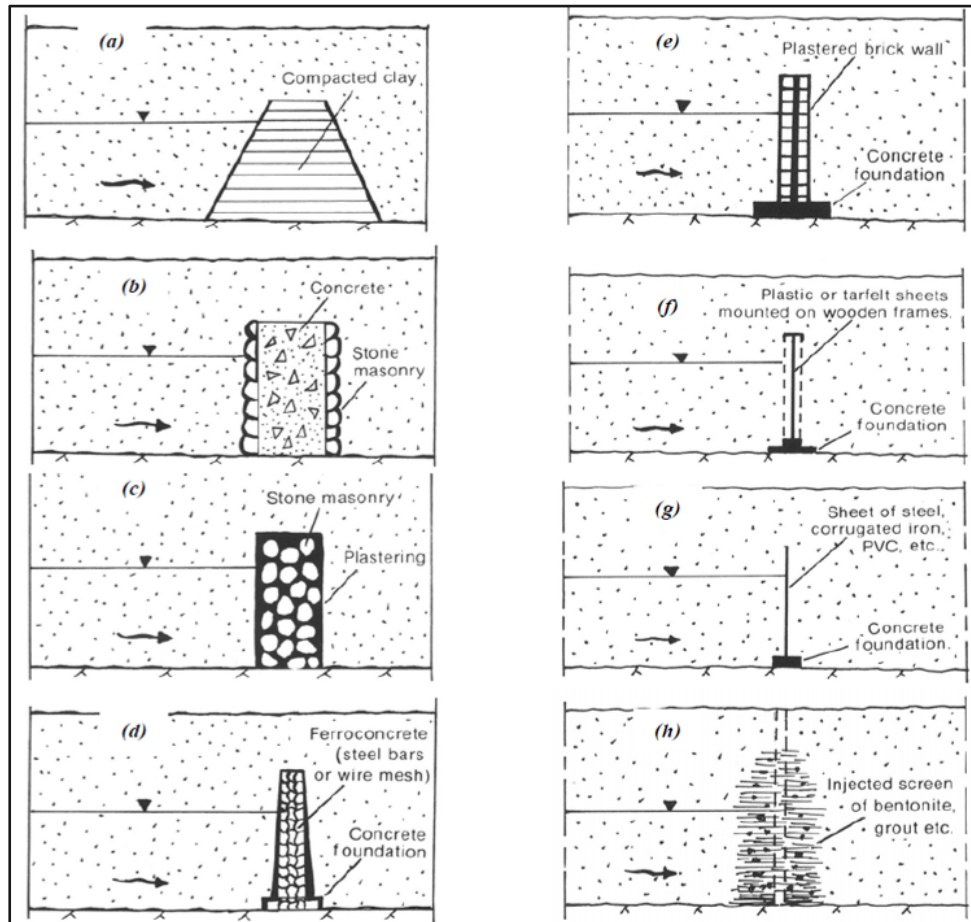
<sup>998</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.





**Figure 114.** An archetypal representation of a subsurface dam<sup>999</sup>.

<sup>999</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. Journal of faculty of Engineering & Technology, 23(1): 121-129.



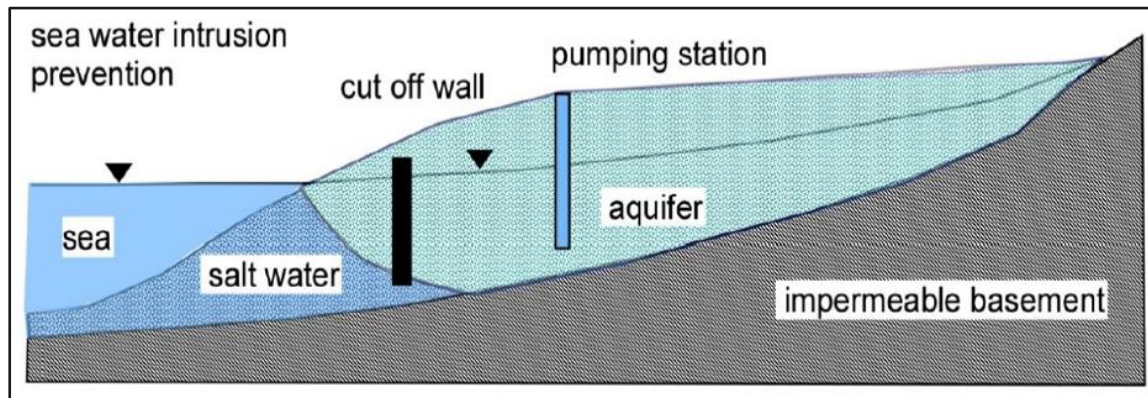
**Figure 115.** Types of subsurface dams based on the materials used: a) clay dike; b) concrete dam; c) stone masonry dam; d) reinforced concrete dam; e) plastered brick wall; f) tarred-felt or plastic sheets; g) corrugated iron, PVC, or steel sheet, h) injection screen<sup>1000</sup>.

The selection of the subsurface dam type is dependent on aspects such as: i) the geological and hydrological conditions; ii) the durability and technical efficacy of the structure; iii) accessibility and feasibility of the materials used; and iv) availability and cost of materials, and v) whether skilled labour is required<sup>1001</sup>. Subsurface or underground dams are also used to avert saltwater intrusion as a result of the dam wall having a much lower hydraulic conductivity<sup>1002</sup>. These types of dams are called saltwater intrusion prevention dams and their structure and function of the cutoff wall is shown in Figure 116 below.

<sup>1000</sup> Onder H. & Yilmaz M. 2005. Underground Dams. *European Water*, 11/12: 35-45.

<sup>1001</sup> Du Preez D. 2018. Feasibility and Geotechnical Design of Subsurface Dams in Dry Ephemeral Rivers for the Augmentation of Shallow Groundwater Supply. Unpublished master's thesis. Stellenbosch: Stellenbosch University.

<sup>1002</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. *Journal of faculty of Engineering & Technology*, 23(1): 121-129.



**Figure 116.** An archetypal representation of a saltwater intrusion prevention dam<sup>1003</sup>.

A sand storage dam — seen in Figure 117 below — is built above the ground and is established in such a way that layers are created to permit sand to deposit while finer materials continue downstream<sup>1004</sup>. This technique involves the construction of a weir across a streambed that permits soil and sand particles, which are transferred during high flow periods, to be deposited before the dam — with water then being stored in these deposits — creating the reservoir to be filled with sand<sup>1005,1006</sup>. The artificial aquifer will then be recharged annually during periods of rainfall allowing local communities to access water from the reservoir during the dry season for agricultural and domestic use<sup>1007,1008</sup>. While dependant on erosion rates at the catchment site, these types of dams require one season–seven years to reach maturity<sup>1009</sup>.

The stored groundwater can be withdrawn using gravity flow or pumping. This is done by either drilling wells into the reservoir or using gravity pipelines, depending on the geological and topographical characteristics<sup>1010,1011</sup>. Groundwater dams are often a combination of subsurface and sand storage dams<sup>1012</sup>. When a subsurface dam is built in a riverbed, the storage volume can be enhanced when the dam wall is risen above the ground level — engendering a gathering of sediments<sup>1013</sup>. Likewise, when a sand storage dam is built, an excavated trench in the sand bed is also required to reach the impervious layer<sup>1014</sup>. While the principles for both dam structures are similar, the use of a sand storage dam is more suited in areas where topographical gradient is high, whereas subsurface dams are better suited in low gradient areas<sup>1015</sup>. The main benefit of using a subsurface dam as opposed to a sand storage

<sup>1003</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. Journal of faculty of Engineering & Technology, 23(1): 121-129.

<sup>1004</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1005</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. Ground Water, 24(4): 497-506.

<sup>1006</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1007</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. Ground Water, 24(4): 497-506.

<sup>1008</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1009</sup> Ritchie H., Eisma JA. & Parker A. 2021. Sand dams as a potential Solution to Rural Water Security in Drylands: Existing research and Future Opportunities. Front. Water, 3: 1-18.

<sup>1010</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. Journal of faculty of Engineering & Technology, 23(1): 121-129.

<sup>1011</sup> Apaydin A. 2016. Applicability of Groundwater Dams in Semi-Arid Regions: A Study in North-Central Turkey. International Journal of Engineering Research and Development, 12(10): 59-69.

<sup>1012</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. Ground Water, 24(4): 497-506.

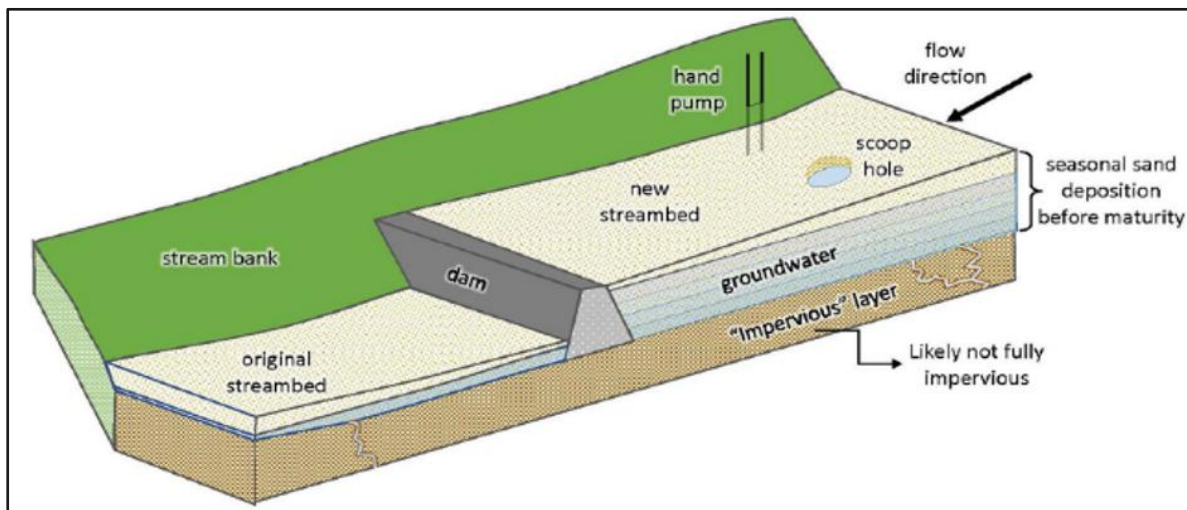
<sup>1013</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. Ground Water, 24(4): 497-506.

<sup>1014</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. Ground Water, 24(4): 497-506.

<sup>1015</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>



dam is its simple design<sup>1016</sup>; however, the site in which it is being constructed will determine which technique is used.



**Figure 117.** An archetypal representation of a sand storage dam<sup>1017</sup>.

#### *Site selection criteria*

Groundwater dams are not globally applicable as they require specific site preconditions<sup>1018</sup>. The technical feasibility of constructing these dams, the potential for creating a large storage reservoir with sufficient recharge conditions, and the ability to minimize seepage losses are all influenced by the topographical characteristics of the area<sup>1019</sup>. The ideal location for groundwater dams would be in area with a soil typology consistent with sands and gravel and an impermeable or rock layer situated a few meters below the surface<sup>1020</sup>. It would also be preferable for the dam to be constructed in an area where rainwater from a large catchment flows into a narrow corridor<sup>1021</sup>. For any project, an in-depth hydrogeological and geological investigation is required to determine an appropriate site for the construction of a groundwater dam; however the following criteria are general guiding principles for site suitability:

- an aquifer with a considerable aerial extent and thickness;
- an impermeable stratum below the aquifer,
- a sufficient recharge amount;
- high hydraulic conductivity and storage coefficient;
- groundwater of a high quality;
- cost-effective but good quality construction material for the dam wall; and
- preferably be located in the narrow area of the valley and the aquifer<sup>1022</sup>.

<sup>1016</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1017</sup> Ritchie H., Eisma JA. & Parker A. 2021. Sand dams as a potential Solution to Rural Water Security in Drylands: Existing research and Future Opportunities. *Front. Water*, 3: 1-18.

<sup>1018</sup> Al-Taiee TM. 2012. Groundwater Dams, a Promise Option for Sustainable Development of Water resources in Arid and Semi-Arid regions., in UNESCO (eds.). *Integrated water resources management and challenges of the sustainable development*. Paris: UNESCO. 35-41.

<sup>1019</sup> Hanson G. & Nilsson A. 1986. Ground-Water Dams for Rural-Water Supplies in Developing Countries. *Ground Water*, 24(4): 497-506.

<sup>1020</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1021</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1022</sup> Apaydin A. 2016. Applicability of Groundwater Dams in Semi-Arid Regions: A Study in North-Central Turkey. *International Journal of Engineering Research and Development*, 12(10): 59-69.



Additionally, the water abstraction method — pumping or gravity — and where it is situated as well as the number and site of the wells requires an assessment<sup>1023</sup>.

### 5.6.2 Lessons learned

Although initiatives implemented under the rural water subsector in Mauritania have achieved considerable improvements in water access rates since 1990, major organisational reforms initiated in 2001 to relieve the state of its operational responsibilities have led to fragmentation within the institution. Moreover, the human and financial resources allocated to new institutions established under the rural water subsector have not materialised, such that the GoM's capacity to improve water services in rural areas is severely constrained<sup>1024</sup>.

These shortcomings can be partly explained by continued political unrest in Mauritania. This has impacted the operation of government institutions since 2005. Some international donors have either reduced or suspended their funding during the periods of political uncertainty and few new external support agencies have become involved in the rural water subsector. Additionally, there have been frequent management changes within the GoM's central departments and limited progress has been made regarding the development and implementation of climate change-responsive public policies. As a result, the process of reforming the water and sanitation sector in Mauritania is relatively slow compared to other countries in North and West Africa<sup>1025</sup>.

As a result of limited institutional capacity within the GoM — and particularly within the rural water subsector — past and ongoing initiatives have noted concerns regarding the sustainability of water management interventions once project implementation timelines have lapsed. Based on this lesson learned, the proposed GCF project will promote self-sufficiency within target communities by: i) establishing independent WUGs within each target hub (Activity 2.2.1); ii) training WUG members (and local communities) on water supply management, demand management, and awareness raising (Activity 2.2.1); and iii) training WUG members (and community members) on effective knowledge dissemination regarding the installation, use and maintenance of RWH systems and physical structures for improved aquifer recharge (Activity 2.2.1). These interventions will facilitate the long-term sustainability of the project, even in the absence of support from government institutions and development partners.

#### **Groundwater dams**

Past projects have shown that there are several advantages to using groundwater dams, including, *inter alia*: i) lower evaporation rates compared to surface dams; ii) prevention of land submergence — commonly affiliated with surface dams; iii) there is no concern regarding breaching relating to natural and human-induced disasters; iv) only a small area is required as opposed to much larger areas required for surface dams; v) the technology used is generally favoured by local communities because it is cost-effective, simple, replicable and easily managed; vi) less risk of water contamination from parasites — which is common concern of sources of surface water; vii) in contrast to surface dams, silting is not a threat<sup>1026, 1027</sup>.

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<sup>1023</sup> Apaydin A. 2016. Applicability of Groundwater Dams in Semi-Arid Regions: A Study in North-Central Turkey. International Journal of Engineering Research and Development, 12(10): 59-69.

<sup>1024</sup> African Ministers' Council on Water (AMCOW). 2011. Water supply and sanitation in Mauritania: Turning finance into services for 2015 and beyond. Available: <https://www.wsp.org/sites/wsp/files/publications/CSO-Mauritania.pdf>

<sup>1025</sup> African Ministers' Council on Water (AMCOW). 2011. Water supply and sanitation in Mauritania: Turning finance into services for 2015 and beyond. Available: <https://www.wsp.org/sites/wsp/files/publications/CSO-Mauritania.pdf>

<sup>1026</sup> Apaydin A. 2016. Applicability of Groundwater Dams in Semi-Arid Regions: A Study in North-Central Turkey. International Journal of Engineering Research and Development, 12(10): 59-69.

<sup>1027</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

Lessons learned from past projects have also noted several limitations to the use of groundwater dams, including: i) less reservoir capacity; ii) higher costs associated with the construction and maintenance of well pumps and pipelines; iii) additional costs required for the in-depth modelling and studies that will need to be carried out prior to the development of the dam<sup>1028</sup>; iv) the design, surveying, and building of the dam necessitate trained personnel to prevent any failures; v) smaller particle sizes lead to only 5% of water available for extraction; and vi) monitoring access to the water is a challenge which can lead to this resource being stolen — land use and economic agreements need to be implemented to protect and manage access to the water<sup>1029</sup>.

The following are lessons learned from a groundwater dam project implemented in Kenya:

- Access to water for both local communities and livestock increased with the quality of the water remaining high and evaporation remaining low — this also increased the amount of permanent grazing areas as herders had previously travelled considerable distances to access water. Problems of overgrazing were minimal<sup>1030</sup>.
- Women were pleased with the project given the increased accessibility of water because prior to its implementation they had to dig shallow wells — as deep as two people — that posed a risk of collapsing. With increased accessibility, women could spend more time doing other activities. Their participation in the project also gave them a sense of satisfaction because they were involved in the same work activities that the men were doing<sup>1031</sup>.
- Local knowledge was integral to the development of the dam as women were able to identify suitable construction materials found in the surrounding areas<sup>1032</sup>.

Overall, groundwater dams are a practical solution for enhancing groundwater supplies in dry regions while also acting as a sustainable mechanism for water supply management. Lessons learned from their establishment in other regions will be considered when installing physical water management infrastructure under Activity 2.2.2. of the proposed project.

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<sup>1028</sup> Ahmed MF., Omed Y., Raza MA. & Ismail S. 2016. Groundwater dams, general characteristics and historical development. Journal of faculty of Engineering & Technology, 23(1): 121-129.

<sup>1029</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1030</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1031</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

<sup>1032</sup> VSF-Belgium. 2006. Subsurface Dams: a simple, safe and affordable technology for pastoralists. Available: <https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4223>

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## 6 Options analysis and site selection

### 6.1 Options analysis

The selection of adaptation interventions to be included in the proposed project design was informed by the results of a multi-criteria analysis (MCA). In order to conduct an MCA, an initial list of adaptation options — presented in Appendix 5 — was compiled based on information obtained from national consultants during site visits to the four target hubs. During these site visits, national experts held consultations with local community members and decision-makers to identify potential solutions for addressing the climate change risks identified in previously developed sectoral risk chains (Section 3.7). Technical staff from the project team later expanded this list to include several other adaptation solutions with proven success in past and ongoing projects. Each option was then reviewed and rated by a group of national experts at a multi-criteria analysis (MCA) workshop in Nouakchott (April 2022).

The group of national experts at the April 2022 MCA workshop included:

- Sid'Ahmed Lehbib Cheikh El Houssein, (Environment and Forestry, National Team Leader);
- Djibril Sarr (Hydrologist);
- Mohamed Sidi Bollé, (Agriculture engineering); and
- Moussa Keita (Socio-economist).

A scoring system comprising four indicators — namely: i) climate justification; ii) ease of implementation; iii) cost effectiveness; and iv) impact potential — was agreed upon during this workshop. This system allowed for all adaptation options to be ranked according to their combined total scores, where higher scores represent higher priority interventions (as perceived by national experts).

During the project design phase, the initial options analysis was further developed by the project technical team. After investigating both national and international best practices and lessons learned for addressing the impacts of desertification in Mauritania (Section 6), several additional adaptation options were incorporated into the final MCA. Using the pre-determined scoring system, a second MCA workshop (September 2022) was held with national consultants, to score and rank all outstanding adaptation solutions.

The national consultants engaged with during the September 2022 MCA workshop included:

- M. Isselmou Sidoumou (national consultant); and
- M. N'Gaide Abderrahmane (mapping expert)

The results of the final MCA are presented in Appendix 6. The total score obtained for each adaptation option was used in combination with information drawn from the best practices and lessons learned (Section 5) to inform the design of proposed project interventions. Additionally, where applicable, the discretion of the project technical team was applied to ensure that all adaptation solutions are technically feasible and respond to the needs of target communities, as outlined in stakeholder consultation reports. The final list of adaptation options selected for inclusion in the proposed project design — together with their respective total scores — is presented in Table 60 below.

**Table 60.** The final selection of adaptation options selected for inclusion in the proposed project design, justified by

Theme	Intervention	Total score
Creation of an enabling environment	Awareness raising and capacity building of community workers/health personnel on climate-sensitive diseases.	15
	Provide training to stakeholders and decision-makers on sustainable natural resource management and strategic land-use planning	14
	Establish commune-level coordination committees	12
	Draft gender- and climate change-responsive policy briefs	10
Knowledge management system	Collect best practices and lessons learned on Nature-Based Solutions and Payment for Ecosystem Services (PES) schemes	16
	Train relevant members of local, regional and national decision-making bodies on the use of the knowledge management tool	14
Sustainable finance	PES schemes	16
Dune fixation and control of sand encroachment	Construction of water and soil conservation/soil restoration works	18
	Stone cordon	18
	Construction of gabion structures in areas without clay (e.g. Adar and Tagant)	18
	Protective treelines	17
	Reforestation with economically profitable species	15
	Protective greenbelts (buffer zones) around villages	15
	Wattling (clayonnage)	14
	Protective fencing (<30%)	15
	Protection of areas for natural regeneration (logging prohibition, etc.) (>50%)	14
Climate-smart livestock management	Strengthening of ongoing experimentation in the integration of agriculture and livestock production (silvopasture)	16
	Supplementing livestock feed during the lean season	15
	Re-seeding to re-establish vegetation lost to grazing/browsing (e.g. aerial seeding)	14
	Introduction of new climate-resilient forage species in rangelands	14
	Rotational grazing	13
	Promotion of livestock mobility (transhumant lifestyle) via the construction and rehabilitation of pastoral water point infrastructure (wells, ponds), marking out of transhumance corridors, rehabilitation of pastoral areas, construction of centres to give livestock farmers access to essential services (storage and supply of foodstuffs and veterinary products).	11
Climate-smart agriculture	Introduction of new adapted seed varieties, resilient to climate variability and change in the farming environment	18

	Regeneration of the phoeniculture heritage (new plantations and regeneration of old plantations)	16
	Protection of crops against livestock grazing/browsing	16
	Establishment of pilot market gardening sites with solar pumped irrigation systems.	16
	Extension of soil fertility improvement techniques	15
	Agricultural perimeters equipped with innovative (water-efficient) and low-cost irrigation equipment	15
	Establish crops behind flood-prevention infrastructure (e.g. behind dikes, stone bunds and hybrid gabions)	15
	Creation of a climate-resilient gene bank (local cultivars)	14
	Mechanical and biological fixation of dunes to protect palm groves against silting	14
Alternative, diversified livelihoods	Market gardening and vegetable cooperatives	17
	Nurseries	16
	Transport (community carts)	16
	Creation of village shops/markets for women's groups	14
Water resources and demand management	Establish well points along historical transhumance routes	17
	Raising awareness of flood risks	16
	Protective dikes for communities exposed to floods	15
	Establish stone bunds ('slowdown thresholds')	14
	Boreholes with solar pumps	14
	Rainwater harvesting	14
	Monitoring of catchment areas and water resources (water quality and quantity)	14
	Hydrogeological studies to estimate the feasibility of withdrawals	13
	Raising awareness of water resource management	13
	Establish earthen bunds with clay bags	12

## 6.2 Site selection

### 6.2.1 Priority commune selection

After finalising the suite of adaptation options to be included in the project design (Table 60), a site selection process was undertaken to identify potential target communes within the pre-selected hubs of Aoujeft, Rachid, Tamcheket and Nema. The proposed project's target hubs comprise a combined total of 25 communes, as shown in Table 61 below.

**Table 61.** Four regional hubs within the Mauritanian arid landscapes where desertification processes are the most severe and the need for adaptation is greatest.

Orthocentre of the hub	Population	Radius of the hub (km <sup>2</sup> )	Number of communes	Names of communes
<b>Aoujeft</b>	15,888	80	5	<ul style="list-style-type: none"> <li>• Aoujeft</li> <li>• Maeden</li> <li>• N'Teirguent</li> <li>• El Medah</li> <li>• Ain Savra</li> </ul>
<b>Rachid</b>	34,662	80	3	<ul style="list-style-type: none"> <li>• El Wahat</li> <li>• Tidjikja</li> <li>• Tensigh</li> </ul>
<b>Tamcheket</b>	43,936	85	5	<ul style="list-style-type: none"> <li>• Tamchaket</li> <li>• El Mabrouk</li> <li>• Radhi</li> <li>• Guaet Teidouma</li> <li>• Sava</li> </ul>
<b>Nema</b>	135,751	80	12	<ul style="list-style-type: none"> <li>• Néma</li> <li>• Achemmim</li> <li>• Jreif</li> <li>• Bangou</li> <li>• Hassi Etila</li> <li>• Oum Avnadech</li> <li>• El Mabrouk</li> <li>• Beribava</li> <li>• Noual</li> <li>• Agoueinit</li> <li>• Oualata</li> <li>• N'Beiket Lahwach</li> </ul>

To maximise the impact potential project activities, given the finite nature of financial resources and human capital<sup>1033</sup>, a subset of 12 priority communes was selected as target sites for the proposed project, with the view to upscale project interventions into all remaining communes in the future. The methodology used to select these 12 priority communes is discussed below (Section 6.2.1), and a description of each commune's main vulnerabilities is provided in Appendix 7: Priority Commune Selection Workshop Results.

In September 2022, a site selection workshop was held with national experts in Mauritania, to identify potential target communes for project interventions. Attendees of the site selection workshop included:

- M. Isselmou Sidoumou (national consultant); and
- M. N'Gaide Abderrahmane (mapping expert).

<sup>1033</sup> Human capital describes the skills, knowledge, and experience possessed by individuals or a population, viewed in terms of their value or cost to an organisation or country.

During the workshop, an Excel-based tool was used to score and rank each of the 24 potential target communes according to their adaptation needs. For each commune, a score sheet comprising eight categories (Appendix 7) was completed by national consultants and the weighted average of all eight scores was calculated as a proxy for adaptation priority. Finally, the 12 communes with the highest final scores were selected as target sites for the proposed project. The specific steps used to identify these priority communes are described in further detail below.

### Step 1: Weightings assigned to score sheet categories

As a first step in the site selection process, national consultants assigned a weighting to each category in the Excel-based score sheet, to reflect the relative importance of each factor in determining commune priority.

Higher weightings represent more severe impacts and a greater need for adaptation interventions. The eight site selection categories and their respective weightings — as assigned by stakeholders during the site selection workshop — are presented in Table 62 below.

**Table 62.** Vulnerability indicators and respective weightings assigned by national experts during site selection workshops

Category	Weighting assigned
Impacts of sand inundation on infrastructure	3
Impacts of sand inundation on water resources	3
Degraded ecosystems	2
Vulnerability of the agricultural sector	2
Vulnerability of the livestock sector	2
Vulnerability of pastoralists/nomads	1
Difficulty in accessing markets	2
Vulnerability in terms of access to water	2

As per the results of the weighting exercise, the impacts of sand inundation on infrastructure and water resources are considered the most important indicators of adaptation need, while the vulnerability of pastoralists is perceived as the least important determinant of site suitability (or priority).

### Step 2: Scoring of communes

Next, national experts rated each of the 25 pre-selected communes according to the eight selection categories presented in Table 62. Each category was assigned a score of 0–5 based on its perceived impact on local communities, where 0 represents the lowest impact and 5 represents the highest impact. Wherever possible, national consultants provided comments to justify score allocations. A final priority rating was then calculated for each commune using the weighted average of all eight scores — using the weightings assigned in Step 1. The priority ratings (weighted averages) obtained for each of the 25 communes are presented in

Hub	Commune	Priority rating
Aoujeft	Ain Savra	4.2
	El Medah	3.8
	Maeden	3.5
	Aoujeft	3.5
	N'Teirguent	3.3
Rachid	Tidjikja	3.9
	El Wahat	3.4



	Tensigh	3.3
Tamcheket	El Mabrouk	4.5
	Guaet Teidouma	3.5
	Sava	3.2
	Tamchaket	3.1
	Radhi	2.8
Nema	Oualata	4.0
	N'Beiket Lahwach	4.0
	Noual	3.7
	Jreif	3.7
	Néma	3.2
	Oum Avnadech	3.1
	Beribava	3.1
	Agoueinit	3.1
	Achemmim	2.6
	Hassi Etila	2.2
	El Mabrouk	2.2
	Bangou	2.1

below.

**Table 63.** Priority ratings of target communes.

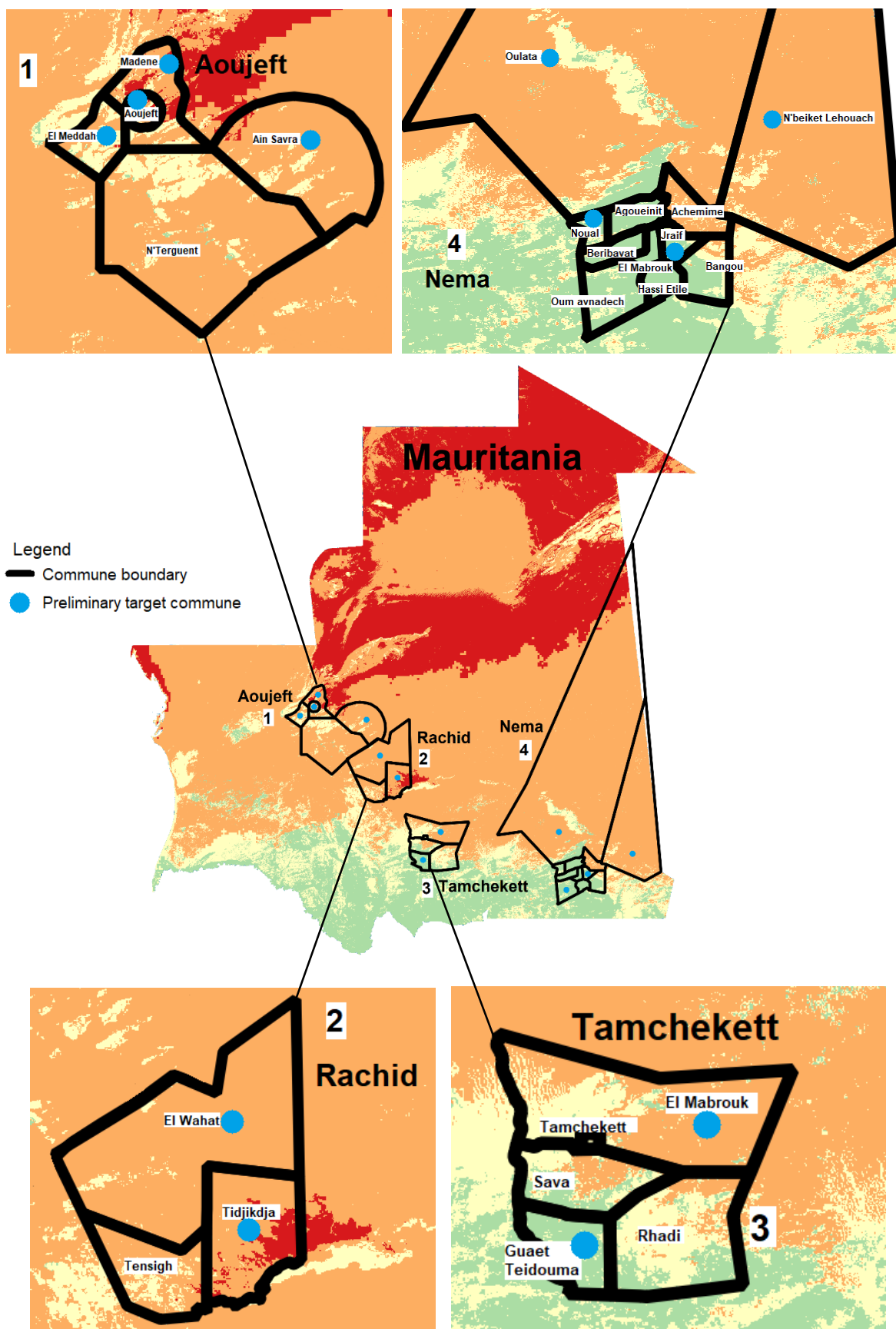
Hub	Commune	Priority rating
Aoujeft	Ain Savra	4.2
	El Medah	3.8
	Maeden	3.5
	Aoujeft	3.5
	N'Teirguent	3.3
Rachid	Tidjikja	3.9
	El Wahat	3.4
	Tensigh	3.3
Tamcheket	El Mabrouk	4.5
	Guaet Teidouma	3.5
	Sava	3.2
	Tamchaket	3.1
	Radhi	2.8
Nema	Oualata	4.0
	N'Beiket Lahwach	4.0
	Noual	3.7
	Jreif	3.7
	Néma	3.2
	Oum Avnadech	3.1
	Beribava	3.1
	Agoueinit	3.1
	Achemmim	2.6
	Hassi Etila	2.2
	El Mabrouk	2.2
	Bangou	2.1

### Step 3: Selection of preliminary target communes

The 12 communes with the highest overall scores were selected as preliminary target sites for project interventions. These preliminary target communes are presented in Table 63 below and shown in Figure 118 below.

**Table 63.** The 12 preliminary target communes for the proposed project

	Hub			
	Aoujeft	Rachid	Tamcheket	Nema
<b>Target communes</b>	<ul style="list-style-type: none"> <li>• Ain Savra</li> <li>• El Medah</li> <li>• Maeden</li> <li>• Aoujeft</li> </ul>	<ul style="list-style-type: none"> <li>• Tidjikja</li> <li>• El Wahat</li> </ul>	<ul style="list-style-type: none"> <li>• El Mabrouk</li> <li>• Guaet Teidouma</li> </ul>	<ul style="list-style-type: none"> <li>• Oualata</li> <li>• N'Beiket Lahwach</li> <li>• Noual</li> <li>• Jreif</li> </ul>



**Figure 118.** Map with panels showing the locations of selected priority communes within each of the four target hubs. Blue markers indicate selection of entire commune.

The types of EbA measures and sustainable landscape management practices introduced in each target commune will be site-specific and responsive to the main climate change impacts identified in each district — as outlined in Appendix 7.

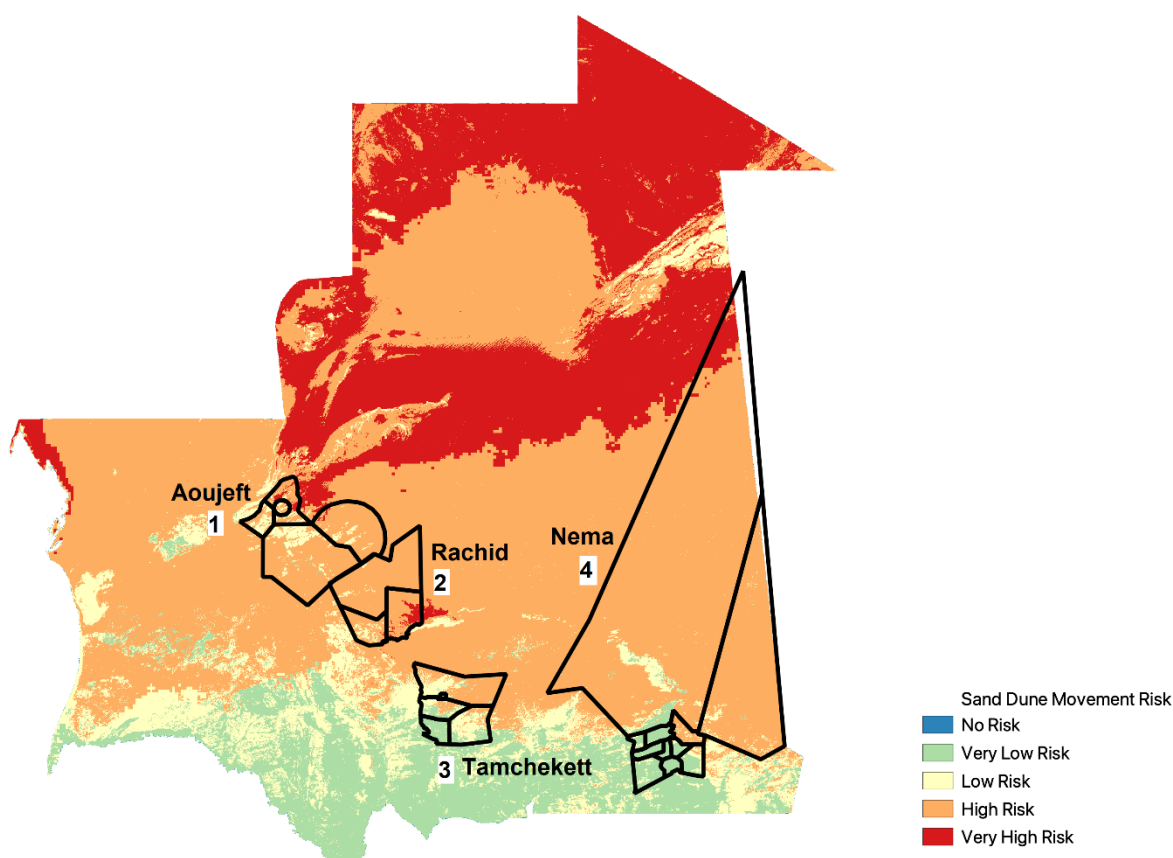
The subset of priority communes to be targeted during project implementation will be finalised during the validation workshop, via round-table discussions involving the NDA (MEDD), UNEP, national consultants and the project technical team. Should there be any conflicts of interest over whether a particular commune should be included in the target subset, the final decision will be made via a majority vote.

### 6.2.2 Site selection for dune-fixation measures

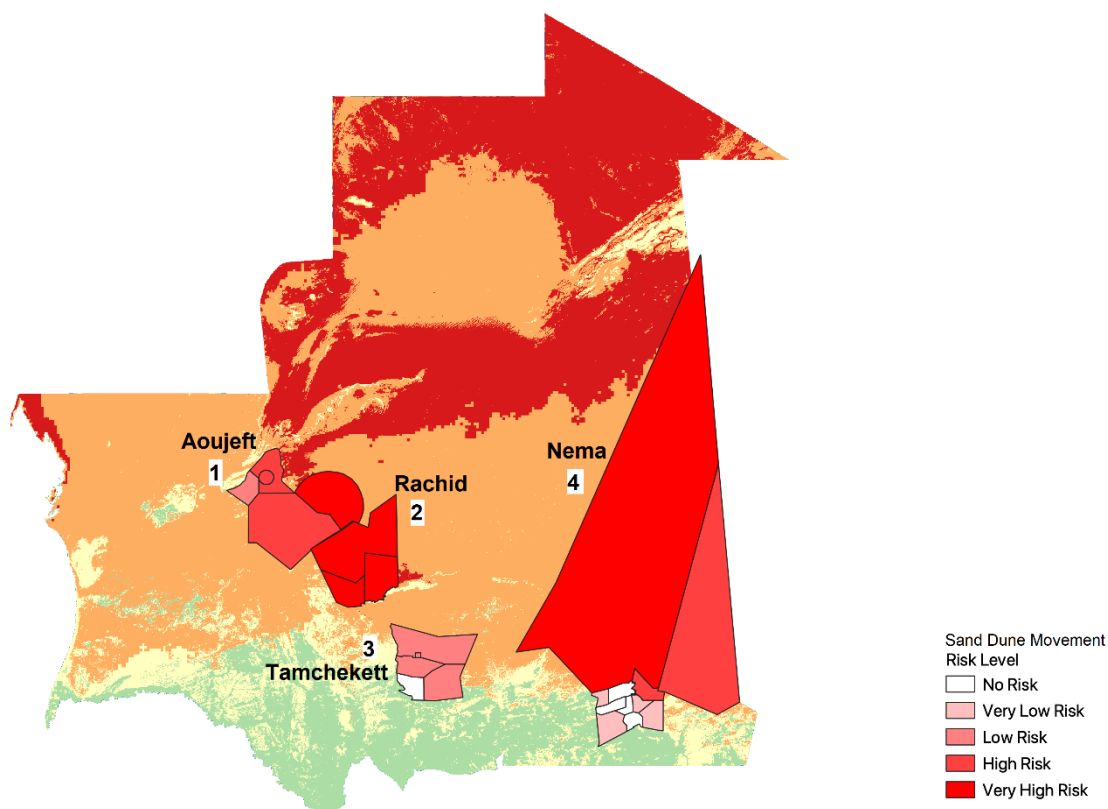
After selecting preliminary target communes within the four regional hubs, remote sensing analyses were used to identify specific sites for dune-fixation interventions, based on sand encroachment risk levels across the target region. The specific steps used in the dune-fixation site selection process are presented below.

#### **Step 1: Mapping of sand encroachment risk**

First, remote sensing data and GIS software were used to map the risk of sand dune movement across Mauritania. The results of this mapping exercise are shown in Figure 119 below. Additionally, a simplified sand encroachment map — wherein the highest risk level has been applied to each commune within the proposed project's target region — is presented in Figure 120.



**Figure 119.** Map depicting the relative risks of sand dune movement across the proposed project's target region.

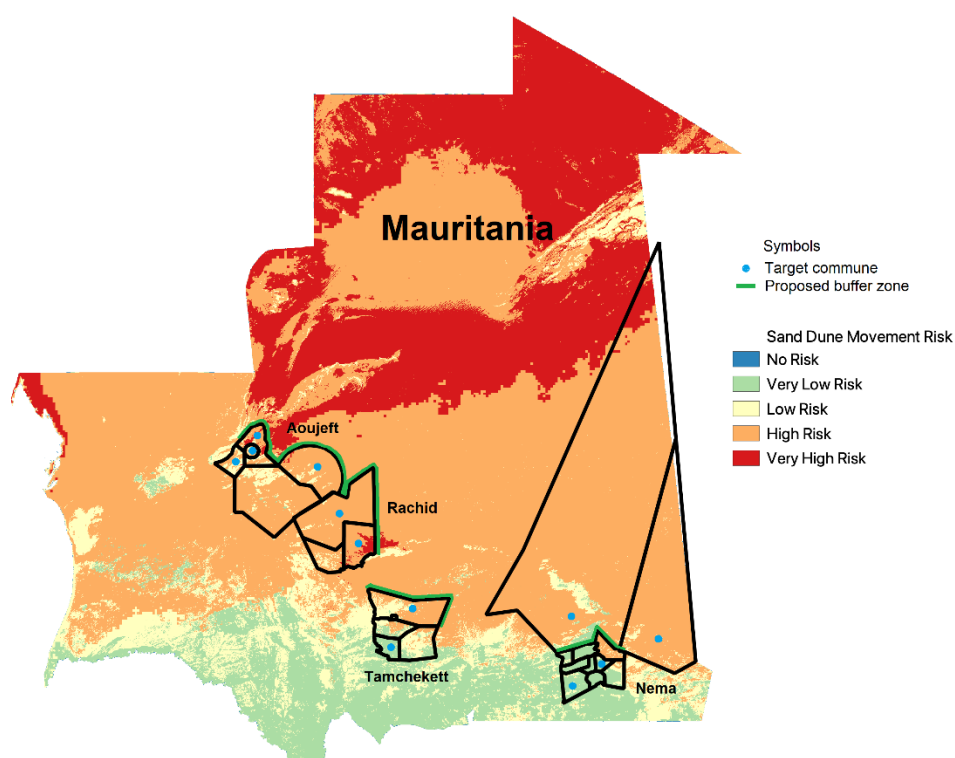


**Figure 120.** Simplified map summarising the highest risk level for sand dune movement within each commune.

## Step 2: Site selection for EbA dune-fixation

### *Buffer zones*

Using the maps generated above as a guide, sites for the establishment of buffer zones — in which EbA dune-fixation measures, including land rehabilitation and afforestation, will be implemented — were strategically selected to ensure that high-risk preliminary target communes are afforded maximum protection against southward-advancing sand dunes. The proposed positioning of community-managed buffer zones comprising rehabilitated ecosystems and protective treelines is shown in Figure 121 below.



**Figure 121.** Proposed positioning of community-managed buffer zones, in which EbA dune-fixation measures will be implemented.

500-metre-wide buffer zones (or greenbelts) will be established along the north-eastern boundaries of preliminary target communes in Aoujeft, Rachid, and Tamchekett, such that restored ecosystems and planted treelines form a continuous barrier against southward-shifting sand dunes. The strategic positioning of these buffer zones will, in turn, shield south-western communes against the impacts of sand encroachment in the long-term.

In Nema hub, the perimeters of Oulata and N'beiket Lehouach (northernmost target communes) are too large to feasibly cover with continuous EbA dune-fixation measures. Instead, a smaller buffer zone will be established along the southern boundaries of these communes, as shown in Figure 121 above, to protect all southward-lying target communes against sand encroachment from the north. Since populations in Oulata and N'beiket will not be shielded by this buffer zone, green-grey dune-fixation infrastructure — comprising a combination of biological- and mechanical dune fixation measures — will be installed around high-risk villages in these communes (identified in Figure 122 below).

Using GIS software, the number of hectares of EbA dune-fixation measures needed to establish proposed buffer zones in each hub was calculated. The final results of area calculations are presented in Table 64 below.

**Table 64.** Total area of EbA dune fixation measures needed to establish proposed buffer zones in each target hub.

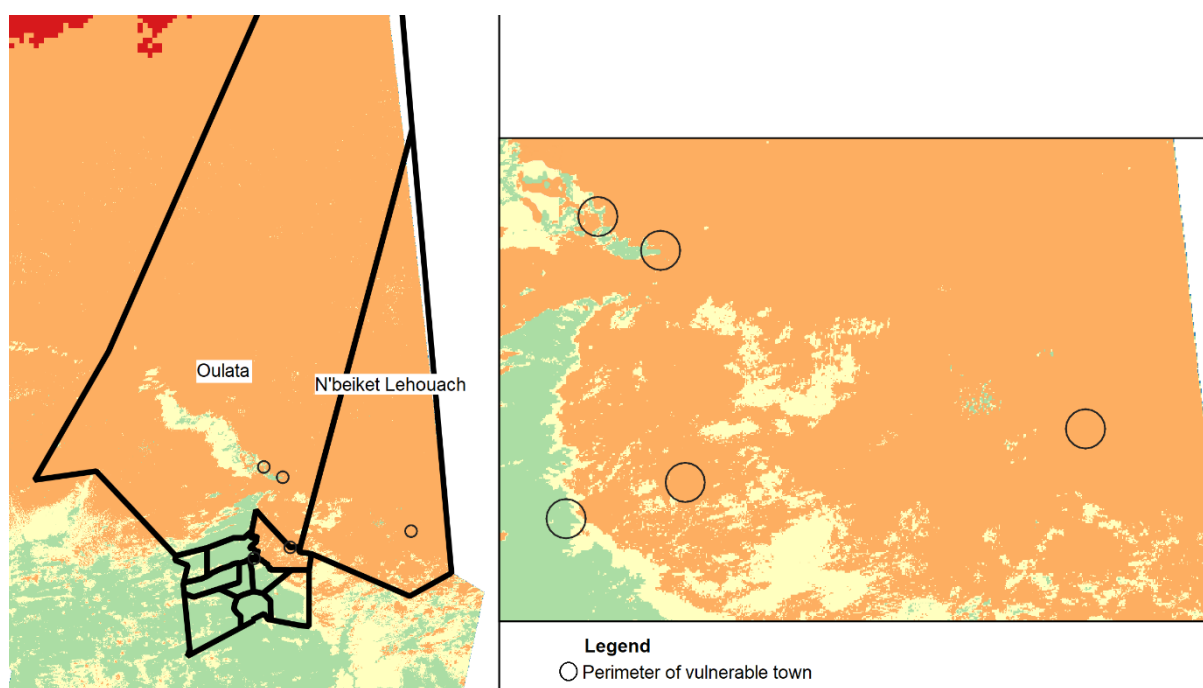
Hub	Area of proposed buffer zone (ha)
Aoujeft	325
Rachid	296
Tamchekett	333
Nema	185
Total	1,139

*Green-grey dune-fixation infrastructure (biological and mechanical dune fixation)*

To ensure that settlements in all preliminary target communes are made more resilient to the impacts of desertification in the short-to-medium term, green-grey dune-fixation infrastructure comprising biological and mechanical dune fixation measures will be installed around vulnerable infrastructure in Oulata and N'beiket Lehouach, which fall outside of the regions protected by proposed buffer zones.

The exact locations of vulnerable settlements in in Oulata and N'beiket Lehouach have been mapped using remote-sensing data, as presented in Figure 122 below. Green-grey dune-fixation infrastructure will be installed along the perimeter of each vulnerable town, to ensure that all critical infrastructure is loosely enclosed by treelines, wattling and check dunes.

Using GIS software, the number of metres of physical dune-fixation measures needed to protect all five vulnerable towns in Nema against sand encroachment was calculated. Each of the five towns was assumed to have an area of ~74 ha (740,000 m<sup>2</sup>); therefore, a total of ~370 ha of green-grey dune-fixation infrastructure (fences, wattling and check dunes) are needed to protect critical infrastructure against sand encroachment at these sites.



**Figure 122.** The locations of vulnerable towns in Oulata and N'beiket Lehouach (left); and a zoomed in view of the perimeters of these settlements within Nema hub (right).

In addition to the vulnerable towns identified using GIS software (Figure 122), community members in the target hubs of Aoujeft, Rachid, Tamcheket and Nema identified several important sites requiring biological and mechanical dune-fixation during stakeholder consultations. These sites — and the number of hectares of green-grey dune fixation infrastructure required at each location — are outlined in Table 65 below. Further details regarding why these sites have been selected are provided in Appendix 3 of Annex 7. The total area of mechanical- and biological dune fixation infrastructure required to protect vulnerable sites identified via GIS software and stakeholder consultation is equivalent to 985 ha.



**Table 65.** Number of hectares (ha) of green-grey dune fixation infrastructure required to protect each of the vulnerable sites identified by stakeholders within the four target hubs.

Hub	Site	Area of green-grey dune-fixation infrastructure (ha)	Proposed dimensions (m)	Perimeter (m)
Aoujeft	Toueïguidit	125	2,500 x 500	6,000
	Ain Savra	70	7,000 x 100	14,200
Rachid	The road on the Hssey Lgara– Touajil axis	350	35,000 x 100	70,200
Tamcheket	Tamchaket town	20	2,000 x 100	4,200
Nema	City of Noual	50	5,000 x 100	10,200
Total		615		104,800

#### *Protective fencing*

To maximise the effectiveness of biological dune fixation measures, it is necessary to install fencing around green-grey dune-fixation sites, to protect vegetation against foraging and trampling by free-roaming animals. Accordingly, fences will be erected around the perimeter of each dune-fixation site identified in Figure 122 and Table 65 above.

If each of the vulnerable towns identified in Figure 115 is assumed to have a circular area of 74 ha, then the circumference of each dune-fixation site is estimated to be ~3050 m. A total of ~120,050 m of fencing will, therefore, be needed to enclose all of the dune fixation sites identified using GIS software. Additionally, using the dimensions of each target area in Table 65, it is estimated that a total of ~105,000 m of fencing will be required to enclose all vulnerable sites identified by stakeholders. This brings the total distance of fencing required under the proposed project to ~120 km.

#### 6.2.3 Site selection for water management infrastructure

Potential sites for the establishment of water management infrastructure are discussed in Section 7 — the SWAT analysis — below.

## 7 SWAT analysis

This section presents a detailed summary of hydrological modelling activities conducted under Output 2 of this project. The goal of these activities was to evaluate the potential impacts of water resource management strategies in selected areas. The hydrological modelling was performed using the Soil & Water Assessment Tool (SWAT+) — a spatially distributed, process-based hydrological model. Developed by the United States Department of Agriculture — Agricultural Research Service (USDA—ARS) and Texas A&M AgriLife Research, SWAT+ is an open-source model that has been widely used in watershed resource management. Two scenarios were considered in the analysis: i) a baseline (business-as-usual) scenario; and ii) an intervention measures scenario that included the installation of physical structures to manage and increase water infiltration.

SWAT+ generated various outputs for the areas of interest, as described in more detail in the complete SWAT Analysis (Appendix 8 to this Feasibility Study). These outputs included precipitation, surface runoff, total evaporation, and groundwater surface water interaction. The importance of these outputs lies in their relative differences between scenarios, which could indicate key areas for intervention.

### 7.1 Methodology

The SWAT+ model was applied to all hydrological activities of this project to meet the modelling objectives. The methodology section provides the rationale for selecting this model and describes the input datasets (including elevation and topography, land cover, soils and slope, and climate) required for the initial setup in the hydrological simulations.

#### 7.1.1 Model selection

SWAT+<sup>1034</sup> was chosen as the most suitable hydrological model for the project objectives for several reasons, including the level of detail required, available data for the site of interest, and previous experience. The model simulates watershed processes at the sub-basin scale, which is then further divided into hydrologic response units (HRUs). HRU delineation is beneficial since it generates discrete areas of the same land-use, slope, and soil characteristics within a particular sub-basin.

#### 7.1.2 Model inputs

Input data for SWAT+ includes spatially explicit soils data, landcover information, and elevation data to drive flows and direct sub-basin routing. These parameters are grouped into HRUs, which override the underlying spatial distribution. The HRUs are grouped according to topography, soils (type/structure/depth/chemical properties), landcover, and slope. Input data were obtained from various sources and were used to generate future scenarios based on land use change modelling results received from simulations conducted in parallel to hydrological modelling.

#### 7.1.3 Elevation and Topography

A digital elevation model (DEM) was used to configure the catchment areas by dividing them into sub-basins or sub-catchments. This was done using the TauDEM<sup>1035</sup> watershed delineation tool — the first step undertaken in the SWAT+ model. The model allows for the creation and selection of outlet nodes and the determination of sub-catchment properties and river reach attributes. Further information is provided in Appendix 8 to this Feasibility Study.

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<sup>1034</sup> SAWT. N.d. The Soil & Water Assessment Tool. Available at: <https://swat.tamu.edu/software/plus/>

<sup>1035</sup> Tarboton D. 1997. TauDEM, Utah State University, USA. Available at: <https://hydrology.usu.edu/taudem/taudem4.0/>

#### 7.1.4 Land Cover

The Sentinel-2 10-m Land Use/Land Cover map was used as the baseline landcover<sup>1036</sup>. SWAT+ clips the land use to the catchment boundary and provides it with a code determined by the user in the QGIS 2.2.6 (Quantum Geographical Information Systems) interface. A text file containing this code and the subsequent SWAT+ land code was compiled by the user for each scenario. This text file was used to reclassify the land use layer to match the attributes contained in the SWAT+ database.

#### 7.1.5 Soils

Global soil maps were retrieved from the Food and Agriculture Organization (FAO) soils portal (800 m x 800 m resolution) and were refined through literature and further investigation where applicable. The global soils data was clipped to the region of interest through an automatic process in QSWAT+. The structure, depth, number of layers and texture were used to construct a moderately detailed soil layer with up to three variable soil horizons, which was then transformed for application outside of the United States.

#### 7.1.6 Slope

Utilizing the TauDEM tool via the SWAT+ interface, slope classes are defined to create Hydrologic Response Units (HRUs) based on user input. More slope classes lead to an increased number of HRUs. In this study, three slope classes were employed: i) 0–5; ii) 5–10; and iii) 10–99. These were then used to generate the final HRUs.

#### 7.1.7 Climate

Climate data, including precipitation, temperature, relative humidity, wind speed, and solar radiation, were obtained for each project area from the Climate Forecast System Reanalysis (CFSR)<sup>1037</sup> from 1979–2014 (35 years). The reference co-ordinates (provided in the variable location file) allowed for the climate variability throughout the catchment to be captured.

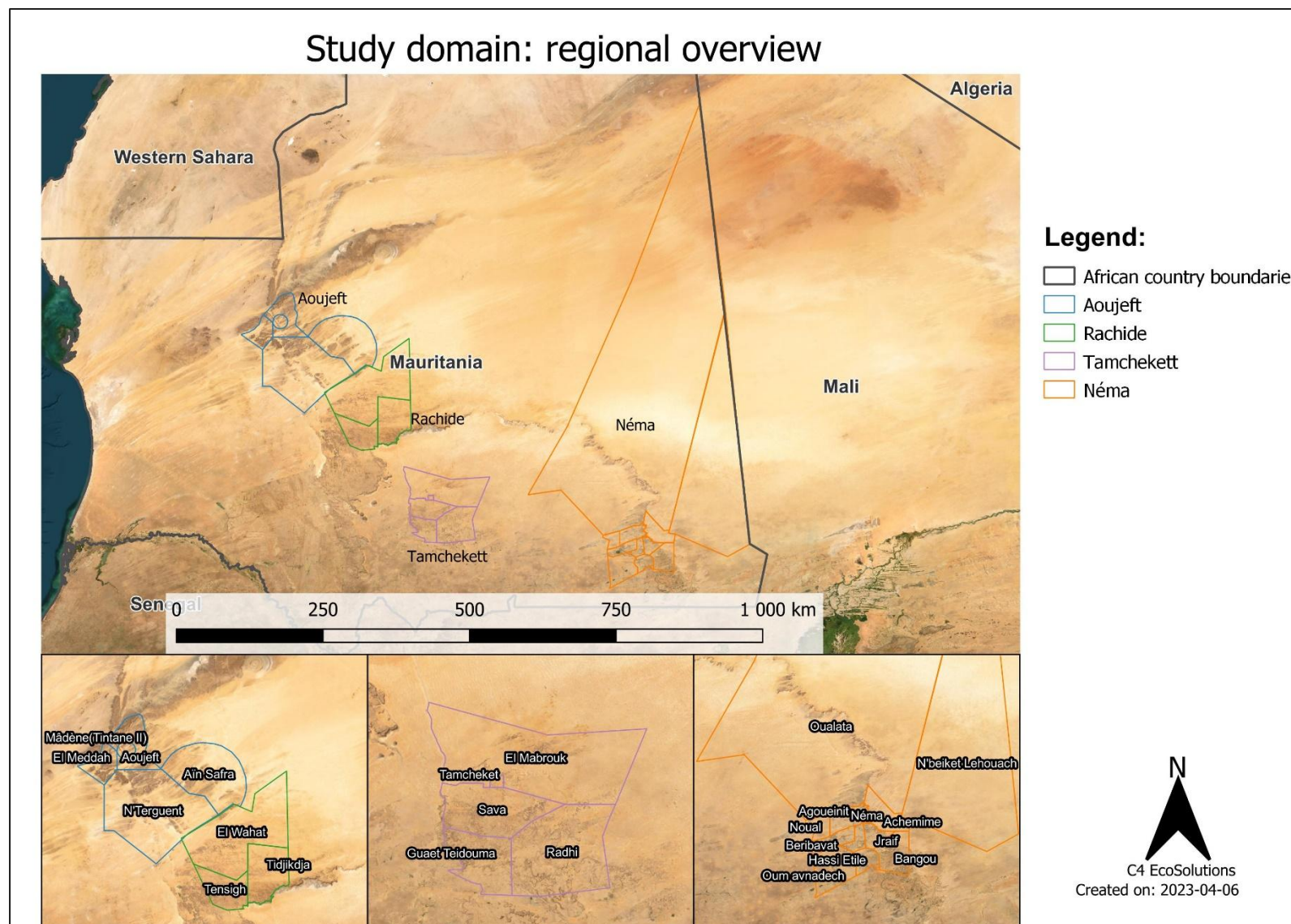
### 7.2 *Model simulation: Baseline scenario*

After carefully examining the input data, a 30-year simulation was conducted using the available climate data, with a daily time step and a five-year warm-up period. Figure 123 displays the study domain, while Figure 124–Figure 126 present preliminary results from the baseline scenario. Figure 127–Figure 129 illustrate the water balance for each of the project areas and the contributions of the various components to the hydrological cycle, expressed as an average value across the basin in millimetres (mm).

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<sup>1036</sup> Earth Map. N.d. Earth Map. Available at: <https://earthmap.org/?map=%7B%22center%22%3A%7B%22lat%22%3A0%2C%22lng%22%3A0%7D%2C%22zoom%22%3A3%2C%22mapType%22%3A%22roadmap%22%7D>

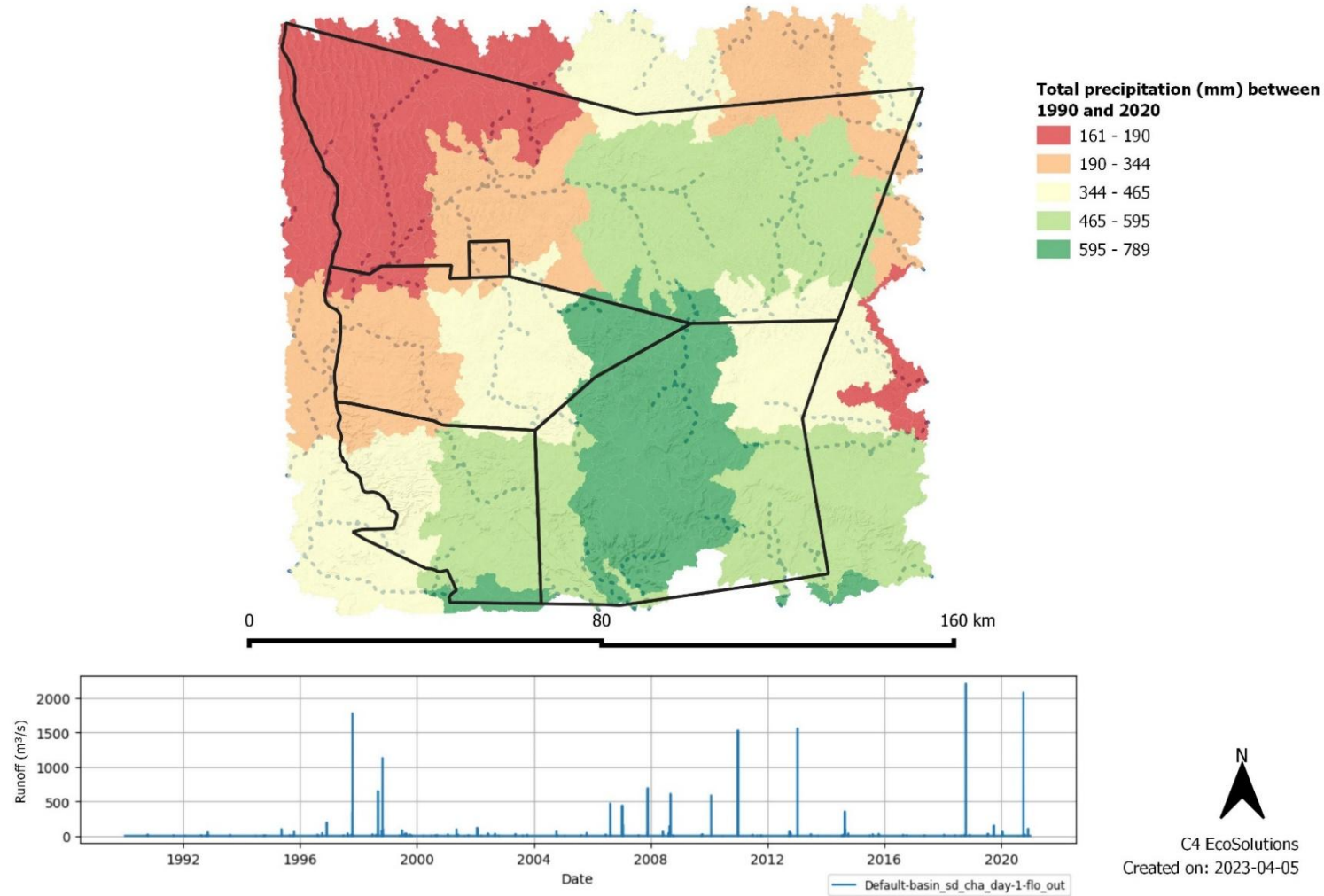
<sup>1037</sup> SWAT. N.d. Global Weather Data. Available at: <https://swat.tamu.edu/data/cfsr>



**Figure 123.** Study domain regional overview showing the four areas studied and the detailed commune names in the sub-maps.

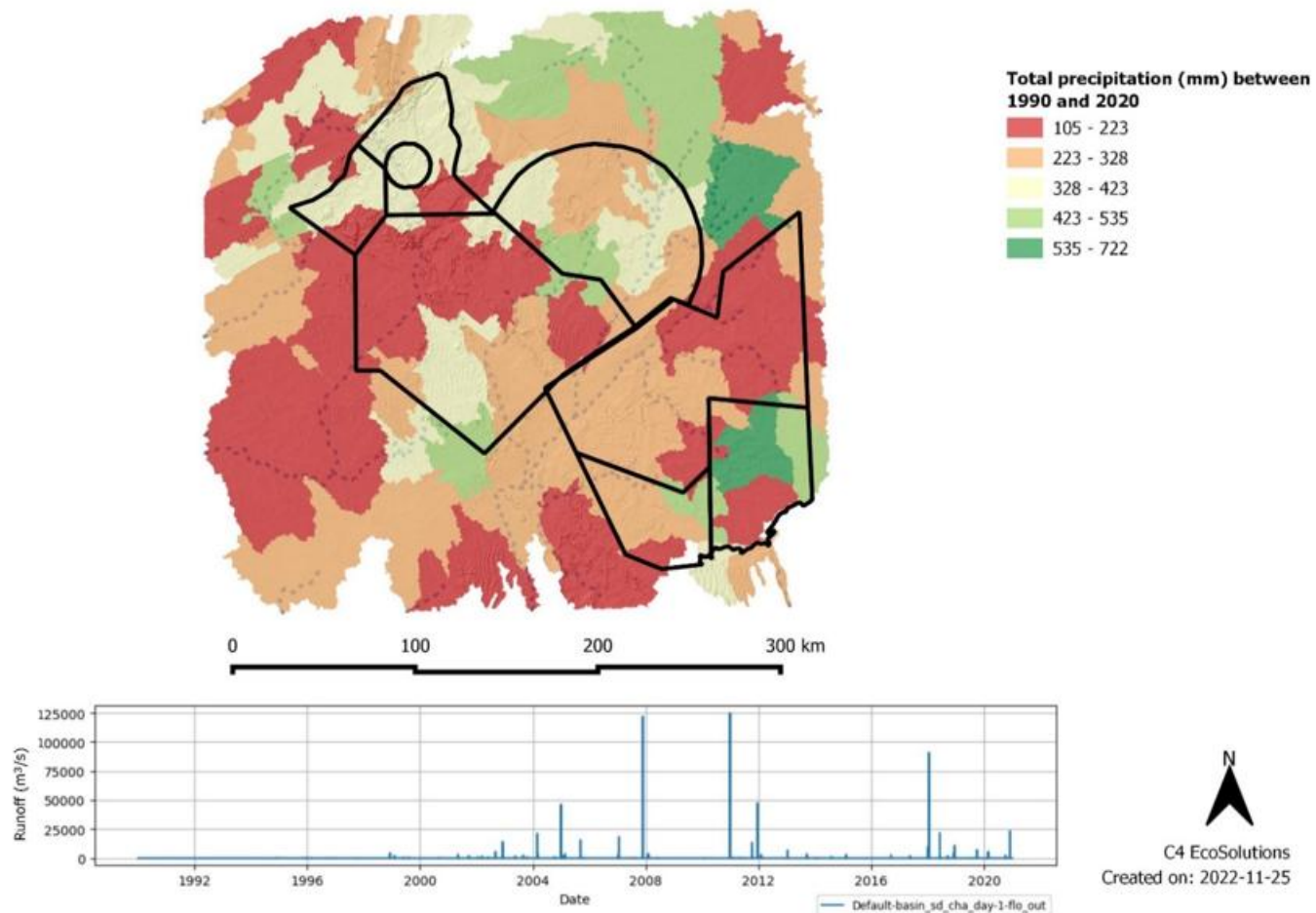


## Tamchekett rainfall distribution and runoff

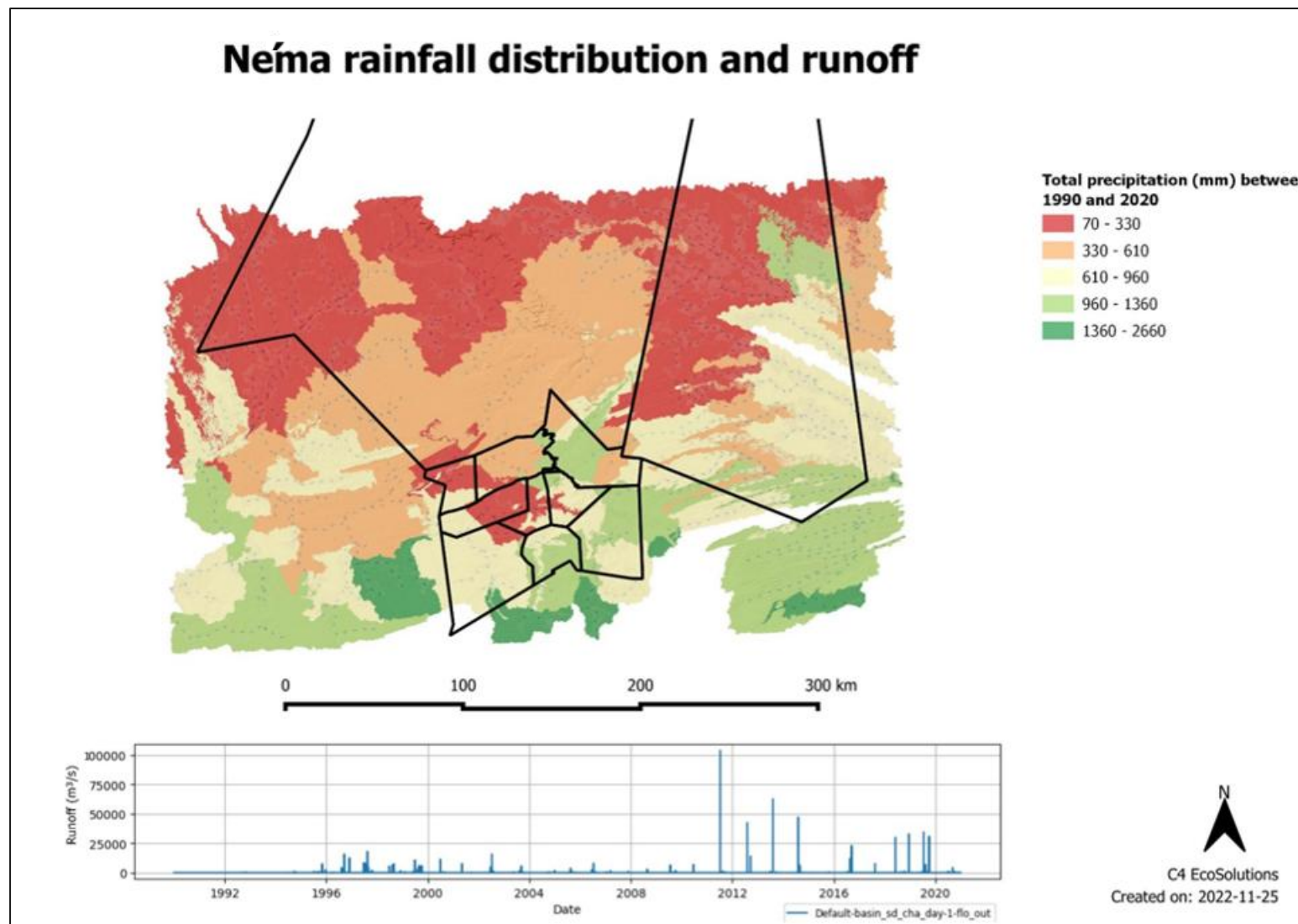


**Figure 124.** Tamcheket rainfall distribution (mm) and runoff (m³/s) results for the period 1990–2020.

## Rachid and Aoujeft rainfall distribution and runoff

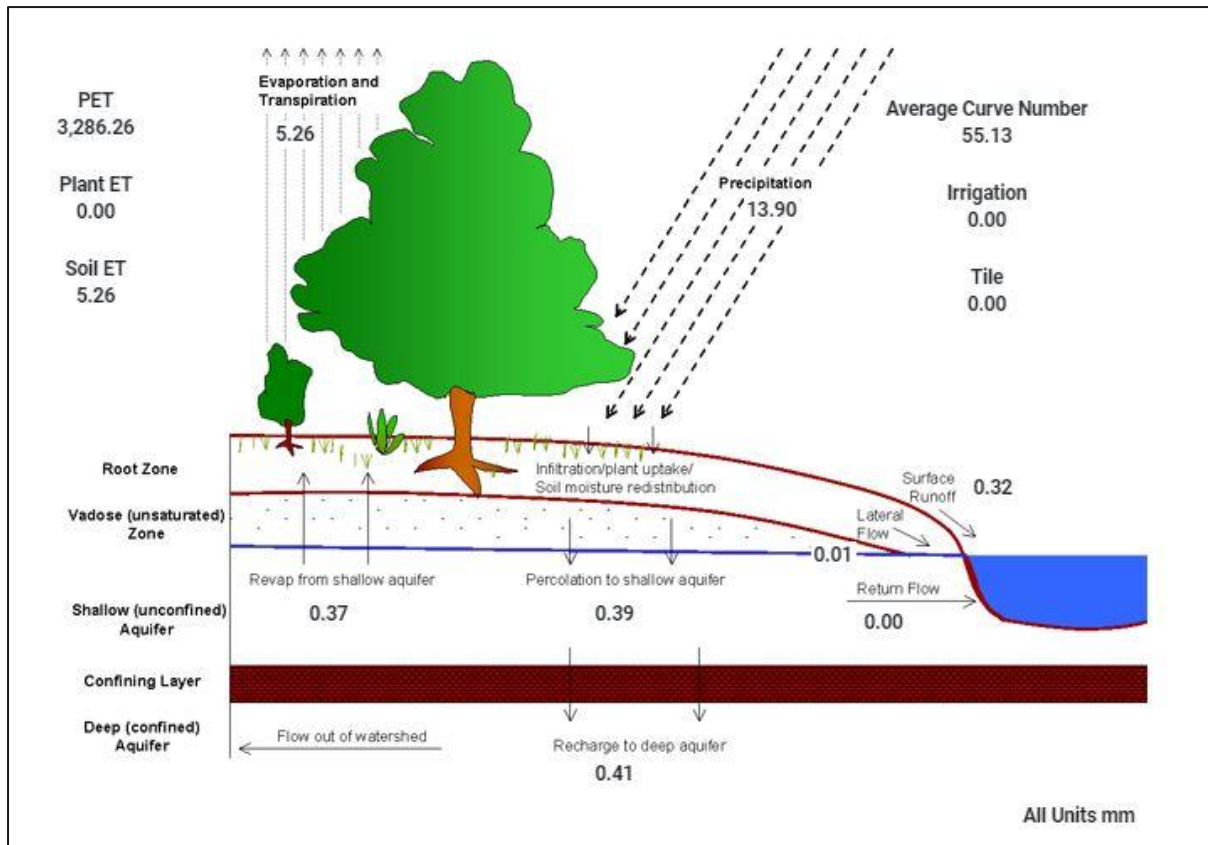


**Figure 125.** Rachid and Aoujeft rainfall distribution (mm) and runoff (m³/s) results for the period 1990–2020.

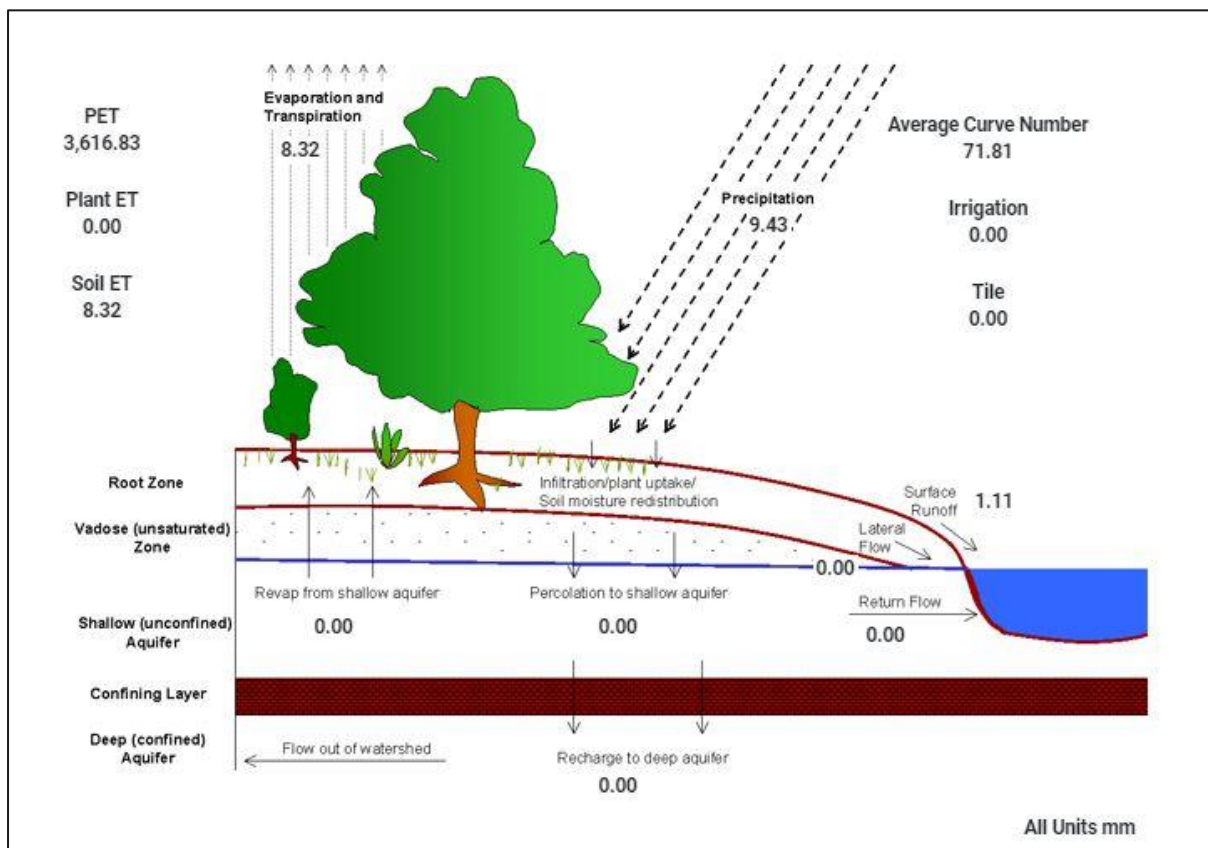


**Figure 126.** Nema rainfall distribution (mm) and runoff (m³/s) results for the period 1990–2020.

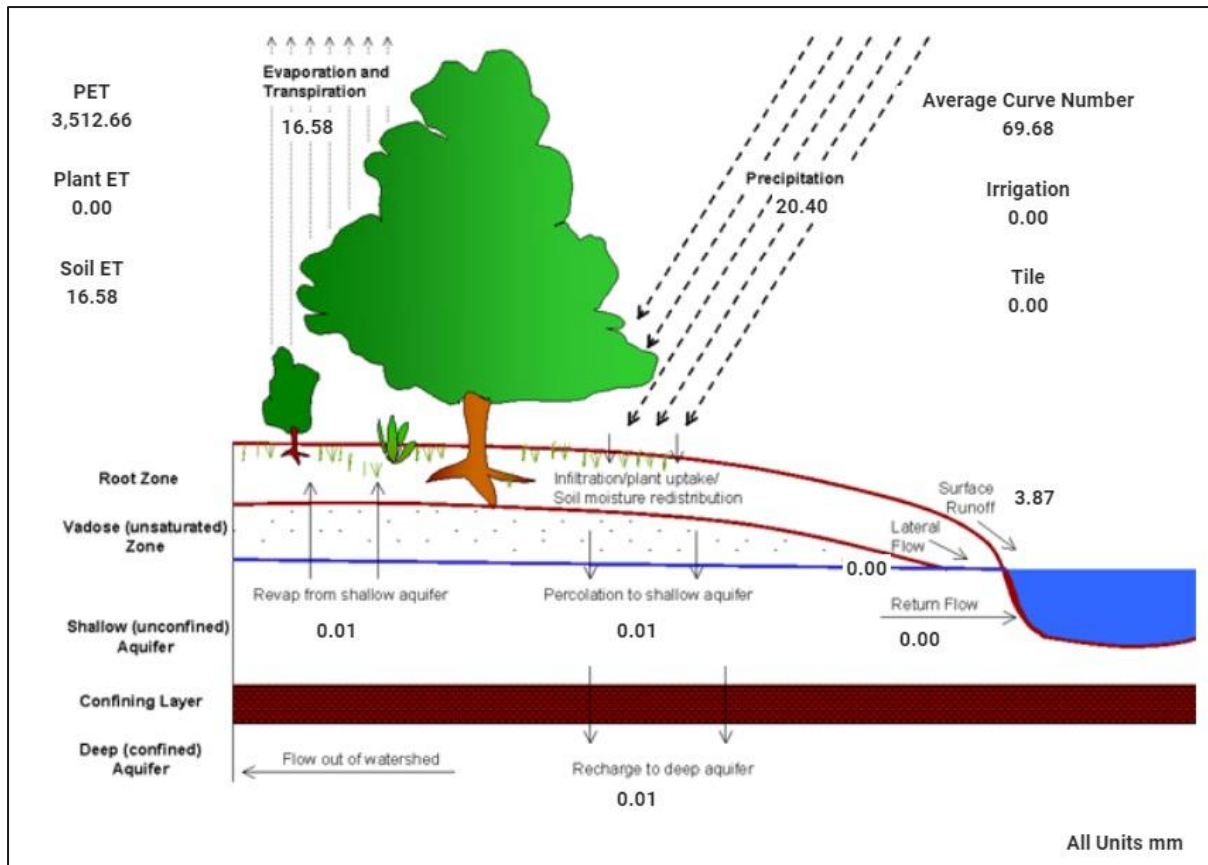




**Figure 127.** Tamcheket baseline water balance.



**Figure 128.** Rachid and Aoujeft baseline water balance.



**Figure 129.** Nema baseline water balance.

### 7.2.1 Baseline scenario results

Figures 1–3 display low and highly variable rainfall patterns in all project areas over the 30-year period from 1990–2020<sup>1038</sup>, with rainfall ranging from 70–660 mm. Precipitation typically occurs during a few isolated showers. Figures 4–6 reveal low surface runoff in project areas because of low rainfall and high evaporation rates. Compacted sandy soils with low permeability restrict infiltration and recharge into both shallow and deep aquifers.

<sup>1038</sup> The selection of the modelling period is based on the high climatological variability observed between the sampled years. This serves as an indication of hydrological responses during varying rainfall patterns (i.e., wetter and drier years) measured at the different project areas.

### 7.2.2 Selection of potential intervention areas

Based on the above results and the population density and distribution within each project area<sup>1039</sup>, sub-basins showing potential for intervention were selected as indicated in Figure 130–

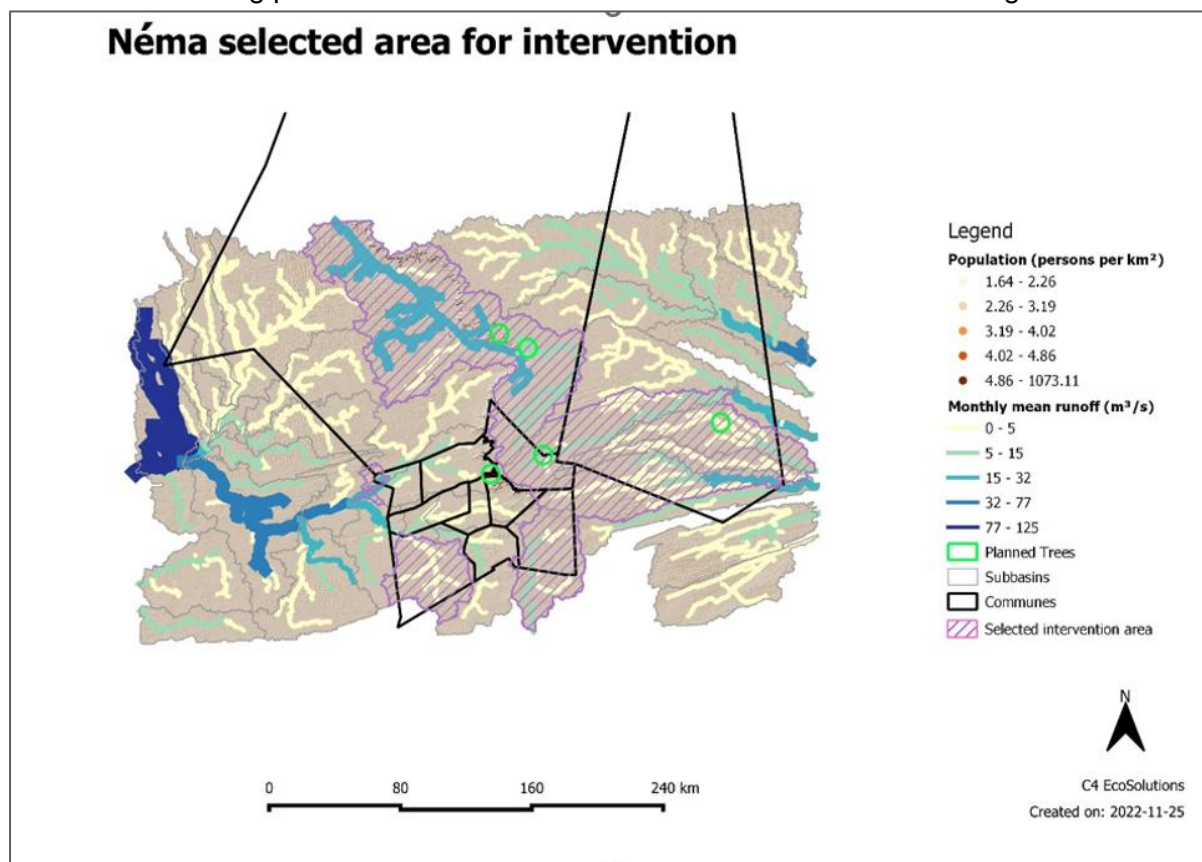
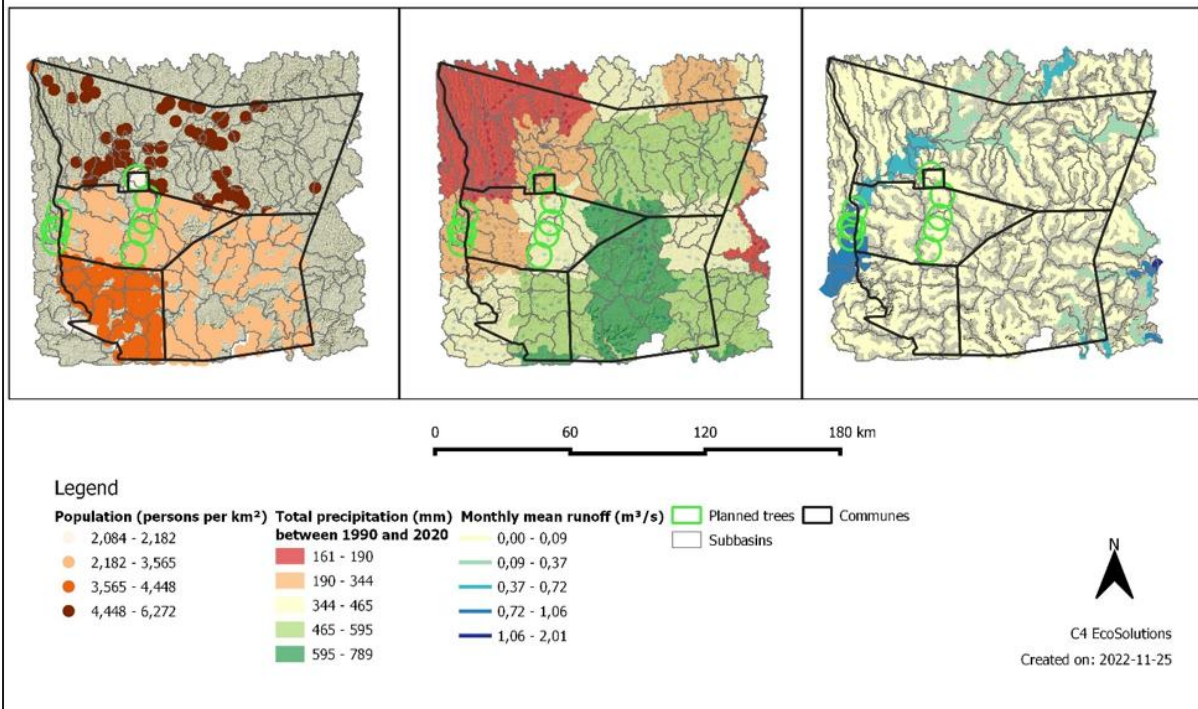


Figure 135 below.

<sup>1039</sup> EarthData. N.d. Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11. Available at: <https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-rev11>.

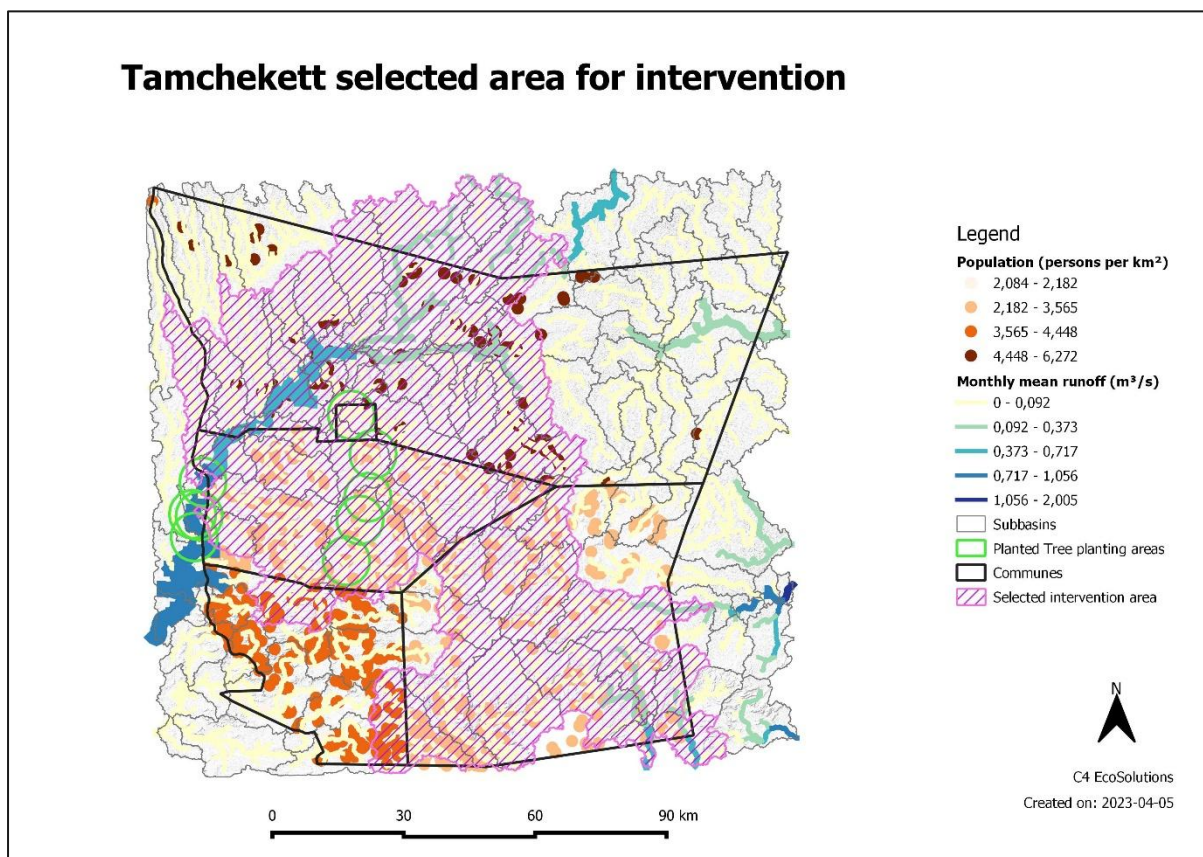


## Tamcheket intervention area selection with population, rainfall and runoff inputs



**Figure 130.** Inputs for Tamcheket intervention area selection.

## Tamchekett selected area for intervention



**Figure 131.** Selected potential intervention area for Tamcheket.

## Rachid & Aoujeft intervention area selection: with population, rainfall and runoff inputs

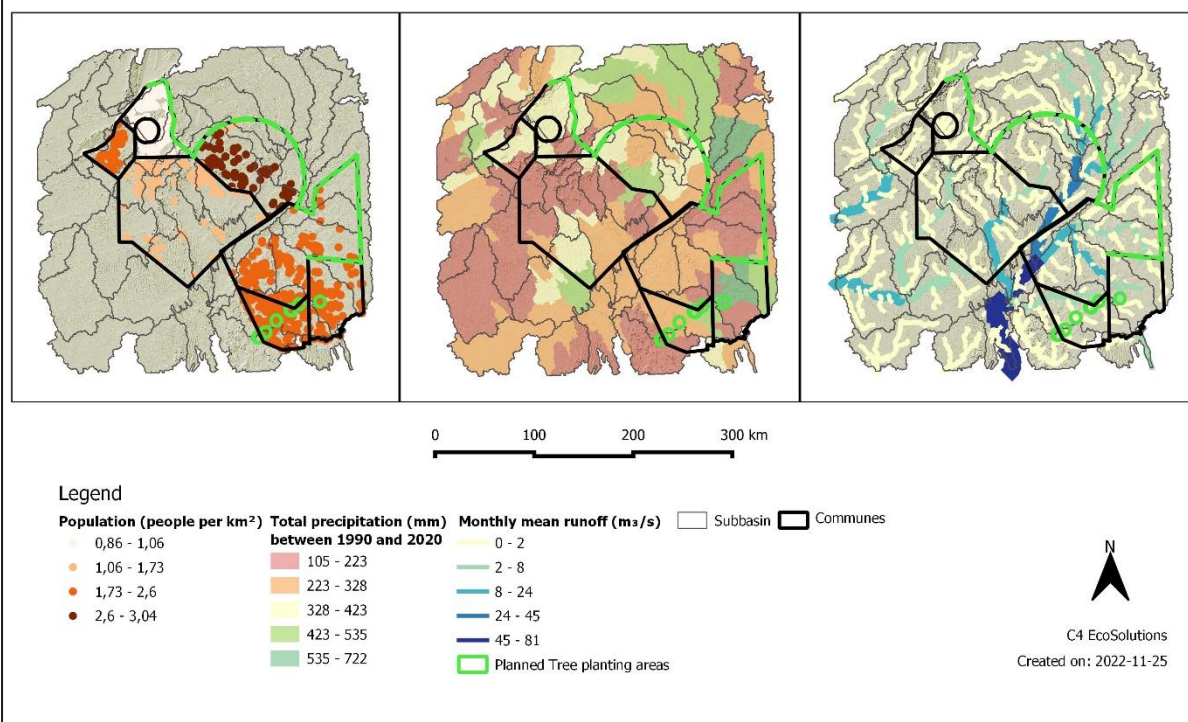


Figure 132. Inputs for Rachid and Aoujeft intervention area selection.

## Rachid & Aoujeft selected area for intervention

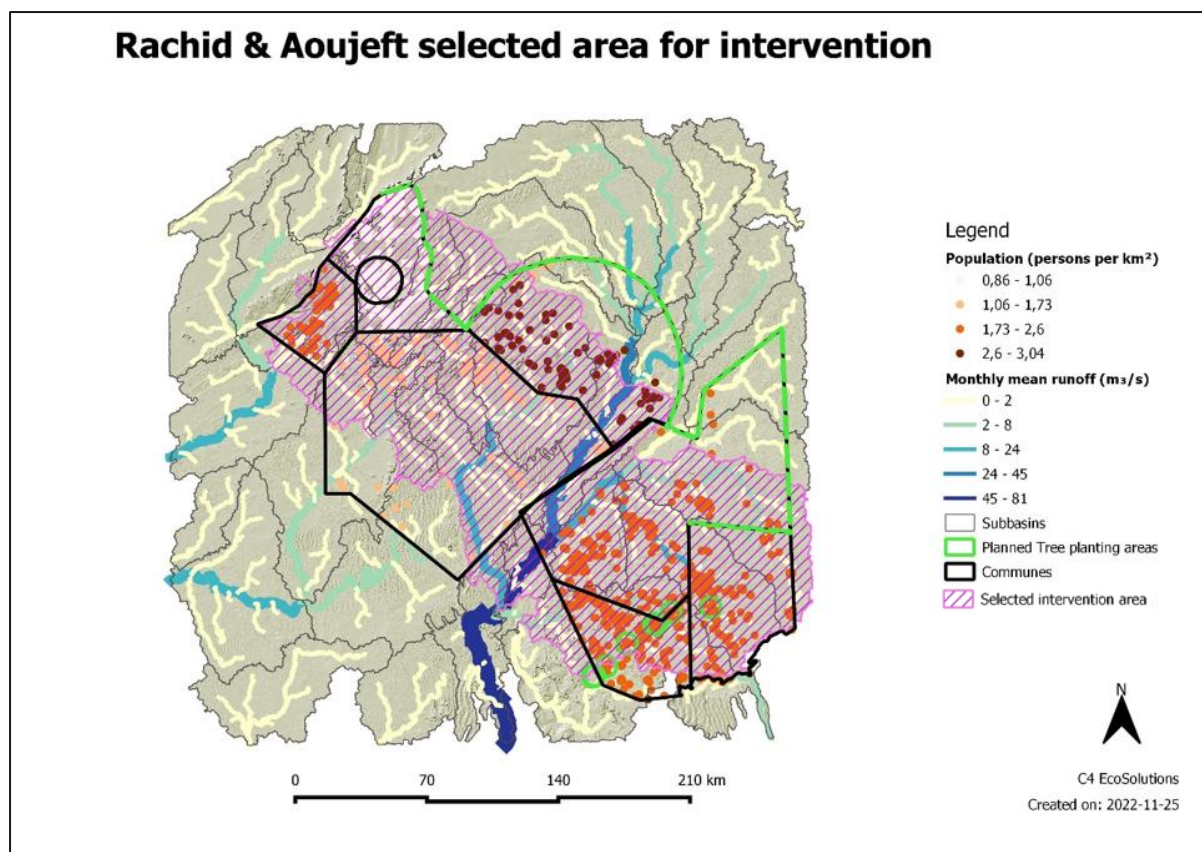


Figure 133. Selected potential intervention area for Rachid and Aoujeft.



## Néma intervention area selection with population, rainfall and runoff inputs

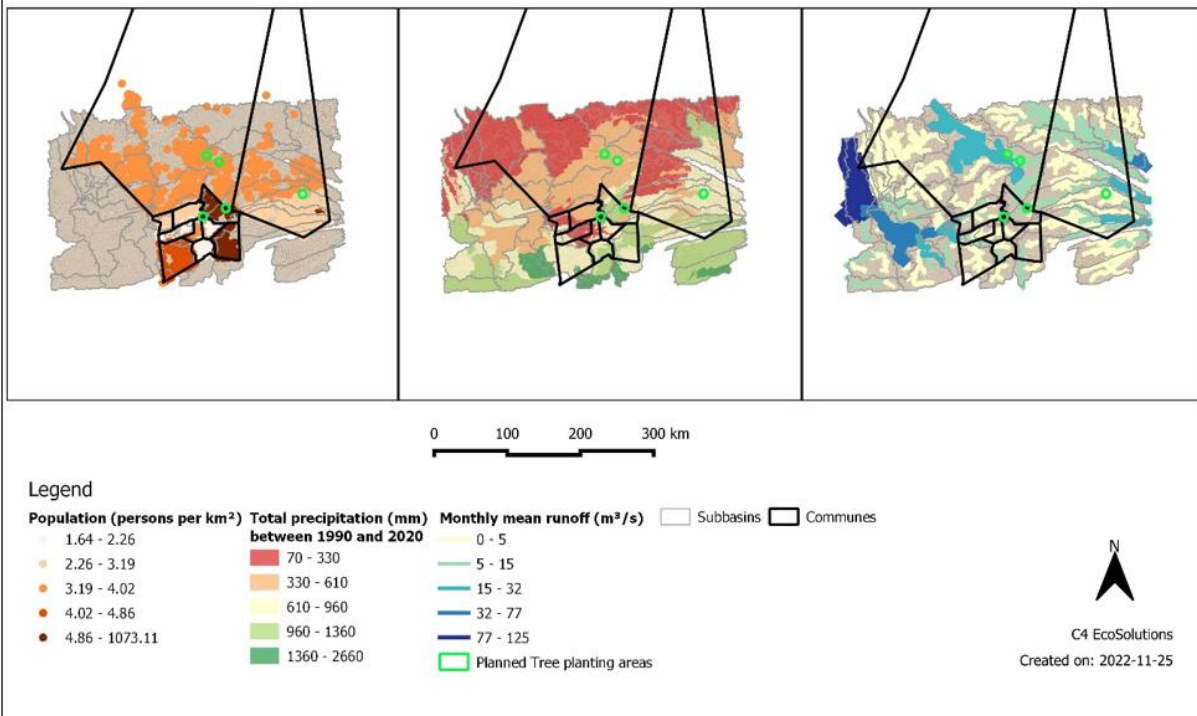


Figure 134. Selected potential intervention area for Nema.

## Néma selected area for intervention

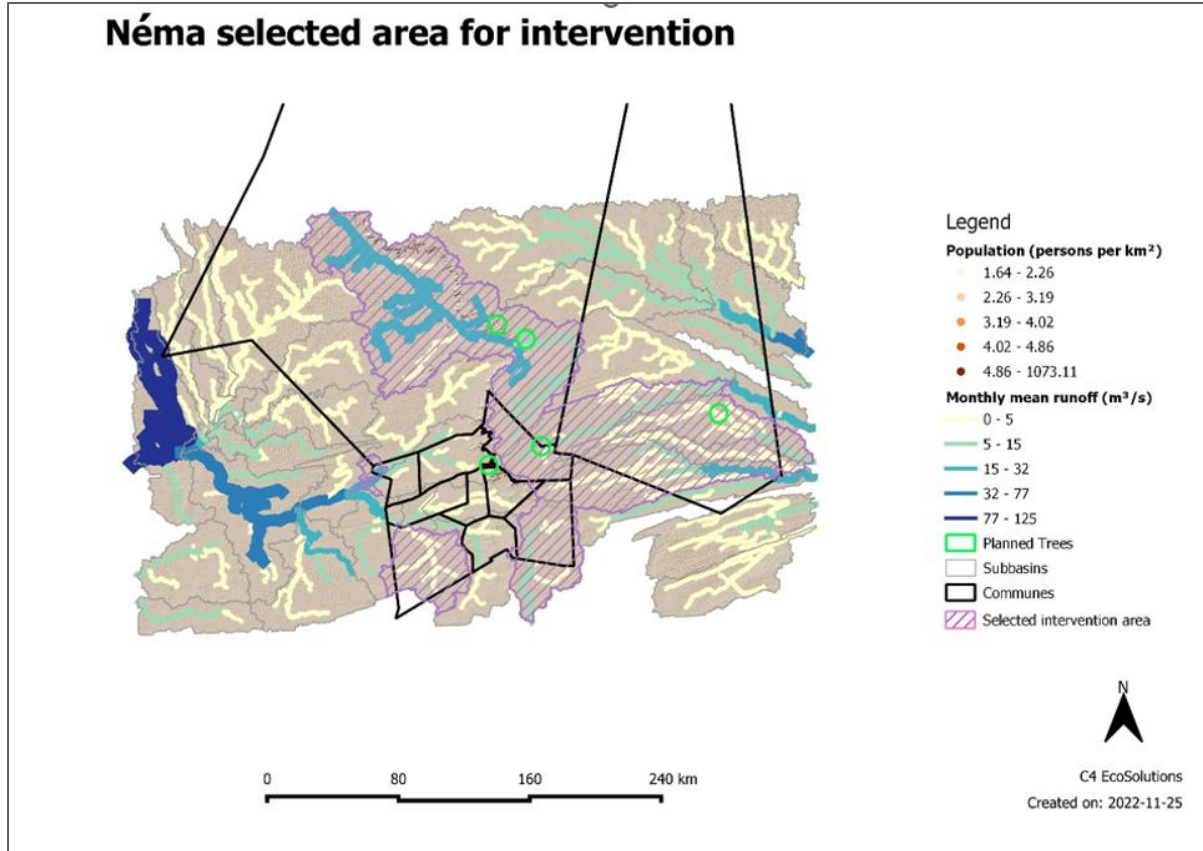
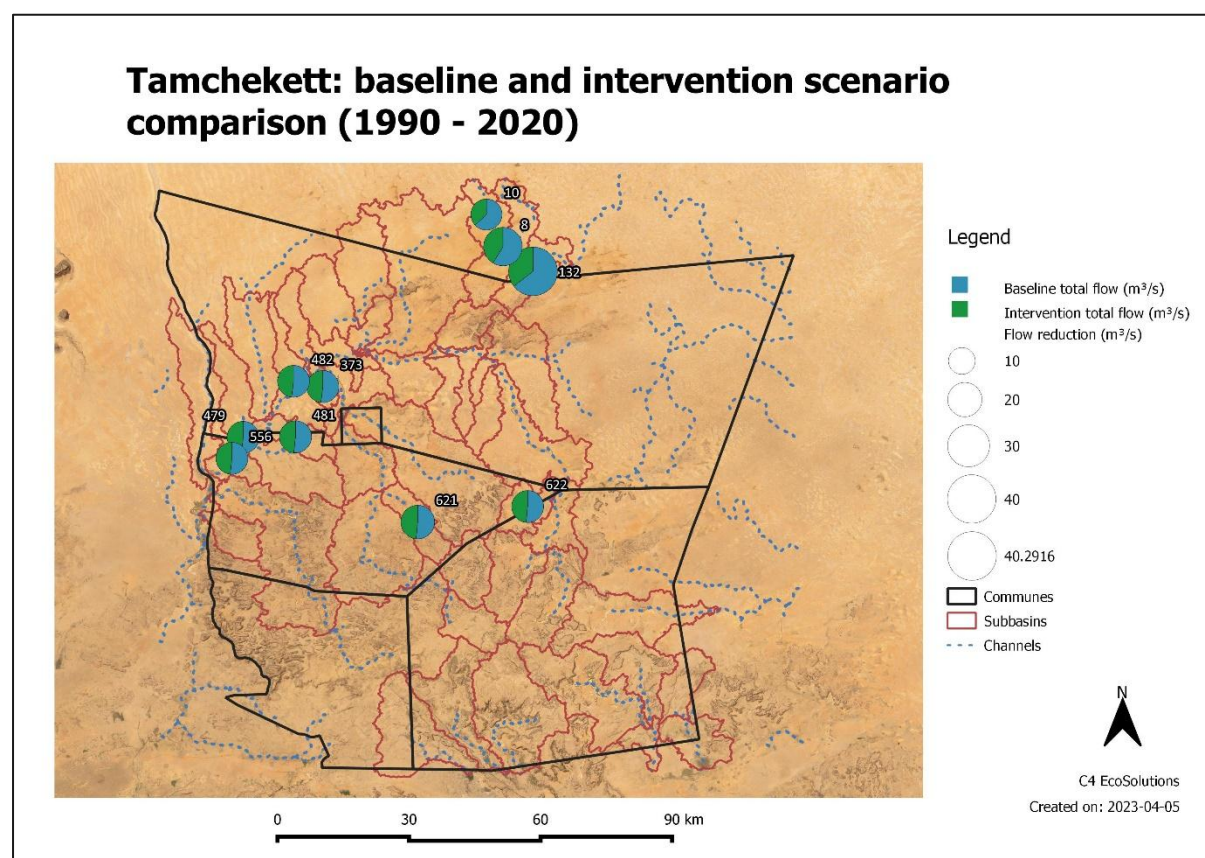


Figure 135. Selected potential intervention area for Nema.

### 7.2.3 Model simulation: Intervention scenario

The management intervention scenario was developed to assess the potential impacts of various water resource management strategies on hydrological processes by introducing engineered measures to reduce the risk of flooding, as well as to improve aquifer recharge within these prioritised sub-basins. Tile drains, which reduce runoff and increase soil infiltration, were added to channels in the priority sub-basins. The SWAT+ model was subsequently run with a simulation period of 30 years (using the maximum amount of climate data available) at a daily time step with a five-year warm-up period.

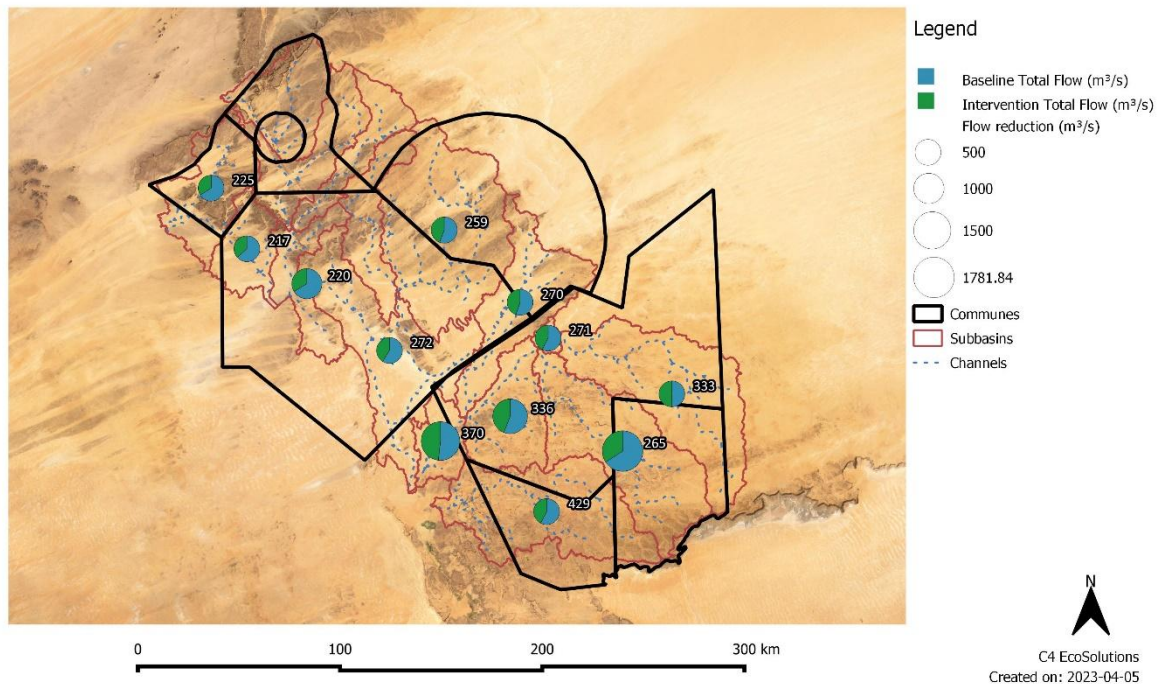
The scenario was compared with the baseline scenario to evaluate the effectiveness of the proposed interventions, with Figure 138 (below) showing these results.



**Figure 136.** Potential channels for intervention in Tamchekett.

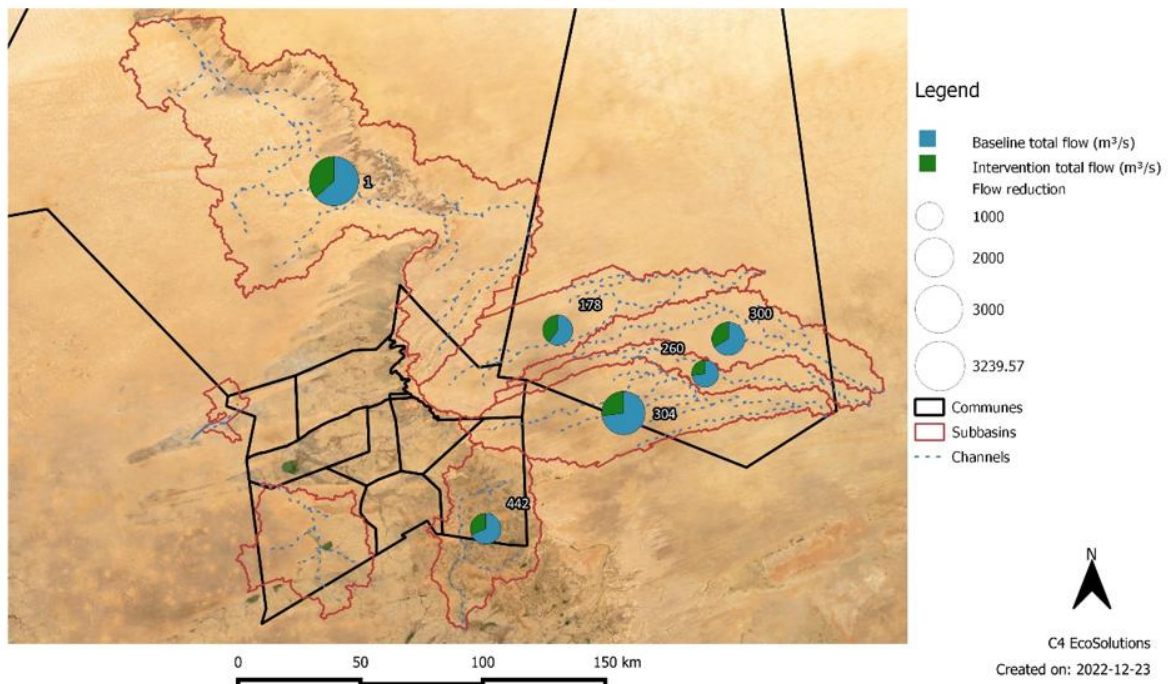


### Rachid and Aoujeft: baseline and intervention scenario comparison (1990 - 2020)



**Figure 137.** Potential channels for intervention in Rachid and Aoujeft.

### Néma: baseline and intervention scenario comparison (1990 - 2020)



**Figure 138.** Potential channels for intervention in Néma.

### *7.3 Conclusion*

The project areas, marked by low rainfall, low surface runoff, and high evaporation, face considerable challenges in implementing ecosystem-based adaptation measures because of factors such as high temperatures and poor soil quality. To enhance environmental resilience, it is crucial to explore a combination of ecosystem-based measures, such as planned tree barriers (Figures 8–13) combined with engineering interventions. Investigating areas with higher rainfall probabilities and natural runoff for hydrogeological exploration and engineering interventions can help optimise groundwater recharge and conserve occasional surface water runoff. Using modelling and geospatial analyses, potential integration zones for ecosystem- and engineering-based interventions have been identified to improve water availability and reduce flood risks in targeted communities.

### *7.4 Recommendations and way forward*

To optimise potential intervention efforts, it is advised to conduct finer scale modelling of sub-basins within the intervention areas. This should involve identifying and prioritising sub-basins with a high likelihood of runoff resulting from rainfall distribution. Furthermore, intervention scenarios should be modelled, incorporating the introduction of physical measures tailored to the selected prioritised sub-basins.

## 8 Financial and Economic Appraisal

### 8.1 Introduction

The purpose of this financial and economic assessment document is to:

- outline the approach and method adopted with respect to performing the financial analysis, quantifying the economic benefits and calculating the relevant financial and economic indicators;
- outline the limitations and primary assumptions of the analysis; and
- outline the data sources used in the analysis.

This financial and economic assessment report builds a robust investment case for GCF support by demonstrating the measurable value of ecosystem service improvements in the four target hubs in Mauritania. The financial and economic assessment report is set out as follows:

- Section 8.8.1 describes the purpose of the economic and financial analysis.
- Section 8.8.2 presents the financial and economic assessment approach.
- Section 8.8.3 describes the detailed methodological approach employed in the modelling process, and takes guidance from the GCF Guideline entitled “ANNEX VI Economic and Financial Analysis (EFA) Guidance”.
- Section 8.8.4 provides information on the implementation costs of the proposed project.
- Section 8.8.5 presents an analysis of the benefits of implementing the project.
- Section 8.8.6 provides the results of the financial and economic analysis (FEA) and the benefit-cost ratio of the project’s intervention.
- Section 8.8.7 describes the method used to check the assessments results against the main parameters of the analysis, including main drivers of the costs and revenues, as well as the discount rate.
- Section 8.8.8 covers the motivation for grant finance.
- Section 8.8.10 details the conclusions arising from the FEA.

### 8.2 Financial and Economic Assessment Approach

This financial and economic assessment uses best-available data and tested methodologies to estimate baseline and post-intervention financial and economic values, focusing on key sectors critical to household resilience, namely crop and livestock production, water access, and overall health.

The assessment begins with the valuation of baseline ecosystem services using data from reliable national and international sources. This includes existing values for agricultural production, livestock yields, and water supply across the oasis-based systems in the intervention areas. These figures represent the starting point for estimating the incremental value added by the GCF project.

To assess the impact of GCF-financed interventions, an evidence-based ecosystem service indexing approach is employed. This approach quantifies the improvement in ecosystem service delivery, such as enhanced agricultural productivity, improved livestock health, and greater availability of water resources, following the implementation of project activities. These improved service values feed directly into the financial analysis model.

The financial analysis is conducted at the household level, with the understanding that households in the targeted hubs depend on a combination of crop cultivation and livestock management to sustain their livelihoods. Importantly, the analysis captures both subsistence use and surplus production that

can be marketed or traded, providing a full picture of the financial potential of oasis-based agriculture. While much of the agricultural output in these systems is retained for household consumption, the financial analysis estimates potential returns based on prevailing local and regional prices. This approach allows the model to reflect both the immediate, tangible benefits to household food security and the broader financial opportunities available through increased productivity and market engagement.

At the macroeconomic level, an integrated economic analysis is undertaken to assess the project's contribution to Mauritania's Gross Domestic Product (GDP). This analysis is holistic, capturing not only direct outputs from increased crop and livestock production but also the enhanced value of ecosystem services, such as water provisioning and the resulting improvements in health and productivity.

By comparing baseline conditions with projected post-intervention outcomes, the model clearly illustrates the financial and economic returns that can be expected through GCF support. These include gains in household income, improved food and water security, and measurable contributions to national GDP.

### **8.3 Detailed Methodology**

#### **8.3.1 Baseline ecosystem service valuation**

The baseline valuation provides a monetary estimate of the key provisioning ecosystem services currently delivered by oasis-based systems in the four targeted hubs. These services include food production from crops and livestock, as well as access to water for domestic and productive use. Establishing a robust baseline is essential to understanding the current state of ecosystem service flows and to quantifying the added value of GCF-financed interventions.

Agricultural production in the targeted hubs is predominantly based on oasis systems, which combine date palm cultivation with rain-fed and flood-recession agriculture. These systems yield a mix of date crops, vegetables, and cereals. To estimate the value of crop production:

- Data from best-available research was used to approximate the area under rain-fed and flood-recession agriculture in each hub.
- Crop yield estimates, specific to the types of crops grown in these systems, were applied to the cultivated area to determine the total annual production volume.
- Similarly, data on date palm production volumes in each hub was gathered from existing agricultural records and studies.
- Market prices for dates, vegetables, and cereals, sourced from local and regional markets, were applied to the estimated volumes to calculate the annual monetary value of crop production per hub.

Livestock is a key component of household livelihoods in the project areas, contributing to both food security and income. To estimate the value of livestock production:

- Official data on livestock populations at the wilayah (regional) level was obtained.
- These figures were scaled down using the relative population share of each hub compared to its corresponding wilayah, to approximate livestock numbers at the hub level.
- Average meat yields per animal were sourced from relevant literature and applied to the estimated livestock populations to determine total annual meat production.
- Current market prices for meat in Mauritania were then used to derive the annual value of livestock production for each hub.

Access to water is another critical provisioning service, particularly in arid environments like those found in the target hubs. To estimate the value of water supply:

- Literature sources provided estimates of current per capita water use in the target areas.

- These figures were multiplied by the population of each hub to determine total annual water consumption, measured in litres.
- The cost of water, as reported in national and project-level studies, was then applied to calculate the annual monetary value of water accessed in each hub.

### 8.3.2 Evidence-based ecosystem service indexing

To quantify the projected benefits of GCF-financed interventions, an evidence-based indexing approach was developed to estimate the increase in ecosystem service values above the baseline. This indexing framework applies rigorously sourced multipliers to each key service, crop production, livestock production, and water supply, based on documented outcomes from comparable interventions in similar agroecological and socio-economic contexts.

The crop production index reflects the expected improvements in agricultural yield resulting from the adoption of climate-resilient agricultural practices. Drawing on findings from a World Bank study on climate-smart agriculture, which examined interventions comparable to those proposed in this project, it was found that crop yields increased by an average of 30% under improved land and water management techniques. This 30% uplift factor was used as the index for increased crop production across the project hubs following implementation of the GCF-supported activities.

For livestock, the index accounts for improved fodder availability and pasture productivity because of land rehabilitation efforts. Empirical research demonstrates that access to better grazing conditions can lead to significant weight gains in livestock, including camels, cattle, and small ruminants. Documented increases in live weight range from 11% to 48%, depending on species and conditions. For the purposes of this model, a conservative average uplift was applied to livestock productivity to estimate the post-intervention increase in meat yields and overall livestock value.

The water supply index is based on bridging the gap between current water access levels and actual daily water demand. According to available research, the average daily water demand in Mauritania is approximately 75 litres per person. However, current consumption in the project hubs is significantly lower, at around 38 litres per person per day. The project is expected to improve water access and infrastructure such that per capita water use approaches the national demand benchmark. The index therefore reflects this increase in per capita water access, nearly doubling the current level, as a proxy for the enhanced ecosystem service value of water provisioning.

### 8.3.3 Financial analysis

The financial analysis was developed to compare the current financial performance of oasis-based livelihoods with the projected improvements resulting from GCF project interventions. It includes two core components: a baseline scenario representing current economic conditions, and a project scenario that incorporates the benefits of improved ecosystem service delivery under the GCF-supported activities.

The baseline analysis captures the financial value generated at the household level from agricultural and livestock production, based on the ecosystem service valuation described earlier. Notably, the majority of this value accrues through subsistence consumption rather than through formal value chains or market-based transactions.

Due to the subsistence nature of these systems, reliable data on annual input costs and capital expenditures is limited. In response to this data constraint, the model draws on credible, research-backed estimates of typical financial returns from oasis-based agriculture systems in similar contexts. These research-derived Internal Rates of Return (IRRs) were applied as a benchmark.

To estimate costs, a goal-seek function was used: the model takes the known value of production (i.e., revenue potential) and solves for the cost input required to achieve the benchmark IRR. This

allows for a consistent and evidence-based representation of the financial performance of the baseline scenario.

In the project scenario, the cash flow model integrates the increased production values obtained from the evidence-based ecosystem service indexing. These enhanced revenue projections reflect the expected gains from higher crop yields, improved livestock productivity, and better water access.

Using the same cost assumptions from the baseline model, the project scenario recalculates the IRR, effectively capturing the incremental financial return made possible through GCF support. This provides a clear, quantitative basis for understanding the value-add of the project from a household finance perspective, demonstrating how improved ecosystem productivity translates into stronger and more resilient rural livelihoods.

#### 8.3.4 Economic analysis

The economic analysis captures the broader, economy-wide benefits of the project, including non-market ecosystem service gains and indirect multiplier effects.

The first component of the economic analysis involves estimating the additional Gross Domestic Product (GDP) generated as a result of increased ecosystem service productivity. Specifically, enhanced crop and livestock production and improved water availability. These outputs, previously quantified through the ecosystem service indexing approach, were monetized and aggregated to reflect their direct contribution to GDP.

To more accurately reflect the macroeconomic impact of improved agricultural performance, a multiplier effect was applied. Agriculture is a sector with high linkages to other parts of the economy. The application of a conservative, evidence-based multiplier accounts for the indirect economic activity generated by increased agricultural output in the project hubs.

In addition to market-based services, the analysis incorporates a critical non-market benefit: cost savings to the healthcare system. This benefit arises from reduced rates of malnutrition expected as a result of improved food and water security. A literature review indicates that treating malnourished individuals incurs significantly higher per capita healthcare costs than treating well-nourished patients.

Using available data, the current per capita healthcare cost in Mauritania was estimated, and the incremental cost of malnutrition treatment was factored in. This additional cost burden was then applied to the relevant segment of the population within the hubs. The economic analysis posits that improved livelihoods through GCF interventions will reduce the prevalence of malnutrition, leading to substantial future cost savings for the healthcare system.

All economic and ecosystem service benefits, market and non-market, were aggregated to estimate the total economic benefit of the project. Against this total, the full cost of the GCF-financed interventions was accounted for, allowing for the calculation of the project's net economic benefit.

### 8.4 **Costs**

The costs of the proposed project are based on the GCF funds per activity. Each output contains multiple activities. Note that the interventions will have capital costs and operating costs. Capital items will need to be maintained and replaced at predetermined time intervals (replacement period).

Table 66 shows the costs of the project interventions. The total cost for the interventions is US\$30,146,845. Table 67 shows the monitoring and evaluation costs. These costs amount to a total of US\$1,752,500. Table 68 shows the project management costs. These costs total US\$1,661,000. This brings the total cost of the GCF project to US\$33,560,345.



**Table 66.** Intervention costs.

Output	Activity	Sub-activity	Financing Source	Total cost (US\$)
<b>Output 1.1.</b> Governance structures are strengthened to support the implementation of EbA measures and the integration of climate change considerations and EbA into government plans, policies and budgets.	<b>Activity 1.1.1.</b> Establish coordination platforms to facilitate knowledge sharing, natural-resource management, sustainable land-use planning and the implementation of EbA activities at regional and local levels.	<b>Sub-activity 1.1.1.1.</b> Establish commune-level technical committees (CTCs) within each priority commune in the four target hubs.	GCF	3,000
			GCF	76,000
			GCF	11,124
			GCF	12,000
			GCF	960,000
			GCF	480,000
			GCF	3,000
		<b>Sub-activity 1.1.1.2.</b> Deliver training workshops to CTCs, enhancing members' capacities to implement and manage project activities, support the integration of climate change in regional- and commune-level policies, plans and budgets, and facilitate knowledge sharing between regional- and local-level stakeholders.	GCF	4,000
			GoM	9,600
			GCF	22,752
			GCF	25,728
			GCF	36,000
		<b>Sub-activity 1.1.1.3.</b> Train CTC members to use the existing National Adaptation Plan (NAP) climate knowledge management platform and facilitate the collection and dissemination of climate information and adaptation best practices by CTC members.	GCF	4,000
			GCF	6,000
			GCF	2,370
		<b>Sub-activity 1.1.1.4.</b> Conduct a review of existing wilayah-, moughataa- and commune-level development plans, policies and budgets and prepare policy briefs for the integration of climate considerations and gender-responsiveness into these documents.	GCF	24,000
			GCF	36,000

		<b>Sub-activity 1.1.1.5.</b> Convene training workshops for Regional and Communal Councils and relevant sectors to support the integration of climate change in regional- and commune-level policies, plans and budgets, including through the presentation of the policy briefs prepared under Sub-activity 1.1.1.4.	GCF	6,000
			GCF	12,000
			GCF	4,944
<b>Subtotal GCF cost for Output 1.1</b>				<b>1,728,918</b>
<b>Subtotal GoM cost for Output 1.1</b>				<b>9,600</b>
<b>Subtotal Output 1.1</b>				<b>1,738,518</b>
<b>Output 1.2.</b> Knowledge products developed and disseminated to support decision making and upscaling.	<b>Activity 1.2.1.</b> Develop knowledge products on project lessons learned and best practices through a participatory process engaging the communities.	<b>Sub-activity 1.2.1.1.</b> Hold bi-annual gender-inclusive discussions between representatives from the PMU, CTCs and communities in the target hubs on project intervention successes and challenges, and develop these discussions into community engagement reports.	GCF	51,456
			GCF	72,000
			GoM	9,600
			GCF	57,600
		<b>Sub-activity 1.2.1.2.</b> Identify lessons learned and best practices used in project interventions, and develop these into implementation guides and best practice reports.	GCF	38,400
	<b>Activity 1.2.2.</b> Enhance the dissemination of adaptation knowledge to sub-national decision-makers and communities to support upscaling.	<b>Sub-activity 1.2.2.1.</b> Upload knowledge products (e.g. implementation guides, monitoring and evaluation reports, community engagement reports, policy briefs, lessons learned and best practice reports) onto the NAP knowledge management platform.	GCF	12,000

		<b>Sub-activity 1.2.2.2.</b> Package knowledge in the NAP knowledge management platform into formats that are accessible at local level (e.g. brochures, TV and radio programmes, awareness-raising materials).	GCF	72,000
		<b>Sub-activity 1.2.2.3.</b> Disseminate locally-accessible knowledge products in target and non-target communes across the four project wilayahs to catalyze upscaling, with support from the DREDDs and CTCs.	GCF	90,000
			GoM	14,400
<b>Subtotal GCF cost for Output 1.2</b>				<b>393,456</b>
<b>Subtotal GoM cost for Output 1.2</b>				<b>24,000</b>
<b>Subtotal Output 1.2</b>				<b>417,456</b>
<b>Output 2.1.</b> Green-grey dune fixation infrastructure is established to control sand encroachment, enhance the provision of ecosystem services and slow the rate of desertification within the four target hubs.	<b>Activity 2.1.1.</b> Establish 2,123 hectares of EbA dune-fixation infrastructure and 120 kilometres of protective fencing across the four target hubs, to facilitate the rehabilitation and maintenance of degraded landscapes and enhance ecosystem services related to dune stabilisation and the supply of natural resources.	<b>Sub-activity 2.1.1.1.</b> Support CTCs to co-develop commune-level land rehabilitation plans in collaboration with village-level stakeholders, members of project management teams and DREDD representatives.	GCF	10,800
			GCF	9,888
			GCF	24,000
			GoM	270,000
		<b>Sub-activity 2.1.1.2.</b> Install ~2,123 ha of dune-stabilisation infrastructure (1,138 ha of green belts; 985 ha of biological and mechanical dune-fixation infrastructure) at strategic sites across the four target hubs — to protect critical areas against the impacts of sand inundation.	GCF	54,000
			GoM	7,200
			GCF	22,752
			GCF	2,129,064
			GoM	1,581,940
			GCF	720,000
			GCF	1,889,470
			GoM	188,030
		<b>Sub-activity 2.1.1.3.</b> Install ~120 km of fence lines around dune-fixation sites established under sub-activity 2.1.1.2, to protect biological dune-fixation infrastructure against damage from livestock and	GCF	2,881,293
			GCF	261,936
			GCF	0
			GCF	0

		unsustainable use of natural resources.		
		<b>Sub-activity 2.1.1.4.</b> Train livestock herders within the target communes to implement climate-resilient livestock management practices, such as rotational grazing, transhumance, supplementary feeding, agro-silvopasture, collective herding and 'livestock collar re-seeding'.	GCF	342,000
			GoM	72,000
			GCF	107,640
<b>Subtotal GCF cost for Output 2.1</b>			<b>8,452,843</b>	
<b>Subtotal GoM cost for Output 2.1</b>			<b>2,119,170</b>	
<b>Subtotal Output 2.1</b>			<b>10,572,013</b>	
<b>Output 2.2.</b> Improved access to water for agricultural and land rehabilitation activities.	<b>Activity 2.2.1.</b> Establish community-managed Water User Groups (WUGs) and commune-level water monitoring and regulation plans.	<b>Sub-activity 2.2.1.1.</b> Establish community-managed Water User Groups (WUGs) within each target commune and train members to implement and maintain water-related activities introduced under Activity 2.2.2 of the project.	GCF	16,000
			GCF	18,000
			GCF	4,944
			GCF	54,000
			GoM	32,800
			GCF	14,400
			GCF	19,296
		<b>Sub-activity 2.2.1.2.</b> Support CTCs to raise awareness about sustainable water usage and co-develop commune-level water monitoring and regulation plans in collaboration with WUGs.	GCF	420,000
			GCF	270,000
			GoM	100,000
		<b>Sub-activity 2.2.1.3.</b> Conduct hydrogeological studies (or consult existing hydrogeological maps, where applicable) and engage with WUG members to identify priority sites to install water-management infrastructure (Sub-activities 2.2.2.1, 2.2.2.2 and 2.2.3.1) in each target commune.	GCF	133,000
			GCF	18,000
			GCF	29,664

		Summarise the finding of site selection into a commune-level water management plan for each priority commune.		
	<b>Activity 2.2.2.</b> Install physical water management infrastructure — including weirs, gabions, dikes, stone- and earthen bunds, groundwater dams and water access points for pastoralists.	<b>Sub-activity 2.2.2.1.</b> Install physical water management infrastructure — including weirs, gabions, dikes, stone- and earthen bunds, groundwater dams and solar-powered pumps — at strategic sites within each target commune, to improve water access and availability, increase groundwater recharge rates and reduce flood risks in the target hubs.	GCF	1,481,200
			GCF	20,000
			GCF	160,000
			GCF	2,064,000
			GCF	288,000
			GCF	40,000
		<b>Sub-activity 2.2.2.2.</b> Establish water access points along historical transhumance routes and in graras, to improve nomadic pastoralists' access to water and reduce sedentarisation among livestock herders.	GCF	768,000
			GCF	110,400
			GCF	24,000
			GoM	20,000
	<b>Activity 2.2.3.</b> Install 12 rainwater-harvesting systems and communal cisterns (5,000 L per system) within each target commune	<b>Sub-activity 2.2.3.1.</b> Install 12 rainwater-harvesting systems and communal cisterns (5000L per system) within each target commune across the four hubs, to improve access to water for agricultural livelihood activities.	GCF	36,000
			GCF	480,240
			GCF	216,000
<b>Subtotal GCF cost for Output 2.2</b>				<b>6,685,144</b>
<b>Subtotal GoM cost for Output 2.2</b>				<b>152,800</b>
<b>Subtotal Output 2.2</b>				<b>6,837,944</b>
<b>Output 2.3.</b> Climate-resilient agricultural livelihoods based on sustainable land- and natural resource-use are developed and/or strengthened to	<b>Activity 2.3.1.</b> Facilitate the adoption of climate-smart agricultural practices and sustainable diversified livelihoods by	<b>Sub-activity 2.3.1.1.</b> Establish nurseries and seed banks in each target commune to supply activities related to land rehabilitation and dune fixation (Activity 2.1.1), CSA practices (Sub-activity 2.3.1.3) and	GCF	186,000
			GCF	72,000
			GCF	19,776
			GCF	438,000
			GCF	284,100

reduce land degradation and support climate-resilient income-generation by community members within the target regions.	farmers and community members within the target communes..	horticultural activities such as market-gardening (Sub-activity 2.3.1.4).	GCF	72,000
			GCF	19,776
			GCF	438,000
		<b>Sub-activity 2.3.1.2.</b> Collect cuttings and seeds from agricultural crop species, as well as indigenous grass and tree species, to serve as stock material for nurseries and seed banks established under Sub-activity 2.3.1.1.	GCF	18,000
			GCF	36,000
			GoM	3,600
		<b>Sub-activity 2.3.1.3.</b> Train farmers within the target communes to practice climate-resilient crop agriculture and use improved agricultural technologies, including drip irrigation kits, solar powered pumps, integrated pest management strategies, zai pits and half-moons.	GCF	270,000
			GoM	72,000
			GCF	96,480
			GCF	95,600
		<b>Sub-activity 2.3.1.4.</b> Conduct site visits and provide technical support to facilitate the uptake of sustainable livelihood activities — including horticulture (market-gardening), apiculture, poultry farming, livestock feed production and the collection and sale of non-timber forest products — by community members within the target communes.	GCF	162,000
			GoM	43,200
			GCF	44,496
		<b>Sub-activity 2.3.1.5.</b> Supply farmers and horticulturalists with water-efficient irrigation equipment and climate-resilient crop varieties to support the uptake of agricultural activities adopted under Sub-activities 2.3.1.3 and 2.3.1.4.	GCF	99,000
			GCF	10,350
			GCF	103,500

		<b>Sub-activity 2.3.1.6.</b> Improve access to urban markets and develop value chains for offloading agricultural produce within each target commune, to enhance income generated from sustainable agricultural livelihoods.	GCF	108,000	
			GoM	23,200	
			GCF	19,776	
	<b>Activity 2.3.2.</b> Establish a small grants facility to facilitate continued investment in upscaling successful EbA activities and sustainable livelihoods.	<b>Sub-activity 2.3.2.1.</b> Establish and operationalise a Small Grants Facility (SGF) to facilitate continued investment in upscaling successful EbA activities and sustainable livelihoods introduced under the project.	GCF	24,000	
			GCF	18,000	
			GCF	960,000	
			GCF	6,000,000	
			GCF	20,000	
			GCF	700,000	
			GCF	18,000	
			<b>Sub-activity 2.3.2.2.</b> Prepare budget briefs for directing regional government funds into the SGF established under Sub-activity 2.3.2.1. to promote government investment in CCA.	GCF	26,000
				GCF	2,060
				GCF	6,000
				GCF	36,000
				<b>Sub-activity 2.3.2.3.</b> Develop monitoring and reporting mechanisms to ensure the traceability and risk management of funds between the SGF and local-level stakeholders.	GCF
<b>Subtotal GCF cost for Output 2.3</b>				<b>10,438,914</b>	
<b>Subtotal GoM cost for Output 2.3</b>				<b>142,000</b>	
<b>Subtotal Output 2.3</b>				<b>10,580,914</b>	

**Table 67 Monitoring and evaluation costs**

<b>Monitoring and Evaluation Costs</b>	<b>Total cost (US\$)</b>
Implementation of safeguards management plan	279,500
Environmental and Social Safeguards Officer	330,000
Implementation of gender mainstreaming	25,000
Gender Officer	330,000
Monitoring and Evaluation officer	330,000



Implementation of M&E plan	315,000
Terminal Evaluation	143,000
<b>Total monitoring and evaluation costs</b>	<b>1,752,500</b>

**Table 68 Project management costs**

<b>Project Management Costs</b>	<b>Total cost (US\$)</b>
Project Coordinator	450,000
Procurement Officer	110,000
Financial and Administrative Officer	330,000
Chief Technical Advisor	390,000
Facilities and administration	180,000
Office supplies and stationary	30,000
IT equipment	39,000
Audits	30,000
PMU travel costs	60,000
Project meeting costs	42,000
<b>Total project management costs</b>	<b>1,661,000</b>

## 8.5 Benefits

As previously mentioned in section 8.3.4 above, the economic benefits consider additions to GDP, a multiplier effect due to the economy-wide impact of agriculture and then the health benefit. Table 69 shows the value of each respective economic benefit (discounted @2% over a 20-year period. See section 8.3.4 for each of the target hubs. The total value (NPV) of the additional GDP created as a result of increased ecosystem services from GCF project interventions is US\$128 million over the 20-year modelled period. The multiplier effect of agriculture further adds US\$29 million (NPV) to the GDP impact. The value (NPV) of the health benefit is US\$24 million, bringing the total value (NPV) of the economic and ecosystem service benefits to US\$182 million over the 20-year modelled period.

**Table 69 Economic and ecosystem service benefits**

<b>Indicator</b>	<b>Unit</b>	<b>Total/Combined</b>	<b>Aoujeft</b>	<b>Rachid</b>	<b>Tamcheket</b>	<b>Nema</b>
NPV of Additional GDP Created: Crop production	\$	59,481,666	15,109,319	11,970,674	6,548,349	25,853,324
NPV of Additional GDP Created: Livestock production	\$	68,062,303	2,608,242	26,018,603	14,118,407	25,317,050
NPV of Additional GDP Created: Water supply	\$	872,455	52,286	197,184	165,542	457,444
NPV of Multiplier effect	\$	29,933,811	4,142,143	8,901,247	4,855,999	12,034,421
NPV of Health Benefit	\$	24,337,247	1,458,515	5,500,464	4,617,809	12,760,459
<b>NPV of Total Economic &amp; Ecosystem Service Benefit</b>	<b>\$</b>	<b>182,687,481</b>	<b>23,370,505</b>	<b>52,588,172</b>	<b>30,306,107</b>	<b>76,422,699</b>

## 8.6 FEA Results

Table 70 presents a comprehensive comparison of baseline and project scenarios across the four target hubs in Mauritania, along with aggregated totals. The analysis confirms that GCF support significantly enhances both the financial viability and economic impact of oasis-based livelihoods. Crop production revenue potential increases by over US\$5.1 million annually in real terms, rising from \$17.0 million to \$22.1 million totalled across all hubs. Notably, hubs like Aoujeft see large gains most likely due to its location in the major date producing region. Livestock production revenue potential

shows a substantial gain of \$5.8 million per annum, increasing from \$53.2 million to \$59.0 million. The water supply revenue potential also more than doubles (from \$76,992 to \$151,959), reinforcing the significance of improved water access in climate-vulnerable zones.

The NPV of total economic and ecosystem service benefits is calculated at over \$182 million, vastly exceeding the NPV of the project costs of \$31.2 million. This translates into a benefit-to-cost ratio of 5.86, meaning that for every \$1 invested by GCF, nearly \$6 is generated in the economy in return.

The projected health benefit NPV of \$24.3 million accounts for future cost savings in treating patients who were malnourished, a powerful, non-market benefit that aligns with SDG 3 (Good Health and Well-Being).

Financial IRR increases from 12% to 22% with GCF support, indicating a notable improvement in the potential for household-level returns from agricultural production. The Economic Rate of Return (ERR) is estimated at 29%, reflecting good economic impact.

It is once again worth noting that much of the value generated accrues to households through local consumption instead of through formal value chains and trade, which would generate the sufficient cashflows needed to sustain alternative funding instruments. This supports the use of grant funding in this project. The GCF-funded intervention will likely enable conditions that can foster the development of nascent markets, contributing to financial sustainability of the intervention in the future beyond the GCF funding cycle. Further to the above, while scaling of the project within existing project sites is not very likely due to the spatial arrangement of oasis-based agricultural systems, the project is replicable in similar socio-economic, climatic and ecological conditions.

**Table 70 Results of financial and economic assessment**

Indicator	Unit	Total/Combined	Aoujeft	Rachid	Tamcheket	Nema
Baseline scenario (without GCF support)						
Revenue potential: Crop production - Real terms	\$/annum	17,036,661	4,327,591	3,428,625	1,875,570	7,404,875
Revenue potential: Livestock production - Real terms	\$/annum	53,166,317	2,037,407	20,324,221	11,028,480	19,776,209
Revenue potential: Water supply - Real terms	\$/annum	76,992	4,614	17,401	14,609	40,368
Financial IRR	%	12%				
Project scenario (with GCF support)						
Revenue potential: Crop production - Real terms	\$/annum	22,147,660	5,625,869	4,457,212	2,438,241	9,626,338
Revenue potential: Livestock production - Real terms	\$/annum	59,014,612	2,261,522	22,559,885	12,241,613	21,951,592
Revenue potential: Water supply - Real terms	\$/annum	151,959	9,107	34,344	28,833	79,675
NPV of Additional GDP Created: Crop production	\$	59,481,666	15,109,319	11,970,674	6,548,349	25,853,324
NPV of Additional GDP Created: Livestock production	\$	68,062,303	2,608,242	26,018,603	14,118,407	25,317,050
NPV of Additional GDP Created: Water supply	\$	872,455	52,286	197,184	165,542	457,444
NPV of Multiplier effect	\$	29,933,811	4,142,143	8,901,247	4,855,999	12,034,421
NPV of Health Benefit	\$	24,337,247	1,458,515	5,500,464	4,617,809	12,760,459
NPV of Total Economic & Ecosystem Service Benefit	\$	182,687,481	23,370,505	52,588,172	30,306,107	76,422,699
NPV of Project Costs	\$	31,161,479				

Financial IRR	%	22%	
ERR	%	29%	
Benefit-to-cost Ratio	%	5.86	

### 8.7 Sensitivity analysis

Given the significant assumptions made in the CBA modelling, it is prudent to assess a range of variables on the modelling outcomes. The key variables that were assessed for variation are identified as:

- Change in date production;
- Change in average meat yield from all livestock;
- Change in health cost per capita;
- Change in social discount rate; and
- Change in commercial (money) discount rate.

The way the FEA model is set up for sensitivity analysis is that one can select one of the above scenarios and specify the percentage by which a variable can be changed. The model then runs and results are updated. One can then make a comparison of the original or most-likely results to the new results based on the changes specified. The parameters specified are as follows:

Scenario definition			
#	Scenario	Description	Specify amount (indicate +/- with value) N/A
0	Most likely scenario		
1	Change in date production	Specify a percentage increase/decrease of date production in each of the hubs	1%
2	Change in average meat yield from all livestock	Specify a percentage increase/decrease of the average meat yield from all livestock	1%
3	Change in health cost per capita	Specify a percentage increase/decrease of the health cost per capita	1%
4	Change in social discount rate	Specify a percentage increase/decrease of the social discount rate used in the economic analysis	1%
5	Change in commercial (money) discount rate	Specify a percentage increase/decrease of the money discount rate used in the financial analysis	1%

The above variables were tested independently and their respective impacts on costs, benefits and the cost-benefit ratio were calculated.

The outcomes of the sensitivity analysis are outlined in Figure 139 below:

Sensitivity Results								
	Hub	Unit						
Scenario indicator			Most likely scenario	Change in date production	Change in average meat yield from all livestock	Change in health cost per capita	Change in social discount rate	Change in commercial (money) discount rate
Revenue potential of agriculture activities (after project interventions)	Aoujeft	\$/annum	7,896,497	7,952,756	7,919,113	7,896,497	7,896,497	7,896,497
	Rachid	\$/annum	27,051,442	27,091,311	27,277,041	27,051,442	27,051,442	27,051,442
	Tamcheket	\$/annum	14,708,686	14,725,017	14,831,102	14,708,686	14,708,686	14,708,686
	Nema	\$/annum	31,657,605	31,686,478	31,877,121	31,657,605	31,657,605	31,657,605
Financial return: IRR with GCF support	Combined	%	21.85%	21.94%	22.24%	21.85%	21.85%	21.85%
NPV of net cashflows with GCF support	Combined	\$	42,639,899	43,194,526	44,929,040	42,648,322	42,648,322	35,866,308
NPV of economic and eco-system service benefits	Combined	\$	182,687,481	184,715,719	191,156,539	182,930,854	161,133,224	182,687,481
Economic rate of return: ERR with GCF support	Combined	%	28.76%	28.99%	29.71%	28.78%	28.76%	28.76%
% Change From Most Likely Scenario								
Indicator								
Revenue potential of agriculture activities (after project interventions)	Aoujeft		0.0%	0.7%	0.3%	0.0%	0.0%	0.0%
	Rachid		0.0%	0.1%	0.8%	0.0%	0.0%	0.0%
	Tamcheket		0.0%	0.1%	0.8%	0.0%	0.0%	0.0%
	Nema		0.0%	0.1%	0.7%	0.0%	0.0%	0.0%
Financial return: IRR with GCF support	Combined		0.0%	0.4%	1.8%	0.0%	0.0%	0.0%
NPV of net cashflows with GCF support	Combined		0.0%	1.3%	5.4%	0.0%	0.0%	-15.9%
NPV of economic and eco-system service benefits	Combined		0.0%	1.1%	4.6%	0.1%	-11.8%	0.0%
Economic rate of return: ERR with GCF support	Combined		0.0%	0.8%	3.3%	0.1%	0.0%	0.0%

**Figure 139 Sensitivity analysis results (see Sensitivity Analysis tab in Annex 3)**

The sensitivity analysis shows how a 1% increase in the variables analysed impacts the results. For example, a 1% increase in date production in each of the hubs causes the NPV of economic and eco-system service benefits to increase by 1.1%.

The reason for using the 2% social discount rate is that this rate is preferred by most economists to discount future economic benefits. The use of a high discount rate implies that people put less weight on the future and therefore that less investment is needed now to guard against future costs. Thus the use of a lower discount rate. If we used an 8% discount rate, it would cause the NPV of the net economic and ecosystem service benefits to be reduced to US\$ 64 million, which is 57% of the original value.

In addition, a 79% reduction in date production causes the NPV and ERR to be negative. Similarly, a 19% reduction in the average meat yield from all livestock would cause the NPV and ERR to be negative. Note that the value of the health benefit contributes a small percentage to the total value of economic and ecosystem service benefits. As such, a minor reduction in this indicator would not cause the total NPV to be negative. This does not understate the value of this indicator, as even minor improved health outcomes yield benefit beyond the project period and across generations in communities.

## 8.8 Motivation for Grant Finance

Although the proposed project supports climate-smart agricultural and livelihood practices, with the potential for increased income and profit generation accrual at the community level, several factors justify the request for 100% grant finance. These factors are listed below.

- **Multidimensional poverty and structural impediments:** Mauritania's substantial interdimensional poverty and structural impediments to sustainable development significantly limit local communities' upfront investment capacity in climate-smart solutions. Despite the potential for long-term economic benefits, the initial financial barrier and the time required to realise returns on investment pose significant challenges for communities already living at the margin. This suggests that proposed project interventions are unlikely to result in surplus income for beneficiaries. Instead, introduced income-generating activities will focus on bringing local GDP, food production and water access up to acceptable minimum standards — thereby providing communal economic benefits rather than individual financial benefits.
- **Fiscal constraints and national prioritisation:** The GoM's high public debt level and fiscal constraints limit the allocation of national resources towards climate change adaptation. National priorities generally focus on immediate development needs; therefore, limited budgetary leeway reduces scope for investing in long-term climate resilience initiatives without external support.
- **Private sector participation:** As described above, the proposed project operates in areas with minimal private sector presence, further compounded by limited potential for immediate cost-recovery and revenue generation due to the nature of EbA interventions. This scenario limits the attraction of private investment in the short to medium term, necessitating grant support to initiate and demonstrate the viability of such interventions.
- **Leveraging grant finance for systemic change:** Grant financing from the GCF is sought not only as a funding mechanism, but as a catalyst for systemic change. By providing 100% grant finance, the GCF will enable the implementation of foundational EbA measures that lay the groundwork for sustainable, climate-resilient development. The grant support will facilitate the establishment of necessary infrastructure, capacity building and institutional frameworks, setting the stage for future investments and scaling.
- **Demonstration effect and scalability:** The successful implementation of the project with GCF grant finance will serve as a demonstration of the viability and effectiveness of EbA measures, potentially attracting future investments from both public and private sectors. By proving the concept and showcasing tangible benefits, the project will create a replicable model for climate resilience that can be scaled both within Mauritania and in other similar contexts. This highlights the scalability of the project in terms of replicability, with low potential for *in situ* scaling at original project sites due to the spatial arrangements of oasis-based agriculture.

## 8.9 General analysis

The project interventions are designed to enhance community resilience and sustainable development in the face of climate change, focusing on long-term benefits rather than immediate financial gain. Given the communal nature of the benefits, such as increased resilience to climate impacts, improved ecosystem services and stronger institutional capacities, the financial returns are social and environmental, not monetarily direct or individual.

On the basis of this high-level financial analysis, 100% grant financing from the GCF is justified for this project, since the activities:

- require significant upfront investment without direct financial return or a secure revenue base;
- deliver communal and environmental benefits that are crucial for long-term resilience and sustainability; and
- support adaptive capacity and livelihood security improvements that are not quantifiable in immediate financial terms.

This analysis demonstrates that grant finance is the most appropriate instrument for the proposed project, considering the communal benefits, the non-revenue-generating nature of the activities and the critical need for adaptation and resilience-building in Mauritania.

## 8.10 Conclusion

In conclusion, the financial and economic assessment strongly supports the viability and impact of the proposed project interventions in northern Mauritania. The cost-benefit analysis reveals that, even under conservative scenarios, the project delivers a positive return on investment with benefit-to-cost ratio of 5.86. These findings underscore the effectiveness of ecosystem-based adaptation (EbA) in strengthening household and community resilience to climate change through improved agricultural productivity, water access, and ecosystem health. Notably, even in the least favourable sensitivity scenario, the interventions remain cost-effective, which provides confidence in the robustness of the proposed measures.

Despite the promising returns, the analysis clearly demonstrates the need for 100% grant financing. Given the communal nature of the benefits, the absence of surplus income for direct beneficiaries, and the high upfront costs of foundational infrastructure and capacity-building activities, the project is not suitable for loan-based or cost-recovery financing. The project is aimed at lifting communities above subsistence thresholds, not generating profit. As such, GCF funding serves as a catalyst for transformative change, enabling systemic shifts in climate resilience, institutional capacity, and long-term development. Ensuring successful implementation will depend on continued technical support, strong governance structures, and active community participation to realize the full potential of the interventions.

## 9 Economic and Social Safeguards

### 9.1 Project categorisation

The environmental and social risks associated with this project have been evaluated in accordance with the GCF's Environmental and Social Safeguards. The proposed project is classified as Category B (moderate risk), based on the screening process and regulations used by the GCF. This indicates that project activities will have minimal adverse environmental and social (E&S) risks and impacts. Justification for this classification is provided in Annex 6: Environmental and Social Management Plan (ESMP), which contains an overview of the general project implementation risks that have been identified to date. A summary of the E&S risks and health and safety (H&S) risks anticipated during the project lifecycle, as well as potential mitigation strategies, is presented in Table 72 below. A detailed risk rating for each activity is provided in Annex 6: Environmental and Social Management Plan.

### 9.2 E&S risk assessment and management at the project activity level

The following two tables provide details on the operationalisation of the ESMP. These tables include: i) an overview of the various project-wide actions that will be undertaken by the project proponents (such as the PMU, Safeguards Officer, CTC's and Contractors) to help reduce and/or manage risk (Table 71); and ii) an ESMP implementation plan, which links specific activity level risks identified during project development with appropriate mitigation actions (Table 72). A more detailed version of Table 72 can be found in Annex 6: ESMP, wherein the specific risks, significance, year of implementation and E&S budget associated with each project component have been included.

As some activities, as well as their implementation modality, need to be finalised at the site-level, the ESMP implementation plan offers recommended actions that will need to be confirmed using the actions in Table 71 during implementation. This structure is intended to provide the PMU and the Safeguards Officer with a sufficient number of established structures, recommended actions and resources to ensure risks are adequately managed, while enabling flexibility at a site-level to identify unforeseen risks and adjust mitigation measures accordingly.

**Table 71.** Project-level ESMP actions, plans and resources<sup>1040</sup>

Project-level ESMP Activities, Plans and Resources		
Aspect	Description	Responsibility
Site level risk assessments	A process for conducting site-level risk assessments for each intervention implemented under the project. A template for this process is included in the ESMP. These should be submitted to the PMU on a biannual basis.	CTC, contractors, community members for compiling assessments Safeguards Officer for monitoring
Safe work instructions / Method Statements	A specific set of step-by-step instructions or a method statement that applies to a specific intervention, taking into account the nature of the intervention, the implementation methodology and any site-specific details that may affect implementation.	Safeguards Officer/Contractors for development and monitoring Contractors, community members for implementation
Legal Compliance Obligations Register	A CTC level register that lists the legal obligations associated with specific activities (e.g. construction regulations for water infrastructure) and compliance thereof. These	Safeguards Officer for development and monitoring CTC, contractors for implementation

<sup>1040</sup> Annex 6: ESMP



Project-level ESMP Activities, Plans and Resources		
	reports should be submitted alongside the risk assessment.	
Emergency preparedness and response plans	An CTC level emergency response and preparedness plan developed to ensure the safety and security of project personnel in the event of an emergency. This should be developed at a PMU level by the Safeguards Officer and customised by CTCs for the site level.	Safeguards Officer for development CTC for site-level customisation, implementation and monitoring
Operation, Monitoring and Maintenance (and/or control) Plans	A intervention specific plan developed by the Safeguards Officer in collaboration with CTCs and input from experts. These plans are intended to ensure safe operation of infrastructure (such as rainwater harvesting systems) and monitor interventions (such as biological dune fixation where potentially invasive species are established).	Safeguards Officer and CTC for development (with technical input from specialists) CTCs, communities for implementation and monitoring
Incident Reporting Register	A CTC level register that is used to record all incidents or accidents that occur as a result of project interventions. This register should be submitted to the PMU on a biannual basis.	Safeguards Officer for development & monitoring CTC for maintaining the register
Construction Reports	Upon completion of each activity that includes construction a construction report should be produced, detailing the design, construction methodology and final infrastructure. These should be compiled by the CTC or contractor and submitted to the PMU on a biannual basis.	Safeguards Officer for development and monitoring CTC, Contractor for compiling and implementation
Community Level Health and Safety Plan	Health and Safety plans developed at the PMU level and customised to address site level risks. This plan should be implemented by the CTC's and communicated to contractors and communities as required. It should take into account all specific site-level risks and risks associated with each expected intervention to be implemented at the site.	Safeguards Officer for development at the PMU level CTC for customisation at a site level CTC and Contractors for implementation and monitoring
Grievance Redress Mechanism	A mechanism for recording and addressing complaints as raised by affected or concerned parties, this mechanism includes a process for receiving grievances, addressing grievances and recording both grievances and outcomes.	CTC/Safeguards Officer/PMU for implementation Safeguards Officer/PMU for monitoring
Key Performance Areas/Indicators	A set of indicators to assess and monitor performance across the different project interventions and risk management categories. These indicators will inform the plans listed above and be inputs into the Monitoring and Evaluation Framework	Safeguards Officer/PMU for development and monitoring CTC, Contractors, Communities for implementation

**Table 72. ESMP Implementation Plan**<sup>1041</sup>

ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
<p><i>Environmental risks associated with mechanical and biological dune-fixation activities (Activity 2.1.1.).</i></p>	<p>The inclusion of <i>Prosopis Juliflora</i> as a potential species for biological dune-fixation is considered to be necessary risk within very specific contexts (such as highly mobile dune environments where indigenous species are not able to establish).</p> <p>Approaches to manage this non-indigenous species are as follows:</p> <ul style="list-style-type: none"> <li>Indigenous species will be prioritised wherever possible, and species such as <i>Prosopis Juliflora</i> will only be selected in specific circumstances and through consensus by the project proponents, affected communities and experts.</li> <li>The project will engage the support of technical specialists, who will work with communities to ensure that the most appropriate species are selected for each site, based on a local level analysis and associated cost-benefit analysis approach.</li> <li>When <i>Prosopis Juliflora</i> is selected for a specific site, a risk assessment will be undertaken and will be submitted and recorded at a central level by the Safeguards Officer.</li> <li>The Project will Site-level ecosystem restoration &amp; rehabilitation management plans, which will ensure adequate monitoring and management of risks associated with <i>Prosopis Juliflora</i>.</li> </ul>	<p><b>Extension Officers, CTCs and Technical Experts</b> are responsible for ensuring indigenous species are prioritised and use of <i>Prosopis</i> is justified if proposed for use in specific circumstances. This will include compiling the risk assessment and a monitoring and control plan at a site level.</p> <p><b>Beneficiary communities</b> and <b>CTCs</b> are responsible for monitoring any <i>Prosopis Juliflora</i> stands established under the project.</p> <p>The <b>Safeguards Officer</b> is responsible for working with the <b>Technical Experts</b> to develop the monitoring and control plan and additionally for aggregating the site-level risk assessments and any monitoring or impact reports submitted by CTC's or communities on an annual basis.</p> <p>The <b>PMU</b> is responsible for ultimate oversight and review of monitoring and evaluation indicators.</p>	<p>The establishment of biological dune fixation prioritises indigenous species wherever possible.</p> <p>Species selection is undertaken through a consultative process and includes material inputs from institutional actors, technical specialists and community-level stakeholders.</p> <p>Where potentially invasive species are utilised, it is done as a 'last resort' and only implemented after the completion of a site level risk assessment.</p> <p>Additionally, if deemed necessary, monitoring and control plans are developed and disseminated to community members.</p>

<sup>1041</sup> Annex 6: ESMP

ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
<i>Unequal access risks associated with the on-granting mechanisms (Activity 2.3.2).</i>	<p>To support accessibility for the on-granting mechanism the Safeguards Officer (with support from the Gender Officer if required) will support the consultants developing the on-granting mechanism to ensure that it is developed in a manner that includes eligibility criteria and a fair and transparent application and selection processes that incorporates input from relevant stakeholders (institutional actors, technical specialists and potential beneficiaries).</p> <p>Additionally, the project will support the development of awareness raising processes to ensure potential beneficiaries are informed of, and understand the process for, applying for support via the mechanism</p>	<p><b>Consultants and Institutional Representatives</b> developing the on-granting mechanism are responsible for ensuring that there are well-defined equitable beneficiary selection processes.</p> <p>The <b>Safeguards Officer</b> and <b>PMU</b> are responsible for ensuring those developing the on-granting mechanism understand the need for transparent process and for providing support to ensure that eligibility criteria and beneficiary selection processes consider local level contexts and needs.</p> <p>The <b>Safeguards Officer</b> is additionally responsible for developing appropriate awareness-raising initiatives to ensure adequate knowledge and access to the on-granting mechanism.</p> <p>The <b>Gender Officer</b> is responsible for providing input where required to ensure the on-granting mechanism is developed in a manner that enables gender equity in terms of eligibility and access.</p>	<p>The on-granting mechanism is developed in a manner that includes eligibility criteria and a fair and transparent application and selection process.</p> <p>Potential beneficiaries / applicants are equally informed of the on-granting mechanism and that they understand the eligibility requirements and process required to apply for support via the mechanism.</p>
<i>Environmental and social risks associated with the establishment of water infrastructure (groundwater dams, weirs and dykes). This includes the potential for disruptions in normal hydrological cycles/groundwater</i>	The establishment of groundwater dams and other water provisioning infrastructure poses both short-term (impacts on water quality and potential for pollution associated with construction) and longer-term (including river-flow disruptions and reduced water provisioning for downstream users). The overall scale of these dams is, however, expected to be small with very minimal attendant risks. The good practice principles	<b>CTCs and Contractors</b> are responsible for developing safe work instructions/method statements and the application of general good practice principles during the establishment of infrastructure. These groups are also responsible for compiling site-level risk assessments and	<p>Groundwater dams and other water infrastructure are established in a safe manner that ensures short-term risks and potential for pollution is minimised.</p> <p>This infrastructure is also implemented considering the local hydrological profile and other long-term risk elements and these interventions result in local</p>

ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
<i>levels with an associated risk to ecosystem services for downstream communities (Activity 2.2.2.).</i>	<p>listed below will be implemented to this end and operationalised through the safe work instructions and method statements developed at a site level for each on-the-ground activity:</p> <ul style="list-style-type: none"> <li>To minimise short-term impacts, construction should be phased to minimise impacts on water quality (such as increased siltation) and good practice principles should be adhered to by contractors or construction teams (this includes adequate provisioning of supplies to minimise the construction period, safe handling and storage of potentially pollutive materials such as fuels, lubricants etc.). This</li> <li>To reduce the significance of long-term impacts, site selection will be undertaken through a methodological process that includes input from relevant experts referencing available hydrological data (including maps of existing dams, hydrological profiles, reports and assessments etc.). In areas where hydrological data are not available the project will conduct assessments and develop profiles for these areas. This will help ensure that the siting and scale of the dams is appropriate, while simultaneously capacitating communities on the water carrying capacity of their own localities.</li> </ul>	<p>construction reports after construction is complete.</p> <p><b>Technical experts</b> engaged under the project are responsible for ensuring that the design specifications of infrastructure and site selection processes take hydrological profiles into consideration and are undertaken in a manner that considers safety and the potential for negative environmental impacts.</p> <p>The <b>Safeguards Officer</b> is responsible for oversight and aggregating local-level risk assessment and construction reports.</p> <p>The <b>PMU</b> is responsible for ultimate oversight and review of M&amp;E indicators.</p>	level enhancement of water provisioning and/or water retention without impacting downstream communities or ecosystems.
<i>Risk of unequal access to water provisioning infrastructure (Activity 2.2.2.).</i>	The project has been designed from the outset to ensure equal access to water provisioning infrastructure. To this end the site selection process for well-points and rainwater harvesting systems will be conducted in a manner that considers both technical considerations and access considerations. In certain cases, technical considerations will need	<p><b>CTCs, Technical Experts</b> and <b>Contractors</b> are responsible for ensuring the infrastructure is established in locations that can ensure adequate and equitable access for community members.</p> <p>Considerations related</p>	Water infrastructure, and particularly access points for this infrastructure is implemented in a manner that prioritises accessibility for all community members, including women, marginalised, vulnerable and/or disabled persons.

ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
	<p>to take precedence (e.g., for safety reasons).</p> <p>To further support equitable access, the siting of infrastructure will take into consideration inputs from community representatives. Given that the CTC's (which include community members) will be implementing the project it is expected that concerns relating to access can be well managed.</p> <p>Reporting and assurance on these processes (i.e., community engagement and assuring accessibility) will be included as an aspect on the site-level risk assessments and construction reports completed by those involved with the construction of infrastructure.</p>	<p>to access should be included in the risk screening and construction reports.</p> <p>The <b>Safeguards Officer</b> is responsible for oversight in ensuring that <b>CTC's, Technical Experts</b> and <b>Contractors</b> understand the risk assessment and construction report requirements. The Safeguard officer is additionally responsible for aggregating the risk and construction reports on an biannual basis.</p> <p>The <b>PMU</b> has ultimate responsibility for oversight of the risk management and for review of M&amp;E indicators</p>	
<p><i>Health and safety risks for project personnel, contracted labour and/or communities associated with construction and dune fixation. (Activities 2.1.1. and 2.2.2.).</i></p>	<p>The risks associated with these activities are inherent risks associated with construction. Overall, these risks are of low significance because of the type and scale of the proposed interventions, but general safety methodologies will be implemented via the safe work instructions and community health and safety plans to support safe practices. The proposed measures are listed below.</p> <p>International best practices (such as the ILO standards on Occupational Safety and Health) and national regulations will be followed to avoid and minimise safety risks and impacts on public health during construction. These practices will be considered during the development of the safe work instructions under the project.</p> <p>This will include measures such as proper planning of construction activities as well demarcation at construction sites (warning signs), fencing of construction sites, road</p>	<p><b>CTCs</b> and <b>Contractors</b> are responsible for ensuring that construction activities are adhere to safety standards as stipulated in any contracts, construction plans and safe work instructions, compiling risk assessments for proposed construction and preparing reports on construction activities undertaken.</p> <p><b>Safeguards Officer</b> and <b>PMU</b> are responsible for ensuring that requirements for safe work standards are included in any contracts or construction plans.</p> <p>The <b>Safeguards Officer</b> is additionally responsible for: i) ensuring that CTC's and Contractors understand the process for</p>	<p>Construction activities are implemented in a safe manner that adheres to good practice and reduces risk for labourers and communities alike. Site level safe work instructions and method statements guide the implementation approach for each intervention, ensuring that interventions are implemented in a safe and consistent manner.</p> <p>The project management unit and safeguards officer receive and log regular reports on the implementation of activities to ensure safe practices are followed.</p>



ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
	<p>safety measures if deemed necessary and minimum safety requirements for contractors, which will be stipulated in employment contracts.</p> <p>Additionally, the procurement process for the project will include guidelines for managing health and safety during construction to ensure contractors and employed labourers are cognisant of, and adhere to, appropriate safety practices.</p>	<p>compiling risk assessments and construction reports; and ii) for aggregating these assessment and reports on an annual basis.</p> <p>The <b>PMU</b> is responsible for ensuring employment contracts have minimum safety stipulations as well as ultimate responsibility for oversight of the risk management and for review of M&amp;E indicators.</p>	
<p><i>Health and Safety risks from establishment of water provisioning infrastructure (Activity 2.2.2.).</i></p>	<p>Overall, there are limited safety risks associated with the proposed infrastructure as a result of the types of interventions – groundwater dams for example have very few structural risks if designed and constructed appropriately.</p> <p>Water-provisioning infrastructure will therefore only be installed in appropriate locations and with input from relevant technical experts (such as engineers, hydrologists etc.). These inputs will be captured in activity-level safe work instructions or method statements and the final design and construction will be recorded and reported to the PMU via a construction report.</p> <p>With regard to rainwater harvesting systems and the potential increase in water-borne disease risk, these systems more likely to decrease the incidence of water-and-vector borne diseases, provided that the infrastructure is maintained in good working order. To this end Operations, Maintenance and Monitoring Plans will be developed in an accessible and appropriate format.</p> <p>This information will be provided to communities where rainwater harvesting systems are installed</p>	<p>The <b>CTCs</b> will be responsible for ensuring that awareness-raising activities are undertaken with communities, that they are aware of the potential risks associated with poor maintenance of the infrastructure and that they are able to implement the Operating, Maintenance and Monitoring plans.</p> <p>The <b>Beneficiary Communities</b> will be responsible for implementing the Operational, Maintenance and Monitoring plans, and for reporting any defects or system failures during the project lifespan.</p> <p>The <b>Safeguards Officer</b> will be responsible for compiling the Operations, Maintenance and Monitoring plan using locally appropriate content. They will also be responsible for communicating these plans to the CTCs who will be responsible for disseminating this</p>	<p>Rainwater harvesting systems and other water provisioning infrastructure is established in a manner that ensures safety for local communities and any risks associated with construction or operations are captured in the Community level H&amp;S plan and disseminated to the community.</p> <p>Communities are capacitated to operate monitor and maintain any established infrastructure, ensuring adequate and consistent operation, thereby enhancing the provisioning of water resources while simultaneously reducing, rather than increasing the incidence of vector-and-water-borne diseases.</p>

ESMP Implementation Plan			
Risk component	Mitigation measures	Responsible party/person	Expected results
	<p>to ensure they are fully aware of and capable of implementing the appropriate practices.</p> <p>In addition to the above, and to ensure safety at a site level during construction and operation, the Safeguards Officer will develop Community Health and Safety plans in collaboration with CTCs.</p>	information to communities	
<p><i>Risk of unequal access to benefits or project activities (Project-wide).</i></p> <p>Includes:</p> <ul style="list-style-type: none"> <li>• Employment opportunities</li> <li>• Access to project benefits</li> <li>• Representation in engagements</li> </ul>	<p>For gender considerations, the project has developed – and will be implementing – a Gender Action Plan (GAP). This will help ensure that benefits are more equitably distributed across different genders.</p> <p>In the case of vulnerable or marginalised persons as well as people who subscribe to different cultural or livelihood practices the project will employ an approach that prioritises these groups. For example, most beneficiary communities have been pre-selected based on their baseline vulnerability (established through a multifactorial assessment). This will be further supported by extensive stakeholder consultations during implementation.</p> <p>To support equitable access at the local level, the project will ensure that local implementing bodies (CTCs) are capacitated to prioritise vulnerable groups and that beneficiary selection mechanisms used to beneficiary selection are communicated during stakeholder engagement processes</p> <p>It is also recommended that the project employ an adaptive management approach on the whole, and be responsive to any concerns, grievances or suggestions raised through the GRM or other forums.</p>	<p>The <b>CTC's</b> are responsible for ensuring that the activities are implemented in a manner that prioritises (or otherwise considers) the needs of the most vulnerable or other marginalised community members. They are additionally responsible for ensuring that adequate engagement is undertaken with communities and that grievances or concerns that are raised with them are either appropriately resolved or escalated to the Safeguards Officer and/or PMU.</p> <p>The <b>Safeguards Officer</b> is responsible for ensuring that the CTC's are adequately capacitated to both understand the need for – and approach to – prioritising vulnerable and/or marginalised communities. This includes the needs to ensure adequate consultation and equitable benefits.</p> <p>The <b>PMU</b> is responsible for ultimate oversight and (are there M&amp;E indicators here?</p>	<p>The project is implemented in a manner that prioritises equity across the beneficiary communities. It furthermore implements an adaptive management approach that is responsive to the context on the ground.</p> <p>The implementation of all activities is done in an agile manner that focuses on representative community consultation and incorporates any grievances and concerns raised by community members or concerned parties, allowing the project to modify implementation modalities and/or shift site prioritisation to reduce risks where they emerge, and/or ensure that benefits can be more equitably shared wherever possible.</p>



## Due diligence, oversight and supervision arrangements

The supervisory roles and responsibilities of the Accredited Entity (AE), Executing Entity (EE), Project Steering Committee (PSC), Project Management Units (PMUs) and Management and Coordination Committees (CTCs) are summarised in Table 73 below.

**Table 73.** The supervisory roles and responsibilities of project personnel during the project implementation stage

Entity	Roles and responsibilities
Accredited Entity (UNEP)	<p>UNEP as the AE will be responsible for overseeing the implementation, financial management, evaluation, reporting and closure of the project, in coordination with the national-level PSC and PMU. As the AE, UNEP will: i) sign a project cooperation agreement with the EE to establish clear roles and responsibilities for project execution; ii) ensure that the project is executed in accordance with GCF and UNEP standards; iii) supervise, oversee and manage the implementation of project interventions; iv) report on project progress; v) co-chair the PSC; and vi) ensure that project activities are well coordinated and aligned with national priorities.</p> <p>A programme officer (po) will be responsible for project supervision to ensure consistency with GCF and UNEP policies and procedures. In addition, the po will: i) participate in biannual PSC meetings; ii) facilitate interim and final evaluations; iii) prepare annual performance reports and relevant documentation; and iv) conduct technical reviews of project outputs.</p>
Executing Entity (MEDD)	<p>As the EE, the MEDD will coordinate the national-level implementation of the project and will be accountable to UNEP as the AE for project execution, as well as for the effective and efficient use of project resources.</p>
Project Steering Committee (PSC)	<p>The PSC will provide oversight and advisory support for the project and will be chaired by a representative from UNEP. Other members of the PSC will include: i) representatives of relevant sectoral ministries; ii) one representative from each of the target hubs; and iii) national experts on local ecosystems, climate change and agriculture. The mandate of the PSC will be to steer the project execution to meet the intended objectives and to facilitate the development and adoption of the adaptive and integrated landscape management approaches at the national and local planning level.</p> <p>The PSC will meet at least twice a year, with ad hoc meetings convened as and when necessary, to discuss the project's main performance indicators and provide strategic guidance. This will largely be project implementation (or execution) related progress review, but the ESMP performance will also need to be subject to evaluation.</p> <p>The PSC will also need to assume overall responsibility for the resourcing and implementation of the ESMP and the related M&amp;E and performance evaluation processes</p>
Project Management Unit (PMU)	<p>The PMU will coordinate between the project's AE, EEs and relevant stakeholders to ensure the effective implementation of the project's day-to-day activities. Monthly meetings will be convened to facilitate this coordination.</p> <p>The PMU will consist of staff recruited through a competitive and inclusive process to fill the following positions: i) the Project Manager (PM); ii) the financial and procurement officer; iii) administrative officer; and iv) other technical staff.</p> <p>The PMU will be responsible for further ESMP development, implementation and the ongoing performance evaluation thereof.</p>
Technical Staff	<p>While the specific details on the technical staff requirements for the project are undefined at this time, the need for specific inputs as it relates to the planning and construction of water infrastructure activities, dune fixation and climate resilient agricultural practice interventions are noted. Where necessary and required they will also provide support in the training, safe work instruction / method statement development, implementation and M&amp;E activities related thereto.</p>
Environmental and Social Safeguards (ESS) Officer	<p>The project will appoint an Environmental and Social Safeguards Officer (ESS Officer) to assist with the implementation of the ESMP, ongoing monitoring and screening of project activities and the further development of planning and mitigation actions as described in this document. This employee will also be responsible for implementing and monitoring the GRM with oversight provided by the PMU and PSC.</p>

Gender Specialist	It is advisable that the Project appoint a Gender Specialist to: i) ensure GAP targets are met; and ii) assist with the further development of any planning and mitigation actions related to gender considerations and requirements.
CTCs	The CTCs will assume responsibility for project implementation and progress monitoring at the hub level with oversight and support provided by the ESS Officer. They will have to provide oversight and guidance to all commune level participants in project activities.
Hub and commune level	<p>The CTCs and technical staff will be the main interface between the PMU/ESS Officer and the participating communities. They will assist these communities to actively participate in the identification and planning for project activity interventions, including the risk screening exercises and any inputs into the safe work instructions / method statements development processes.</p> <p>The participant communities need to be involved in the project E&amp;S risk screening exercises at a site-level. They are best placed to contextualise the E&amp;S risk aspects under consideration within their communities and provide input into their overall potential significance at the local scale. This exercise can also serve as a platform to sensitise communities to the potential E&amp;S risks associated with project activities, as well as utilise their inputs to develop and refine the management and mitigation measures that will be subject to formal planning interventions - specifically the safe work instructions / method statements.</p> <p>The participating communities will also be the main source of the project's labour needs for activities such as landscape rehabilitation, infrastructure construction and water source maintenance interventions etc. It is essential therefore that in the project identification and E&amp;S risk screening phases that the skills requirements for these activities, and the existing capacity within these communities, is appropriately assessed with the aim of identifying the necessary training interventions that will be required going forward.</p> <p>Water-user groups (WUGs) will also play a significant role in these activities once established at the individual hub level.</p>

### 9.3 Capacities of project personnel to implement the ESMP

During the project inception phase, a training and capacity-building needs analysis will be performed on all project personnel — including any technical staff that may be represented in the PMU — to ensure that they have the requisite skills to implement the project activities and are sufficiently competent and confident to undertake the ESMP implementation and project monitoring and evaluation processes. Based on the outcomes of these analyses, all project stakeholders will be subject to varying degrees of capacity-building and training initiatives.

The PSC will assume overall responsibility for ensuring these upskilling and training initiatives are resourced, developed and implemented. It is assumed that: i) PSC members will, themselves, be sufficiently capacitated on the Project Intervention Strategy modalities and implementation requirements; and ii) the training needs of the PSC will be minimal in comparison to the PMU and hub-level CTC upskilling requirements.

Further detail on the project ESMP implementation roles, responsibilities and capacity-building requirements are detailed in Annex 6.

### 9.4 Stakeholder consultation

To date, extensive stakeholder consultations have informed the project preparation process. The full Stakeholder Engagement Plan is presented in Annex 7: Stakeholder Engagement Plan, which includes the full list of stakeholders consulted and a summary of their feedback. The results of stakeholder consultations have closely informed the design of the proposed project and development of the ESMP. These consultations are expected to continue during the implementation phase, to ensure regular communication between project personnel and affected communities. Accordingly, a participatory approach will be used when conducting E&S risk screening exercises, such that local

community members' input is incorporated into activity-level risk registries and associated risk management strategies. As a minimum, it is recommended that specific Stakeholder Engagement Plans be developed for each project Outcome, since each activity set will have different consultation requirements, stakeholders and E&S risks.

### 9.5 *Project grievance redress mechanism*

A Grievance Redress Mechanism (GRM) has been developed for this project and are described in detail in Chapter 9 of the ESMP (Annex 6). The proposed mechanism is compatible with Mauritanian legislation and compliant with UNEP and GCF standards, enabling any project stakeholders with complaints or grievances related to the project to communicate their concerns through an appropriate process. The GRM will be available to stakeholders at all stages of the project and will provide an accessible, rapid, fair and effective response to concerned community members — including any vulnerable groups that may lack access to formal legal systems or support.

All project grievances (both internal and external) will be resolved using the steps below, with the hub-level CTCs assuming most of the duties and responsibilities in this regard:

- **Step 1.** Receipt of complaint/grievance;
- **Step 2.** Acknowledgement of complaint/grievance;
- **Step 3.** Assessment, investigation and resolution of complaint/grievance;
- **Step 4.** Closure of investigation and redress process; and
- **Step 5.** Outcome of the corrective action is verified with the complainant.

The GCF<sup>1042</sup> Independent Redress Mechanism (IRM) will also be available to stakeholders and affected persons who have grievances or issues relevant to the project's activities. The GCF IRM operates independently from the proposed Project GRM to address complaints and grievances from those adversely impacted by GCF projects or programmes. It verifies eligibility, engages relevant parties for problem resolution, and conducts compliance appraisals if necessary. The IRM works with stakeholders to develop a jointly agreed problem-solving process or refers the case for compliance review. It conducts independent compliance investigations, ensuring adherence to GCF policies and procedures, and makes recommendations to the GCF Board for appropriate redress.

### 9.6 *Monitoring and evaluation (M&E)*

The M&E objectives are:

- To confirm compliance with commitments to any applicable legislative and non-legislative E&S standards that the Project will adhere to;
- To provide early warning of potential impacts, determine the extent of predicted impacts and identify any unforeseen impacts associated with Project activities;
- To provide feedback on the adequacy of E&S risk management practices and allow for improved practices to be developed to continuously improve performance;
- To detect and measure E&S trends or changes and enable the analysis of their root cause; and
- To provide Project management structures with information and data that can be used as a basis for informed decision making.

The primary M&E indicators for assessing project implementation, execution progress, evaluation, and success will be based on performance related to Outcome 1 and 2 sub-activities and deliverables, as detailed in Appendix 3 of Annex 6.

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<sup>1042</sup> [About the IRM | Independent Redress Mechanism | Green Climate Fund](#)

## 10 Market study

A high-level market study has been conducted to illustrate the feasibility of climate-smart agriculture within the proposed project's target region. The overview provided here identifies several viable crop species, apart from palm dates, that can be grown within the target region — potentially underneath palm date plantation (agroforestry). The findings of the market study also suggest that implementing CSA practices within the target region will enhance income generation within the twelve priority communes, since CSA practices — which are based on the use of climate-resilient seed varieties and the efficient use of agricultural inputs (water, organic compost etc.) — are generally associated with: i) increased crop yields; and ii) improved crop quality.

### 10.1 Viable agricultural species for agroforestry and market gardening

Date palms are the most widely grown agricultural species within the proposed project's target region; however, additional opportunities for income diversification and agricultural value-chain development exist within the twelve priority communes.

Other agricultural crops successfully produced within the four target hubs, albeit on a smaller scale, include:

- vegetables such as carrots, tomatoes and cabbages;
- cereals such as wheat, barley and alfalfa; and
- henna.

A detailed description of the small-scale crop varieties grown in the four target hubs is provided in Section 1.6 above.

Small-scale vegetable production, particularly through oasis-irrigated market gardens, is important as a potential source of income generation for women and the youth. Seed sowing for market gardens across the four hubs generally takes place in November, with harvesting occurring in April. As a result of this seasonality, income generation through market gardens only occurs during certain times of the year

Flood recession agriculture occurs primarily in lowlands or behind dams on sandy loam soils. This conventional agricultural technique produces an average annual yield of 0.6 tonnes/ha, which mainly consists of sorghum and cowpea. Seed sowing under flood recession is done in October, while crops are harvested in February. Rainfed crops — including sorghum, wheat and barley — heavily depend on rainfall and produce average annual yields of 0.4 tonnes/ha. Seeds for rainfed crops are sown in June, with harvesting occurring in November and December.

The installation of water-harvesting and -storage infrastructure and the use of drip irrigation kits (CSA) may improve crop productivity outside of conventional growing seasons, which are highly dependent on rainfall patterns.

### 10.2 Market overview

Table 1 provides the most recent value of some common crop types grown in Hodh El Gharbi and Adrar — two of the proposed project's target wilayah. Data pertaining to the remaining two wilayah (Tagant and Hogg Ech Chargui) are not readily available.

**Table 74.** Summary of the most recent food prices for different cash crops grown in Hodh El Gharbi and Adrar wilayahs<sup>1043</sup>.

Wilayah	Nearest local market	Category of commodity	Type of commodity	Value (MRU) per kilogram	Value (USD) per kilogram	Date
Hodh El Gharbi	Twil	Cereals and tubers	Maize (local)	18.92	0.52	15 Jan 2023
			Pasta (macaroni)	42.71	1.18	
			Rice (imported)	36.0	0.99	
			Rice (local)	34.17	0.94	
			Sorghum ( <i>r'haya</i> )	22.25	0.61	
			Wheat flour	27.35	0.75	
			Wheat meal	30.0	0.83	
		Pulses and nuts	Beans ( <i>niebe</i> )	95.0	2.61	
Adrar	Quadane	Cereals and tubers	Pasta (macaroni)	50.0	1.34	15 Dec 2022
			Rice (imported)	40.0	1.07	
			Rice (local)	40.0	1.07	
			Wheat	30.0	0.81	
			Wheat flour	40.0	1.0738	
			Wheat meal	35.0	0.94	
		Pulses and nuts	Beans ( <i>niebe</i> )	140.0	3.76	

### 10.2.1 Markets for offloading produce

The distribution of domestic cereal functions reasonably well in all areas where people have regular access to urban centres, which are important for food procurement. These areas, predominantly located in the central and southern regions of the country, are home to the bulk of the population, who mainly receive food supplies from Nouakchott — the country's main distribution centre. In contrast, in more secluded and remote areas like Aftout and Affolé (rural communes), the market distribution leans more towards regional capitals than departmental ones. It has also become common for households in rural areas to depend on cereal remittances from family members living in cities such as Nouakchott, Nouadhibou, and Zouerate. This shift has led to a significant decline in market food purchases, which would usually be the only source of food once households deplete their reserves<sup>1044</sup>. Since access to urban markets is limited in rural areas, there is a need to develop value chains within the target region. Establishing local markets for the sale of agricultural produce presents an important opportunity for enhanced income generation and resilience to climate change impacts in the rural-urban hubs of Aoujeft, Rachid, Tamcheket and Nema.

<sup>1043</sup> Humanitarian Data Exchange. Mauritania – Food Prices. Available at: <https://data.humdata.org/dataset/wfp-food-prices-for-mauritania>

<sup>1044</sup> Famine Early Warning Systems Network. 2012. Mauritania Summary of Food Security Outlook. Available at: <https://fews.net/west-africa/mauritania/food-security-outlook/february-2012#market-context>

### 10.3 Evidence for financial benefits of CSA

As described in Section 5 above, in 2020, the WB compiled a country profile outlining best practices for CSA in Mali, which shares a border with Mauritania and is characterised by a similar arid environment. To counter the threat of climate change-induced desertification and improve crop production in Mali, several climate-smart practices have been prioritised, including:

- the use of improved varieties that are drought-tolerant and fast-growing;
- drip irrigation;
- composting — to increase soil fertility;
- fertiliser microdosing;
- urea deep placement; and
- soil and water conservation.

Farmer-managed natural regeneration (FMNR), particularly in the context of reducing desertification, has also become increasingly common. Generally, forestry and agroforestry have been promoted, with stands of *Senegalia senegal* (formerly *Acacia senegal*) commonly planted for the extraction of gum Arabic — a food additive used in a wide variety of products produced globally, including soft drinks. Additionally, academic research has found evidence that drip irrigation and *zai* pits<sup>921</sup> have favourable impact potential across all three CSA pillars (i.e., productivity, resilience, and emissions)<sup>922</sup>. In 2014, a terminal evaluation of the WB-supported program titled '*The West Africa Agricultural Productivity Program*', found that ~175,000 farmers who had used at least one of the abovementioned CSA technologies experienced an average increase in agricultural yield and income of ~30% and ~34%, respectively<sup>1045</sup>.

If a similar yield increase is applied in Mauritania, those practicing flood recession agriculture (annual yield of 0.6 tonnes/ha) could expect to produce yields of ~0.78 tonnes/ha, while those practicing rainfed agriculture (annual yield of 0.4 tonnes per year) could expect yields of ~0.52 tonnes/ha.

By way of example — using the figures presented in Table 62 above — a farmer using conventional farming methods to grow maize in the wilayah of Hodh Chargui might produce ~0.6 tonnes of maize on a hectare of land. If the total yield were sold at the global commodity price (USD0.52/ha), this would generate ~USD322 of income. In contrast, a farmer using CSA practices within Hodh Chargui (~30% yield increase) might generate ~0.78 tonnes of maize on an agricultural plot of the same size. If sold at the same price, the CSA-yield would generate ~USD405. This example illustrates extent to which CSA techniques will provide opportunities for enhanced income generation within the proposed project's target regions.

Further support for the financial benefits of CSA is provided in Annex 3: Financial and Economic Analysis.

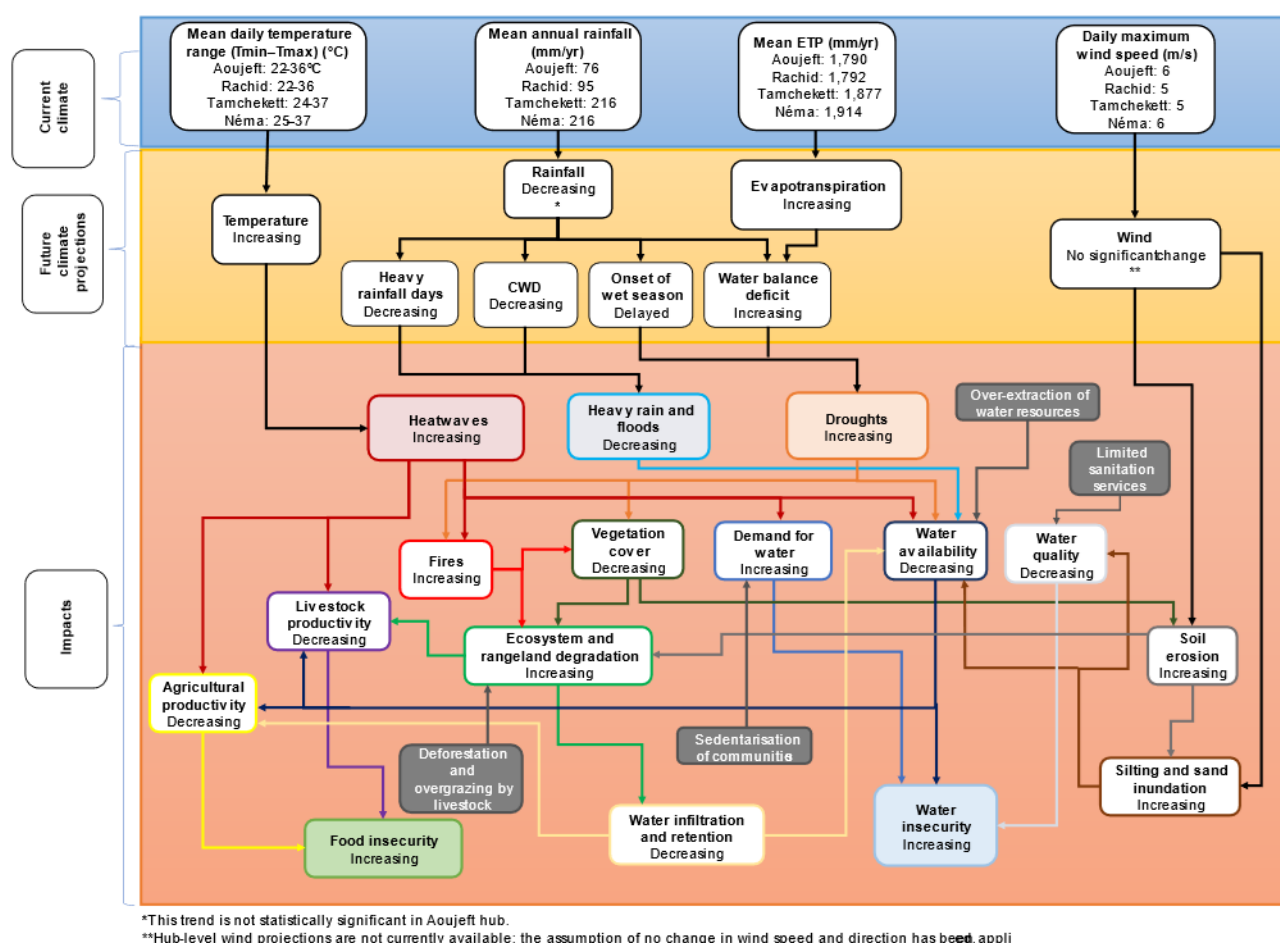
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<sup>1045</sup> WB. 2014. The West Africa Agricultural Productivity Program: a major boost for agriculture in Mali. WB: Washington, DC. Available at: <http://www.worldbank.org>

## 11 Detailed project description

A project description was developed based on the analyses described in this Feasibility Study. The description includes the problem tree, a comprehensive explanation of outcomes, outputs and activities, and details the interventions chosen from the options analysis (see Appendix 6: Adaptation options and multi-criteria analysis). This section comprises a detailed version of the project description included in the Funding Proposal.

The problem tree diagram (Figure 140) provides an overview of the climate change projections and impacts to be addressed within the target regions of the proposed project. This diagram was developed based on available climate change data (as presented in this Feasibility Study), expert opinion and community consultations held in the four target hubs of Aoujeft, Rachid, Tamcheket and Nema. During these consultations, national experts and other relevant stakeholders elaborated on perceived climate change trends and impacts.



**Figure 140.** Problem-tree diagram.

The objective of the proposed project is to employ an ecosystem-based adaptation (EbA) approach to enhance the resilience of communities and ecosystems against the impacts of climate change-induced desertification in the Sahara-Sahel boundary of Mauritania. The project will focus on four rural-urban hubs: Aoujeft (in the Adrar wilayah), Rachid (in the Tagant wilayah), Tamcheket (in the Hodh El Gharbi wilayah) and Nema (in the Hodh Chargui wilayah).

To achieve this, the GCF Funding Proposal has been designed in accordance with the 'ecosystem-based management of terrestrial and freshwater ecosystems' paradigm-shifting pathway identified



within the GCF Ecosystem and Ecosystem Services Sectoral Guide<sup>1046</sup>. This pathway is underpinned by four pillars, namely: i) transformational planning and programming; ii) catalysing climate innovation; iii) mobilising finance at scale; and iv) building coalitions and knowledge to scale up success. Alignment of the proposed project outputs with these four pillars is depicted in Table 75 below, while further detail regarding the project design is provided in the text to follow.

**Table 75.** Links between project activities and the four paradigm-shifting pathways to achieve climate resilient ecosystems and ecosystem services.

Transformational planning and programming	Catalysing climate innovation	Mobilising finance at scale	Establishing coalitions and enhancing knowledge to scale up success
<ul style="list-style-type: none"> <li>Develop commune-level coordination platforms for climate change adaptation and sustainable natural resource management (Activity 1.1.1).</li> <li>Establish community-level WUGs (Activity 2.2.1).</li> </ul>	<ul style="list-style-type: none"> <li>Establish a small grants facility to improve access to finance for upscaling EbA activities and sustainable, agricultural livelihoods (Activity 2.3.2).</li> <li>Enhance the provision of ecosystem services through EbA activities (Activities 2.1.1).</li> <li>Install green-grey dune fixation infrastructure to protect critical areas from sand inundation (Activity 2.1.1).</li> <li>Introduce practices and technologies for climate-resilient and sustainable agricultural practices and alternative livelihoods that can be scaled up through traditional information-sharing systems (Activities 2.3.1).</li> <li>Install rainwater harvesting systems and aquifer recharge infrastructure (Activity 2.2.2, Activity 2.2.3).</li> </ul>	<ul style="list-style-type: none"> <li>Facilitate and promote investment in upscaling successful EbA measures and agricultural-based livelihoods in each target hub (Activity 2.3.2).</li> <li>Implement an on-granting mechanism within the target hubs (Activity 2.3.2)</li> <li>Develop budget briefs for channelling regional government funds (within existing fiscal space) towards the SGF established under the proposed project (Activity 2.3.2).</li> </ul>	<ul style="list-style-type: none"> <li>Develop a knowledge base on climate change adaptation best practices (Activity 1.2.1).</li> <li>Establish the following coalitions for improved coordination and knowledge sharing: <ul style="list-style-type: none"> <li>commune-level technical committees (CTCs) (Activity 1.1.1);</li> <li>community-level decision-making groups (Activity 2.1.1)</li> <li>commune-level livestock cooperatives (Activity 2.3.1); and</li> <li>water-user groups (WUGs) (Activity 2.2.1).</li> </ul> </li> <li>Community capacity-building and awareness-raising about monitoring and reporting mechanisms pertaining to the on-granting mechanism and Small Grants Facility (SGF) (Activity 2.3.2).</li> <li>Train communities on the application and maintenance of physical infrastructure for preventing sand inundation and practices that support climate resilience livelihoods (Activity 2.1.1, Activity 2.3.1).</li> <li>Undertake large-scale hydrogeological assessments on surface and groundwater (Activity 2.2.1).</li> <li>Train WUG members on disseminating knowledge on the installation, use and maintenance of rainwater harvesting systems (Activity 2.2.1).</li> </ul>

### 11.1 Outcome 1

**Outcome 1.** Increased implementation and upscaling of Ecosystem-based Adaptation (EbA) measures across the Sahara-Sahel boundary in Mauritania.

Outcome 1 will contribute to creating an enabling environment for climate change and gender-responsive land-use planning and natural resource management at the sub-national level in

<sup>1046</sup> GCF. 2022. Ecosystem and Ecosystem Services Sectoral Guide. Sectoral Guide Series. Yeosu: Green Climate Fund.

Mauritania. This will enhance the long-term sustainability and scalability of climate resilience-building interventions across the Sahara-Sahel boundary. Output 1.1 will strengthen governance structures to support the integration of climate change considerations and Ecosystem-based Adaptation (EbA) into government plans, policies and budgets. This will be achieved by establishing and training coordination committees to facilitate natural resource management, sustainable land-use planning, EbA implementation and knowledge sharing at regional and local levels. Output 1.2 will focus on developing and disseminating knowledge products that support informed decision-making for climate change adaptation. Knowledge products generated under the project will include training manuals developed under the project, lessons learned and best practices identified by both experts and local stakeholders, and monitoring and evaluation reports. These knowledge products will be disseminated to stakeholders using the NAP Knowledge Management Platform, which is currently under development, to ensure alignment with Mauritania's ongoing NAP efforts.

### 11.1.1 Output 1.1

**Output 1.1.** Governance structures are strengthened to support the implementation of EbA measures and the integration of climate change considerations and EbA into government plans, policies and budgets.

#### **Baseline**

##### *Governance structures*

At the national level, The Ministry of Environment and Sustainable Development (MEDD) and the National Climate Change Program Coordination Unit (CCNPCC) coordinate and implement Mauritania's climate change policies and programmes. The MEDD is responsible for climate policy development, integrating climate change into national-level environmental and development frameworks, and facilitating cross-sectoral coordination through the National Committee on Climate Change (NCCC)<sup>1047</sup>. The legal and policy framework in Mauritania also incorporates provisions for adaptation to climate change at the national level. These provisions are outlined in the 2015 Intended Nationally Determined Contribution (NDC)<sup>1048</sup>, the National Sustainable Development Strategy (SNEDD)<sup>1049</sup> and the National Environment Action Plan (PANE II)<sup>1050</sup>.

The sub-national governance system in Mauritania comprises four administrative divisions. From the broadest scale to the finest scale, these administrative divisions include: i) *wilayahs* (regions); ii) *moughataa*<sup>1051</sup> (departments); iii) *arrondissements* (districts); and iv) communes, which consist of several villages centred around a commercial focal point. Each *wilayah* is governed by a *wali*; each department is overseen by a *hakem* ('prefect'); each *arrondissement* is governed by a *sous-prefet* ('sub-prefect') and each commune is led by a mayor<sup>1052</sup>. This legal framework provides for the decentralisation of national government directorates — including the treasury, economic and social affairs, agriculture and water — to streamline the country's institutional environment and decision-making processes, as recommended by the 1995 Declaration of Municipal Policy<sup>1053</sup>. In practice, however, the gradual transfer of powers from national authorities to regional and local authorities has seen limited implementation. Accordingly, there is a need for enhanced coordination across sectors and administrative levels in Mauritania.

<sup>1047</sup> GoM. 2023. Ministère de l'Environnement et du Développement Durable. Available at:

<http://www.environnement.gov.mr/fr/index.php/features/mission-vision>

<sup>1048</sup> World Bank. 2016. (Intended) Nationally Determined Contribution — Mauritania. Available at:

[http://spappssecext.worldbank.org/sites/indc/PDF\\_Library/mr.pdf](http://spappssecext.worldbank.org/sites/indc/PDF_Library/mr.pdf)

<sup>1049</sup> GoM. 2017. Available at: <https://www.fao.org/faolex/results/details/es/c/LEX-FAOC175844/#:~:text=Sp%C3%A9cifiquement%2C%20la%20SNEDD%20vise%20%C3%A0,%C3%A9cosyst%C3%A9miques%20et%20des%20ressources%20naturelles>. Accessed on 27 August 2022.

<sup>1050</sup> GoM. 2012. Plan d'Action National pour l'Environnement 2012-2016 (PANE II). Available at: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC146663>. Accessed on 27 August 2022.

<sup>1051</sup> Administrative division below the level of *wilayah*.

<sup>1052</sup> GoM. 1995. Livre blanc de la décentralisation en Mauritanie [White paper on decentralisation in Mauritania].

<sup>1053</sup> GoM. 1995. Livre blanc de la décentralisation en Mauritanie [White paper on decentralisation in Mauritania].

To this end, several baseline initiatives have enhanced cross-sectoral coordination, planning and monitoring for environmental and sustainable development in Mauritania. For example, in 2006, Regional Delegations for Environment and Sustainable Development (DREDDs) were established in each wilayah, to lead and coordinate MEDD interventions at the provincial level and ensure regional alignment with national environmental policies, strategies and plans<sup>1054</sup>. Each DREDD is led by a regional MEDD representative, who oversees a team of technical specialists in various portfolios, including hydrology (hydraulics), agriculture, livestock, economics, women and children, education, and science and technology. The DREDD technical team ensures that all operations undertaken by the MEDD are in alignment with other ministries' priorities. The DREDDs meet regularly with national-, wilayah-, moughataa- and commune-level authorities, to gather information and coordinate environmental activities across all administrative levels.

Additionally, in 2012, the Prime Minister established the National Council for the Environment and Sustainable Development (CNEDD), to promote intersectoral consultation and coordination on the environment and sustainable development. The CNEDD council decides on policies, strategies and work programs, produces execution reports and gives recommendations for more efficient management of environmental action at the political, technical and local levels. Subsidiaries of the CNEDD include: i) the Permanent Environment and Sustainable Development Committee (CP); ii) the Technical Committee for Environment and Sustainable Development (CTEDD); and iii) the Regional Environment and Sustainable Development Committees (CREDD). These subsidiaries were responsible for implementing activities under the National Action Plan for Environment and Sustainable Development (PANEDD)<sup>1055</sup> (2017–2021); however, their roles have largely been absorbed by the DREDDs. Moreover, by 2014, most of the GoM's ministries had appointed designated focal points for climate change<sup>1056</sup>, while at the community level, Associations for the Management of Natural Resources (AGLCs<sup>1057</sup>) were established — predominantly in the Hodh El Gharbi wilayah — to support the sustainable management of natural resources in rural areas<sup>1058</sup>.

Several donor-funded initiatives have also been implemented to improve CCA coordination. For example, activities under the 2014–2019 PARSACC Project — implemented by the World Food Programme — village management committees were established in two of the proposed project's target wilayah: Hodh El Gharbi and Hodh Ech Chargui. Additionally, the ongoing GEF project titled *'Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania'* (2016) aims to strengthen technical and institutional capacity at various levels by: i) establishing new AGLCs; ii) training existing AGLC management committees on the use of EbA; iii) and developing community-level Climate Action Plans (CAPs) with a gender focus in the Guidimaka, Assaba, Hodh El Gharbi and Hodh Ech Chargui wilayahs. Finally, the International Fund for Agricultural Development (IFAD), in partnership with the MEDD, facilitated the creation of Participatory Oasis Management Associations (Association de gestion participative des oasis, or AGPOs) under the Oasis Sustainable Development Programme (*Programme de développement durable des oasis*, or PDDO). These community-based organisations have played a central role in developing oases in Mauritania's desert landscapes. By September 2014, 96 AGPOs had been established, with more than 135,000 members across the country. Across the proposed project's four target hubs there are approximately 29 AGPOs; however, these organisations operate at the scale of oases, and not communes. Commune-level coordination bodies are, therefore, needed to coordinate fragmented efforts by the AGPOs and minimise the duplication of climate change adaptation interventions.

Under the proposed project, members of community-level organisations such as the AGPOs and AGLCs, along with representatives from DREDDs and CREDDs, will be engaged during the

<sup>1054</sup> Délégation Régionale de l'Environnement et du Développement Durable

<sup>1055</sup> <https://www.iowater.org/avancementdenosprojets/mauritania-national-action-plan-nature-and-environment-pane>

<sup>1056</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

<sup>1057</sup> Association de Gestion Locale Collective des ressources naturelles. Located mainly in Hodh El Gharbi.

<sup>1058</sup> GEF. 2016. Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/5580>

implementation of the proposed GCF Funding Proposal. These stakeholders will be invited to join coordination committees (CTCs) established under the project, to promote knowledge-sharing and coordination among target communities within the region.

### Project approach

The proposed project will enhance coordination and technical capacity for CCA across the four target hubs by establishing commune-level technical committees (CTCs) in 12 priority communes across Aoujeft, Rachid, Tamchekett and Néma (process for selection of priority communes is detailed in Section 6 of Annex 2: Feasibility Study). Each CTC will be chaired by the respective commune's mayor, with members comprising:

- DREDD representatives;
- AGLC and AGPO representatives;
- 1-2 members of the Communal Council;
- civil society representatives; and
- local community members.

The CTCs will be trained by extension officers from the MEDD and DREDDs to supervise, manage and upscale CCA measures introduced under Output 2.1, Output 2.2 and Output 2.3 of the proposed project. Additionally, the CTCs will coordinate knowledge-sharing between local community members, commune-level authorities (mayors) and regional authorities (DREDDs and walis).

These objectives will be delivered via Activity 1.1.1, described in detail below.

**Activity 1.1.1.** Establish coordination platforms to facilitate knowledge sharing, natural-resource management, sustainable land-use planning and the implementation of EbA activities at regional and local levels.

Under Activity 1.1.1, the proposed GCF project will:

- establish 12 commune-level technical committees (CTCs) across the four target hubs;
- enhance capacity for coordination and knowledge-sharing between local and regional stakeholders within the target hubs; and
- support the integration of climate change considerations and EbA into sub-national plans, policies and budgets.

To maximise the impact potential project activities, given the finite nature of financial resources and human capital<sup>1059</sup>, CTCs will be established within the 12 priority communes targeted by the project, with the view to upscale project interventions to additional communes in the future. In September 2022, a site selection workshop was held with national experts in Mauritania, to identify priority target communes for project interventions. During the workshop, a statistical tool was used to score and rank each of the 24 potential target communes according to their adaptation needs. For each commune, a score sheet comprising eight risk categories (Annex 2: Appendix 7) was completed by local consultants and the weighted average of all eight scores was calculated as a proxy for adaptation priority.

Maximising the impact of CCA interventions within the highest ranking (i.e., most vulnerable and exposed) target communes will be critical for protecting key infrastructure and ecosystems within the target rural-urban hubs against the impacts of desertification. Accordingly, the 12 communes with the highest final scores were selected as final target sites for proposed project interventions (Table 76). The selection process used to identify target communes is described in greater detail in Section 6 of Annex 2: Feasibility Study.

**Table 76.** The 12 priority communes for the proposed project

<sup>1059</sup> Human capital describes the skills, knowledge, and experience possessed by individuals or a population, viewed in terms of their value or cost to an organisation or country.

	Hub			
	Aoujeft	Rachid	Tamcheket	Nema
<b>Target communes</b>	Ain Savra El Medah Maeden Aoujeft	Tidjikja El Wahat	El Mabrouk Guaet Teidouma	Oualata N'Beiket Lahwach Noual Jreif

Under the proposed project, a single CTC will be established within each priority commune. Representatives of the CTCs will coordinate with DREDD directorates in each target wilayah to oversee mandates to:

- enhance cross-sectoral coordination for CCA between national, regional and local stakeholders;
- ensure that target communities' needs and concerns are considered when developing and implementing natural-resource management and sustainable land-use plans and policies;
- facilitate two-way information- and knowledge-sharing between local-level stakeholders and regional authorities<sup>1060</sup>;
- support the training of community members to implement and maintain adaptation interventions introduced under proposed the project;
- support the integration of climate change considerations into regional- and commune-level policies, plans and budgets for natural-resources management and land-use planning; and
- develop the technical and institutional capacities of relevant stakeholders to drive scalable and sustainable climate action.

In accordance with Mauritanian law, the 12 CTCs will be formally established via announcement; however, over the course of the project, their legitimacy in the relevant legislature will also be sought via registration with the Ministry of the Interior. Formalisation of these project structures will maintain their medium- to long-term sustainability and facilitate community ownership of project activities beyond the project implementation period.

Each CTC will be chaired by the mayor of its respective commune and members will include, *inter alia*, representatives from the regional environmental delegation (DREDD), and 1-2 members of the Communal Council. Community representation will include members of established civil society organisations (CSOs) in the four target hubs — for example, AGLCs, AGPOs and Breeders' Associations — along with elected local community members from each village within the commune. The inclusion of local community members and CSOs in the CTCs will enable: i) community input towards decision-making processes; ii) transparency and effective communication between project coordinators and communities; and iii) knowledge-sharing and improved community access to information. Notably, existing community structures and systems — such as already established AGLCs — will be leveraged, where applicable, to accelerate the establishment of the CTCs and support their sustainability.

To strengthen the technical and executing capacities of the CTCs in the four hubs, regular training workshops focused on the design and implementation of context-specific adaptation interventions will be provided by MEDD extension officers, with support from the Project Management Unit (PMU). These training workshops will focus on designing, implementing and managing on-the-ground interventions, including: i) EbA solutions and physical measures for dune fixation and rehabilitation of degraded ecosystems; ii) climate-smart agricultural and livestock practices; iii) diversified and natural resource-based livelihoods; iv) climate-resilient water resource management; and v) channelling funds generated from enhanced ecosystem services and sustainable agricultural-based livelihoods towards reinvestment in the operation, maintenance and upscaling of successful project interventions

<sup>1060</sup> CTCs will provide a platform for regular engagement between stakeholders at all administrative levels. This will facilitate the two-way flow of information between representatives at the village-, commune-, moughataa, wilayah- and national levels, as shown in Table 10.

CTC training handbooks will be developed by a National Consultant (NC) specialising in environmental management and all material related to EbA measures for dune fixation and ecosystem restoration will follow the principles outlined in the EbA handbooks developed under the GEF-funded '*Climate change adaptation and livelihoods in three arid regions of Mauritania*' project. Once the training material has been developed and approved by MEDD officials, annual one-day workshops will be hosted in each priority commune and delivered to CTC members. This training will enhance coordination and knowledge-sharing between national-, regional- and local-level stakeholders, while capacitating CTCs to implement and manage project activities in a gender-responsive manner. All training materials developed under Output 1.1 will be stored and disseminated via Mauritania's NAP knowledge management platform, described in further detail below, to align with knowledge management activities implemented under Output 1.2.

To strengthen stakeholders' capacities for coordination and knowledge management across multiple levels, a one-day knowledge-management workshop will be hosted in each target hub during the first year of project implementation. These workshops will focus on training CTCs members to access, generate and disseminate adaptation best practices through existing climate knowledge-management platforms developed under the National Adaptation Plan (NAP). This will strengthen institutional capacity to deliver Output 1.2, which focuses on knowledge management.

The proposed project will also strengthen institutional capacity for CCA by supporting efforts to mainstream climate change and gender considerations into regional policies, plans and budgets. This will ensure that the CTCs' mandates are clear and funds are available to support their operations in the long term. A National Consultant (policy expert) will be contracted to review all existing wilayah-, moughataa-, and commune-level development plans, policies and budgets for the target region. Based on this analysis, the NC will prepare policy briefs for integrating climate considerations and gender-responsiveness into these documents. Training workshops will then be convened to present and validate the prepared policy briefs to representatives from relevant government ministries and departments and to support the integration of climate change in regional- and commune-level policies, plans and budgets.

Sub-activities implemented to deliver this activity are:

- **Sub-activity 1.1.1.1.** Establish commune-level technical committees (CTCs) within each priority commune in the four target hubs.
- **Sub-activity 1.1.1.2.** Deliver training workshops to CTCs, enhancing members' capacities to implement and manage project activities, support the integration of climate change in regional- and commune-level policies, plans and budgets, and facilitate knowledge sharing between regional- and local-level stakeholders.
- **Sub-activity 1.1.1.3.** Train CTC members and government staff to use the NAP Knowledge Management Platform and facilitate the collection and dissemination of climate information and adaptation best practices by CTC members.
- **Sub-activity 1.1.1.4.** Conduct a review of existing wilayah-, moughataa- and commune-level development plans, policies and budgets and prepare policy briefs for the integration of climate considerations and gender-responsiveness into these documents.
- **Sub-activity 1.1.1.5.** Convene training workshops for Regional and Communal Councils and relevant sectors to support the integration of climate change in regional- and commune-level policies, plans and budgets, including through the presentation of the policy briefs prepared under Sub-activity 1.1.1.4.

#### 11.1.2 Output 1.2

**Output 1.2.** Knowledge products developed and disseminated to support decision making and upscaling.

#### **Baseline**



### *Knowledge management*

In recent years, climate knowledge management in Mauritania has been improved via various initiatives and collaborations. The GEF-funded EbA South Project (2016–2019) — implemented in Mauritania, China, Nepal and the Seychelles — led to the development of a Long-Term Research Plan (LTRP) to understand the long-term impacts of EbA interventions and enhance the tolerance of socio-economically important species in arid environments. Moreover, the EbA South Project established an online knowledge centre to house EbA best practices, tools for enhancing climate policy, educational resources and other relevant material to facilitate knowledge-sharing and improve access to climate change information in the four pilot countries<sup>1061</sup>.

To further support climate knowledge generation and dissemination in Mauritania, the GoM established the National Adaptation Plan (NAP) and allocated an annual investment of ~USD900,000 from 2021 for its operation and maintenance. Under the ongoing GEF project titled '*Development of an improved and innovative management system for sustainable climate-resilient livelihoods in Mauritania*' (2016), the NAP will be equipped with a knowledge-management platform, and staff capacities for evidence-based knowledge collection and dissemination will be strengthened<sup>1062</sup>. Additionally, under the GCF National Adaptation Programme (NAP) readiness and preparatory support programme, UNEP and the MEDD have initiated the development of a national climate knowledge-management platform to document adaptation interventions and best practices from past and ongoing projects in the region<sup>1063</sup>.

Despite these platforms, several gaps and limitations persist in climate change information generation and dissemination. The NAP platform exist as prototypes, limiting access for end-users, especially in rural areas with low awareness of climate knowledge-management platforms. Additionally, government ministries and departments have limited technical capacities to integrate information from the NAP into natural-resource management policies and plans. As a result, national-level stakeholders seldom pass on information to regional or local levels. Other barriers to climate-knowledge collection and dissemination include: i) limited inter-sectoral collaboration and knowledge-sharing between relevant ministries, departments and stakeholders; ii) limited availability of baseline climate information and data to update climate knowledge; and iii) the need for a clear funding strategy for climate information and adaptation collection and dissemination.

The UNEP-supported NAP Readiness Programme in Mauritania will address some of these gaps by enhancing the capacity of policymakers, decision-makers and technical staff.<sup>1064</sup> Moreover, donor-funded initiatives — such as the ongoing GCF-funded '*Africa Integrated Climate Risk Management Programme*' (2018)<sup>1065</sup> — contribute considerably to building resilience and adaptive capacity through effective knowledge management in the country.

While progress has been made in climate knowledge management, further efforts are needed to address capacity gaps, limitations and barriers hindering effective integration of CCA into national policies, strategies and governance structures. This GCF Funding Proposal will build on existing efforts to enhance Mauritania's capacity for climate change knowledge management by training regional- and local-level stakeholders to effectively use the existing NAP knowledge management platform. This will, in turn, enable the generation and dissemination of best practices and lessons learned under the proposed project and drive scalable and sustainable climate action.

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<sup>1061</sup> EbA South. 2023. Knowledge Centre. Available at: <http://www.ebasouth.org/knowledge-centre>

<sup>1062</sup> GEF Scientific and Technical Advisory Panel (STAP). 2016. STAP guidelines for screening GEF projects. Available at: [https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/b493c4bc-0511-ea11-a811-000d3a3370dc/Roadmap/STAPreview\\_b493c4bc-0511-ea11-a811-000d3a3370dc\\_STAPReview.pdf](https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/b493c4bc-0511-ea11-a811-000d3a3370dc/Roadmap/STAPreview_b493c4bc-0511-ea11-a811-000d3a3370dc_STAPReview.pdf)

<sup>1063</sup> MEDD. 2023. Plateforme de la Recherche Scientifique sur L'adaptation aux Changements Climatiques en Mauritanie. Available at: <https://azertyuiop-pna.taiba-consulting.com/>

<sup>1064</sup> GEF Scientific and Technical Advisory Panel (STAP). 2016. STAP guidelines for screening GEF projects. Available at: [https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/b493c4bc-0511-ea11-a811-000d3a3370dc/Roadmap/STAPreview\\_b493c4bc-0511-ea11-a811-000d3a3370dc\\_STAPReview.pdf](https://publicpartnershipdata.azureedge.net/gef/GEFDocuments/b493c4bc-0511-ea11-a811-000d3a3370dc/Roadmap/STAPreview_b493c4bc-0511-ea11-a811-000d3a3370dc_STAPReview.pdf)

<sup>1065</sup> GCF. 2018. The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW). Available at: <https://www.greenclimate.fund/project/fp162>



## Project approach

Over the course of the project implementation period, knowledge products will be developed to capture, *inter alia*:

- all training materials developed under the proposed project;
- all reports produced from workshops, consultations, studies and assessments;
- all plans, policies, policy briefs and strategies developed;
- best practices and lessons learned identified throughout project implementation;
- the results of monitoring and evaluations; and
- community perspectives on project interventions.

These products will serve as a critical resource for informing future adaptation initiatives and ensuring that lessons learned are effectively shared with relevant stakeholders. These knowledge products will be uploaded to the NAP knowledge management platform and made accessible through multiple dissemination channels to ensure widespread reach and uptake. To enhance access to climate change adaptation information for local project beneficiaries, the project will leverage the NAP knowledge management platform alongside other widely used dissemination methods, including local radio broadcasts, SMS systems, awareness-raising campaigns and printed materials distributed through community networks. By integrating digital and traditional communication methods, the project will support informed decision-making at both local and national levels, contributing to the long-term sustainability of adaptation actions.

**Activity 1.2.1.** Develop knowledge products on project lessons learned and best practices through a participatory process engaging the communities.

To ensure that project interventions are responsive to local adaptation needs and generate lasting benefits, Activity 1.2.1 will focus on systematically capturing community perspectives and best practices that emerge throughout project implementation. By integrating participatory approaches, the project will facilitate knowledge exchange between local stakeholders and the Project Management Unit (PMU), enabling adaptive management and the dissemination of successful adaptation strategies that can be referenced when upscaling or replicating climate change adaptation strategies across Mauritania, or when developing new climate change adaptation projects.

Under this activity, bi-annual gender-inclusive discussions will be held between the PMU and communities in the target hubs. These discussions will provide a structured forum for community members to share their experiences, voice concerns and highlight successes and challenges related to project interventions. Ensuring gender inclusivity in these engagements will help capture diverse perspectives, particularly from marginalised groups that may otherwise be excluded from decision-making processes. The insights gained from these discussions will be synthesised into community engagement reports, which will serve as a record of local experiences and provide valuable feedback for refining project implementation strategies.

In parallel, the project will undertake a systematic identification of best practices and lessons learned emerging from project interventions. These knowledge products will be documented in best practice reports, as well as regular M&E reports, capturing successful approaches, lessons learned and strategies that have proven effective in enhancing climate resilience at the community level. These reports will be made accessible to the public via the NAP knowledge management platform and other channels appropriate to the local context (Activity 1.2.2).

By generating and sharing knowledge products that reflect community experiences and successful adaptation practices, this activity will contribute to evidence-based decision-making and capacity building at local, national and regional levels.

Sub-activities contributing to the delivery of Activity 1.2.1. are:

- **Sub-activity 1.2.1.1.** Hold bi-annual gender-inclusive discussions between representatives from the PMU, CTCs and communities in the target hubs on project intervention successes and challenges, and develop these discussions into community engagement reports.
- **Sub-activity 1.2.1.2.** Identify lessons learned and best practices used in project interventions, and develop these into implementation guides and best practice reports.

**Activity 1.2.2.** Enhance the dissemination of adaptation knowledge to sub-national decision-makers and communities to support upscaling.

To ensure that knowledge generated through the project is widely accessible and supports long-term climate change adaptation efforts, the proposed project will facilitate the dissemination of knowledge products through both national and international platforms. The primary mechanism for this will be the NAP knowledge management platform, which is currently under development in Mauritania, where monitoring reports, GCF evaluation reports, community engagement reports, records of the validation workshop, final policy briefs and best practices generated under Activity 1.2.1 will be uploaded and stored. This centralised repository will enhance access to critical adaptation information for policymakers, practitioners and community-level stakeholders.

To extend the reach of these knowledge products beyond digital platforms, the project will strengthen the dissemination of stored materials through community-based communication channels. A communications expert will be consulted to design knowledge-management campaigns that are adapted to the local context. These campaigns will include targeted knowledge-sharing efforts via local radio stations, TV programmes and printed materials such as flyers distributed by DREDD officers. These efforts will ensure that information is accessible to local beneficiaries, including vulnerable populations with limited internet access, thereby supporting enhanced awareness, informed decision-making and the replication of best practices at the community level.

Sub-activities contributing to the delivery of Activity 1.2.2. are:

- **Sub-activity 1.2.2.1.** Upload knowledge products (e.g. implementation guides, monitoring and evaluation reports, community engagement reports, policy briefs, lessons learned and best practice reports) onto the NAP knowledge management platform.
- **Sub-activity 1.2.2.2.** Package knowledge in the NAP knowledge management platform into formats that are accessible at local level (e.g. brochures, TV and radio programmes, awareness-raising materials).
- **Sub-activity 1.2.2.3.** Disseminate locally-accessible knowledge products in target and non-target communes across the four project wilayahs to catalyze upscaling, with support from the DREDDs and CTCs.

## 11.2 Outcome 2

**Outcome 2. Communities in four rural-urban hubs along the Sahara-Sahel boundary in Mauritania have increased livelihood and water security as a result of investment in EbA measures, water access, and sustainable land- and natural resources management practices.**

Outcome 2 will enhance livelihood security for communities in the four target hubs by promoting investment in Ecosystem-based Adaptation (EbA) measures and sustainable land and natural resource-management practices.

To achieve this, Output 2.1 will establish 2,123 hectares of green-grey dune fixation infrastructure across the four target hubs (~5% of the total land area covered by the hubs). This will include: i) ~1,138 ha of protective greenbelts installed along the perimeters of priority communes (Table 76) to serve as a barrier against prevailing winds; and ii) ~985 ha of biological and mechanical dune fixation infrastructure installed around critical infrastructure, as identified by community members and remote sensing analyses (**Error! Reference source not found.** and Table 65). These strategically positioned

dune fixation measures will control sand inundation, enhance the provision of ecosystem services and slow desertification under future climate scenarios.

At the same time, Output 2.2 will improve access to water for agricultural and land rehabilitation activities. This will be achieved by establishing community-managed Water User Groups (WUGs), implementing water monitoring and regulation plans, and installing physical water management infrastructure — including weirs, gabions, check dams, and groundwater storage systems — in each of the target hubs. Additionally, large-capacity rainwater harvesting systems and communal cisterns will be installed to enhance water security for agricultural production and domestic uses.

The final output under Outcome 2, Output 2.3, will strengthen climate-resilient agricultural livelihoods by facilitating the adoption of climate-smart agricultural practices, diversifying income sources, and establishing an on-granting mechanism to support continued investment in EbA-based livelihoods.

Together, these outputs will enhance the long-term sustainability and scalability of climate resilience interventions across the Sahara-Sahel boundary. By addressing key environmental and socio-economic challenges — such as sand encroachment, water scarcity and land degradation — Outcome 2 will ensure that communities have the necessary resources and capacities to adapt to future climate conditions. These efforts align with Outcome 1 by reinforcing institutional support, knowledge sharing and financial mechanisms to scale up EbA measures across the four target hubs.

#### 11.2.1 Output 2.1

**Output 2.1.** Green-grey dune fixation infrastructure is established to control sand encroachment, enhance the provision of ecosystem services and slow the rate of desertification within the four target hubs.

##### **Baseline**

###### *Dune fixation and land rehabilitation*

Mauritania's extreme climatic conditions, characterised by more frequent and intense droughts, have contributed to vegetation loss in fragile oases and accelerated desertification. This climate-induced land degradation is exacerbated by anthropogenic factors such as overgrazing, deforestation and maladaptive land-use practices. For instance, nomadic pastoralists are becoming increasingly sedentary in response to reduced water availability and the decline of rangeland vegetation along traditional transhumance routes. This sedentarisation, in turn, intensifies pressure on oases as populations become increasingly concentrated around and dependent on limited natural resources.

Land degradation and accelerated sand inundation have also directly impacted water resources in the target region, with increased sand encroachment causing the siltation of open surface water bodies. For instance, siltation in Rachid has led to the drying up of seven ephemeral rivers and five wells, while Tamcheket has lost seven *wadis* and Néma at least five. The resulting decline in surface water availability has increased dependence on non-renewable groundwater resources in the region.

To address the impacts of land degradation and sand inundation across Mauritania, several initiatives have been introduced to protect desert landscape ecosystems and biodiversity. For example, under the Great Green Wall (GGW) initiative (2012–ongoing), 3,500 ha of dryland and forest ecosystems will be restored across six wilayah: Trarza, Brakna, Assaba, Tagant, Hodh El Gharbi and Hodh Chargui. As of 2023, GGW restoration activities in Mauritania have: i) planted ~2.2 billion trees; ii) fixed ~2,860 ha of mobile sand dunes; iii) established ~550 ha of fenced protected areas; and iv) produced over 2 million commercially viable plants and seedlings. Consequently, this has protected vulnerable infrastructure from advancing sand dunes and created income-generating opportunities for rural communities by enabling the valorisation of various fruit and non-timber forest products. Furthermore, income-generating activities developed under the GGW initiative have generated

~US\$1.5 billion in revenue since 2007<sup>1066</sup>. Also under the IMPADRA project (2021–ongoing), a new protected area of 200,000 ha of desert landscape is currently being established in the Adrar wilayah to serve as a buffer zone against shifting sands, and a corridor between important biodiversity conservation areas<sup>1067</sup>. A summary of relevant past and ongoing baseline initiatives in Mauritania, and their intersection with the proposed GCF project, is provided in **Error! Reference source not found.** above.

Under these and other projects, several ecosystem restoration and biodiversity conservation activities have already been implemented in the proposed GCF project's target wilayahs, namely: Adrar (Aoujeft), Tagant (Rachid); Hodh El Gharbi (Tamchekett) and Hodh Ech Chargui (Néma).

**Error! Reference source not found.** presents a summary of the estimated number of hectares already covered by dune-fixation infrastructure within the four target wilayahs.

**Table 77.** Estimated area of existing dune-fixation measures within each target wilayah<sup>1068</sup>

Target wilayah	Rural-urban hub	Estimated area of existing dune fixation measures (ha)
Adrar	Aoujeft	500
Tagant	Rachid	250
Hodh El Gharbi	Tamchekett	100
Hodh Ech Chargui	Nema	800

The abovementioned initiatives have generated valuable insights into the effective management of desert ecosystems. Despite this progress, the scale of these initiatives has not been sufficient to combat the extent and rate of desertification being experienced in Mauritania. For instance, an interim evaluation of the PARSACC project (2014–2019) — which facilitated dune fixation, reforestation, soil and water conservation, and the protection of vulnerable infrastructure against sand encroachment, in six southern wilayah, including Tagant, Hodh El Gharbi and Hodh Ech Chargui<sup>1069</sup> — found that only ~15% of the dune-fixation work originally planned by the project had been achieved by 2017. As a result, the PARSACC project's dune fixation target was reduced from 2000 ha to 900 ha, while the reforestation target was reduced from 1500 ha to 400 ha<sup>1070</sup>.

In many instances, the scale of impact achieved by past and ongoing initiatives has been constrained by the limited technical capacities of local-level decision-makers to draw from best practices when planning for EbA. Although poverty-environment objectives have been incorporated into Mauritania's 15-year Growth and Prosperity strategy for 2016–2030 (SCAPP), the National Strategy for Sustainable Development (SNEDD)<sup>1071</sup> and the third national Poverty Reduction Strategy Paper (PRSP 3)<sup>1072</sup>, very few communes across Mauritania have engaged in developing plans for local-level ecosystem restoration, dune fixation or sustainable land management. To illustrate, there is no record of commune-level land-use plans across the 25 communes located in the Aoujeft, Rachid, Tamchekett and Néma hubs. The proposed project will bridge this gap by facilitating the development of local-level ecosystem restoration plans and supporting the

<sup>1066</sup> UNCCD. 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. Available at:

[https://catalogue.unccd.int/1551\\_GGW\\_Report\\_ENG\\_Final\\_040920.pdf](https://catalogue.unccd.int/1551_GGW_Report_ENG_Final_040920.pdf)

<sup>1067</sup> UNEP. 2021. New protected area buffers Mauritania's shifting sands. Available at: <https://www.unep.org/gef/news-and-stories/story/new-protected-area-buffers-mauritanias-shifting-sands>

<sup>1068</sup> JICA. 2004. Oasis Development Project (PDDO) — Annex E: Fixing Sand. Available at:

[https://openjicareport.jica.go.jp/pdf/11775491\\_02.pdf](https://openjicareport.jica.go.jp/pdf/11775491_02.pdf)

<sup>1069</sup> Trarza, Brakna, Gorgol, Tagant, Assaba, Guidimakha, Hodh El Gharbi, and Hodh Ech Chargui

<sup>1070</sup> Saadani Y. 2017. Project of Enhancing Resilience of Communities to the adverse effects of Climate Change on Food Security in Mauritania (PARSACC): Mid-term evaluation. Available at: <https://www.adaptation-fund.org/projects-document-view/?URL=https://pubdocs/en/880911532334932499/pdf/14-MTE-AF-Project-Mauritania-English.pdf>

<sup>1071</sup> UNDP. 2015. Mauritania: Project to support the implementation and monitoring of the Poverty / Environment objectives of the SCAPP and sectoral policies in relation to the SDGs in Mauritania. Available at: <https://pea4sdgs.org/countries/mauritania>

<sup>1072</sup> Sustainable Development Goals Fund. Case study: Mauritania converts national policies into concrete action on natural resource management. Available at: <https://www.sdgsfund.org/sites/default/files/Case%20Study%20-%20MAURITANIA%20-%20EN.pdf>

establishment of community-managed buffer zones and conservation areas within the target rural-urban hubs.

### *Livestock management*

Since the 1960s, climate change has adversely affected livestock management in the target areas. Severe droughts in the 1970s and 1980s led to smaller herds and income loss for many Mauritanian farmers, as livestock accumulation is vital for capital-building in rural communities. Reduced water and fodder availability during these periods prompted a rural exodus among pastoralists. Many sold their livestock to urban investors, who established stationary livestock systems near main roads, offering better access to fodder supplements and administrative services.

This shift to stationary livestock production and population settlement in surrounding areas has contributed to an increase in unsustainable land-use activities, further degrading nearby landscapes. Increased deforestation and woodcutting for fuel and construction have reduced the number of trees providing essential ecosystem services — such as dune stabilisation, water infiltration, fodder production and shading for nomadic communities — within the target region<sup>1073</sup>.

Climate change-induced declines in rangeland vegetation and livestock productivity have also led to transhumant pastoralists expanding their rangelands. This expansion has accelerated ecosystem degradation in areas further away from traditional transhumance routes. Action on land rehabilitation and protection against overgrazing by free-roaming livestock would ensure that the carrying capacity of natural ecosystems is not exceeded.

Several past and ongoing initiatives for the sustainable management of livestock in rural Mauritania have addressed these challenges and yielded positive results (**Error! Reference source not found.**). For example, the PADEL project (2000–2010) enhanced livestock productivity in seven wilayahs<sup>1074</sup> — including Hodh El Gharbi and Hodh Ech Chargui — by, *inter alia*: i) financing water infrastructure (12 boreholes and 45 wells) along historical transhumance routes; ii) facilitating the regeneration of natural rangelands by establishing 4000 ha of grazing reserves and soil scarification; and iii) improving the quality of pastures. In terms of water infrastructure, 12 boreholes and 45 wells were established, while to improve pasture quality, 4000 km of firebreaks were established, 4000 ha of dikes to improve water infiltration were built, 2000 ha of grazing land was enriched with leguminous plants and 200 km of fortified hedges were established. Interventions implemented under the PADEL project benefitted ~40 pastoral associations and livestock cooperatives across the region<sup>1075</sup>.

Regional livestock cooperatives and breeders' associations exist within all of the proposed project's target wilayah; therefore, the proposed project will collaborate with representatives from these organisations — via the commune-level CTCs — to facilitate the adoption of climate-resilient livestock-management practices.

### **Project approach**

The project will stabilise dunes and reduce sand encroachment by utilising EbA dune-fixation measures (green infrastructure) within twelve priority communes across the Aoujeft, Rachid, Tamchekett and Néma hubs. EbA dune stabilisation techniques will include: i) establishing community-managed buffer zones, or protective greenbelts, along priority communes' borders; and ii) utilising both biological and mechanical dune-fixation techniques (described below) to stabilise dunes in vulnerable areas identified by target communities. These EbA measures will be supplemented by fencing (grey infrastructure), which will be installed around newly established dune-stabilisation sites to protect newly planted vegetation from livestock. The exact positioning of buffer

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<sup>1073</sup> Annex 2: Feasibility Study

<sup>1074</sup> Assaba, Gorgol, Brakna, Guidimaka, Trarza and the two Hodhs.

<sup>1075</sup> AfDB. 2010. Project Completion Report: Mauritania - Livestock Development and Range Management Project (PADEL). Available at: <https://projectsportal.afdb.org/dataportal/VPProject/show/P-MR-AAE-002>



zones and fenced-off dune-fixation sites will be finalised during the project implementation stage, through the development of commune-level restoration plans. This will take place in consultation with local community members in each priority commune, using culturally appropriate and site-specific indicators to promote local ownership.

In addition to establishing green-grey infrastructure, the project will train livestock herders in the target communes to implement climate-resilient livestock-management practices. These practices will include rotational grazing, supplementary feeding and 'livestock collar re-seeding'. By incorporating these climate-resilient livestock management practices, the project will enhance the resilience of pastoral livelihoods and reduce pressure on natural resources. This approach will complement the establishment of green-grey infrastructure to control sand encroachment and slow the rate of desertification.

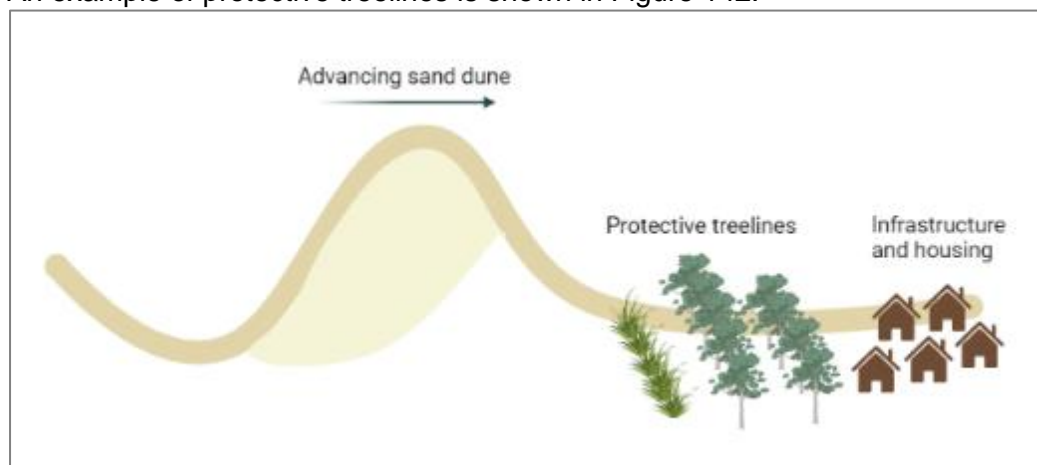
**Activity 2.1.1.** Establish 2,123 hectares of EbA dune-fixation infrastructure and 120 kilometres of protective fencing across the four target hubs, to facilitate the rehabilitation and maintenance of degraded landscapes and enhance ecosystem services related to dune stabilisation and the supply of natural resources.

Under this activity, ~2,123 hectares (ha) of EbA dune-fixation measures will be implemented across the four target hubs. These measures will include:

- ~1,138 ha of protective green belts (buffer zones); and
- ~985 ha of mechanical and biological dune-fixation infrastructure.

Collectively, these measures will help restore ecosystem functions related to dune stabilisation, water infiltration, flood attenuation and the provision of natural resources, such that the impact of desertification on oases and rural-urban centres in the four target hubs is minimised.

The establishment of community-managed green belts in strategic locations will help slow sand encroachment and subsequent desertification under future climate change conditions, with natural vegetation serving as a barrier to approaching sand dunes — as shown in Figure 141. This will involve restoring degraded ecosystems and actively planting protective tree lines along the boundaries of priority communes, to create buffer zones between vulnerable communities and mobile sand dunes. An example of protective treelines is shown in Figure 142.

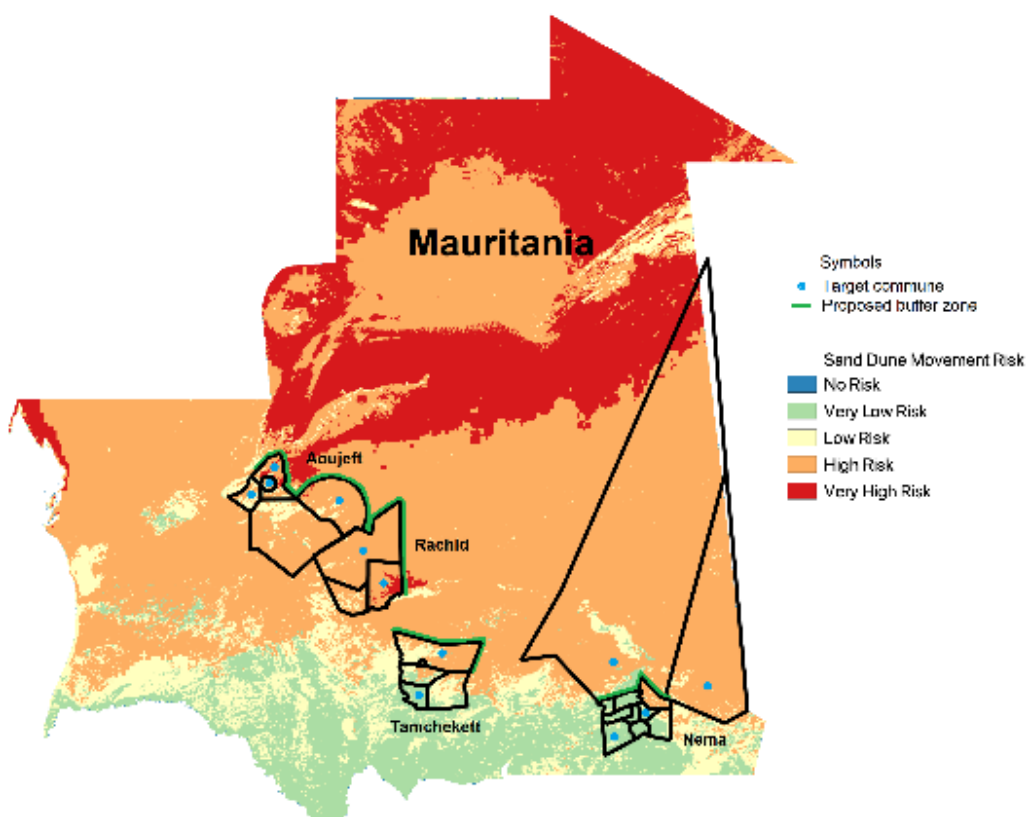


**Figure 141.** The dynamics of protective tree lines for stabilising dunes and protecting settlements against sand encroachment



**Figure 142.** Example of dune stabilisation tree lines planted as part of a previous Adaptation Fund-supported project in Tamcheket.

A preliminary site selection for the establishment of green belts across the four target hubs has already been conducted, as described in Section 6. The preliminary locations of these buffer zones are shown in Figure 143 below, covering a total area of ~1,138 ha.



**Figure 143.** Proposed positioning of community-managed green belts (buffer zones), in which degraded ecosystems will be restored and protective treelines will be planted.



Each green belt will be ~500 m wide, with restored ecosystems and planted treelines forming a continuous barrier against southward-shifting sand dunes. The strategic positioning of these buffer zones along the north-eastern boundaries of Aoujeft, Rachid and Tamcheket will, in turn, shield south-western communes against the impacts of sand encroachment in the long-term.

In Nema hub, the perimeters of Oulata and N'beiket Lehouach (northernmost target communes) are too large to feasibly cover with continuous EbA dune-fixation measures. Instead, smaller buffer zones will be established along the southern boundaries of these communes, as shown in Figure 13 above, to protect all southward-lying target communes against sand encroachment from the north. Using GIS software, the number of hectares of EbA dune-fixation measures needed to establish proposed buffer zones in each hub was calculated (Table 78).

**Table 78.** Total area of EbA dune fixation measures needed to establish proposed buffer zones in each target hub.

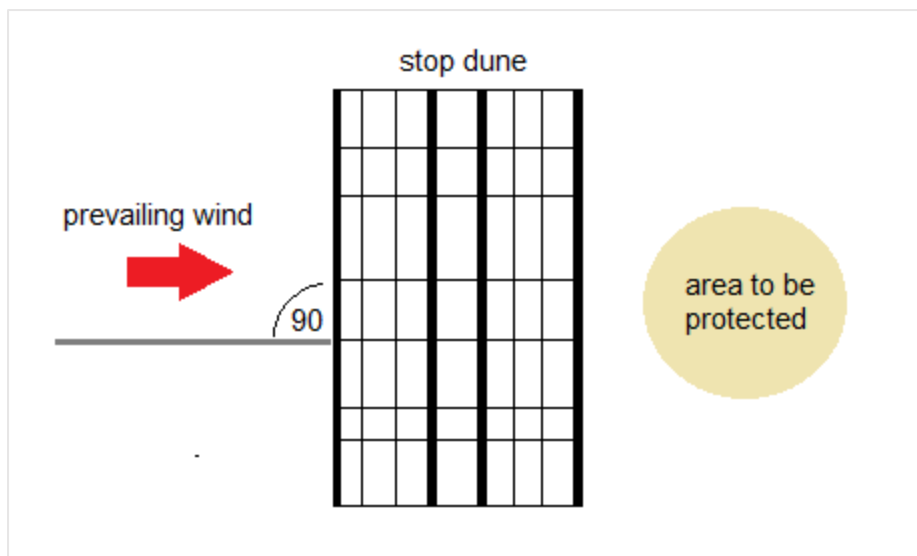
Hub	Area of proposed buffer zone (ha)
Aoujeft	325
Rachid	296
Tamcheket	333
Nema	185
Total	1,139

Since beneficiary populations in the more northern communes of Oulata and N'beiket will not be shielded by the buffer zones shown in Figure 143, green-grey dune-fixation infrastructure — comprising a combination of biological- and mechanical dune fixation measures — will be installed around high-risk villages in these communes. Mechanical dune-fixation will involve the construction of windbreak hedges via wattling (Figure 144, Figure 101), to form 'stop dunes', or 'check dunes' (Figure 145). These structures form a physical barrier between advancing sand dunes and target communities, while the checkerboard pattern assists with capturing sand as it is carried by prevailing winds.



**Figure 144.** Wattling (*clayonnage*) constructed using bundles of dead date palm fronds<sup>1076</sup>.

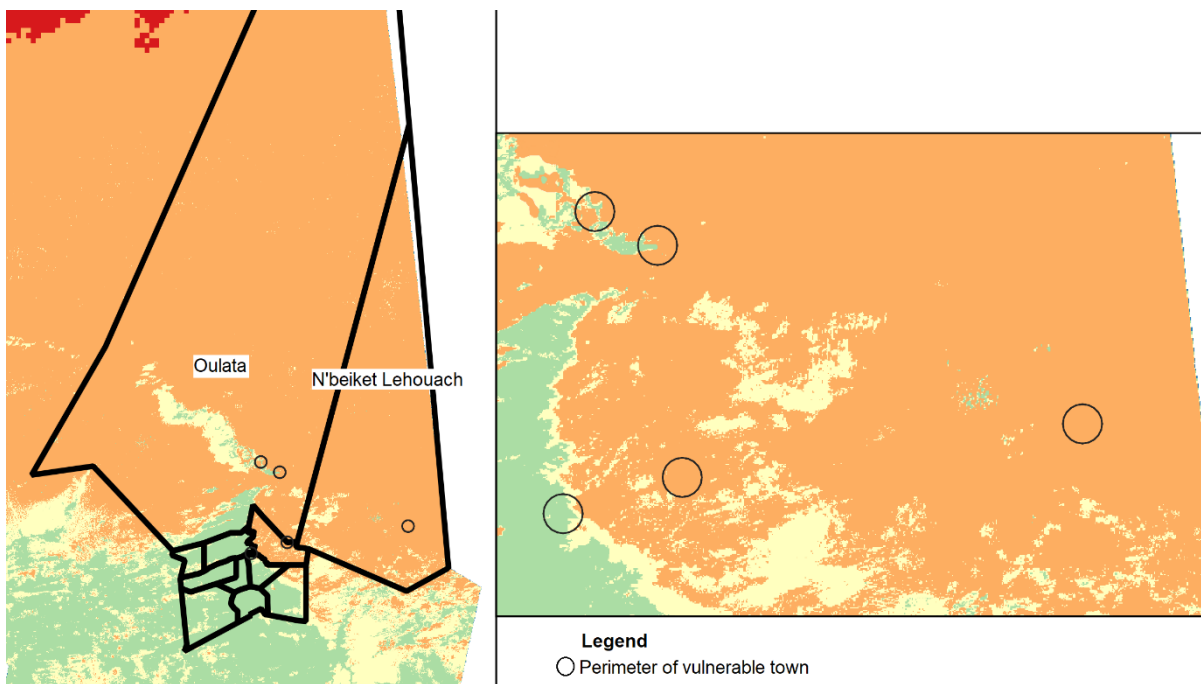
<sup>1076</sup> Image supplied by national consultants in Mauritania



**Figure 145.** The structure and dynamics of a 'stop dune', or 'check dune'.

Wattling involves the use of locally available materials such as date palm fronds, dead *Euphorbia* stalks and branches from mature trees — for example, *Prosopis juliflora*, *Balanites aegyptiaca* and various *Vachellia* (formerly *Acacia*) — to create physical barriers that prevent sand encroachment. If available, by-products (straw) from crop species such as millet, sorghum and rice, as well as other natural leafy vegetation such as *Panicum turgidum*, can also be utilised for constructing these barriers. Indigenous trees, shrubs and grasses can then be planted in between wattling, to fill the 'checkerboard' pattern with vegetation and provide anchorage for biological dune fixation.

The exact locations of vulnerable settlements in Oulata and N'beiket Lehouach have been mapped using remote-sensing data, presented in Figure 146 below. Green-grey dune-fixation infrastructure will be installed along the perimeter of each vulnerable town, to ensure that all critical infrastructure is loosely enclosed by treelines, wattling and check dunes.



**Figure 146.** The locations of vulnerable towns in Oulata and N'beiket Lehouach (left); and a zoomed in view of the perimeters of these settlements within Nema hub (right).

Each of the five towns in Figure 146 has an assumed area of ~74 ha (740,000 m<sup>2</sup>); therefore, a total of ~370 ha of green-grey dune-fixation infrastructure (fences, wattling and check dunes) are needed to protect critical infrastructure against sand encroachment at these sites.

In addition to the vulnerable towns identified using GIS software (Figure 122), community members in the target hubs of Aoujeft, Rachid, Tamcheket and Nema identified several important sites requiring biological and mechanical dune-fixation during stakeholder consultations. These sites — and the number of hectares of green-grey dune fixation infrastructure required at each location — are outlined in Table 79 below. Further details regarding why these sites have been selected are provided in Appendix 3 of Annex 7. The total area of mechanical- and biological dune fixation infrastructure required to protect vulnerable sites identified via GIS software and stakeholder consultation is, therefore, equivalent to 985 ha.

**Table 79.** Number of hectares (ha) of green-grey dune-fixation infrastructure required to protect each of the vulnerable sites identified by stakeholders within the four target hubs.

Hub	Site	Area of green-grey dune-fixation infrastructure (ha)	Proposed dimensions (m)	Perimeter (m)
Aoujeft	Toueïguidit	125	2,500 x 500	6,000
	Ain Savra	70	7,000 x 100	14,200
Rachid	The road on the Hssey Lgara–Touajil axis	350	35,000 x 100	70,200
Tamcheket	Tamchaket town	20	2,000 x 100	4,200
Nema	City of Noual	50	5,000 x 100	10,200
Total		615		104,800

To maximise the effectiveness of biological dune fixation measures, it is necessary to install fencing around green-grey dune-fixation sites, to protect vegetation against foraging and trampling by free-roaming animals. Accordingly, fences will be erected around each of the dune-fixation sites identified in Table 79 and Figure 122 above.

If each of the vulnerable towns identified in Figure 122 is assumed to have a circular area of 74 ha, then the circumference of each dune-fixation site is estimated to be ~3050 m. A total of ~120,050 m of fencing will, therefore, be needed to enclose all of the dune fixation sites identified using GIS software. Additionally, using the dimensions of each target area in Table 79, it is estimated that a total of ~105,000 m of fencing will be required to enclose all vulnerable sites identified by stakeholders. This brings the total distance of fencing required under the proposed project to ~120 km.

The planting of treelines for biological dune fixation in buffer zones will follow the best practices described in Section 6 of Annex 2: Feasibility Study and all tree seedlings used during planting exercises will be sourced from local nurseries established under Activity 2.2.1, to support livelihood diversification efforts undertaken by the project.

The criteria against which suitable species will be selected include:

- the ability to grow in a nutrient-poor environment subject to major variation between day- and night-time temperatures;
- a tap-root system that can quickly reach residual soil moisture, thereby offsetting the effects of drought;
- adaptation to strong, hot, dry winds and their abrasive action on leaves and stems;
- rapid growth and the ability to regenerate easily following disturbance; and
- the capacity to improve the state of dune soil<sup>1077</sup>.

Treelines will comprise a mixture of fast- and slow-growing, climate-resilient species, in accordance with the best practices and lessons learned outlined in Section 5.

The CTCs established under Activity 1.1.1 will oversee the establishment and maintenance of community-managed green belts and dune-fixation infrastructure across the four target hubs. These efforts will be guided by commune-level restoration plans, which will be co-developed by the CTCs and a restoration ecologist under the proposed project.

To inform the design of commune-level restoration plans, a local restoration ecologist will be contracted to determine current land-use practices — gazetted and non-gazetted<sup>1078</sup> — within each priority commune. This data will be obtained via land-use surveys, with support from the CTCs. After developing a comprehensive inventory of land-use practices within the 12 priority communes, the restoration ecologist will identify exact locations for the establishment of community-managed greenbelts, dune-fixation infrastructure, and fenced-off conservation areas within each target commune. This process will validate the preliminary site selection outlined in Section 6.2 or propose new sites for green-grey dune fixation in instances where pre-selected sites are found to be unsuitable for project interventions.

The local restoration ecologist will also be mandated to identify strategic locations for smaller-scale biological and mechanical dune-fixation interventions within priority areas identified by stakeholders (Annex 2: Feasibility Study). The final locations for dune fixation measures will be based on: i) a range of environmental variables, including soil type, soil moisture content, potential evapotranspiration and heat exposure; and ii) the proposed positioning of dune-fixation infrastructure in relation to both the prevailing wind and the locations of vulnerable infrastructure.

To ensure that the site-selection process incorporates a participatory approach, workshops will be hosted in each target commune — led by the CTCs and supported by the contracted restoration ecologist — to refine the specific locations and approaches for ecosystem restoration and planting treelines in each region. During this process, any existing land-use restrictions or maintenance plans will be considered (including restrictions on access for livestock grazing or browsing). The outputs of each workshop will be incorporated into commune-level restoration plans.

Once the locations for community-managed conservation areas and dune-fixation infrastructure have been approved by all relevant stakeholders, the CTC in each commune will recruit local labour from nearby villages to install fences around these areas (grey infrastructure). It is estimated that a total of 120 km of fencing will be required to enclose dune-fixation sites within the priority communes. Wherever feasible, raw materials for the construction of fences will be locally sourced — for example, from sustainably managed timber stands — and fences will be locally manufactured to support livelihood diversification under Activity 2.2.1. Additionally, guards will be recruited from nearby villages, and a guarding roster developed by CTCs, to facilitate the stewardship of natural resources contained within fenced rehabilitation conservation areas and rehabilitation sites.

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<sup>1077</sup> Food and Agriculture Organisation. 2010. Fighting sand encroachment: Lessons from Mauritania. Available at: <https://www.fao.org/3/i1488e/i1488e.pdf>

<sup>1078</sup> Non-gazetted land uses are those land uses which: i) take place on land whose proprietary rights are held by another party; or ii) contravene the official land use permits assigned to a specific area. In contrast, gazetted land uses are those which take place on land specifically acquired for those land-use activities.

Participatory workshops will be hosted by extension officers to train local community members on best practices for: i) identifying sites that are particularly vulnerable to sand inundation; and ii) the installation and maintenance of physical measures — including fences — to protect these areas against advancing sand dunes while protective treelines grow and take effect. Training workshops will also build local communities' capacities to oversee the operation and maintenance of these structures in the long term. Once appropriate sites have been selected within each of the target communes, capacitated community members will construct mechanical dune-fixation infrastructure via wattling.

In addition to establishing dune-fixation measures, Activity 2.1.1 will promote the implementation of climate-resilient livestock management practices among local livestock farmers, to help protect degraded ecosystems from overgrazing. Measures will include replacing local livestock breeds with climate-resilient breeds, growing climate-resilient fodder varieties for supplementary feeding during the lean season<sup>1079</sup>, and establishing 'set-aside' rotational grazing systems to rehabilitate degraded ecosystems and rangelands. Additionally, pastoral water points and livestock corridors will be established to reverse sedentarisation trends among historically transhumant pastoralist communities, reducing anthropogenic pressure on natural ecosystems and minimising conflict between land users competing for natural resources. By employing these strategies, livestock farmers' resilience to climate change-induced desertification within the four target hubs will be enhanced.

Extension officers from the MEDD, Ministry of Rural Development (MDR) and Ministry of Livestock Farming (MLF) will host participatory workshops to train local livestock cooperatives on the implementation of climate-resilient and sustainable livestock management practices. A national livestock specialist from the Ministry of Livestock (MLF) will be recruited to engage with local community members and collaboratively develop a rotational grazing strategy (or manual) for dissemination to local livestock farmers in the target communes.

In addition, extension officers from the Ministry of Agriculture will train livestock cooperatives on establishing and maintaining agro-silvopastoral systems — in which agriculture, forestry and livestock production are integrated within the same area — to reduce ecosystem degradation by livestock foraging and make effective use of limited land availability and natural resources within the target regions. Finally, members of community-level livestock cooperatives will be encouraged to pool their livestock into communal herds, which will enable resource-sharing, improve the efficiency of livestock management and reduce conflict among local farmers over scarce natural resources.

Upon receiving training in climate-resilient livestock management practices, livestock cooperatives in each target commune will be able to apply for funding to upscale these techniques through the on-granting mechanism established under Activity 2.2.3. This approach will not only improve rural livestock farmers' access to financial resources but also facilitate continued investment in sustainable livestock management practices for the long term.

Sub-activities contributing to the delivery of Activity 2.1.1. are:

- **Sub-activity 2.1.1.1.** Support CTCs to co-develop commune-level land rehabilitation plans in collaboration with village-level stakeholders, members of project management teams and DREDD representatives.
- **Sub-activity 2.1.1.2.** Install ~2,123 ha of dune-stabilisation infrastructure (1,138 ha of green belts; 985 ha of biological and mechanical dune-fixation infrastructure) at strategic sites across the four target hubs — to protect critical areas against the impacts of sand inundation.
- **Sub-activity 2.1.1.3.** Install ~120 km of fence lines around dune-fixation sites established under sub-activity 2.1.1.2, to protect biological dune-fixation infrastructure against damage from livestock and unsustainable use of natural resources.

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<sup>1079</sup> The period between successive wet seasons and harvests

- **Sub-activity 2.1.1.4.** Train livestock herders within the target communes to implement climate-resilient livestock management practices, such as rotational grazing, transhumance, supplementary feeding, agro-silvopasture, collective herding and 'livestock collar re-seeding'.

## 11.2.2 Output 2.2

### **Output 2.2.** Improved access to water for land rehabilitation and agricultural activities

#### **Baseline**

##### *Water resources and use*

Mauritania's geography and climate make water access a long-standing challenge. Over 96% of the renewable surface water is in the fertile Senegal River Basin, while the remainder of the country comprises Saharan desert and Sahel semi-desert zones. These areas are characterised by low, variable precipitation and scarce water resources<sup>1080</sup>.

There is a notable disparity in water access between rural and urban populations. In 2019, 89% of the urban population had access to basic drinking water services — markedly higher than the estimated 50% in rural areas<sup>1081</sup>. This inequality is apparent in the four target wilayah, where more than half of all households do not have access to water on their properties. Consequently, communities in the project area rely heavily on streams, lakes and dams, leaving them vulnerable to climate change impacts on hydrological cycles in these regions. Many rural households depend on public water access points for their domestic water consumption needs; however, these are often unsuitable for drinking as a result of poor water quality.

Human settlements in the target areas have, therefore, shifted in response to diminishing water sources. For instance, in the Aoujeft hub, repeated droughts in the 1970s and 1980s led to the migration and permanent settlement of many traditionally nomadic herders, as well as changes in herd ownership from nomadic herders to wealthy urban and settlement-based owners. Similarly, the overall decline in living conditions and access to water in the Néma hub has resulted in a substantial rural exodus to larger cities<sup>1082</sup>.

Given the current unpredictable nature of water provisioning by lakes, dams and ephemeral streams in the target hubs, aquifers beneath Mauritania's arid soil surface are an important source of fresh water. Mauritania has one of the largest reserves of groundwater storage in Africa<sup>1083</sup>, with a total reserve of ~23,400 km<sup>3</sup>. As a result, since 2008, the GoM has invested heavily in improving water access infrastructure to tap into Mauritania's underground water resources, including the installation of 650 wells and 1,100 drinking water-supply networks across the country, benefiting around 1.2 million Mauritians<sup>1084</sup>.

Groundwater extraction in oases is conducted either manually (84% in 2004) or by motor pump (16% in 2004); however, groundwater extraction is hindered by low levels of aquifer recharge, which limits groundwater availability following a drought<sup>1085</sup>. Moreover, while laws and regulations exist to control water extraction at oases, enforcement is limited and regulations are often breached, leading to overuse that adversely affects marginalised groups, particularly women<sup>1086</sup>. Indeed, baseline

<sup>1080</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>1081</sup> WHO/UNICEF Joint Monitoring Programme. 2021.

<sup>1082</sup> ARIA/ACTERRA/AGRER. 2021. Climate Risk Analysis Report.

<sup>1083</sup> MacDonald AM, Bonsor HC, Dochartaigh BÉO, Taylor RG. 2012. Quantitative maps of groundwater resources in Africa. *Environmental Research Letters*, 7: 024009.

<sup>1084</sup> Feukeng L. 2019. Mauritania: government plans to install 300 boreholes by 2020. Afrik21. Available at: <https://www.afrik21.africa/en/mauritania-government-plans-to-install-300-boreholes-by-2020/>.

<sup>1085</sup> FAO. 2005. AQUASTAT profil de pays — Mauritanie. Available at: <https://www.fao.org/3/ca0201fr/CA0201FR.pdf>

<sup>1086</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). *Farming systems and food security in Africa*. Routledge: London.



assessments conducted during project development highlight the risk of groundwater depletion when the use of motorised pumps (diesel- or solar-powered) is not strictly monitored<sup>1087</sup>.

Despite groundwater's importance for rural water supply, limited data on groundwater systems and levels across the country are available in the national water point database (BADIHA<sup>1088</sup>)<sup>1089</sup>. This paucity in data further exacerbates the vulnerability of rural communities, as their capacity to monitor long-term water availability is limited.

The restoration and creation of water-management infrastructure in oases can lead to more efficient and sustainable water use, promote groundwater recharge and more productive agriculture<sup>1090</sup>. These benefits would reduce the push factors causing rural inhabitants to migrate into urban zones, which places considerable pressure on already limited resources in cities and towns. For this reason, conserving, mobilising and utilising water-management facilities are considered priority intervention strategies for managing oases in Mauritania<sup>1091</sup>. To improve access to surface water in the wilayah, several infrastructure developments have been built, such as dams and dikes.

An integrated watershed approach has also been identified by past projects as an appropriate strategy for managing both groundwater and surface water resources. The WFP, FAO and IFAD are currently piloting an integrated watershed approach in the Sahel, based on a comprehensive understanding of the territory's characteristics (plateau, slopes and lowland) and how these interact with one another. The installation of infrastructure for controlling water flow — including the construction of dikes<sup>1092</sup>, check dams<sup>1093</sup> and gabions<sup>1094</sup> — has been implemented in each territory to reduce runoff flow rates, increase water infiltration and prevent erosion<sup>1095</sup>.

In addition to the above, the ongoing GEF-funded project entitled '*Climate change adaptation and livelihoods in three arid regions of Mauritania (2021–2024)*' aims to improve water access in the Adrar, Inchiri and Trarza wilayahs using an EbA approach to enhance the functioning of desert, oasis and wadi ecosystems. This four-year project is being implemented by UNEP, executed by the MEDD and funded by GEF's Least Developed Countries Fund (LDCF). The proposed GCF project will collaborate with the GEF project team to upscale existing EbA practices related to sustainable water management in Adrar and achieve project complementarity.

## Project approach

Under Output 2.2, the proposed project will invest in both supply- and demand-side water resource management, to ensure that water is used sustainably within the target region, while simultaneously enhancing access to water for agricultural and land-rehabilitation purposes. To address existing water supply challenges, the construction of groundwater dams, reservoirs and rainwater-harvesting systems will be promoted to enhance water storage and availability during dry seasons. Additionally, flood management infrastructure — including gabions, dikes and stone bunds — will be installed to slow the rate of water flow during extreme rainfall events, such that groundwater recharge and surface runoff capture are enhanced. To address water demand-related challenges, the proposed project will facilitate the adoption of water-efficient irrigation methods, such as drip irrigation, reducing water

<sup>1087</sup> ARIA/ACTERRA/AGRER. 2021. Climate Risk Analysis Report.

<sup>1088</sup> Base de de Données des Investissements d'Hydraulique et d'Assainissement

<sup>1089</sup> Ministère de L'Hydraulique et de l'Assainissement. 2016. Stratégie nationale pour un accès durable à l'eau et à l'assainissement à l'horizon 2030. SNEADEA – 2030.

<sup>1090</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>1091</sup> Chaibou M, Bonnet B. 2019. The arid pastoral and oasis farming system: key centres for the development of trans-Saharan economies. In: Dixon J, Garrity DP, Boffa J-M, Williams TO, Amede T, Auricht C, Lott R, Mburathi G (eds.). Farming systems and food security in Africa. Routledge: London.

<sup>1092</sup> A dike is a barrier used to regulate or hold back water from a river.

<sup>1093</sup> A check dam is a small dam constructed across a drainage ditch, swale, or channel to lower the velocity of flow.

<sup>1094</sup> A gabion is a semi-permeable barrier, made of boulders in a mesh of steel wires and anchored to the stream bank, to slow but not stop, the flow of stormwater in a small watercourse so as to favour water infiltration to groundwater and help prevent soil erosion.

<sup>1095</sup> Cooper R. 2018. Natural Resources Management Strategies in the Sahel. Available at:

[https://assets.publishing.service.gov.uk/media/5c6acc2340f0b61a196aa83a/453\\_Sahel\\_Natural\\_Resources\\_Management.pdf](https://assets.publishing.service.gov.uk/media/5c6acc2340f0b61a196aa83a/453_Sahel_Natural_Resources_Management.pdf)



wastage and improving water-use efficiency. Moreover, the project will promote water-saving practices among farmers, such as mulching and minimum tillage, to help retain soil moisture and reduce evaporation.

**Activity 2.2.1.** Establish community-managed Water User Groups (WUGs) and commune-level water monitoring and regulation plans.

Drawing from the best practices and lessons from past and ongoing initiatives in Mauritania, improved water-demand management practices will be introduced in the Aoujeft, Rachid, Tamchekett and Néma hubs. These demand-management practices will be supplemented by sustainable water harvesting and storage solutions to address rural communities' declining water security resulting from climate change.

These interventions will be supported by hydrogeological assessments to determine the quality and quantity of surface and groundwater in the target hubs, as well as communities' vulnerability to water stress and declining water security. Preliminary hydrogeological maps have been created and inserted into the Feasibility Study for this project (Refer to SWAT Analysis); however, more detailed assessments are needed. During consultations, community members expressed the need for improved hydrogeological data to adequately inform: i) sustainable water demand-management; and ii) the identification of priority areas for installing water-harvesting systems and managed aquifer recharge infrastructure.

A team of national experts — comprising two hydrogeologists from the Ministry of Water and Sanitation (MHA<sup>1096</sup>) and two meteorologists from the Meteorological Service of Mauritania (ONM) — will conduct hydrogeological studies to quantify and map groundwater and surface water resources within each of the target hubs. In particular, this team will be mandated to identify flood-risk areas and determine the interconnectivity of aquifers, informing the selection of strategic sites to install: i) groundwater dams, for improving aquifer recharge; ii) gabions, dikes and stone bunds for reducing flood risks; and iii) reservoirs, boreholes, well points and rainwater-harvesting systems to increase rainwater capture and storage. The selection of target sites for water management infrastructure will be summarised in the form of commune-level water management plans.

Subsequently, the technical abilities of community-level stakeholders will be enhanced to implement water supply and demand-management interventions. This process will involve forming commune-level water user groups (WUGs) in the 12 priority communes. Each WUG will be led by elected community leaders from the respective priority communes and will report to the CTCs established in Activity 1.1.1.

WUG members will comprise local community members and representatives from livestock cooperatives, farmer-based organisations and women's farmer groups in each target commune. WUGs will be trained to monitor water availability and usage within their respective communes. Additionally, members will be trained to oversee and manage the construction, operation and maintenance of infrastructure for capturing surface water, managing runoff flow, increasing groundwater recharge and reducing flood risks (described in more detail below). Training will be conducted by extension officers from the MEDD (or DREDDs) in collaboration with a national expert from the MHA. All training materials will be grounded in best practices and lessons learned for water management, as detailed in Annex 2: Feasibility Study. The types of physical water infrastructure managed by WUG members will include:

- weirs and dikes;
- gabions;
- stone and earthen bunds;
- rainwater-harvesting (RWH) systems;
- groundwater dams; and

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<sup>1096</sup> Ministère de l'Hydraulique et de l'assainissement

- pastoral well points, boreholes and solar-powered pumps.

Sub-activities contributing to the delivery of Activity 2.2.1. are:

- **Sub-activity 2.2.1.1.** Establish community-managed Water User Groups (WUGs) within each target commune and train members to implement and maintain water-related activities introduced under Activity 2.2.2 of the project.
- **Sub-activity 2.2.1.2.** Support CTCs to raise awareness about sustainable water usage and co-develop commune-level water monitoring and regulation plans in collaboration with WUGs.
- **Sub-activity 2.2.1.3.** Conduct hydrogeological studies (or consult existing hydrogeological maps, where applicable) and engage with WUG members to identify priority sites to install water-management infrastructure (Sub-activities 2.2.2.1, 2.2.2.2 and 2.2.3.1) in each target commune. Summarise the finding of site selection into a commune-level water management plan for each priority commune.

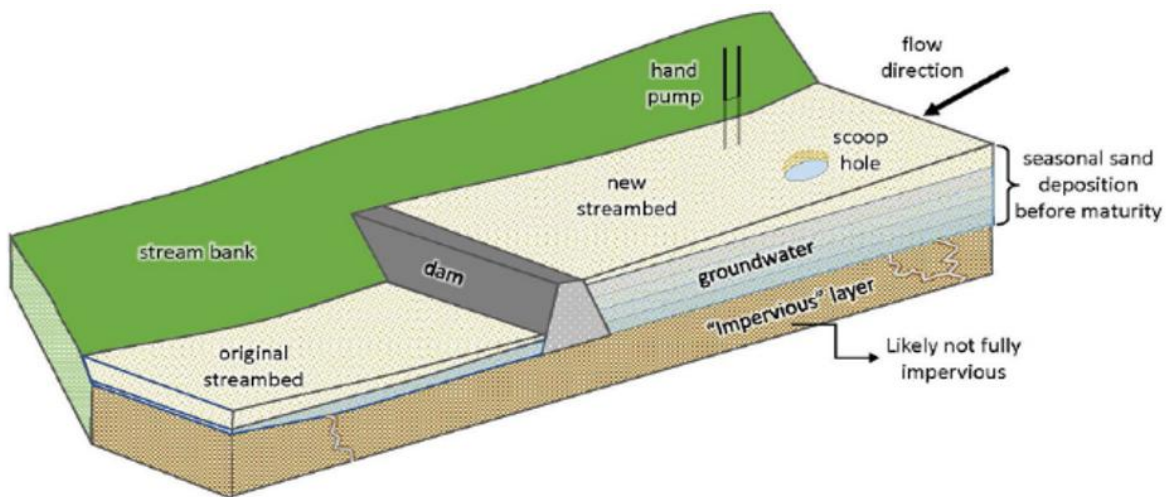
**Activity 2.2.2.** Install physical water management infrastructure — including weirs, gabions, dikes, stone- and earthen bunds, groundwater dams and water access points for pastoralists.

Under Activity 2.2.2, water security within the proposed project's target hubs will be strengthened by installing flood management infrastructure — including weirs, gabions, dikes, stone bunds, earthen bunds and groundwater dams — in each priority commune. These measures will reduce surface water runoff, increase groundwater infiltration and recharge rates, and enhance the capture of rainfall for use in supporting sustainable agriculture and climate-resilient livelihoods.

To reduce flood-risk levels and increase groundwater recharge rates within the proposed project's target communes under future climate scenarios, local labour will be procured to install physical measures that: i) reduce the flow rate of surface water runoff; and ii) increase the rate of water infiltration. In accordance with the best practices outlined in Section 6 of Annex 2: Feasibility Study, physical measures constructed to manage surface and groundwater resources will include:

- groundwater dams (Figure 147 **Error! Reference source not found.**);
- earthen dikes (constructed using clay) (Figure 148 **Error! Reference source not found.**);
- stone gabions (Figure 149 **Error! Reference source not found.**); and
- stone bunds (Figure 150 **Error! Reference source not found.**).

The exact sites to establish physical water resources management interventions within each priority commune will be selected during participatory site-selection workshops hosted by CTCs and hydrogeological experts, in consultation with WUG members in each target commune. As a maximum, the extent of physical water-management infrastructure installed within each target hub should not exceed: i) four groundwater dams (each with a storage capacity of ~10,000 m<sup>3</sup>); ii) 4 km of clay dikes; iii) 4 km of stone gabions; and iv) 80 ha of stone bunds arranged in 50 x 50 m squares.



**Figure 147.** An archetypal representation of a sand storage dam (groundwater dam)<sup>1097</sup>.



**Figure 148.** Clay dike constructed along a water course within the proposed project's target region<sup>1098</sup>.



**Figure 149.** Stone gabions constructed to stabilise the banks of a water course and reduce the risk of flooding within the proposed project's target region<sup>1099</sup>.

<sup>1097</sup> Ritchie H., Eisma JA. & Parker A. 2021. Sand dams as a potential Solution to Rural Water Security in Drylands: Existing research and Future Opportunities. *Front. Water*, 3: 1-18.

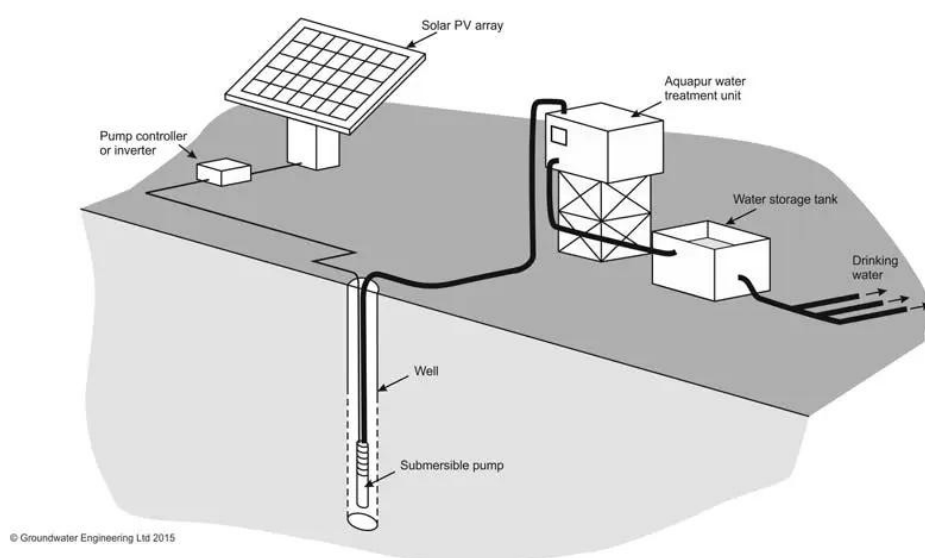
<sup>1098</sup> Image provided by national consultants

<sup>1099</sup> Image provided by national consultants



**Figure 150.** Stone bunds constructed in the proposed project's target region<sup>1100</sup>.

Additionally, pastoral water access points — that is, boreholes equipped with solar pumps — will be established in *graras* and along historical transhumance routes, to support year-round agricultural production and transhumance and reverse sedentarisation trends among nomadic pastoralists. These physical measures will: i) improve the availability of fresh water for use in agriculture and livestock farming; ii) reduce unsustainable abstraction from aquifers; and iii) ensure the long-term sustainability of climate-resilient livestock management, agricultural practices and livelihoods introduced under Output 2.3. Within each commune, the exact installation sites for solar-powered groundwater pumps, will be determined by WUG members, in consultation with CTC representatives and DREDD representatives and informed by commune-level water management plans developed under Activity 2.2.1. As described in the baseline description above, solar-powered groundwater pumps (Figure 151; Figure 152Error! Reference source not found.Error! Reference source not found.) will provide a cost-effective and water-efficient solution for improving communities' access to groundwater in arid target communes,



**Figure 151.** Figure illustrating the different components of a solar-powered pump.

<sup>1100</sup> Image provided by national consultants





**Figure 152.** Solar-powered groundwater pump installed on an agricultural plot under the PDDO programme in Mauritania.

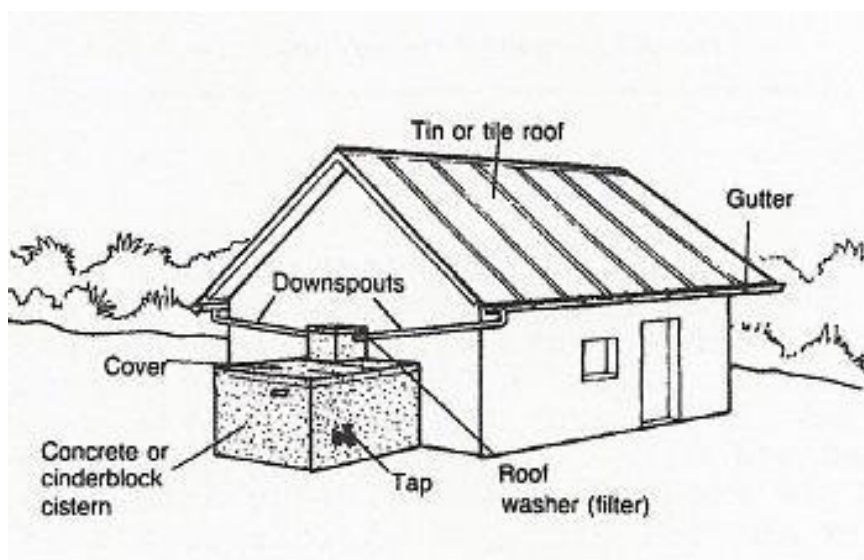
Sub-activities contributing to the delivery of Activity 2.2.2. are:

- **Sub-activity 2.2.2.1.** Install physical water management infrastructure — including weirs, gabions, dikes, stone- and earthen bunds, groundwater dams and solar-powered pumps — at strategic sites within each target commune, to improve water access and availability, increase groundwater recharge rates and reduce flood risks in the target hubs.
- **Sub-activity 2.2.2.2.** Establish water access points along historical transhumance routes and in *graras*, to improve nomadic pastoralists' access to water and reduce sedentarisation among livestock herders.

**Activity 2.2.3.** Install 12 rainwater-harvesting systems and communal cisterns (5,000 L per system) within each target commune

Under Activity 2.2.3 of the proposed project, the installation of RWH systems and communal cisterns will increase the capture of surface water runoff during extreme rainfall events and increase target communities' capacities to store water for use during prolonged periods of drought. Within each commune, the exact installation sites RWH systems and cisterns will be determined by WUG members, in consultation with CTC representatives and DREDD representatives; however, to promote fair access, sites located near communal buildings (town halls, schools and health posts) and agricultural areas (including market gardens and nurseries) will be given preference, to ensure water is used for agricultural activities and sustainable livelihoods introduced under the proposed project. Selected sites for RWH systems and communal cisterns will be incorporated into commune-level water management plans developed under Activity 2.2.1.

To establish the RWH systems and communal cisterns, local labour will be employed and supervised by trained WUG members. Twelve RWH systems and communal cisterns, with a capacity of 5,000 litres each, will be distributed to each of the 12 priority communes, totalling 144 RWH systems and cisterns across the four target hubs.



**Figure 153.** Rainwater-harvesting system with cistern<sup>1101</sup>.

Sub-activities contributing to the delivery of Activity 2.2.2. are:

- **Sub-activity 2.2.3.1.** Install 12 rainwater-harvesting systems and communal cisterns (5000L per system) within each target commune across the four hubs, to improve access to water for agricultural livelihood activities.

### 11.2.3 Output 2.3.

**Output 2.3.** Climate-resilient agricultural livelihoods based on sustainable land- and natural resource-use are developed and/or strengthened to reduce land degradation and support climate-resilient income-generation by community members within the target regions.

#### **Baseline**

##### *Agriculture*

Climate change-driven rainfall variability is diminishing agricultural productivity in the proposed project's target regions. Irregular rainfall, limited spatial and temporal distribution and a prolonged dry season contribute to seed-germination failures and crop losses. As a result of rainfall scarcity, Mauritanian agriculture and food production depend heavily on groundwater. However, stakeholder consultations in Aoujeft, Rachid, Tamchekett and Néma revealed a decline in the water table level, which has adversely impacted crop productivity. For instance, in Aoujeft, farmers reported groundwater levels falling from ~6 m to a minimum of 12 m since the 1960s. This lowering of the water table, attributed to recurrent droughts and water-resource overexploitation, has caused progressive soil degradation and reduced oasis water quality. Droughts in the 1970s and 1980s, coupled with unsustainable farming practices, have also led to groundwater salinisation, with salt concentrations rising as groundwater levels decrease. Consequently, there is insufficient freshwater for date palm grove and crop irrigation in the target region. This major constraint on agricultural productivity is worsened by sand encroachment, as increasing mobile sand dune heights have completely buried date palm trees in some cases<sup>1102</sup>.

In response to climate change-related declines in agricultural productivity, farmers have expanded agricultural lands to compensate for reduced crop yields, or resorted to over-extracting limited groundwater resources for irrigating underproductive crops. This often necessitates the removal of natural vegetation and exacerbates ecosystem degradation in the proposed project's target regions, thereby diminishing valuable ecosystem services such as sediment stabilisation and groundwater

<sup>1101</sup> Payero J. in: UNEP. 1997. Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean. Unit of Sustainable Development and Environment General Secretariat, Organization of American States: Washington, D.C.

<sup>1102</sup> Annex 2 — Appendix 6: Sidoumou I. 2022. National consultant field mission report.

recharge. As a result, the suitability of agricultural lands for crop production has decreased, leading farmers to expand agricultural areas further and perpetuating a vicious cycle of reduced agricultural productivity, overextraction of water resources, ecosystem degradation and reduced ecosystem services<sup>1103</sup>.

In other cases, farmers in Mauritania have adapted to climate change by adopting a range of climate-smart agricultural (CSA) practices<sup>1104</sup>. CSA practices currently implemented within the four target hubs include: i) growing drought-resistant crop species; ii) investing in crop diversification; iii) establishing greenhouses and market gardens; iv) increasing the area of farmland under irrigation; v) installing water-efficient drip and spray irrigation systems; and vi) applying fertilisers. For example, in response to a shortened wet season (and growth season), the use of fast-maturing crops<sup>1105</sup> and flood-recession crops<sup>1106</sup> has become increasingly popular across the target region<sup>1107,1108</sup>.

Several past and ongoing projects in Mauritania have facilitated the adoption of these CSA practices (Table 8). For instance, under the PARSACC project, over 4,100 community producers (76% of whom were women) were trained to implement CSA agricultural techniques across eight wilayah in southern Mauritania<sup>1109</sup>, including Tagant, Hodh El Gharbi and Hodh Ech Chargui, which fall within the proposed project's target region. **Error! Reference source not found.** provides a summary of the types of CSA practices currently being implemented by local community members in each of the proposed project's rural-urban hubs, as identified by national consultants using community surveys<sup>1110</sup>. Under the proposed project, successful CSA practices, drawn from local knowledge and past and ongoing projects, will be upscaled or replicated within the project's 12 priority communes as necessary.

Although small-scale farmers in Mauritania are generally aware of adaptation options to mitigate climate change's adverse effects on agricultural production, many rural households lack the financial resources and technical knowledge required to implement CSA practices. Consequently, agricultural production systems remain underdeveloped, with minimal use of irrigation systems and fertilisers in numerous communes across the target region. For example, less than 100 ha of total agricultural land is under irrigation within each priority commune in the four target rural-urban hubs.

**Table 80.** Summary of the types of CSA practices currently being implemented in each target hub<sup>1111</sup>

Target hub	Types of CSA practices currently implemented	Adaptation needs
Aoujeft	Water-stress resistant crops (sorghum, barley, beans, watermelons, and vegetables) grown in <i>grara</i> Small-scale fruit tree and Henna planting for crop diversification in market gardens Drip irrigation and solar pumping of groundwater (~100 ha)	Training on developing climate-resilient agricultural areas Finance for upscaling CSA practices

<sup>1103</sup> A sequence of reciprocal cause and effect in which two or more elements intensify and aggravate each other, leading inexorably to a worsening of the situation.

<sup>1104</sup> Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that address the interlinked challenges of food security and climate change.

<sup>1105</sup> Fast-growing crops such as melons, cowpea, lettuce, radish, turnips are often interplanted with larger, wider-spaced, or slower-developing crops such as tomatoes, maize, onions, cabbage, eggplant, and potatoes.

<sup>1106</sup> Shallow wells are hand-dug in watershed catchments and flood plains, which seasonally flood and irrigate crops planted in the wells. Among the most common flood recession crops are tomatoes, eggplant, onions, sweet potatoes, potatoes, okra, cabbage, cowpeas, squash, maize, and melons.

<sup>1107</sup> FAO and USAID. 1979. Mauritania Vegetable Production Project. Available at: [https://pdf.usaid.gov/pdf\\_docs/PNAAQ468.pdf](https://pdf.usaid.gov/pdf_docs/PNAAQ468.pdf)

<sup>1108</sup> FAO. 2018. Drought characteristics and management in North Africa and the Near East. Available at: <https://www.fao.org/3/ca0034en/CA0034EN.pdf>

<sup>1109</sup> Saadani Y. 2017. Project of Enhancing Resilience of Communities to the adverse effects of Climate Change on Food Security in Mauritania (PARSACC): Mid-term evaluation. Available at: <https://www.adaptation-fund.org/projects-document-view/?URL=https://pubdocs/en/880911532334932499/pdf/14-MTE-AF-Project-Mauritania-English.pdf>

<sup>1110</sup> Annex 7: Summary of Stakeholder Consultations and Stakeholder Engagement Plan

<sup>1111</sup> Annex 7: Summary of Stakeholder Consultations and Stakeholder Engagement Plan



Rachid	Palm date species grown are resilient to water stress and high temperatures Solar pumping of groundwater <sup>1112</sup>	Crop diversification Training on CSA techniques Equipping farmers with cost-effective agricultural tools and advanced technologies (e.g., drip irrigation kits)
Tamchekett	Market gardening Planting crops in low-lying basins where water collects during rainfall events ( <i>graras</i> ) Solar pumping of groundwater	Introduction of market gardening Introduction of profitability-increasing tools Improved storage facilities for produce Seed banks for climate-resilient crop species
Nema	Market gardening Planting crops in low-lying basins where water collects during rainfall events ( <i>graras</i> ) Solar pumping of groundwater	Introduction of short-cycle sorghum varieties (3 months cycle) Introduction of advanced agricultural tools and technologies for increased profitability Upscaling and replication of market gardens Establishment of seed banks for climate-resilient seed varieties

Historically, farmers in Mauritania's desert landscapes have irrigated agricultural lands either by lifting groundwater with *shadufs* (rope-and-bucket systems) or using diesel pumps to pump groundwater towards crops. The Oasis Sustainable Development Programme (PDDO) (2005–2014) piloted solar-powered water pumping for agricultural use in several Mauritanian oases across Adrar, Tagant, Assaba, Hodh El Gharbi and Hodh Ech Chargui<sup>1113</sup>. These pilots proved highly successful, increasing fruit and vegetable farmers' revenues by up to 200% in some cases. Moreover, the PDDO project introduced enhanced water-distribution systems, such as drip irrigation kits (**Error! Reference source not found.**), which resulted in water savings of up to 30% compared with conventional water-distribution systems (earthen channels). Although solar pumps required a high initial investment, they were found to be more cost-efficient than traditional *shadufs* and diesel pumps over their 10-year lifespan.

This strong business case for investing in solar-powered water pumps generated considerable interest among local farmers in the target region. By the end of the project, the number of solar-powered pumps in operation had doubled as a result of autonomous adoption by local community members<sup>1114</sup>. Consequently, opportunities exist for upscaling water-efficient irrigation within the proposed project's target region.

<sup>1112</sup> The use of solar pumps as an alternative to diesel pumps is only considered climate-smart if groundwater pumping is well managed, to prevent the depletion of underground water resources. The risk of groundwater mismanagement is raised in Appendix 1 to Annex 2: Feasibility Study.

<sup>1113</sup> PDDO. 2013. Introducing solar-powered pumping in the oases of Mauritania. Available at: [https://www.ifad.org/documents/38714170/41000412/casestudy\\_mauritania\\_pumping\\_e.pdf/7f68d7ff-2d3e-bdf4-d3ef-25667080f318?t=1548948813000](https://www.ifad.org/documents/38714170/41000412/casestudy_mauritania_pumping_e.pdf/7f68d7ff-2d3e-bdf4-d3ef-25667080f318?t=1548948813000)

<sup>1114</sup> PDDO. 2013. Introducing solar-powered pumping in the oases of Mauritania. Available at: [https://www.ifad.org/documents/38714170/41000412/casestudy\\_mauritania\\_pumping\\_e.pdf/7f68d7ff-2d3e-bdf4-d3ef-25667080f318?t=1548948813000](https://www.ifad.org/documents/38714170/41000412/casestudy_mauritania_pumping_e.pdf/7f68d7ff-2d3e-bdf4-d3ef-25667080f318?t=1548948813000)



**Figure 154.** Drip irrigation kit (tube with valve) installed around a date palm tree under the PDDO programme.

#### *Natural-resource-based livelihoods*

Numerous past and ongoing projects have been implemented to reduce vulnerable communities' reliance on rainfall-dependent, natural resource-based livelihoods (such as agriculture and pastoralism) in Mauritania, by promoting livelihood diversification and facilitating the adoption of alternative, sustainable income-generating activities. For instance, the ongoing GEF project titled '*Climate Change Adaptation and Livelihoods in Three Arid Regions of Mauritania*' (2021–2024) has facilitated the uptake of poultry production, cereal banks, *jujube* fruit processing and livestock rearing as alternative natural resource-based livelihoods in the wilayah of Inchiri, Trarza, and Adrar<sup>1115</sup>.

**Error! Reference source not found.** provides a summary of alternative livelihoods currently practised by local communities within the proposed GCF project's target hubs, as identified by national consultants. Generally, these income-generating activities are practised on a small scale as a result of rural households' limited access to financial resources for upscaling and restricted market access<sup>1116</sup>. Under Output 2.2, measures will be implemented to improve market access and facilitate investment in upscaling and replicating sustainable natural resource-based livelihoods within the twelve priority communes. This will, in turn, strengthen rural communities' capacities to adapt to climate change.

**Table 81.** Summary of potential alternative livelihoods within the proposed project's target regions, as identified by national consultants<sup>1117</sup>.

Alternative livelihood activity	Description
Market gardening (small-scale fruit and vegetable production)	Areas equipped with a borehole, water tower, solar pumping kit and cisterns for the production of fruits and vegetables, both for resale and home consumption.
Animal fattening (fattening of small ruminants for resale)	Provide a group of farmers with capital to: i) buy small ruminants at a good price during the lean season; ii) obtain livestock feed; and iii) sell livestock to butchers for a profit.
Butcheries	The establishment of butcheries for the sale of meat to households for consumption will complement animal fattening by developing the market for livestock products.
Poultry farming	Poultry farming requires less land than other forms of livestock farming. Chickens can be kept for resale or home consumption, as well as egg production.

<sup>1115</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<sup>1116</sup> GEF. 2018. Climate change adaptation and livelihoods in three arid regions of Mauritania. Available at: <https://www.thegef.org/projects-operations/projects/10103>

<sup>1117</sup> Annex 2 — Appendix 6: Sidoumou I. 2022. National consultant field mission report.

Depot for sale of domestic gas	This activity has the potential to provide households with an energy source other than firewood.
Establishment of village shops	The establishment of village shops — to be run by women's cooperatives — will not only provide income generating opportunities for local women, but also provide community members with basic necessities and improve access to products in areas where the private sector is not present as a result of limited demand.
Production of livestock feed from date nuts	Date nuts can be crushed and ground down to produce nutritious livestock feed. A small amount of capital and nut crushers are needed to initiate this activity.
Drying fruit and vegetables (preservation of consumables)	The drying of fruits and vegetables is conventionally carried out by women, to preserve agricultural produce and increase food security during the lean season. This activity could be upscaled via the provision of solar-powered dryers.
Drying red meat ( <i>Tichtar</i> )	Conventionally, nomadic communities dried meat by spreading it out on the ground and exposing it to the sun. This activity can be upscaled through the provision of solar-powered dryers, which will simultaneously make the operation healthier. Dried meat is then cut into small pieces, or <i>tichtars</i> , and sold for human consumption. This practice provides communities with a valuable source of protein when fresh meat is not available; therefore, the demand for this product is high.
Collection and sale of non-timber forest products	Non-timber forest products for example, the <i>jujube</i> fruit — can be collected from protected areas for a small fee and sold for a profit.
Establish pastoral water points to re-establish transhumant lifestyle (boreholes with solar pumps)	Using solar pumps and water towers, pastoral water points can be established along historical transhumance routes, to improve herders' access to water and promote the re-establishment of transhumant livestock practices.
Sewing production unit	Women's cooperatives can sew traditional African kikois to sell to households for profit.
Mills for grinding wheat into flour	Small-scale mills with grinding equipment for crushing sorghum into flour can be established and the produce can be sold to bakeries or households for making traditional breads.
Bakery for bread production using gas ovens	Many households struggle to find fuelwood, and its use as a fuel for cooking harms the environment. To avoid these challenges, households can be equipped with gas ovens or more efficient cookstoves, enabling them to bake bread without harming the environment. The sale of bread baked using gas ovens/cookstoves will constitute an income-generating activity.
Transport (community carts)	'Community carts' (horse-, ox-, or donkey-drawn carts) provide a means of transport in rural areas — for example, to transport trees to protected areas for planting, water for agricultural purposes and to nurseries, and stones for the construction of stone bunds. This transport can be used to generate income and maintain the condition of the cart animals.

### *Investment in climate change adaptation*

The GoM has limited financial capacity to invest in developing climate-resilient, natural resource-management strategies and land-use planning, especially for vulnerable communities at regional and local levels.

At the national level, the 2020–2022 Presidential Priority Program (PPP) allocated 0.3% of annual GDP to 'greening the economy'<sup>1118</sup>, 2.3% of GDP to 'social spending and income support' and 1.5% of GDP to 'agriculture and fisheries support'. Consequently, public-sector investment in sectors with potential CCA benefits under the 2020–2022 PPP equated to less than 5% of Mauritania's annual

<sup>1118</sup> 'Greening the Economy' comprises two sub-categories with distinct budget line items in the Presidential Priority Program, namely: 'support to agricultural sector' (0.2% of GDP) and 'water and sanitation' (0.1% of GDP).

GDP. Over the same period, annual GDP growth associated with climate-sensitive sectors such as agriculture, livestock husbandry and fisheries was estimated at -5.4%, indicating declining economic growth. To this end, there is a demonstrable need to increase the effectiveness of government investment in CCA-related expenditures.

At the wilayah-level, regional budgets for sustainable development do exist; however, funding allocations vary considerably from year to year and investment in donor-funded projects and programmes is capped at 40% of the total sustainable development budget. Moreover, there are limited guidelines and policies dictating what percentage of this investment should be channelled towards CCA. For this reason, information on available fiscal space within municipal budgets for channelling government funds towards CCA investment is not readily accessible<sup>1119</sup>.

### Private sector

Although community-level investment programmes focused on protecting and rehabilitating degraded ecosystems in rural Mauritania are scarce, several basic Payment for Ecosystem Services (PES) schemes and agriculture-based livelihoods have been identified within the four target hubs. These income-generating activities incentivise the protection of natural ecosystems and the services they provide, but are currently only practiced on a small scale throughout the target region. The full list of these PES schemes and natural resource-based livelihood opportunities is presented in Section 5 of Annex 2: Feasibility Study. The number of households generating income from each of these activities is currently unknown; however, on average, households deriving income from agricultural-based activities generate ~MRU7,600 (~USD220) income per month<sup>1120</sup>.

National consultants have identified considerable opportunities for upscaling PES and climate-resilient agriculture-based livelihoods within all four target hubs; however, limited access to microfinance has served as a barrier to this in the past. Although the GoM has introduced a number of regulatory and legislative reforms in an attempt to boost the private sector by 2025 — for example, through the establishment of the Higher Council for Investment in 2020 — several obstacles persist, including: i) difficulty in accessing microfinance for local business development; ii) limited market access within rural and semi-urban areas; iii) low levels of technical and professional training; iv) limited governance within the financial services sector; and v) limited private-sector organisation<sup>1121</sup>. Consequently, past projects have been unable to mobilise substantial private-sector investment in CCA.

Several lessons learned from implementing PES schemes and sustainable agricultural-based livelihoods within the target region are outlined in Annex 2: Feasibility Study, including:

- the need to offer incentives that sufficiently compensate for the loss of resource extraction, unsustainable agricultural practices or excessive livestock grazing to promote conservation over extractive activities;
- the importance of preserving entire ecosystems — as opposed to only the portion of land being remunerated — to prevent productive activity displacement from ecosystems under a PES scheme to other, previously untapped ecosystems within the target area; and
- the requirement to establish financially and institutionally robust funding mechanisms guaranteeing continuous resource flow for ongoing investment in CCA and climate-resilient livelihoods beyond the proposed project's implementation period.

These lessons highlight the need for innovative financial mechanisms that: i) provide local community members with the initial capital needed to switch from unsustainable livelihood activities to sustainable natural resource-based alternative livelihoods; and ii) facilitate fund reinvestment and upscaling of EbA interventions and climate-resilient livelihood development in the long term. To date, no small

<sup>1119</sup> Appendix 3 of Annex 7: Summary of Stakeholder Consultations and Stakeholder Engagement Plan

<sup>1120</sup> Appendix 3 of Annex 7: Summary of Stakeholder Consultations and Stakeholder Engagement Plan

<sup>1121</sup> Arab NGO Network for Development (ANND). 2022. The Private Sector and Sustainable Development in Mauritania. Available at: [https://annd.org/uploads/publications/Arab\\_Watch\\_Report\\_-\\_The\\_Private\\_Sector\\_and\\_Sustainable\\_Development\\_in\\_Mauritania\\_-\\_En.pdf](https://annd.org/uploads/publications/Arab_Watch_Report_-_The_Private_Sector_and_Sustainable_Development_in_Mauritania_-_En.pdf)

grants facility (SGF) dedicated to CCA has been established in any of the proposed GCF project's four target hubs.

### **Project approach**

Under Output 2.3, the proposed GCF project will develop and strengthen climate-resilient agricultural livelihoods based on sustainable land and natural resource, reducing land degradation and supporting climate-resilient income generation by community members within the target regions. To deliver this output, the proposed project will facilitate the adoption of CSA practices and sustainable livelihood activities by farmers and community members living within the target communes and oases (Activity 2.3.1). The project will encourage livelihood diversification by supporting the uptake of sustainable income-generating activities such as beekeeping, poultry farming and value-added processing, reducing dependence on traditional agricultural activities and building resilience against climate-related risks.

Additionally, the project will support continued investment in CCA interventions and sustainable livelihood options via the established of a small grants facility (SGF) (Activity 2.3.2). This innovative financing mechanism will provide opportunities for enhanced public and private sector investment in activities that support improved oasis management, while empowering local communities to independently adopt sustainable livelihood options introduced under the project. Additionally, budget briefs will be prepared with recommendations for enhancing government expenditure and channelling fiscal space towards the SGF — to support investment in EbA and climate-resilient, agricultural-based livelihoods beyond the proposed project's six-year implementation period. Budget briefs will include opportunities for redesigning CCA expenditure within the following government ministries:

- the Ministry of the Environment and Sustainable Development;
- the Ministry of Agriculture;
- the Ministry of Livestock Farming;
- the Ministry of Water and Sanitation; and
- the Ministry of Housing, Urbanism and Regional Planning.

By implementing these activities, the GCF project will contribute to the long-term resilience and adaptation to climate change impacts, ensuring the well-being and economic stability of community members in the target regions.

#### **Activity 2.3.1. Facilitate the adoption of climate-smart agricultural practices and sustainable, diversified livelihoods by farmers within the target communes**

Climate-smart agriculture is an integrated approach to managing agricultural landscapes — including croplands, pastures and forests — while synergistically addressing the interlinked challenges of food security and climate change.

Under Activity 2.3.1, CSA practices will be introduced within the proposed project's four target hubs by:

- hosting workshops to provide farmers with training on CSA practices;
- establishing demonstration plots showcasing the benefits of CSA to develop a solid business case for autonomous investment in CSA technologies;
- improving local communities' access to finance for investment in CSA technologies (via on-granting under Activity 2.3.2);
- supplying farmers with climate-resilient crop varieties (seeds) and technical training on seed replication techniques; and
- supplying farmers with water-efficient irrigation equipment and overseeing its installation.



Within each of the proposed project's four target hubs, representatives of CTCs, farmer-based organisations (FBOs)<sup>1122</sup> and women's farmer groups (WFGs) will be trained to implement CSA practices. Training will be provided via regional workshops facilitated by: i) expert agronomists from the Ministry of Agriculture; and ii) agricultural extension officers from the MEDD and MDR.

Topics covered during CSA workshops (refer to Section 6) will include:

- the introduction of climate-resilient crop varieties;
- the regeneration and upscaling of oasis agriculture<sup>1123</sup> (mostly carried out by women);
- the use of water-efficient irrigation technologies;
- low-input soil fertilisation methods;
- the use of agro-silvopastoral systems; and
- the establishment of zai pits<sup>1124</sup> (**Error! Reference source not found.**) and half-moons (**Error! Reference source not found.**)<sup>1125</sup> to improve the capture of surface-water runoff.



**Figure 155.** The construction of zai pits for improved rainfall and runoff capture<sup>1126</sup>.



**Figure 156.** Half-moons constructed to improve rainfall and runoff capture in croplands.

<sup>1122</sup> Cooperatives or organisations established to address the common needs of smallholder farmers in the territory

<sup>1123</sup> Oasis agriculture (*phoeniculture*) is an important part of local communities' heritage. This practice entails growing a mixture of vegetables and cereal crops in between palm groves, which are irrigated by natural springs or tapped groundwater sources. Oases vary in size from a cluster of date palms to extensive croplands. Dates, cotton, olives, figs, citrus fruits, wheat and corn (maize) are common oasis crops.

<sup>1124</sup> Zai pits are 20–30cm-wide depressions in which the seeds of crops species are planted. These small basins improve rainfall and runoff capture. When available, crop residue, mulch or manure is added to every pit to increase soil fertility and promote vegetation growth.

<sup>1125</sup> Crescent-shaped trenches dug on gentle slopes with the removed soil placed downslope.

<sup>1126</sup> Histories of Geographical Knowledge. 2015. Technological advancements within the regeneration of the Sahel. Available at: <https://historiesofgeography.wordpress.com/2013/02/15/84/>

With support from expert agronomists and extension officers, champion farmers<sup>1127</sup> nominated by CTCs, FBOs and WFGs will establish demonstration plots in priority commune, to showcase the medium- to long-term benefits of implementing CSA practices. A one-hectare demonstration plot will be established within each priority commune and focus will be placed on the establishment of phoeniculture (oasis agriculture) plots and small-scale agro-silvopastoral systems, as these types of demonstration plots will be important for exemplifying how multi-use agricultural systems can strengthen communities' resilience to climate change through the provision of multiple ecosystem products and services. Throughout the implementation period, all agricultural plots will be carefully monitored and evaluated by champion farmers and extension officers so that the productivity of CSA technologies and conventional technologies can be compared over time.

Establishing demonstration plots will not only provide local communities with ecosystem services, but also contribute to developing a strong business case for private-sector investment in CSA technologies. Local farmers wanting to adopt CSA methods will benefit from improved access to finance via the on-granting mechanism developed under Activity 2.3.2. This funding will facilitate upscaling and continued investment in sustainable farming practices under future climate scenarios.

To further improve rural farmers' resilience to the impacts of climate-change desertification, MEDD and MDR extension officers will supply local nurseries with an initial stock of climate-resilient<sup>1128</sup> seed varieties for sale and distribution to local farmers and market gardeners within each of the target hubs. Additionally, extension officers will train nursery operators and other relevant stakeholders (CTC, FBO and WFG representatives) to maintain sustainable stocks (or seed banks) of these varieties in the long-term, ensuring that access to climate-resilient genotypes<sup>1129</sup> is not limited after a single growth cycle.

Under this sub-activity, community members will be taught how to:

- sustainably collect seeds from mature climate-resilient stock plants<sup>1130</sup>;
- effectively preserve seeds; and
- maintain a sufficient quantity of seeds in community-managed seed banks established under the project<sup>1131</sup>.

The collection and resale of climate-resilient crop varieties by nurseries and seed banks will synergistically support the adoption of sustainable, diversified livelihoods under the proposed project.

Strengthening local farmers' capacities to irrigate croplands within the four target hubs (using water extracted from water management infrastructure installed under Activity 2.2.2) will further increase communities' resilience to climate change by decreasing dependence on rainfed agriculture for subsistence during periods of drought. As a sub-activity under Activity 2.3.1, MEDD and MDR extension officers will supply WUGs with water-efficient irrigation equipment — i.e. drip-irrigation kits — for distribution to champion farmers (nominated by CTCs, FBOs and WFGs) and horticulturalists.

When distributing irrigation kits, preference will be given to champion farmers or organisations representing vulnerable groups, including women and the youth. This will ensure that CSA interventions respond to the needs and best interests of the target communities, to maximise the impact potential of the proposed adaptation solution. Members of CTCs, FBOs and WFGs will be trained by MEDD and MDR extension officers on how to use and maintain irrigation equipment for the long term.

Under Activity 2.3.1, CTC members will also facilitate the adoption of sustainable, alternative livelihoods to: i) reduce communities' dependence on climate-sensitive sectors — such as agriculture

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<sup>1127</sup> Farmers who have extensive experience in farming and have transferred knowledge and skills to other farmers

<sup>1128</sup> Crop varieties with drought- and heat-resistant genotypes

<sup>1129</sup> The genetic makeup of an organism, i.e. an organism's complete set of genes

<sup>1130</sup> Stock plants are the source of cuttings, graft material, seeds, bulbs, or tubers.

<sup>1131</sup> A seed bank is a place where seeds are stored to preserve genetic diversity for the future.



and livestock husbandry; ii) increase income security; and iii) limit further ecosystem degradation, which intensifies the impacts of climate change-induced desertification. A list of potential diversified livelihoods to be investigated is provided in **Error! Reference source not found.** above. Additional support will be provided to individuals wanting to upscale or replicate existing small-scale sustainable livelihoods within the proposed project's target regions, including businesses that focus on: i) the sustainable harvest of timber and non-timber forest products for the construction of physical dune-fixation infrastructure; ii) the establishment and operation of nurseries and seed banks within each target commune, to supply plant material for EbA dune-fixation interventions (Activity 2.1.1); and iii) market gardening.

Training for the uptake of alternative, sustainable livelihoods will be provided by an expert agronomist and MEDD and MDR extension officers. The expert agronomist will be recruited to provide initial technical support for the uptake of horticultural practices — such as market gardening and establishing nurseries — by local community members within the proposed project's four target hubs. Market gardening is a concept based on the efficient use of small areas of land to grow fruits and vegetables, for home consumption and sale, using manual labour and simple mechanised equipment (**Error! Reference source not found.**). Expert agronomists will, therefore, advise community members on the best practices for sowing, growing and harvesting fruit and vegetable varieties within the proposed project's target regions. Similarly, to support the establishment of nurseries and seed banks, the expert agronomist will provide training on:

- collecting and preserving seeds;
- planting and pruning techniques;
- the growth requirements (light, temperature, humidity, water) for different plant species;
- cost-effective fertilisation methods;
- water-efficient irrigation techniques; and
- business theory.

Training will also be provided to support the uptake of other sustainable alternative livelihoods identified by CTCs within each target commune — as required. Finally, a financial expert will be hired to provide technical advice and train community members on best practices for establishing and running their respective businesses. For example, the expert will help community members develop a business model and teach community members how to calculate income, expenses and final profits (or losses).



**Figure 157.** Market garden in Ain Savra village, with livestock exclusion fence and measures to prevent sand inundation.

To facilitate the initial uptake of horticultural practices (market-gardening and nurseries) and beekeeping (apiculture), horticultural centres established in each priority commune will be supplied with the initial materials needed to commence business operations. These may include beehives for apiculture, climate-resilient seed varieties for seed banks and irrigation kits for market gardens. Materials for these will be distributed by members of commune-level CTCs. Following initial investments in materials by the GCF and GoM, community members and business owners will be expected to maintain and repair all equipment using income generated from these diversified livelihood initiatives in the long term. However, local community members — particularly women and the youth — wanting to autonomously replicate or upscale sustainable, alternative livelihoods within the proposed project's target communes, will benefit from improved access to finance through the on-granting mechanism established under Activity 2.3.2.

Within target communes, access to markets to sell horticultural produce will be improved by: i) organising weekly markets in each priority commune — arranged by CTCs — to facilitate trade between local community members; and ii) using 'community carts'<sup>1132</sup> to transport goods to larger, urban markets within the target hubs and surrounding areas. To transport their goods to and from urban markets, horticulturalists will pay cart-owners a small fee, which will later be covered by income generated via the sale of produce. In this way, the project will support another means of livelihood diversification — namely, transport services — with income generated via cart fees being re-invested into animal care and the production of fodder. Notably, Annex 3: Financial and Economic Appraisal and Section 10 above provide support for statements indicating that proposed project activities (CSA, climate-resilient livestock husbandry and the uptake of sustainable alternative livelihoods) will enhance income-generation within target communities.

Sub-activities contributing to the delivery of Activity 2.3.1 are:

- **Sub-activity 2.3.1.1.** Establish nurseries and seed banks in each target commune to supply activities related to land rehabilitation and dune fixation (Activity 2.1.1), CSA practices (Sub-activity 2.3.1.3) and horticultural activities such as market-gardening (Sub-activity 2.3.1.4).
- **Sub-activity 2.3.1.2.** Collect cuttings and seeds from agricultural crop species, as well as indigenous grass and tree species, to serve as stock material for nurseries and seed banks established under Sub-activity 2.3.1.1.
- **Sub-activity 2.3.1.3.** Train farmers within the target communes to practice climate-resilient crop agriculture and use improved agricultural technologies, including drip irrigation kits, solar powered pumps, integrated pest management strategies, zai pits and half-moons.
- **Sub-activity 2.3.1.4.** Conduct site visits and provide technical support to facilitate the uptake of sustainable livelihood activities — including horticulture (market-gardening), apiculture, poultry farming, livestock feed production and the collection and sale of non-timber forest products — by community members within the target communes.
- **Sub-activity 2.3.1.5.** Supply farmers and horticulturalists with water-efficient irrigation equipment and climate-resilient crop varieties to support the uptake of agricultural activities adopted under Sub-activities 2.3.1.3 and 2.3.1.4.
- **Sub-activity 2.3.1.6.** Improve access to urban markets and develop value chains for offloading agricultural produce within each target commune, to enhance income generated from sustainable agricultural livelihoods.

**Activity 2.3.2.** Establish a small grants facility to facilitate continued investment in upscaling successful EbA activities and sustainable livelihoods.

A project Small Grants Facility (SGF) will be established to enhance local communities' access to finance to upscale successful EbA interventions and sustainable, agriculture-based livelihoods introduced under the project. The on-granting mechanism will promote and support community-led

<sup>1132</sup> 'Community carts' (horse-, ox-, or donkey-drawn carts) provide a means of transport in rural areas — for example, for transporting trees to be planted in protected areas, water for agriculture and nurseries, and stones for the construction of stone bunds. This transport can be used by individuals for a small fee, to generate income and maintain the condition of animals

initiatives, fostering the autonomous uptake of EbA practices by community members. GCF Proceeds will be used to finance the sub-grants. The SGF will be housed in MEDD, and sub-grant agreements will be executed between MEDD and each sub-grant recipient.

An SGF Steering Committee will be instituted to guide and oversee the establishment and operations of the SGF. It will be chaired by UNEP as the project AE, and will include representation from MEDD and other relevant Ministries (the Ministry of Economy and Finance; the Ministry of Agriculture; the Ministry of Livestock Farming; the Ministry of Housing, Urbanism and Regional Planning), as well as from UNDP (to ensure links and synergies with the Small Grants Programme it manages). The SGF Steering Committee will review the recommended funding proposals and jointly make the grant award decisions. UNEP as the chair of the SGF Steering Committee will report on its operations to the PSC. Table 81 below outlines the preliminary proposed design of the SGF, and the process for submitting and screening sub-grant proposals. The screening begins with CTCs (including representatives of vulnerable groups and CSOs) and is completed by the SGF team housed in MEDD (see below), before submission to the SGF Steering Committee.

Establishing and operating a project SGF requires procuring an SGF management team to be housed in MEDD, to: i) oversee the facility's operation and maintenance; and ii) manage the approval, disbursement and monitoring of small grants throughout the project implementation period. Prior to the SGF establishment, an international consultant (finance expert) will develop the SGF's policies, frameworks and guiding principles. Additionally, the international consultant will design a funding proposal template and accompanying selection criteria for the SGF, streamlining the small-grants approval process.

Capacity building support will be provided to MEDD to strengthen MEDD's institutional, operational and financial capacity for the design, execution and oversight of the SGF. This consultancy will also provide technical backstopping to MEDD on these aspects throughout the implementation of the SGF. As a first step, building on the findings of the HACT micro-assessment undertaken in 2023, specific capacity or process gaps will be identified that may impact the management of the SGF. In addition, experiences and lessons learnt from MEDD's ongoing small grants programme will be reviewed. This programme has been operational since 2022, with \$250,000 awarded annually to approximately 20 local NGOs, cooperatives and other CSOs for climate change adaptation and environmental initiatives.

Furthermore, to increase the capacity of potential recipients of the grants, a suitable service provider will be contracted to work with potential recipients to: i) strengthen their organisational and financial management capacity; ii) increase their capacity to develop and submit project concepts so as to access funds from the SGF; and iii) improve their capacity to successfully implement EbA measures funded through the SGF. It is anticipated that 5 projects per year in each of the 12 target communes will receive grants (60 grants per year) over the final four years of the proposed project. Sub-grants will only be awarded to low-risk projects and will be screened to avoid duplication of other project activities.

Other indicative criteria for projects to be awarded sub-grants will include:

- Recipients should be legally registered entities, such as NGOs, CSO, cooperatives, associations or local enterprises.
- The proposed initiative to be financed by the sub-grant should support households or communities to adapt to specific climate change risks.
- The proposed initiative should support the uptake or strengthening of climate-resilient livelihoods, or EbA approaches that build the resilience of households or communities.
- The proposed initiative should include measures to ensure the long-term sustainability of the impacts to be achieved with the sub-grant financing.
- The proposed initiative should ensure the development of business skills and market linkages, where relevant. Level of co-financing contribution (cash or in-kind).

- The recipient entity should provide the required ratio of co-financing contribution (cash or in-kind) – to be set at SGF inception stage.
- Maximum request of ~\$25,000.

Indicative criteria for recipients of sub-grants are:

- The recipient of the sub-grants must be registered legal entity, such as an NGO, a CSO, a cooperative, an association or a local enterprise.
- The recipient entity must have a track-record of activities that are directly relevant to climate change adaptation, EbA approaches and/or climate-resilient livelihood strengthening.
- The recipient entity must have a track-record of working directly with households or communities to strengthen their resilience or livelihoods.
- The recipient entity must be operational in at least one of the project target hubs.
- The recipient entity must provide in-kind co-financing (with the level to be set at SGF inception phase).

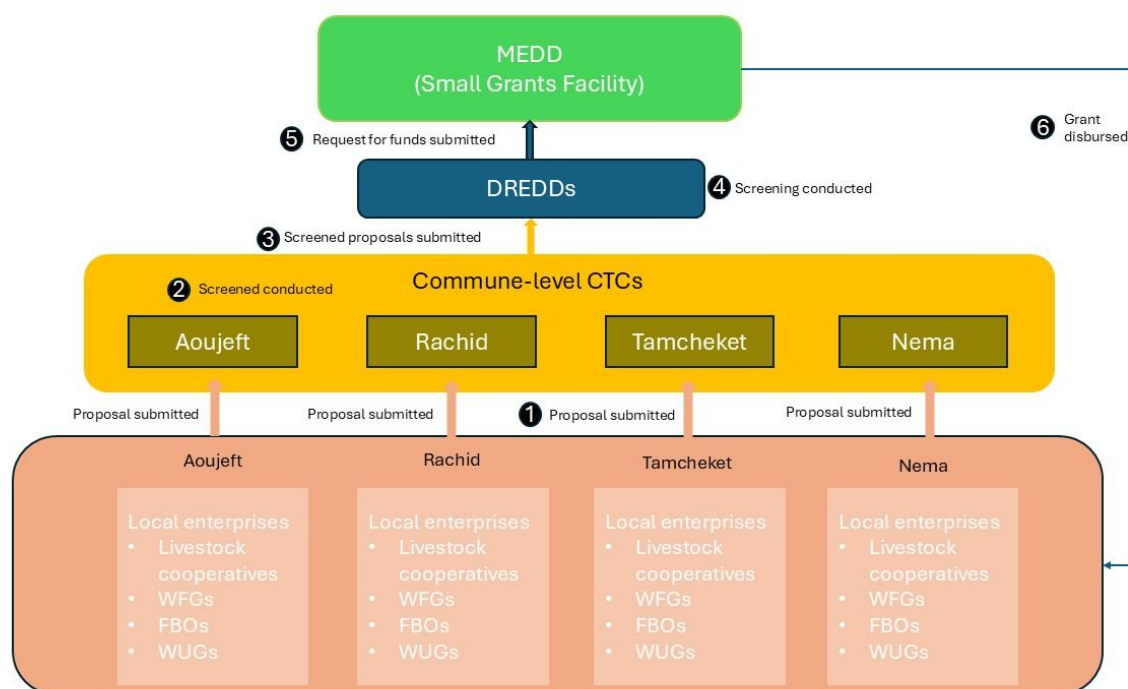
The finance expert will also inspect regional government budgets in the four target wilayah (Adrar, Tagant, Hodh Ech Chargui and Hodh El Gharbi) and prepare budget briefs with recommendations for channelling a percentage of sustainable development funding towards the project SGF, ensuring the pool of funds for CCA within the target region is topped up annually. This will ensure the long-term sustainability of the on-granting mechanism.

Once established, the SGF will operate according to the process detailed in **Error! Reference source not found.** and **Error! Reference source not found.** below.

**Table 82.** Proposed design of the SGF established under Activity 2.3.2 of the proposed project.

Step	Description	Additional details
1	Community members, CSOs or local enterprises submit a funding proposal to commune-level CTCs, requesting funding for the implementation of EbA measures or the uptake of climate-resilient livelihood activities.	A funding proposal template will be provided by the SGF. There will be a pre-selected list of activities that qualify for GCF sub-grants.
2	Commune-level CTCs, along with representatives from vulnerable groups and CSOs, will conduct an initial screening exercise, to ensure proposed activities are in line with the SGF selection criteria.	Commune-level CTCs will conduct quarterly screening of submitted proposals and collectively decide which projects will benefit local communities most.
3	CTCs submit screened proposals to regional coordination bodies (DREDDs) within their respective wilayah.	CTCs in Aoujeft hub will submit to the DREDD in Adrar; CTCs in Rachid hub will submit to the DREDD in Tagant; CTCs in Tamchekett hub will submit to the DREDD in Hodh Ech Chargui; and CTCs in Néma will submit to the DREDD in Hodh El Gharbi.
4	The DREDDs conduct a second screening to ensure all eligibility criteria for GCF sub-granting are met.	Eligibility criteria will be developed by an international consultant and shared with relevant DREDDs upon establishment of the SGF. The second screening conducted by the DREDDs will serve as an additional checkpoint for improved financial regulation.
5	The DREDDs submit all eligible funding proposals to the SGF team, which conducts a final screening and ranking of the received proposals, before forwarding these to the SGF Steering Committee for approval.	Staff members at the SGF conduct a final screening to ensure submitted funding proposals are in accordance with all selection criteria. In the event that the number of proposals exceeds funds available, SGF staff will rank the proposals based on set evaluation criteria.

6	The SGF Steering Committee reviews the recommended funding proposals, and jointly makes the decision on grant award. In case of lack of agreement among the SGF Steering Committee members, UNEP and MEDD will jointly make the final decision.	
7	After conclusions of a legal agreement between MEDD and each grant recipient entity, funds are released by MEDD.	



**Figure 158.** Proposed structure of the on-granting mechanism developed under Activity 2.3.2 of the project.

To capture the results of Activity 2.3.2, all lessons learned and best practices under this activity will be collected and stored in the knowledge-management platform developed under the NAP Readiness Programme. To this end, the finance expert will design robust monitoring and reporting mechanisms that will also ensure traceability and the risk management of the SGF funds.

Sub-activities contributing the delivery of this activity are:

- **Sub-activity 2.3.2.1.** Establish and operationalise a Small Grants Facility (SGF) to facilitate continued investment in upscaling successful EbA activities and sustainable livelihoods introduced under the project.
- **Sub-activity 2.3.2.2.** Prepare budget briefs for directing regional government funds into the SGF established under Sub-activity 2.3.2.1. to promote government investment in CCA.
- **Sub-activity 2.3.2.3.** Develop monitoring and reporting mechanisms to ensure the traceability and risk management of funds between the SGF and local-level stakeholders.
- **Sub-activity 2.3.2.4.** Produce annual monitoring and evaluation reports for sub-projects funded via the on-granting mechanism established under Sub-activity 2.3.2.1.

Importantly, Sub-activity 2.3.2.3 will establish a comprehensive monitoring and reporting framework to ensure the traceability and risk management of funds channelled through the on-granting mechanism. This framework will encompass the development of digital tools for tracking fund distribution and utilisation, as well as standardised reporting protocols to document financial flows and project impacts. Interventions introduced under Sub-activity 2.3.2.3 are listed below.



- **Implementation of a digital tracking system:** Deployment of a digital ledger or a financial management information system (FMIS) that provides real-time data on fund allocations, disbursements and expenditures, enhancing transparency and enabling effective oversight.
- **Capacity building for financial oversight:** Training programs for local financial officers and project managers on the use of the digital tracking system, financial reporting and risk management practices to ensure adherence to financial integrity and accountability standards.
- **Risk management framework:** Development of a risk management plan to identify, assess and mitigate financial and project-related risks, ensuring the sustainable and effective use of funds.
- **Regular reporting mechanisms:** Establishment of periodic reporting schedules for project implementers at various levels to document progress, financial status and impact assessments, facilitating adaptive management and stakeholder engagement.

Similarly, to ensure the results of Activity 2.3.2 are captured, Sub-activity 2.3.2.4 will focus on evaluating the on-granting mechanism's impact on promoting sustainable, climate-resilient practices among target communities. This will involve assessing the effectiveness of fund utilisation in achieving desired environmental and socio-economic outcomes using the tools listed below.

- **Impact assessment studies:** Conducting baseline and follow-up studies to measure the tangible impacts of projects funded through the on-granting mechanism on community resilience, ecosystem health and economic well-being.
- **Beneficiary feedback:** Gathering feedback from project beneficiaries and stakeholders to evaluate satisfaction levels, identify challenges and capture lessons learned.
- **Success stories and case studies:** Documenting successful initiatives and transformative projects enabled by the on-granting mechanism to highlight best practices, catalyse replication and attract further investment.
- **Adaptive management:** Utilising impact evaluation results to refine and adjust the on-granting mechanism's operational guidelines, funding priorities, and support structures to enhance future performance and outcomes.

By integrating these sub-activities within the structure of Activity 2.3.2, the project ensures a robust approach to managing, monitoring and assessing the on-granting mechanism's contributions to climate change adaptation and resilience building. Sub-activity 2.3.2.3 establishes the foundational systems for transparency and accountability, while Sub-activity 2.3.2.4 builds on this foundation to evaluate and showcase the mechanism's real-world impacts, facilitating informed decision-making and continuous improvement.

### *11.3 Mainstreaming gender responsiveness into the proposed project design*

The project design acknowledges the crucial role gender plays in shaping vulnerabilities and capacities in the face of climate change. It outlines specific actions aimed at mainstreaming gender considerations across all project activities, reflecting the insights from Annex 8: Gender Action Plan. Gender responsive actions implemented via the Gender Action Plan include those listed below.

- **Capacity building and empowerment:** Training programs will be tailored to address the unique needs and potentials of women and men, enhancing their knowledge and skills in climate adaptation practices, sustainable agriculture, and natural resource management. Special emphasis will be placed on empowering women, raising awareness about sexual exploitation and harassment (SEAH) and gender-based violence (GBV) and recognising the role of women in the communities' adaptation efforts.
- **Participation and leadership:** Strategies will be implemented to ensure equitable participation and leadership of women in project-related decision-making processes. This will involve creating enabling environments that support women's voices and leadership in community consultations, project planning and implementation phases.
- **Access to resources:** The project will implement measures to improve women's access to essential resources including land, water, and financial services. This will involve advocating for policy changes, facilitating access to credit and markets, and supporting women's land rights.

- **Monitoring and evaluation (M&E):** Gender-sensitive indicators will be integrated into the M&E framework to track progress in addressing gender gaps and enhancing women's empowerment. This data will inform adaptive management and ensure that gender equity goals are met throughout the project lifecycle.

Through these gender-focused interventions — implemented under the supervision of a project Gender Officer — the project will achieve the dual objective of enhancing climate resilience and advancing gender equality. By embedding gender mainstreaming in the project's design, implementation and evaluation stages, more inclusive, effective and sustainable outcomes will be delivered. Further detail regarding the gender approach employed by the project is detailed in Annex 8: Gender Action Plan.