Feasibility Study

Multi-country Project Advancing Early Warnings for All (EW4All)

Updated 2024-Dec-9

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EXECUTIVE SUMMARY

This feasibility study report provides the technical details and context to the global Multi Country Project on Early Warnings for All (EW4All). The climate risk profile includes maps and data on the climate context at the global level and for the regions of relevance to the project, namely Sahel and West-Central Africa, Eastern Africa and the Horn of Africa, Latin America and the Caribbean and the Southwestern Pacific. Most of the data used is based on the IPCC6 reports and interactive Atlas. The analysis focuses on temperature, precipitation and sea level rise, including derivatives from these datasets. The section on gaps, needs and barriers expands the discussion of the funding proposal by exploring the challenges faced along the EWS value chain, keeping in mind the needs of end-users and the limitations they face given the context of LDCs and SIDS. The section on innovations provides details of the wide-ranging innovations that the project explores across the four pillars. In addition, it provides details on how linkages between academia and centres of technical excellence, as well as with regional technical bodies can ensure long-term, consistent support and contribute to sustainability of Multi-hazard warning systems (MHEWS) in the participating countries. The theory of change is expanded upon in this FS (compared to the proposal document), highlighting the coherence between the global and country projects and elaborating on the cost-effectiveness and sustainability strategy for the project. The final section provides further detail on the implementation arrangements and how the technical support provided by the global team is expected to ensure cost-efficiency and effective technical support to the projects, as well as close coherence and cross learning between the seven country projects.

REGIONAL CLIMATE RISK PROFILE

Regional context and background

This section provides a background of the environmental and climatic conditions, livelihoods and political history of the four regions selected under this multi-country project. This is to situate these regions in the climate change context (described in the subsequent section). The design of interventions that address gaps in the development and use of MHEWS need to be informed by the local conditions.

The seven countries selected for the initial proposal fall under four geographic regions (Table 1), each with their unique context described below.

Table 1. Geographic region under which the different countries selected for this multi-country proposal lie. Note that different publications use different geographical extents. Here we are using the descriptions used in the IPCC-6 report

S/N	Country	Geographic Region
1	Antigua and Barbuda	Latin America and the Caribbean (LAC)
2	Ecuador	Latin America and the Caribbean (LAC)
3	Cambodia	South-West Pacific
4	Fiji	South-West Pacific
5	Chad	Sahel/Central Africa
6	Ethiopia	Horn of Africa/East Africa
7	Somalia	Horn of Africa/East Africa

Sahel and West-Central Africa

Geography, Environment and Climate

The Sahel is a semi-arid region in Africa, south of the Sahara Desert and north of the Sudanian savanna. It stretches longitudinally (roughly between 10° and 20°N) from the Atlantic Ocean in the west to the Red Sea in the east, and covers parts of Mauritania, Senegal, Mali, Burkina Faso, Niger, Chad, Sudan, Eritrea, and Ethiopia.[1] The region is characterised by a mix of grasslands, savannas, and desert ecosystems. The region has two distinct seasons, the long dry season from October to May characterised by hot, dry weather and dusty winds, and the short rainy season from June to September with unpredictable rains. The Sahel faces extreme temperature fluctuations and low and erratic rainfall ranging from 200 - 600 mm/year and is characterised by extreme weather events, rainfall variability, and droughts. The vegetation comprises of sparse trees and shrubs, grasses supported by largely sandy soils with low nutrient content and high erosion risk. Agricultural systems in the Sahel are largely rain-fed and comprise of a mix of crops and livestock.[2]

[1] Michela Biasutti, "Rainfall Trends in the African Sahel: Characteristics, Processes, and Causes," *Wires Climate Change* 10, no. 4 (2019): e591, https://doi.org/10.1002/wcc.591.

[2] UNEP, "Sahel Atlas of Changing Landscapes: Tracing Trends and Variations in Vegetation Cover and Soil Condition" (Nairobi, Kenya: United Nations Environment Programme, 2012).

The Sahel has four distinct climatic zones:[3]

1. Sahelo-Saharan Zone: Arid, with sparse vegetation and little rainfall with an average annual rainfall ranges from 0 to 150 mm.
2. Sahelian Zone: Semi-arid, with grasslands and scattered trees and average annual rainfall between 150 and 600 mm.
3. Sudaninan Zone: Transition zone between the Sahel and Guinea Savanna, with tall grasslands and rainfall between 600 and 1,200 mm.
4. Guinean Savanna Zone: Grasslands with scattered trees and rainfall between 1,200 and 2,200 mm.

Livelihoods and Socioeconomic Conditions

The main livelihoods of the largely rural population are pastoralism and agriculture with millet, sorghum, cowpea and groundnut as the main crops. Communities in the Sahel are highly vulnerable to climate change and other environmental stressors and face chronic poverty, food insecurity and conflict. The region has among the highest poverty rates globally with the frequent droughts and limited access to food driving food insecurity and rapid population growth putting strain on natural resources. The region is also characterised by poor infrastructure, healthcare, transportation and education. The latter is reflected in poor literacy rates, particularly for girls. Climate change is a potential "threat multiplier" in the Sahelian context where there is a confluence of economic, political, social and environmental factors, and the near total reliance on climate sensitive agriculture based livelihoods.[4]

Five of the six Sahelian countries are in the bottom twenty-five of the Notre Dame Global Adaptation Initiative Country Index.[5] Sahelian countries also rank among the lowest on the Human Development Index.[6]

Political History and Conflict

The region, during pre-colonial times comprised of diverse empires and kingdoms. The colonial period, dominated by the French, shaped the borders and governance systems in the Sahel giving way to largely authoritarian regimes, coups and political instability. This has continued into the recent decades with a rise of Islamic militancy[7] and political transitions which have had a direct impact on governance and security in the region.[8] The increase in violent conflict since 2000 has increased in spite of counter terrorism efforts, leading to the loss of thousands of lives and displacement of over 2.5 million people.[9] There are two "axes of instability" in this region: the LiptakoGourma area at the borderlands between Burkina Faso, Mali, and Niger, and the Lake Chad Basin, which stretches across Chad, Niger, and Nigeria.[10] Chad, Mali, Nigeria, Niger and Burkina Faso are ranked among the bottom twenty five on the Fragile States Index, with Mauritania scoring 34.[11]

Country context

Chad

Chad is among the poorest and least developed countries in the world and is ranked 119th of 125 countries of the global hunger index 2023, with a level of hunger classified as serious. Chad's extreme vulnerability to the impacts of climate change is reflected in its position on the ND-GAIN index (185): a combination of high poverty, frequent conflicts, and the risk of both droughts and floods have placed Chad as the lowest ranked country overall, with a score of 27.0. In 2024, Chad had an Inform risk index of 7,8, placing it in the "very high" risk class, meaning that the country is at substantial risk of a humanitarian crisis in case of natural or man-made disaster. The gender inequality index is 0.7, indicating pervasive inequality in women's empowerment. With a literacy rate of 28.1% (compared to 57.6% for men), women face challenges in accessing information. The specific vulnerabilities of refugees, returnees, minority groups and people living with disabilities also need to be considered.

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[3] OECD, *Regional Atlas on West Africa* (Paris: Organisation for Economic Co-operation and Development, 2009); G. Gray Tappan et al., *Landscapes of West Africa: A Window on a Changing World*, 2016.
[4] Beza Tesfaye, "Climate Change and Conflict in the Sahel," n.d.
[5] Marketing Communications: Web // University of Notre Dame, "Rankings // Notre Dame Global Adaptation Initiative // University of Notre Dame," *Notre Dame Global Adaptation Initiative*, accessed April 12, 2023, https://gain.nd.edu/our-work/country-index/rankings/.
[6] United Nations, "Human Development Index" (United Nations), accessed April 12, 2023, https://hdr.undp.org/data-center/human-development-index.
[7] Camillo Casola, ed., "Unraveling the Sahel: State, Politics and Armed Violence" (Italian Institute for International Political Studies, March 2021).
[8] Judd Devermont, "Politics at the Heart of the Crisis in the Sahel" (Center for Strategic & International Studies, 12AD).
[9] UN News, "Decade of Sahel Conflict Leaves 2.5 Million People Displaced," *Un News Global Perspective Human Stories* (https://news.un.org/en/story/2022/01/1109772, January 2022).
[10] Tesfaye, "Climate Change and Conflict in the Sahel."
[11] The Fund for Peace, "Fragile States Index," *Global Data* (https://fragilestatesindex.org/global-data/, 2024).

The Human Development Index ranking of Chad is 189 out of 193 in 2023/24. The World Bank estimates that 40% of Chadians live in poverty and face severe deprivation of a range of basic needs. The percentage of households with access to electricity is 8 percent (NAP). Climate change itself is also having a negative impact on the viability of rural production systems including agricultural production, rangeland production capacity and livestock watering possibilities. This has led to increased competition between users of rural areas and a deterioration in social cohesion. This underlines the country's great need for investment and innovations to improve readiness, and a great urgency for action.

Food production and livelihood systems in Chad are highly dependent on climatic factors, particularly rainfall patterns and distribution. Extreme heat, heavy rainfall and flooding pose risks to crops, health, farmers' and herders' livelihoods, food security and farm workers' productivity. Rain-fed agriculture accounted for almost 46% of GDP in 2019, and 77% of the labour force works in agriculture. The effects of high temperatures, and of hunger, are more acute for children, the elderly, and those with chronic diseases.

Chad also faces severe environmental degradation, exemplified by the drying up of Lake Chad, increased desertification, declining fish stocks, the disappearance of certain animal and plant species, and soil degradation (National Adaptation Plan, 2022). Increased competition for access to pasture and water, soil depletion and lower agricultural productivity have the potential to exacerbate existing conflict factors or contribute to new forms of dispute.

Due to fragility and conflict within the country and beyond its borders, individuals, households and communities in Chad are vulnerable to shocks and climate change. Fragile national and sub-national institutions (e.g. governmental, legal and financial) are responsible for under-investment and weak systems for essential services, disaster and climate risk management, and natural resource management.

Climate change is aggravating the challenging climatic conditions in Chad by increasing the frequency and magnitude of extreme events. The current and projected warming is increasing evapotranspiration, and while rainfall projections for the region are very uncertain, they suggest that extreme rainfall will increase while overall precipitation decreases. As a result, both floods and longer droughts are very likely. This is likely to accelerate what is already a severe rate of environmental degradation.

Access to climate finance is insufficient to meet the acute challenges posed by climate change. There is a financing shortfall to build climate resilience in Chad, with annual climate finance are estimated at a quarter of annual needs. Recently-approved projects are investing in critical aspects of the EW/EA value chain, however additional financing is needed to ensure that effective, actionable and intelligible communication and dissemination strategies are delivered, to work specifically on institutional governance and coordination challenges, and to deliver a multi-hazard EWS that is functional, impact-based, people-centred, and end-to-end.

Eastern Africa and the Horn of Africa

Geography, Environment and Climate

Eastern Africa, as defined by the UN geo-scheme stretches from South Sudan and Eritrea in the north to Mozambique in the south. The region features diverse landscapes including the Ethiopian Highlands, the East African Rift System and coastal plains along the Indian Ocean. Eastern Africa encompasses a mosaic of ecosystems including savannas, montane forests and coastal mangroves and coral reefs. The seismically active East African Rift System runs along the region and comprises volcanoes, mountains, deep valleys and lakes. The latter including the "Great Lakes" which feed the Nile, the Zambezi and the Congo rivers. These varying landscapes make the Eastern African Region among the biodiversity hot-spots of the world.[12] Deforestation, poaching, agricultural expansion and poaching are key threats to biodiversity in the region.[13] -tropical Convergence Zone (ITCZ). While lowlands and coastal areas are hot and humid year-round, highlands enjoy cooler temperatures. The ITCZ brings distinct wet and dry seasons to much of the region, though rainfall patterns can be highly variable, leading to both droughts and floods. The region is increasingly susceptible to climate change impacts like droughts and floods.

The Horn of Africa (Somalia, Djibouti, Eritrea, and parts of Ethiopia), and the Greater Horn of Africa (also includes all of Ethiopia, Kenya, South Sudan, Sudan, Uganda, Rwanda, Burundi and Tanzania) are both part of the Eastern African Region. The GHA region characterised by arid and semi-arid conditions in 80% of its land area with about 40% of the total land mass being economically unproductive.[14]

[12] Uwe Ring, Christian Albrecht, and Friedemann Schrenk, "The East African Rift System: Tectonics, Climate and Biodiversity," *Mountains, Climate and Biodiversity* 2018 (2018): 391–412.
[13] CEPF, "Eastern Afromontane Biodiversity Hotspot," Ecosystem Profile (Critical Ecosystems Partnership Fund, 2012).
[14] C-ADAPT, "Greater Horn of Africa Climate Risk and Food Security Atlas" (WFP, ICPAC, 2018).

Livelihoods and Socioeconomic Conditions

Agriculture is the backbone of the economies in the region, employing a majority of the population, particularly in rural areas. Smallholder farming is prevalent, producing staples like maize, coffee, tea, and livestock. However, both Eastern Africa and Central Africa have the highest prevalence of under-nourishment in the African regions, driven in part by climate variability and extremes.[15] The COVID-19 pandemic had a major impact on the economy of East African countries. Estimates suggest a loss of $15.7bn in GDP in 2020 and the equivalent of 10 million full-time jobs. This directly increased poverty and dramatically increased inequality with the richest 10% East Africans earning an average of 47% of pre-tax national income with the poorest 50% earning just 13.3%. In the recent past, erratic weather including both droughts and floods and ocust infestations in some countries have contributed to food insecurity in the region.[16]

Reliance on climate sensitive agriculture and natural resources makes the region among the most vulnerable to climate related disasters. This includes rain fed agriculture and pastoralism - the latter a dominant livelihood in the drier regions (Somalia, Eritrea, parts of Ethiopia, Kenya, Uganda and South Sudan).[17] Pastoral communities, in particular, have livelihood and production strategies and associated customary governance and land use arrangements adapted to the inherent variability in rainfall and availability of pasture.[18] Droughts, floods, and unpredictable weather patterns disproportionately impact agricultural livelihoods and exacerbate food insecurity and health in this region.[19]

The region is among the poorest in the world with most communities, particularly those in rural areas, lacking access to food, potable water, health care, transport and education. Climate change is likely to increase risk of drought-related stresses for natural and human systems in East Africa, directly affecting agricultural production and food security as well as causing increased crop pests and both crop and livestock diseases.[20]

Key climatic drivers of vulnerability in the region are frequent droughts, dry spells and floods which result in increased animal and crop diseases and pests, negatively affecting production. This also causes and increase in human diseases such as malaria which have a negative impact labour availability for food production. This has a direct impact on livelihoods which are predominantly dependent on climate sensitive natural resources and agriculture.[21] It also increases conflict emerging from competition over these resources which includes trans-boundary competition. This vulnerability is compounded by environmental and land degradation which is also accelerated by climatic drivers. Additional factors contributing to food insecurity include high population growth which outpaces food production.[22]

The considerable population engaged in pastoralism and small farmers engaged in subsistence agriculture, particularly in the Greater Horn of Africa is highly vulnerable to droughts, heat stress and flooding which trigger mass migration within the region and combine with large scale environmental degradation to increase conflict over depleted resources.[23] Climate change has also disrupted traditional arrangements between farmers and transhumant pastoralists by inducing pastoral groups to migrate to agricultural lands before the harvest, when earlier the land was used for crop farming in the wet season and animal grazing in the dry season.[24]

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[15] FAO, "Africa - Regional Overview of Food Security and Nutrition 2023" (FAO; AUC; United Nations Economic Commission for Africa (ECA); WFP;, December 2023), https://doi.org/10.4060/cc8743en.

[16] Matthew Martin, Anthony Kamande, and Jonas Gielfeldt, "The Inequality Crisis in East Africa: Fighting Austerity and the Pandemic" (Oxfam International; Development Finance International, 2022).

[17] Magda Nassef, "Pastoralism and Climate in African Drylands" (USAID,Washington DC; Feinstein International Center, Medford; International Institute for Environment and Development, Edinburgh., 2024).

[18] Ced Hesse and Andy Catley, "Pastoralism in Africa:A Primer" (USAID,Washington DC; Feinstein International Center, Medford; International Institute for Environment and Development, Edinburgh., 2023).

[19] IPCC, "Africa. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change," 2022, https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter09.pdf.

[20] Jeetendra Prakash Aryal et al., "Climate Risks and Adaptation Strategies of Farmers in East Africa and South Asia," *Scientific Reports* 11, no. 1 (2021): 10489.

[21] Paul I. Palmer et al., "Drivers and Impacts of Eastern African Rainfall Variability," *Nature Reviews Earth & Environment* 4, no. 4 (2023): 254–70.

[22] C-ADAPT, "Greater Horn of Africa Climate Risk and Food Security Atlas"; World Meteorological Organization (WMO) and World Meteorological Organization (WMO), *WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019) (WMO-No. 1267)*, WMO, WMO-No. 1267 (Geneva: WMO, 2021).

[23] T. K. Seife, "The Impact of Climate Change on Agriculture and Food Security in the Greater Horn of Africa," *Politikon* 48, no. 1 (January 2021): 98–114, https://doi.org/10.1080/02589346.2020.1861509.

[24] Eoin F. McGuirk and Nathan Nunn, "Transhumant Pastoralism, Climate Change, and Conflict in Africa," *Review of Economic Studies*, 2024, rdae027.

Political History and Conflict

The colonial legacy of European colonisation of East Africa often contributes to the civil unrest and insecurity in many of the countries in the region.[25] Many East African nations have had extended periods of one-party rule which in some cases has become increasingly authoritarian leading to limited political participation and increasing descent. This has along with triggered by poverty, unemployment and inequitable distribution of resources, prompted civil unrest and military coups.[26] Competition for resources and political power along ethnic lines has also fueled conflict within and across-borders. The political instability is also linked to rebel groups which have plagued the region.

In the Horn of Africa, territorial disputes over borders and control of climate vulnerable resources such as water and grazing land, are a major cause of conflict between some countries. In countries such as Somalia, there has been protracted civil war, clan conflict, and the rise of extremist groups like al-Shabaab. Regional and international actors have frequently intervened in the Horn of Africa, often driven by strategic interests, complicating conflicts and hindering sustainable peace building.[27] Climate change induced impacts on trans-boundary water resources are likely to add to tensions among countries in the coming years.[28]

Country Context

Ethiopia

Ethiopia's climate varies significantly across its regions, classified into three primary zones based on seasonal rainfall patterns. The northern and central western areas experience a single rainy season, with peak precipitation occurring in July and August. The southern areas are characterized by two distinct rainy seasons: a short rainy period from September to November and a long rainy period from March to May. The eastern and central parts experience two rainy periods: a spring season from February to May and a summer rainy season from June to September (Paleoclimate Research Institute, 2021). The variability in Ethiopia's rainfall is influenced by large-scale climatic phenomena such as the El Niño-Southern Oscillation (ENSO) and sea surface temperatures (SSTs) in the Indian and Pacific oceans. SSTs, with their gradual variations, affect long-term rainfall patterns and are crucial for improving the accuracy of regional-scale climate predictions.

Climate change poses a significant threat to Ethiopia’s development, exacerbating existing vulnerabilities. The country faces high impacts from natural hazards and increasing climate variability, which threaten its development goals. Ethiopia's ambitious reform agenda aims to address these challenges amidst conflict and inflation. Balancing development needs with climate adaptation and mitigation efforts is crucial for ensuring sustainable growth.

Climate change impacts various sectors in Ethiopia, including water, agriculture, energy, transport, and urban development. The country faces significant water challenges, with variable and unpredictable rainfall affecting millions of people. Essential adaptation measures include improving storage efficiency and integrated watershed management. The agricultural sector must become more productive and climate-resilient, while energy, transport, and urban infrastructure need to be adapted to withstand climate impacts. Additionally, diversifying the economy through mining and tourism can enhance resilience (World Bank Group, 2023). Climate change has profound implications for Ethiopia's macroeconomic stability and poverty levels. Rising temperatures and increased rainfall variability threaten economic growth and exacerbate poverty. Structural reforms are crucial to expanding fiscal space and enabling private sector participation in climate adaptation. Managing residual risks and mobilizing external finance are essential for addressing climate impacts. Supporting the most vulnerable populations through targeted interventions is critical to building resilience and ensuring equitable development.

Ethiopia faces significant economic losses from various climate hazards. Droughts cause substantial economic damage, with a drought event having a 1-in-5 year return period leading to losses exceeding US$1 billion, and a 1-in-100 year drought event resulting in losses of over US$3 billion. Flooding also has a severe impact on GDP, with a flood event with a 25-year return period causing a 3.3% deviation in GDP baselines, and a 100-year flood leading to a 7% deviation. Additionally, heat stress results in significant losses due to its impact on labor productivity and livestock yields. Infrastructure damage, particularly to roads and bridges, can incur annual costs of up to US$755 million under certain scenarios. These economic impacts highlight the urgent need for effective climate adaptation and mitigation strategies in Ethiopia (World Bank Group, 2023). The country faces critical challenges, including ethnic conflicts and

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[25] Swati Parashar and Michael Schulz, “Colonial Legacies, Postcolonial “Selfhood’ and the (Un)Doing of Africa,” *Third World Quarterly* 42, no. 5 (March 2021): 867–81, https://doi.org/10.1080/01436597.2021.1903313.

[26] Megan Duzor and Brian Williamson, “By The Numbers: Coups in Africa,” *Voa News* (https://projects.voanews.com/african-coups/, October 2023).

[27] John Markakis, Günther Schlee, and John Young, *The Nation State A Wrong Model for the Horn of Africa* (Max Planck Research Library for the History and Development of Knowledge, 2021).

[28] Florian Krampe et al., “Water Security and Governance in the Horn of Africa,” SIPRI Policy Paper (Stockholm International Peace Research Institute, 2020).

climate-related risks such as droughts and floods, which impact agriculture and water resources. Effective climate services and early warning systems are essential for enhancing resilience.

Somalia

Somalia is one of the most climate-vulnerable countries in the world. Somalia is ranked 178 out of 182 countries on the ND-GAIN Index 2024, with the least capacity to respond and recover from extreme weather events. Located in the Horn of Africa, Somalia extends south of the Equator northward to the Gulf of Aden, between sub-Saharan Africa and the Middle East. As a predominately arid and semi-arid country with a hot desert climate , the country is susceptible to both droughts and flash floods. Prolonged dry seasons result in water scarcity, reduced grazing land, reduced livestock production, livestock perishes, reduced agricultural productivity, food insecurity, and ultimately, famine and the loss of human life. Somalia's chronic climate-associated shocks, including cycles of floods, droughts, and locust infestation, are compounded by increased conflict and insecurity, and have aggravated the nation's growth and slowed the transition from fragility. Climate change has exacerbated this vulnerability by increasing the frequency, persistence and intensity of droughts in Somalia.

Somalia is a low-income country with a fragile economy that relies largely on agriculture, livestock, remittances and international assistance. Desertification is reducing the viability of rain-fed agriculture and livestock production. Unemployment, particularly among youth, is alarmingly high while poverty rates are highest in rural areas. Somalia has faced recurrent humanitarian crises, including droughts, famines, and displacement due to conflict. These crises have exacerbated food insecurity, malnutrition, and displacement, with millions of Somalis reliant on humanitarian assistance for survival. Somalia is considered the world's fifth-poorest country , and with ongoing and regular climate disasters, Somalia's early warning and response needs are significant, without the domestic resources to invest effectively in MHEWS and AA.

Drought is a critical issue for Somalia, which disparately affects nomadic and agro-pastoral communities who are more vulnerable to such droughts. During 2015 – 2022, 6.1 million people were affected by the drought, and 760,000 - 1.2 million people were displaced by drought. However, the following year of 2023 saw a further 468,000 people impacted by flood, including 247,000 displaced people. Somalia experiences regular river floods and flash flooding that result in major economic impacts and damage, as well as many human casualties, with riverine flooding typically occurring along the Juba and Shabelle Rivers in southern Somalia and flash flooding tending to occur in the north along intermittent watercourses. Yet, intense rainfall events and subsequent floods have become more frequent, resulting in water runoff on the earth's surface, washing away fertile soil and causing widespread devastation. Most recently, the 2023 Deyr flood has been reportedly the worst flood Somalia has faced, resulting in total damages of US$126.6 million and total losses of $49.5 million across sixteen districts, mostly affecting agriculture, livestock, and WATSAN and transport. Around 2.48 million people were affected, with over 1.2 million displaced from their homes. The floods also resulted in the loss of 188 lives. Cyclones, such as Cyclone Sagar (2018) and coastal inundation, tend to affect northern Somalia's Somaliland and Puntland regions rather than the southern areas.

Latin America and the Caribbean

Geography, Environment and Climate[29]

The region is characterised by high topographic and geographic diversity which in turn drives and defines it range of climatic conditions and biomes. The Andes are about 8,850 km long, are the longest mountain chain in the world and the dominant feature of the western portion of South America running across Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela. The low lying Amazon Basin at about seven million square kilometres is the largest basin and rain forest in the world and a critical biodiversity hot-spot. About 60% of this lies in Brazil with the rest falling in Peru, Columbia, Bolivia, Venezuela, Guiana, Suriname and Ecuador. Other low-lying areas include Gran Chaco and Pampas and the coastal plains which include the Atacama Desert in the west. The LAC region has extensive coastline of about 250,230 km along the Atlantic and Pacific Oceans, as well as the Caribbean Sea.

The Caribbean is composed of thousands of islands ranging from large islands such as Cuba, Jamaica, Hispaniola (shared by Haiti and the Dominican Republic), and Puerto Rico, to small islets, cays and reefs. These islands can have varied and diverse topography and are known for their beauty, many featuring white-sand beaches, coral reefs, clear waters and some with diverse mangrove forests.

The Amazonian rain-forest is critical preserve for global bio-diversity and also plays an important role in climate regulation, together with the vast areas of the region that fall under tropical and sub-tropical forests. At the other

[29] National Geographic, "South America: Physical Geography" (https://education.nationalgeographic.org/resource/south-america-physical-geography, 2023); Wikipedia, "Caribbean," *Wikipedia*, August 2024; Wikipedia, "Latin America," *Wikipedia*, August 2024.

extreme is the Atacama Desert in Chile, which is among the driest places on Earth and stretches for 105,000 square km.[30]

The climate in Latin America and the Caribbean is significantly varied due to the variable altitude, proximity to the coast, and ocean currents. The Amazon Basin, Central America and Caribbean is characterised by a tropical climate, with high temperatures and humidity. Parts of Brazil, Argentina and Chile are subtropical and with distinct seasons and the higher altitudes and southern parts of the region have cooler temperatures and four distinct seasons. Finally, the deserts, like the Atacama have extremely dry conditions.

Livelihoods and Socioeconomic Conditions

Countries in the region have diverse economies and livelihoods. The majority of the countries are middle-income, however income disparities between and within the countries are high. The informal sector is dominant in the poorer countries and particularly vulnerable to crisis, such as the COVID-19 pandemic.[31] Per capita and employment growth in the region has remained sluggish with persistence of gender gaps and intensification of climate shocks in the region is expected to have significant negative effects on the economies which are highly reliant on climate sensitive sectors such as agriculture, mining and tourism.[32]

Political History and Conflict

Spanish and Portuguese colonisation between the 15th to 19th centuries played a central role in the power structures and social hierarchies of the region and shaped the shared history of the countries in the region, including the movements of independence in the early 19th century.[33] Colonial regimes also perpetuated social and economic inequalities, relegating Afro-descendants and indigenous groups to the bottom of the social pyramid and limiting their access to opportunities and systematic exclusion.[34] In the 19th and 20th centuries, the region went through a period of political instability with the US interventions under the Monroe Doctrine playing a significant role, particularly after the 1800s when it was used to justify unilateral US interventions in the region.[35] Populist governments in Argentina and Brazil gained support in the early to mid 20th century with social revolutions in Cuba and US backed coups in Chile underlining the contrasting ideologies and the role of the "colossus of the North" in shaping the economy and political landscape.[36]

The social inequalities in the region are considered the root cause of insecurity in the LAC. The richest 10 percent of the population earns 22 times more than those the poorest 10 percent, the richest 1 percent earn 21 percent of the income of the entire economy and the top 10 percent earn more than half of pre-tax national income.[37]

Country Context

Antigua and Barbuda

Antigua and Barbuda is on the front-line of climate change, facing a range of intensifying climatic hazards that threaten their very existence. Ranked as the 5th highest in the World Risk Index in 2023, the islands are exposed to an array of baseline hazards, including hurricanes, extreme rainfall, droughts, and rising sea levels. These risks are exacerbated by the islands' geographical position and limited land area, making them particularly vulnerable to the cascading and compounding impacts of climate change.

As a SIDS, Antigua and Barbuda is particularly vulnerable to extreme climate events such as hurricanes, droughts and coastal flooding, ranking 85th on the ND-GAIN index. The country's NDC identifies five primary reasons for the country's vulnerability, including: i) inefficient planning and management of the built environment; ii) high costs of repairing damage caused by recurrent extreme climate events; iii) the composition of the country's economy; iv) high population density in the coastal zone; and v) limited availability of freshwater resources.

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[30] Wikipedia, "Atacama Desert," *Wikipedia*, August 2024.
[31] Roxana Maurizio, "Employment and Informality in Latin America and the Caribbean: An Insufficient and Unequal Recovery," Technical Note (International Labour Organisation, 2021).
[32] and Economic Commission for Latin America the Caribbean, *Economic Survey of Latin America and the Caribbean, 2024: Low-Growth Trap, Climate Change and Employment Trends. Executive Summary* (Economic Commission for Latin America and the Caribbean, 2024).
[33] James Lockhart and David Bushnell, "History of Latin America | Meaning, Countries, Map, & Facts," *Britannica* (https://www.britannica.com/place/Latin-America, August 2024).
[34] Matías Busso and Julián Messina, "The Inequality Crisis: Latin America and the Caribbean at the Crossroads," *Idb Publications*, September 2020, https://doi.org/10.18235/0002629.
[35] Office of the Historian, "Monroe Doctrine, 1823," *Milestones in the History of U.S. Foreign Relations* (https://history.state.gov/milestones/1801-1829/monroe, n.d.), accessed August 18, 2024.
[36] Max Paul Friedman, "Retiring the Puppets, Bringing Latin America Back In: Recent Scholarship on United States-Latin American Relations," *Diplomatic History* 27, no. 5 (November 2003): 621–36, https://doi.org/10.1111/1467-7709.00375.
[37] Busso and Messina, "The Inequality Crisis."

Climate change is increasing the frequency of high-intensity hurricanes, which will have severe impacts on the country, including loss of life, economic losses and damage to infrastructure. These impacts are further exacerbated by the potential to disrupt key economic activities, including tourism which makes up the largest proportion of the country's GDP (~60%) and accounts for the highest overall investment, at ~40%. Antigua and Barbuda is also heavily reliant on imports of basic supplies, including food, medicine and building materials, increasing vulnerability to disruptions to shipping routes and associated increases in insurance costs during and after extreme events. Fisherfolk are also particularly vulnerable given the limited availability of risk information and forecasts for ocean conditions or environmental impacts of climate change on reef fisheries.

Hurricanes pose the most significant threat in Antigua and Barbuda, with the country having faced 15 hurricanes and 14 tropical storms between 1995 and 2021. The devastation from Hurricanes Irma and Maria in 2017 serving as stark reminders of the destructive power of these storms. These hurricanes not only caused widespread destruction of infrastructure but also disrupted essential services such as healthcare, electricity, water, and waste management. In Barbuda, nearly 90% of the island's infrastructure was destroyed, rendering the island temporarily uninhabitable. The increasing intensity of these storms, fueled by climate change, is expected to lead to even more catastrophic events in the future.

Droughts, while less dramatic than hurricanes, pose a persistent and growing threat to the islands. Historically, droughts have led to severe water shortages, impacting utilities, agriculture, and even leading to economic crises, such as the need to import water during the drought of 1983-1985.

The low-lying geography of Antigua and Barbuda makes it particularly susceptible to land loss due to sea-level rise, which presents a long-term existential threat to Antigua and Barbuda.

The interplay of these climatic hazards creates a highly vulnerable environment for Antigua and Barbuda, where the effects of one event can exacerbate the impacts of another. For example, a severe hurricane can lead to flooding, which disrupts essential services and exacerbates water shortages caused by droughts. The cascading effects of these hazards, coupled with the islands' low-lying topography and concentration of economic activities along the coast, underscore the urgent need for comprehensive climate adaptation strategies.

Local stakeholders have identified several key areas that require urgent attention to strengthen the islands' resilience. The first is the need for improved observation and forecasting systems, particularly for marine hazards. Given the islands' exposure to ocean-related hazards such as storm surges and coastal erosion, there is a critical need for accurate and locally specific advisories to protect vulnerable groups. The built environment is another area of concern, as many buildings are not resilient to high-intensity storms due to the cost of building to code and the existence of outdated infrastructure. An improved understanding of building resilience is crucial for planning emergency responses, including evacuations and sheltering.

The tourism sector, which employs a large percentage of the population and is heavily concentrated in exposed coastal areas, also requires targeted preparatory actions. International visitors, who may lack local knowledge of climate hazards, are particularly vulnerable, highlighting the need for better integration of the tourism sector into the islands' Multi-Hazard Early Warning Systems (MHEWS) and Anticipatory Action (AA) systems. Finally, the island of Barbuda, still recovering from the devastating impacts of Hurricane Irma, has been flagged as a key focus area for improving preparedness and response capabilities.

Ecuador

Ecuador is recognized as vulnerable to climate change impacts due to a combination of political, geographic, and social factors. It ranks 115 out of 185 countries in the 2021 ND-GAIN Index When coupled with a low readiness score, this makes Ecuador highly susceptible to climate-related impacts. These impacts, such as droughts, floods, and landslides, undermine development and reduce the availability of natural resources, affecting the majority of the population. This vulnerability was evident during the droughts of 2023 and 2024 , as well as the floods of 2016, 2023 and 2024.

Ecuador's climate is highly diverse due to its location on the equator and its varied topography, which includes the Amazon rainforest, the Andes mountains, and the Pacific coast. Ecuador is highly vulnerable to a range of climate-related hazards, including floods, landslides, and droughts. These events disproportionately affect vulnerable populations, including Indigenous communities, low-income households, and women, who often have less access to resources and information needed for effective disaster preparedness and response. The project's focus on integrating gender-sensitive approaches into early warning systems directly addresses these vulnerabilities. Through tailoring climate services and early warning messages to the needs of these groups, the project aims to reduce their exposure to climate risks and enhance their resilience.

Ecuador's economic and social development is uneven, with significant disparities between urban and rural areas. Many rural and Indigenous communities rely on agriculture and natural resources, making them particularly

susceptible to climate hazards. The MHEWS project will contribute to enhance the resilience of these vulnerable populations by providing timely and accurate early warnings, which can prevent significant economic losses and support sustainable development.

Floods are the most frequent hydro-meteorological disaster in Ecuador and rank second in terms of casualties, with landslides, storms, and droughts also contributing significantly. According to the Desinventar database , there has been an increase in both the number of events and deaths over the past 40 years, although with significant fluctuations. The rise in the intensity and frequency of these extreme climatic events has caused economic damages and losses to goods and services, with annual losses reaching between $927 million and $3.3 billion . Associated non-economic losses include loss of life, health impacts, human mobility, biodiversity, cultural heritage, and indigenous knowledge. In this context, 18 indigenous peoples and 13 nationalities are at risk from the threats and impacts of climate change.

Climate change projections indicate significant impacts, including the continued melting of glacier cover on volcanoes, variations in sea surface temperatures, changes in spatial and temporal precipitation patterns, expansion of flood-prone areas, intensification of droughts, reduced water quantity and quality, the spread of disease-transmitting vectors (such as dengue and malaria), and loss of biodiversity. The increased intensity and frequency of both extreme and slow-onset climatic events will continue to cause economic and non-economic losses to goods, services, and human well-being .

South Western Pacific

Geography, Environment and Climate

The Southwest Pacific encompasses diverse archipelagos situated in the Pacific "Ring of Fire" which is characterised by active volcanoes, earthquakes and tsunamis.[38] These island nations are ethnographically divided into Melanesia, Polynesia and Micronesia, the former making up three fourths of the the total indigenous population of the region. Many of these islands are characterised by mountainous terrain, dense rain-forests and narrow coastal plains. They are interspersed with the vast Pacific Ocean with rich marine life, coral reefs, atolls and deep ocean trenches and are home to unique floral and fauna, much of which is highly vulnerable to climate change. The small islands are particularly susceptible to cyclonic storms, sea level rise and lack of freshwater resources.[39]

The climate is hot and humid throughout the year and significantly influenced by trade winds and ocean currents. Cyclone and typhoons occur largely between November and April causing high winds, extreme rainfall and resulting in coastal flooding. This adds to the fragility of the region which faces challenges of over fishing and loss of corals due to ocean acidification and heat waves, which is expected cause unprecedented bleaching and reduction of the reefs in the next 30 years.[40]

Livelihoods and Socioeconomic Conditions

Countries in the region are predominantly developing economies with significant variation in income levels and development indicators. Most are highly dependent on climate vulnerable natural resources with little diversification into other sectors. Livelihoods in the region are predominantly dependent on fisheries[41] and smallholder agriculture - both highly vulnerable to the impacts of climate change.[42]

Country Context

Fiji

Fiji is considered a high-risk country due to its vulnerability to natural disasters, ranking 75th out of 193 countries in the World Risk Report 2023. The country faces significant impacts from tropical cyclones and floods, with annual asset losses exceeding F$500 million, reaching over 5% of the GDP. In extreme cases like a 100-year fluvial flood, losses could surpass F$2 billion, affecting the transport and building sectors the most. Droughts, particularly during El Niño events, have led to reduced crop production and the need for emergency water and food supplies in Fiji.

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[38] Royal Berglee, *World Regional Geography* (University of Minnesota Libraries Publishing edition, 2016. This edition adapted from a work originally published in 2012 by Flatworld Knowledge., 2016), https://doi.org/10.24926/8668.2701.
[39] Francis James West and Sophie Foster, "Pacific Islands Region, Pacific Ocean," *Britannica* (https://www.britannica.com/place/Pacific-Islands, July 2024).
[40] Shannon Sully, Gregor Hodgson, and Robert Van Woesik, "Present and Future Bright and Dark Spots for Coral Reefs through Climate Change," *Global Change Biology* 28, no. 15 (August 2022): 4509–22, https://doi.org/10.1111/gcb.16083.
[41] Matthew B. Roscher et al., "Unpacking Pathways to Diversified Livelihoods from Projects in Pacific Island Coastal Fisheries," *Ambio* 51, no. 10 (October 2022): 2107–17, https://doi.org/10.1007/s13280-022-01727-x.
[42] James R. A. Butler et al., "How Feasible Is the Scaling-Out of Livelihood and Food System Adaptation in Asia-Pacific Islands?," *Frontiers in Sustainable Food Systems* 4 (April 2020), https://doi.org/10.3389/fsufs.2020.00043.

Climate change poses a threat to food security, especially in coastal areas impacted by sea level rise and salinity intrusion. Traditional crops exhibit more resilience to climate change than non-traditional ones, but staples like rice, taro, and yams remain vulnerable. Fiji's limited capacity to manage and adapt to climate risks contributes to health risks and increased poverty rates. Natural hazards like tropical cyclones and floods annually push around 25,700 people into poverty, disproportionately affecting communities reliant on subsistence fishing and facing water security challenges. Changing weather patterns also threaten sectors like agriculture and tourism, critical to Fiji's economy, as evidenced by the increasing impact of 124 natural disasters over the past 37 years, with tropical cyclones, floods, and earthquakes being the most frequent occurrences.

South East Asia

Geography, Environment and Climate[43]

South East Asia comprises of eleven countries of Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. The region has a diverse range of land-forms including and is bordered by the Indian Ocean to the west, the Pacific Ocean to the east, and China to the north. Major rivers, including the Mekong River, the Irrawaddy River, and the Chao Phraya River flow through this landscape and play a significant role in irrigation, transportation, while also being the source of regular flooding. The topography of the region is highly varied with the highest peak of Mount Hkakabo in northern Myanmarat 5,881 metres. Most of the island nations too have highly undulating terrain with mountains/hills and plateaus which often contribute to devastating landslides during extreme rain events. The plains and coastlines are the third most significant feature of the landscape, and are prone to frequent floods. The coastlines are long and varied coastline, with many bays, gulfs, and peninsulas. The region is also home to a number of archipelagos, including the Indonesian Archipelago and the Philippines.

South East Asia is a hot-spot of global biodiversity[44] with tropical rainforests, mangroves, coral reefs, and grasslands housing a number of endangered species, such as the Sumatran tiger, the Javan rhinoceros, and the orangutan which are among the over 15,000 species of plants, 1,000 species of birds, and 500 species of mammals. However, the region has experienced significant deforestation in recent decades, attributed to logging, agriculture, especially the spread of oil palms, and other human activities. Many countries in teh region are also facing increasing levels of pollution due to industrialisation and urbanisation.

Southeast Asia falls within the tropical and subtropical climatic zones. The region receives high annual precipitation, most of it during the monsoons in the period between April and September. The wind reverses direction during the other six, drier months.The tropical climate has high temperatures and humidity throughout the year. The average annual temperature in the region is around 27 degrees Celsius and about 2,000mm of rainfall. The region has a number of climate related disasters with floods being the most common. The source of floods are not entirely natural and include heavy rainfall and storm surges but also dam releases and failures. The latter includes those in upstream countries which makes managing floods and building reliable flood early warning systems a complex challenge. Floods can cause widespread damage to infrastructure, agriculture, and homes and regularly lead to large scale displacement, disease and mortality. Droughts in the region are another common climate related hazards and are triggered by rainfall deficits and the high temperatures. Droughts can lead to crop failures, water shortages, and wildfires with a significant negative impact on livelihoods, health and the economy. Another critical climate-related hazard is tropical cyclones which bring torrential rains, high winds and storm surges leading to flooding and landslides and causing widespread destruction of infrastructure, displacement of people and the spread of disease. Heat waves are becoming more common in the region, exacerbating illnesses and causing heat strokes and exhaustion.[45]

The impact of climate change in the region includes 1) significant loss of life, particularly due to floods and landslides, often triggered by cyclones; 2) economic losses due to damage to infrastructure; 3) large scale displacement of people, largely due to floods and landslides; and 4) spread of water borne and vector borne diseases such as cholera.

Livelihoods and Socioeconomic Conditions

Agriculture is the main source of livelihoods in the region, employing about 40% of the workforce in both farming and fishing. The region also has a growing manufacturing and service sector, the former focusing largely in textiles and electronics and the latter on tourism, financial services and telecommunications. The region has experienced strong

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[43] Britannica, "Southeast Asia | Map, Islands, Countries, Culture, & Facts," *Southeast Asia* (https://www.britannica.com/place/Southeast-Asia, October 2024); Wikipedia, "Southeast Asia," *Wikipedia*, October 2024.
[44] Russell A. Mittermeier et al., *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*, ed. Peter A. Seligmann and a Foreword by Harrison Ford (Conservation International, 2005).
[45] R. Shaw et al., "Asia," Book Section, in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. H. O. Pörtner et al. (Cambridge, UK and New York, USA: Cambridge University Press, 2022), 1457–1579, https://doi.org/10.1017/9781009325844.012.1457.

economic growth in the recent decades in which technological advances in mobile communications and access to internet plays a significant role. However there has also been a rapid growth in urban areas which house over half the population, leading to challenges in housing, infrastructure and pollution. The region has also seen an increase in climate change related hazards as described earlier. Poverty remains a key challenge in Southeast Asia, in spite of the economic growth in the region. Income disparities are high and living standards for the majority of the population remain a challenge. Environmental degradation poses a significant challenge, particularly in the poorer countries. Growing urbanisation is contributing to pollution and rapid expansion of agriculture and increased extraction of natural resources, illegal mining and illegal trade in wildlife have contributed to significant loss of biodiversity.[46]

Political History and Conflict

The region has a complex political history shaped by colonialism, nationalism and geopolitical conflicts and rivalries. European colonial powers including the British, French, Dutch and Spanish, established colonies in Southeast Asia from the 16th century causing a disruption in the traditional political and economic systems and social structures. Most countries gained independence in the decades following the end of World War II. However regional conflicts and civil war erupted in the following decades, some of which continue along with territorial disputes between countries. However, there has been relative peace in the region since the end of the Cold War.

Country Context

Cambodia

Cambodia faces a high level of disaster risk, ranking 58th out of 191 countries in the 2024 INFORM Risk Index. The country is especially vulnerable to flood and drought events, with about 80% of its land in the Mekong River and Tonle Sap regions. Underlying vulnerabilities such as economic and environ-mental challenges further heighten the risk from climate hazards for disadvantaged populations.

Cambodia, a country still recovering from decades of conflict, faces significant development challenges and is particularly susceptible to compounding and cascading risks. These risks disproportionately affect vulnerable populations, including rural communities, women, children, and ethnic minorities. Climate change intensifies the frequency and severity of floods, droughts, and storms, exacerbating poverty and food insecurity. Economic downturns and health crises further amplify poverty, unemployment, and inequality, while discrimination based on gender, ethnicity, and disability exacerbates vulnerability to shocks and stresses. Specific examples in Cambodia include rural communities highly vulnerable to climate-related shocks, women and girls facing gender-based discrimination and limited economic opportunities, children affected by displacement and lack of education, and ethnic minorities experiencing discrimination and increased vulnerability to exploitation. Economic and Social Development Level of the Country and the Affected Population

Between 2014 and 2021/22, Cambodia made significant progress in reducing poverty, dropping the poverty incidence from 36.7% to 16.6%. However, after the 2019 COVID-19 outbreak and economic shock, approximately 4.5 million people were still classified as falling under ID poor 1 or 2, and at-risk households are in danger of falling into poverty due to economic instabilities, natural disasters, and environmental degradation. Cambodia is highly vulnerable to the impacts of climate change, which is projected to exacerbate flooding and drought risks and decrease the country's GDP by as much as 10% by 2050.

Climate related disasters and associated losses and damages

Climate change related disasters in the different regions selected for this multi-country project are summarised with statistics on their impacts over the past decade presented in Table 3. The disasters were taken from the EM-dat database (2000-2024) and only disasters which were driven by or can be influenced by climate related drivers were analysed. These include the following disasters/hazards and the aspects of climate which influence them (Table 2):

Table 2. Climate related disaster/hazards and their driving climate variables

Disaster/hazard	Driving climate variables
Drought	Precipitation, evaporation, wind
Forest fire	Precipitation, temperature, wind
Land fire (Brush, Bush, Pasture)	Precipitation, temperature, wind
Wildfire (General)	Precipitation, temperature, wind
Avalanche	Precipitation, temperature
Coastal flood	SLR, pressure, wind

[46] World Bank, "The World Bank in Malawi," Text/HTML, *World Bank*, accessed December 29, 2023, https://www.worldbank.org/en/country/malawi/overview.

Disaster/hazard	Driving climate variables
Flash flood	Precipitation
Flood (General)	Precipitation, evaporation
Landslide (wet)	Precipitation, temperature, evaporation
Mudslide	Precipitation, temperature, evaporation
Riverine flood	Precipitation, evaporation
Rockfall (wet)	Precipitation, temperature
Blizzard/Winter storm	Precipitation, temperature
Cold wave	Temperature
Extra-tropical storm	Precipitation, temperature, wind
Hail	Precipitation, temperature
Heat wave	Temperature
Lightning/Thunderstorms	Humidity, temperature, precipitation
Severe weather	Precipitation, temperature, wind
Severe winter conditions	Precipitation, temperature, wind
Storm (General)	Precipitation, temperature, wind
Storm surge	Pressure, winds
Tornado	Pressure, winds, temperature
Tropical cyclone	Precipitation, temperature, pressure, wind

The frequency of different disaster sub-types, as well as the resulting deaths, people affected and associated damages varies between each region, highlighting that hazards/disasters and their impacts are variable geographically on a range of time scales. The countries participating in this proposal likewise suffer from different hazards to varying degrees necessitating different approaches to identifying risks, as well as monitoring and forecasting (depending on the focus hazard and location).

Table 3. Summary of climate hazards from year 2000 and their impacts in different regions of the world where the multi-country project is proposed. Source EM-Dat, accessed [2024-04-01 Mon]

Disaster Subgroup	Disaster Subtype	No. Disasters.	Deaths	Affected	Damage, Adjusted ('000 US$)
Latin America and the Caribbean					
Climatological	Drought	84	53	58,243,666	27,868,595
	Forest fire	25	67	10,457,340	1,089,371
	Land fire (Brush, Bush, Pasture)	5	12	12,432	42,031
	Wildfire (General)	12	508	167,844	1,024,933
Hydrological	Coastal flood	6	11	375,413	67,803
	Flash flood	71	838	1,124,294	2,399,496
	Flood (General)	259	2,780	18,997,817	7,274,172
	Landslide (wet)	65	2,209	339,438	947,321
	Mudslide	17	890	206,904	462,551
	Riverine flood	391	10,716	35,068,334	28,094,828
	Rockfall (wet)	1	33		
Meteorological	Blizzard/Winter storm	6	152	98,879	108,003
	Cold wave	38	2,209	4,593,472	783,581
	Extra-tropical storm	1	3	1,600	
	Hail	3		62,155	
	Heat wave	2	50	17,490	
	Lightning/Thunderstorms	7	44	415,803	4,982

Disaster Subgroup	Disaster Subtype	No. Disasters.	Deaths	Affected	Damage, Adjusted ('000 US$)
	Severe weather	23	86	213,492	250,573
	Severe winter conditions	9	83	1,010,889	1,256,261
	Storm (General)	22	119	177,464	356,999
	Storm surge	1	12	20,000	
	Tornado	5	28	20,685	
	Tropical cyclone	350	9,338	50,946,550	183,127,219
Total			30,241	182,571,961	255,158,719
Melanesia					
Climatological	Drought	3	24	2,587,000	74,085
Hydrological	Coastal flood	3	4	75,300	
	Flash flood	6	61	57,986	39,549
	Flood (General)	3	12	27,300	
	Landslide (wet)	9	175	10,895	
	Mudslide	1	1	300	
	Riverine flood	18	62	415,313	252,438
Meteorological	Tropical cyclone	49	379	2,832,476	1,654,165
Total			718	6,006,570	2,020,237
South-eastern Asia					
Climatological	Drought	28	11	62,960,847	13,630,008
	Forest fire	8	19	410,064	1,255,066
	Wildfire (General)	1			
Hydrological	Avalanche (wet)	1	6	1,200	
	Coastal flood	10	241	863,255	731,964
	Flash flood	126	3,925	15,287,496	5,394,041
	Flood (General)	208	1,657	24,379,522	1,888,124
	Landslide (wet)	84	3,977	2,724,247	151,271
	Mudslide	3	106	56,215	92,793
	Riverine flood	242	7,375	76,019,585	72,430,241
	Rockfall (wet)	1	12	55	
	Sudden Subsidence (wet)	1	287	2,838	
Meteorological	Cold wave	2	77	1,000,000	
	Extra-tropical storm	1	5	4,652	1,696
	Hail	4	14	35,204	17,771
	Lightning/Thunderstorms	10	56	170,287	5,772
	Severe weather	11	22	176,573	11,308
	Storm (General)	27	349	3,696,492	336,934
	Storm surge	4	36	968,359	56,946
	Tornado	5	20	6,508	7
	Tropical cyclone	275	162,022	166,312,180	45,089,154
Total			180,217	355,075,579	141,093,096
Sub-Saharan Africa					
Climatological	Drought	164	23,374	396,444,808	6,456,676
	Forest fire	4	29	3,855	
	Land fire (Brush, Bush, Pasture)	9	79	63,450	601,482

Disaster Subgroup	Disaster Subtype	No. Disasters.	Deaths	Affected	Damage, Adjusted ('000 US$)
	Wildfire (General)	7	109	43,801	501,449
Hydrological	Coastal flood	5	157	1,200,829	70,575
	Flash flood	118	5,704	4,642,635	245,181
	Flood (General)	285	6,487	32,577,759	9,343,600
	Landslide (wet)	54	1,709	226,536	32,675
	Mudslide	3	1,173	11,922	35,818
	Riverine flood	446	7,950	37,517,242	4,947,719
Meteorological	Blizzard/Winter storm	1	22	100,000	8,135
	Cold wave	1	22		
	Hail	4	52	10,146	
	Heat wave	2	71	20	
	Lightning/Thunderstorms	18	271	52,253	723,041
	Severe weather	26	83	74,731	33,539
	Storm (General)	45	152	194,823	
	Storm surge	3	47	22,487	
	Tornado	7	9	82,327	14,643
	Tropical cyclone	109	5,355	17,449,765	4,230,900
Total			52,855	490,719,389	27,245,433
Total Result		3,858	264,031	1,034,373,499	425,517,485

Observed and projected climate changes which will increase the frequency and intensity of hazards and risks

Data from the IPCC Interactive Atlas[47] was used to generate maps of global projections for climate change for four scenarios and the near, medium and long term are presented in Annex 1. Tables summarising the changes are presented in Annex 2 and time-series plots are presented in Annex 3. The implication of changes in these indices and variables are described in Annex 4.

The projections show changes in the following variables:

1. Mean temperature change (°C).
2. Annual precipitation change (%).
3. Maximum five day precipitation change (%).
4. Change in consecutive dry days (days).
5. Change in standard precipitation index (%).
6. Change in sea level rise (m).

These variables were chosen because: i) they describe the range of climate changes expected in each region; ii) they describe changes in both the average climate and extremes; iii) they can be related to the range of impacts described in Table 2 (with the exception of temperature extremes, which are related to heatwaves)

Global

Historical changes in weather and climate and associated impacts

Rising global temperatures associated with anthropogenic climate change are on track[48] or, have already exceeded 1.5 °C from pre-industrial levels for annual average near surface temperature.[49] In many countries, societies and the natural systems on which they depend are unable to cope and adapt to the impacts of climate change, some of which

[47] Iturbide, M. et al., "IPCC WGI Interactive Atlas," *Ipcc Working Group I (Wgi): Sixth Assessment Report* (https://interactive-atlas.ipcc.ch/atlas, 2021).
[48] World Meteorological Organisation (WMO), "Global Annual to Decadal Climate Update Target Years: 2023 and 2023-2027," 2023.
[49] Malcolm T. McCulloch et al., "300 Years of Sclerosponge Thermometry Shows Global Warming Has Exceeded 1.5°C," *Nature Climate Change* 14, no. 2 (2024): 171–77, https://doi.org/10.1038/s41558-023-01919-7.

are irreversible.[50] The intensity and frequency of both slow as well as rapid onset disasters has increased, creating food insecurity for millions of people by reducing production from agriculture and natural resources and disrupting ecosystem services.[51]

The impact of climate change varies in different regions of the world. However a common theme emerging from literature including the IPCC[52] (Figure 1), the WMO State of the Climate Reports[53] and the World Bank Country Climate and Development Reports[54] is the necessity for food system resilience. This is on account of agriculture being the most heavily impacted sector, particularly in countries where it supports a high proportion of livelihoods, employs a sizeable proportion of the population and contributes significantly to the national economy. This is supported by the NDC synthesis report of 2022, where freshwater resources, food production and nutritional security and terrestrial and wetland ecosystems are the highest ranked priority areas and sectors.[55] The review of National Adaptation Plans[56] submitted by 48 countries identified drought, floods, increasing temperatures, sea level rise, and land and forest degradation as critical impacts of climate change. Cyclones and typhoons and storm surges were major concerns in most of the SIDS. The major impacts of these hazards reported included reduced crop yield, faster soil degradation, outbreaks of animal diseases, loss of livestock, reduction of water supply, salinisation of water resources, seasonal migration of agricultural workers, ecosystem and biodiversity loss, increased rate of coastal erosion, damage to infrastructure and increased incidence of forest fires.

The probability of compound extreme events has likely increased due to human-induced climate change. Concurrent heatwaves and droughts have become more frequent over the last century, and this trend will continue with higher global warming. The probability of compound flooding (storm surge, extreme rainfall and/or river flow) has increased in some locations and will continue to increase due to both sea level rise and increases in heavy precipitation, including changes in precipitation intensity associated with tropical cyclones. Earlier occurrence of peak stream-flow in high-latitude and mountain catchments have also been observed.[57]

The intensity, geographic extent and frequency of both slow and rapid onset disasters has increased, exacerbated by changes in the weather and climate, including increases in temperature (leading to heatwaves, damages to agriculture and human health) and the intensity of rainfall, storms and cyclones (causing floods, landslides and coastal inundation), as well as decreases in rainfall (leading to agricultural and hydrological droughts). These crises increase the climate related risks faced by communities and the livelihoods on which they depend, as well as creating food and water insecurity for millions of people by reducing production from agriculture and natural resources and disrupting ecosystem services.[58]

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[50] David I. Armstrong McKay et al., "Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points," *Science*, September 2022, https://doi.org/10.1126/science.abn7950.

[51] Valérie Masson-Delmotte et al., "Global Warming of 1.5 C," An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty, 2019.

[52] IPCC, "IPCC — Intergovernmental Panel on Climate Change," 2024.

[53] "WMO E-Library" (https://library.wmo.int, n.d.), accessed March 23, 2024.

[54] World Bank, "Country Climate and Development Reports (CCDRs)," *Country Climate and Development Reports (Ccdrs)* (https://www.worldbank.org/en/publication/country-climate-development-reports, 2024).

[55] UNFCCC, "Report of the Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement on Its Third Session, Held in Glasgow from 31 October to 13 November 2021 Addendum Part Two: Action Taken by the Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement at Its Third Session," March 2022, https://unfccc.int/sites/default/files/resource/cma2021_10_add1_adv.pdf.

[56] UNFCCC LDC Expert Group, "National Adaptation Plans 2023: Progress in the Formulation and Implementation of NAPs" (Bonn, Germany: United Nations Framework Convention on Climate Change, 2023).

[57] Paola A. Arias et al., "Technical Summary," in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Valérie Masson-Delmotte et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2021), 33–144, https://doi.org/10.1017/9781009157896.001.

[58] Masson-Delmotte et al., "Global Warming of 1.5 C."

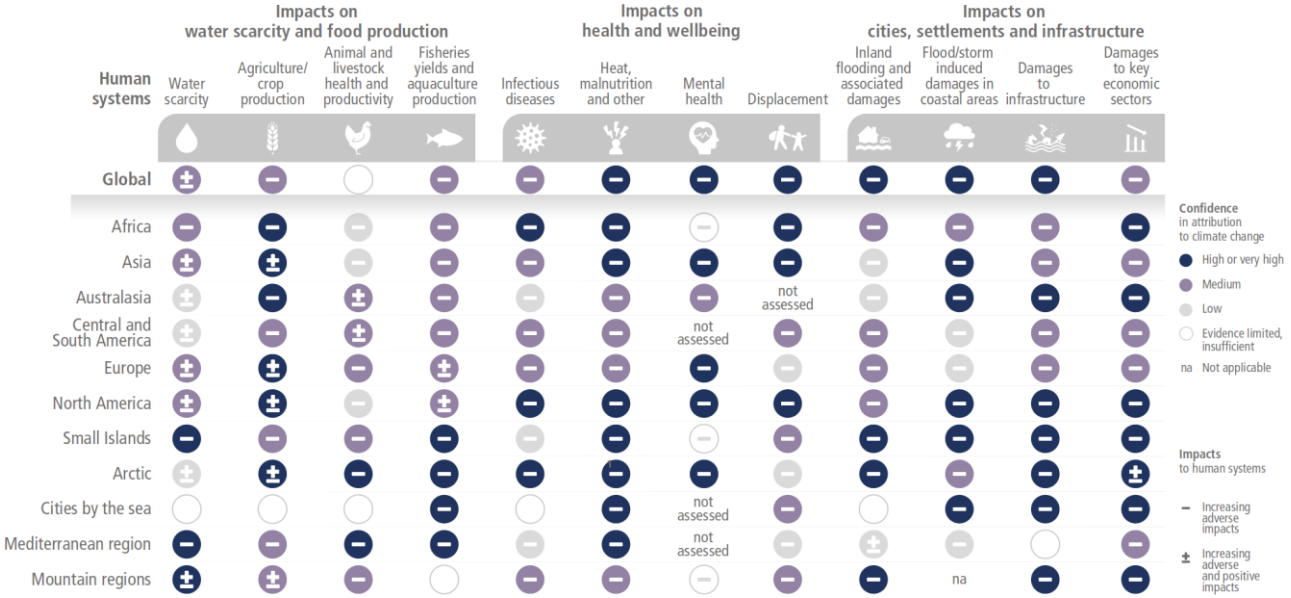

Figure 1. Observed global and regional impacts on human systems attributed to climate change[59]

Projected changes in weather/climate and associated impacts

Early warning systems to monitor climate and weather changes are a critical investment to enhance climate resilience at a national and community level, by providing critical information to guide risk management and make informed long term decisions that can result in avoided losses. Early warnings can save lives and assets worth at least ten times their cost. Just 24 hours warning of a coming storm or heat wave can cut the ensuing damage by 30%, while spending USD800 million on such systems could avoid losses of $3–16 billion per year .

The technical summary of the Physical Science report of the IPCC[60] projects change in a wide range of indicators across all components of the climate system, which provide a coherent picture of the warming world.

Temperature

Compared to 1850–1900, average global surface temperature over the period 2081–2100 is very likely to be higher by 1.0°C to 1.8°C in the SSP1-1.9 scenarios and by 3.3°C to 5.7°C by the SSP5-8.5 scenario (Table 4. Further changes in hot and cold extremes will occur throughout the 21st century in nearly all inhabited regions, even if global warming is stabilized at 1.5°C

Table 4. 20-year averaged change in global surface temperature in °C relative to the 1850–1900 reference period[61]

Term	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Near, 2021–2040	1.5 [1.2 to 1.8]	1.5 [1.2 to 1.8]	1.5 [1.2 to 1.8]	1.6 [1.3 to 1.9]
Mid, 2041–2060	1.7 [1.3 to 2.2]	2.0 [1.6 to 2.5]	2.1 [1.7 to 2.6]	2.4 [1.9 to 3.0]
Long, 2081–2100	1.8 [1.3 to 2.4]	2.7 [2.1 to 3.5]	3.6 [2.8 to 4.6]	4.4 [3.3 to 5.7]

Global Mean Sea Level Rise

Global mean sea levels, which are 20cm higher, are projected to increase by an additional 30 cm to 1 m or more by 2100. I needs to be noted, however, that sea level rise may continue for thousands of years. It is therefore likely that GMSL will continue to rise over the 21st century in response to continued warming of the climate system, reaching 0.28–0.55 m under SSP1-1.9 and 0.63–1.01 m under SSP5-8.5 relative to the 1995–2014 average.

Precipitation

Global annual precipitation over land is projected to increase on average by 2.4% under SSP1-1.9, 4.6% under SSP2-4.5, and 8.3% under SSP5-8.5 by 2081–2100 relative to 1995–2014. The rates of change in mean precipitation and runoff, and their variability is likely to increase with global warming. Heavy precipitation will become more frequent and more intense with additional global warming translating to an increase in the frequency and magnitude of pluvial floods. The severity of very wet and very dry events increase in a warming climate. Water cycle variability and related

[59] Source: Hans-Otto Pörtner et al., eds., "Summary for Policymakers," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2022).

[60] Pörtner et al.

[61] Source: Pörtner et al.

extremes are projected to increase faster than mean changes in most regions of the world and under all emission scenarios.

Increases in near-surface atmospheric moisture capacity of about 7% per 1ºC of warming are likely to lead to an increase in the intensification of heavy precipitation from sub-daily up to seasonal time scales, increasing the severity of flood hazards. The average and maximum rain-rates associated with tropical and extratropical cyclones, atmospheric rivers and severe convective storms will therefore also increase with future warming. For some regions, peak tropical cyclone rain-rates will increase by more than 7% per 1°C of warming due to increased low-level moisture convergence caused by increases in wind intensity. Interannual variability of precipitation and runoff over land is projected to increase at a faster rate than changes in seasonal mean precipitation. This is expected to be year-round in the tropics and in the summer season elsewhere. Sub-seasonal precipitation variability is also projected to increase, with fewer rainy days but increased daily mean precipitation intensity over many land regions.

Water Resources

Projected increases in precipitation amount and intensity will be associated with increased runoff in northern high latitudes. Projected runoff from contributions of small glaciers will decrease due to glacier mass loss, while that from larger glraciers is expected to increase with increasing global warming levels until their mass becomes depleted. Water cycle variability and related extremes are projected to increase faster than mean changes in most regions of the world and under all emissions scenarios. The warmer climate is projected to increase moisture transport into weather systems, which will intensify wet seasons and events.

Evapotranspiration and Plant Water Demand

Warming over land is projected to drive an increase in atmospheric evaporative demand and in the severity of drought events. Greater warming over land than over the ocean alters atmospheric circulation patterns and reduces continental near-surface relative humidity, which is projected to contribute to regional drying. Projected increases in evapotranspiration due to growing atmospheric water demand will decrease soil moisture over the Mediterranean region, south-western North America, South Africa, South-Western South America and south-western Australia. Some tropical regions are also projected to experience enhanced aridity, including the Amazon basin and Central America. The total land area subject to increasing drought frequency and severity will expand, and in the Mediterranean, South-Western South America, and Western North America, future aridification will far exceed the magnitude of change seen in the last millennium.

Central and West Africa (Sahel)

Observed Changes in weather/climate and their impacts

Between late 1960s and mid 1990s the Sahel faced a series of droughts during which there was a 30% percent decrease in rainfall compared with the 1950s. This led to a famine where more than a hundred thousand people died in 1973 alone.[62] Droughts have also been credited for drastic ecological changes such as the shrinking of Lake Chad and a reduction in plant cover linked to desertification fuelling conflict and violence between fishermen and farmers.[63]

Sahel has seen the largest temperature increases in Africa[64] - which is warming faster than the global average.[65] Temperature increases in West Africa for 2022 have been 0.03 °C and 0.71 °C relative to the 1991-2020 and 1961-1990 reference period. In Central Africa these were 0.13 °C and 0.80 °C. The rains in West Africa were higher than normal, albeit there was a delayed monsoon rainy season.[66] In terms of extreme events, many parts of West and Central Africa faced flooding towards the end of the monsoon. Chad was among the countries worst affected by the heaviest rainfall received in the past 30 years causing extensive damage to houses and agriculture.

[62] Hal Sheets and Morris, Roger, “Disaster in the Desert : Failures of International Relief in the West African Drought” (The Carnagie Endowment for International Peace, 1974).
[63] Maha Skah and Rida Lyammouri, “The Climate Change-Security Nexus: Case Study of the Lake Chad Basin” (Rabat, Morocco: Policy Center for the New South, June 2020).
[64] Climate & Development Knowledge Network and African Climate & Development Initiative, “The IPCC’s Sixed Assessment Report: Impacts, Adaptation Options and Investment Areas for a Climate-Resilient West Africa,” Fact Sheet, 2022.
[65] IPCC, “Africa. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.”
[66] World Meteorological Organisation (WMO), *State of the Climate in Africa*, WMO-No. 1330 (Geneva, Switzerland: WMO, 2023).

The major driver of the drought is the Sahel is changes in ocean temperature,[67] although vegetation cover did play a role in albedo.[68] This evidence has built on earlier critiques[69] to debunk the popular belief that local practices were leading to climate change and the southward spread of the Sahara.[70] In fact, the practices that were once seen as the cause of degradation and climate change in the region are now regarded as adaptations to climate change by local communities.[71] The rainfall regime in the Sahel is the most sensitive to atmospheric circulation in the world and the climate gradient in the Western Africa is considered the most extreme.[72]

Projected changes in weather/climate and associated impacts

Monsoon precipitation is also projected to increase in the mid to long term over West Africa and eastern-central Sahel, but decrease in western Sahel, while it is expected to have a delayed onset and retreat over West Africa. The distribution of rainfall is projected to be highly variable across the Sahel with a later monsoon and an increase in the number of consecutive dry days and reduced growing season days. Drought conditions are expected over the Sahel through 2020.[73]

Regional projections from the IPCC Atlas[74] based on CMIP-6 model ensemble for Central and West Africa including most of the Sahel Region are presented in Annex 2 - West and Central Africa and the Sahel and the time-series plots are presented in Annex 3 - West and Central Africa and the Sahel.

These are summarised below for the near (2020 to 2040), medium (2040-2060) and long terms (2080 to 2100) and for four SSP scenarios (1-2.6, 2, 4.5, 3-7.0 and 5-8.5).

- Temperature: Projected to increase between 1.5–1.6 °C in the near term, 1.9–2.5 °C in medium term and by 2.0–4.9 °C for the long term.
- Total precipitation percent change: Projected to increase by 4.9–6.4 in the near, 5.5–7.0 in the medium and 4.8–9.8 in the long term.
- Annual Standardised Precipitation Index (SPI-6) percent change: Projected to increase by 35.5–42 in the near, 32–44.4 in the medium and 36.9–60.3 in the long term. This implies there will be near normal conditions in the region.
- Annual maximum 5-day precipitation percent change: Projected to increase by 10.4–13.0 in the near, 12.3–18.8 in the medium and 11.6–32.8 in the long term, suggesting an in crease in flooding.
- Annual Consecutive Dry Days change in days: Projected to reduce by -0.9—−0.8 in the near, reduce by -0.3—-0.2 in the medium term and change by -0.1–0.4 days in the long term.
- Annual change in days for Bias Adjusted Temperature Exceeding 35 °C (SSP 1-2.6, 3-7.0 and 5-8.5): Projected to increase by 15.2–16.7 in the near, 25.7–40 in the medium and 30.1–115 in the long term, suggesting an increase in heat waves.
- Change in sea level in metres: Projected to increase by 0.1 m in the near, by 0.2–0.3 in the medium and by 0.5–0.8 m in the long term.

The time-series plots show an increasing inter-annual variability in most of these variables and indices (Annex 3 - West and Central Africa).

Country context

Chad

Sixty two natural disasters were recorded in Chad between 1971 and 2022. Of these 68 percent (42 events) occurred since 2000 (EM-DAT, 2024). Successive droughts have affected the food security and livelihoods of households across large swathes of the country, with 1.5 million people affected in 1981-85, and 2.4 million people affected in 2009-

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[67] I. M. Held et al., "Simulation of Sahel Drought in the 20th and 21st Centuries," *Proceedings of the National Academy of Sciences* 102, no. 50 (December 2005): 17891–96, https://doi.org/10.1073/pnas.0509057102; A. Giannini, R. Saravanan, and P. Chang, "Oceanic Forcing of Sahel Rainfall on Interannual to Interdecadal Time Scales," *Science* 302, no. 5647 (November 2003): 1027–30, https://doi.org/10.1126/science.1089357; Martin Hoerling et al., "Detection and Attribution of Twentieth-Century Northern and Southern African Rainfall Change," August 2006, https://doi.org/10.1175/JCLI3842.1.

[68] Jule Charney et al., "A Comparative Study of the Effects of Albedo Change on Drought in Semi–Arid Regions," September 1977; C. K. Folland, T. N. Palmer, and D. E. Parker, "Sahel Rainfall and Worldwide Sea Temperatures, 1901–85," *Nature* 320, no. 6063 (April 1986): 602–7, https://doi.org/10.1038/320602a0.

[69] Jerrold L. Dodd, "Desertification and Degradation of Africa's Rangelands.," *Rangelands Archives* 16, no. 5 (1994): 180–83.

[70] Charney et al., "A Comparative Study of the Effects of Albedo Change on Drought in Semi–Arid Regions"; H. F. Lamprey, "Report on the Desert Encroachment Reconnaissance in Northern Sudan," *Desertification Control Bulletin*, no. 17 (1988): 1–7.

[71] Nick Brooks, "Drought in the African Sahel: Long Term Perspectives and Future Prospects," Working Paper, October 2004.

[72] Sharon E. Nicholson, "Climate of the Sahel and West Africa," in *Oxford Research Encyclopedia of Climate Science*, 2018.

[73] Nicholson; Biasutti, "Rainfall Trends in the African Sahel."

[74] Iturbide, M. et al., "IPCC WGI Interactive Atlas."

2010. The most recent drought in 2022 affected 2.1 million people while floods in the same year rendered 121,088 people homeless. Floods and droughts have also been associated with outbreaks of disease, and with under-nutrition. Together, these disasters led to a total of 10,556 recorded deaths, of which two thirds were a result of viral or bacterial disease epidemics such as cholera, meningitis and measles.

Studies have shown a continuous increase in temperatures, as well as increased variability in rainfall in the sub-region since the 1990s. After a sequence of wet years covering the 1950s and 1960s, followed by a sequence of dry years in the 1970s and especially dry years in the 1980s, inter-annual variations have increased since the 1990s, though with relatively higher rainfall. Overall precipitation in Chad has been above average over several years since the 1990s, particularly in the Sahelian zone, but with variability in its distribution over the year. The spatial distribution of precipitation has changed, with the retreat of the 300 mm and the 1,200 mm isohyets.

Air temperature is expected to increase by 2.1°C to 4.3°C (very likely range) by 2080. Relative to pre-industrial levels, the median temperature increase from climate models in Chad is 2.1°C in 2030, 2.6°C in 2050, and 3.5°C in 2080 under RCP6.0. The number of very hot days per year is also expected to increase across the country with a high degree of certainty. For the RCP6.0 scenario, the median of the multiple models (averaged over the entire country) predicts 17 additional very hot days per year in 2030, 31 additional days in 2050 and 49 additional days in 2080, compared to 2000. In some parts of the country, particularly in the center, this equates to over 300 very hot days per year by 2080.

Projections of precipitation and variations in rainfall for 2030, 2050 and 2100 vary greatly, according to the country's zones owing to the high natural variability from year to year and high level of uncertainty and differences between models. The more conservative models would lead to a reduction in precipitation while the models with higher emissions driving higher global temperature increases suggest higher precipitation, with higher variability. Critically, all models project more variability in precipitation than the pre-1980 situation.

Climate change is likely to affect the vast majority of the population in Chad which remains dependent on rain-fed agriculture. Projected changes in rainfall patterns and distribution, high temperatures are likely to affect food production and livelihoods and directly impact over 77% of the labour work force reliant on agriculture and further exacerbate hunger which will acutely affect children, elderly and those with chronic diseases.

East Africa

Observed Changes in weather and climate and their impacts

Africa, as a whole received a significant deficit in rainfall. However certain parts of East Africa received more than normal amounts of rainfall, except countries in the Horn including Norther Uganda, Ethiopia, Somalia and Kenya had drier the normal conditions with most of the latter three facing the fifth consecutive below-average rainfall season. Observed temperatures increases of 0.9 °C in East Africa were the highest in Africa. Drought have intensified in the Greater Horn of Africa, including Ethiopia and Somalia, where rainfall was well below average and this being the fifth consecutive poor wet season with major impacts on agriculture and food security. Reduced agricultural productivity in these regions is driving agricultural expansion with consequent impacts on biodiversity and ecosystems, diminished natural resources and conflict over productive land. In some areas this is triggering conflict between farmers and herders. Crop and pasture lands in Easter Africa have driven up the costs of food an increased the number of food insecure people. The number of internally displaced persons has increased, with conflict in some regions adding to the number of refugees and asylum seekers…[75]

Climate hazards in East Africa include floods, droughts, storms and landslides. Floods have caused widespread damage to infrastructure and crops and have contributed to waterborne diseases. Droughts have resulted in crop failures leading to food and water insecurity while storms have damaged infrastructure, crops and loss of lives. Landslides, which are linked to heavy rains have also contributed to loss of lives, infrastructure and crops.

Projected changes in weather and climate and associated impacts

Climate induced changes over East Africa are projected to follow the "dry gets drier and wet gets wetter" paradigm. Drought area in East Africa is likely to increase at the end of the 21st century by 16%, 36%, and 54% under RCP 2.6, 4.5, and 8.5, respectively, with the areas affected by extreme drought increasing more rapidly than severe and moderate droughts.[76] On the other hand, the short rains are likely to become more intense. These events in the recent past have resulted in severe flooding, landslides and mud slides that led to the destruction of property, loss of human lives, livestock and crops, and displacement of people.[77]

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[75] World Meteorological Organisation (WMO), *State of the Climate in Africa*.

[76] Gebremedhin Gebremeskel Haile et al., "Projected Impacts of Climate Change on Drought Patterns Over East Africa," *Earth's Future* 8, no. 7 (July 2020): e2020EF001502, https://doi.org/10.1029/2020EF001502.

[77] Caroline M. Wainwright et al., "Extreme Rainfall in East Africa, October 2019–January 2020 and Context under Future Climate Change," *Weather* 76, no. 1 (January 2021): 26–31, https://doi.org/10.1002/wea.3824.

Regional projections from the IPCC Atlas[78] based on CMIP-6 model ensemble for East Africa, including the Horn of Africa Region are presented in Annex 2 - EAF and the time-series plots are presented in Annex 3 - East Africa and the Horn of Africa.

Climate projections for the East Africa region for the near (2020 to 2040), medium (2040-2060) and long terms (2080 to 2100) for four SSP scenarios (1-2.6, 2, 4.5, 3-7.0 and 5-8.5) are summarised below.

- Temperature: Projected to increase between 1.5–1.6 °C in the near term, 1.9–2.5 °C in medium term and by 1.9–4.8 °C for the long term.
- Total precipitation percent change: Projected to increase by 5.3–6.9 in the near, 6.5–10.5 in the medium and 8.0–22.4 in the long term.
- Annual Standardised Precipitation Index (SPI-6) percent change: Projected to increase by 20.6–24.6 in the near, 26.4–41.1 in the medium and 31.3–78.5 in the long term. This implies there will be near normal conditions in the region.
- Annual maximum 5-day precipitation percent change: Projected to increase by 8.7–9.5 in the near, 10–15.7 in the medium and 12.1–34 in the long term, suggesting an in crease in flooding.
- Annual Consecutive Dry Days change in days: Projected to reduce by 1.4–1.5 in the near,1.5–1.9 in the medium term and 2.2–5.8 days in the long term.
- Annual change in days for Bias Adjusted Temperature Exceeding 35 °C (SSP 1-2.6, 3-7.0 and 5-8.5): Projected to increase by 13.8–14.2 in the near, 20.6–33.1 in the medium and 22–90.4 in the long term, suggesting an increase in heat waves and higher stress on vegetation, crops and livestock.
- Change in sea level in metres: Projected to increase by 0.1 m in the near, by 0.2–0.3 in the medium and by 0.4–0.7 m in the long term.

Country Context

Ethiopia

Ethiopia is highly vulnerable to a range of climate-related hazards, including recurrent droughts, floods, landslides, and wildfires, which are increasingly exacerbated by climate change. This vulnerability significantly impacts specific populations, particularly women, children, and rural communities that heavily depend on agriculture for their livelihoods. Women of reproductive age face substantial challenges due to systemic inequalities, with over 22% suffering from chronic under-nutrition. Furthermore, more than 1.2 million children under five are affected by acute malnutrition, illustrating the severe repercussions of climate-induced food insecurity on these vulnerable demographics. Addressing these vulnerabilities is crucial for enhancing preparedness through effective early warning systems, ensuring that critical information reaches those most at risk, and empowering them to respond proactively to climate-related shocks.

Projections indicate that temperatures in Ethiopia will rise by 1.5-2.5°C by mid-century under RCP4.5 and up to 3-4°C under RCP8.5. Rainfall will become more erratic, with prolonged dry spells worsening drought conditions, wild land and forest fires, and intensified rainfall events leading to severe flooding, land and mudslides. Significant impacts of climate change in Ethiopia include reduced water availability, frequent crop failures, and heightened food insecurity. South-West Ethiopia is facing devastating floods causing widespread destruction of homes, public infrastructure and affecting essential services like water, sanitation, and hygiene. In July 2024, torrential rains in the Gambella region triggered floods and landslides severely affecting 143,000 people and causing more than 2,300 fatalities. Wildfires have ravaged ecosystems, including humid forests and protected areas. The IOM Displacement Tracing Matrix DTM, 2024 reports that drought in the Somali region is causing the highest number of displacements caused by climate-induced events (17% of IDPs), followed by floods, landslides and fires (9% of IDPs).

Climate-related risks such as droughts and floods, which impact agriculture and water resources. Climate change poses a significant threat to Ethiopia's development, exacerbating existing vulnerabilities. The country faces high impacts from natural hazards and increasing climate variability, which threaten its development goals. Sectors affected include water, agriculture, energy, transport, and urban development. The country faces significant water challenges, with variable and unpredictable rainfall affecting millions of people. Rising temperatures and increased rainfall variability threaten economic growth and exacerbate poverty. Both droughts and floods cause substantial economic damage. These economic impacts highlight the urgent need for effective climate adaptation and mitigation strategies in Ethiopia.

Somalia

Historical and projected climate change impacts in Somalia are drought and flood, although Somalia is also affected by cyclones and coastal flooding is also classified as being high. Daily temperature maximums have increased over the

[78] Iturbide, M. et al., "IPCC WGI Interactive Atlas."

last two decades and are projected to continue over the next decade. In 2023 around 2.48 million people were affected by floods,188 lives were lost and over 1.2 million were displaced. During 2015 – 2022, 6.1 million people were affected by drought, and 760,000 - 1.2 million people were displaced. Daily temperature maximums have also increased across Somalia over the last two decades and are projected to continue over the next decade.

Intense rainfall events and subsequent floods have become more frequent in Somalia, resulting in water runoff on the earth's surface, washing away fertile soil and causing widespread devastation. Riverine flooding typically occurs along the Juba and Shabelle Rivers in southern Somalia and flash flooding tending to occur in the north along intermittent watercourses. The 2023 Deyr flood was reported to be the worst flood Somalia has faced, resulting in the loss of 188 lives and affecting ≈2.48 million people and displacing over 1.2 million. The floods resulted in damages to the tune of 126.6 million and losses of 49.5 million across sixteen districts. Agriculture, livestock, water and sanitation and transport were the most affected sectors. Cyclones, such as Cyclone Sagar (2018) and coastal inundation, tend to affect northern Somalia's Somaliland and Puntland regions.

Climate change projections suggest that the duration, frequency and intensity of droughts will increase by the end of the 21st Century under all scenarios and that drought areas will increase by 16 per cent, 36 per cent and 54 per cent under increasing Representative Concentration Pathways (RCPs) (2.6, 4.6, 8.5 respectively). The frequency and intensity of heavy precipitation events are projected to increase with potential impacts of flooding and soil erosion. The higher rainfall and runoff expected across the various climate scenarios, are likely to lead to increased flash flooding.

Increased frequency, persistence and intensity of droughts in Somalia are likely. Climate change projections suggest that the duration, frequency and intensity of droughts will increase by the end of the 21st Century under all scenarios and that drought areas will increase by 16 per cent, 36 per cent and 54 per cent under increasing Representative Concentration Pathways (RCPs) (2.6, 4.6, 8.5 respectively). The very southern areas of Somalia are projected to experience extreme heat, and the southern and some parts of the northern areas are projected to experience very high heat. The impacts of prolonged dry seasons have led to water scarcity, reduced grazing land, reduced livestock production, livestock perishes, reduced agricultural productivity, food insecurity. Climate projections suggest these impacts are likely to be exacerbated in the future.

Somalia's chronic climate-associated shocks are compounded by increased conflict and insecurity, and have aggravated the nation's growth and slowed the transition from fragility. Climate change has exacerbated this vulnerability by increasing the frequency, persistence and intensity of droughts in Somalia to which nomadic and agro-pastoral communities are the most vulnerable.

Latin America and the Caribbean (LAC)

Observed Changes in weather/climate and their impacts

This region has seen the strongest warming trend of about 0.2 °C per decade on record, warming faster than global averages with projected temperatures to rise by 1.5 to 2.5 °C by 2050. Prolonged droughts have affected multiple sectors including agriculture, energy, transportation and water supply. Droughts have combined with higher temperatures and lower humidity to trigger wildfires in the region. Sea levels have risen at a higher rate than the global mean and tropical storms such as Fiona, Lisa and Ian caused extensive damage as did floods and landslides triggered by heavy rain which also caused hundreds of deaths.[79] Climate change-driven impacts and risks are amplified for small islands. More severe and frequent hurricanes compound the impacts of sea level rise, coastal erosion, flooding and salinisation of water bodies and aquifers, threatening coastal communities and infrastructure.[80] In Central and South America, changes in the timing and magnitude of precipitation and extreme temperatures are affecting agricultural production among subsistence farmers. This includes more frequent long dry spells, reduced precipitation and altered rainfall during the start and end of the rainy season. Warming temperatures have further increased the transmission of vector borne diseases.[81]

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[79] World Meteorological Organisation (WMO), *State of the Climate in Latin America and the Caribbean 2022*, WMO-No. 1322 (Geneva, Switzerland: WMO, 2023).

[80] Michelle Mycoo et al., "Small Islands," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Hans-Otto Pörtner et al. (Cambridge University Press, 2022); M. Mycoo et al., "Small Islands," Book Section, in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. H. O. Pörtner et al. (Cambridge, UK and New York, USA: Cambridge University Press, 2022), 2043–2121, https://doi.org/10.1017/9781009325844.017.2043.

[81] E. Castellanos et al., "Central and South America," Book Section, in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. H. O. Pörtner et al. (Cambridge, UK and New York, USA: Cambridge University Press, 2022), 1689–1816, https://doi.org/10.1017/9781009325844.014.1689.

Projected changes in weather/climate and associated impacts

Regional projections from the IPCC Atlas[82] based on CMIP-6 model ensemble for Latin America and Caribbean Region are presented in Annex 2 - Latin America and Caribbean and the time-series plots are presented in Annex 3 - Latin America and Caribbean.

Climate projections for the near (2020 to 2040), medium (2040-2060) and long terms (2080 to 2100) and for four SSP scenarios (1-2.6, 2, 4.5, 3-7.0 and 5-8.5) are summarised below.

- Temperature: Projected to increase between 1.4–1.5 °C in the near term, 1.8–2.4 °C in medium term and by 1.8–4.5 °C for the long term.
- Total precipitation percent change: Projected to change by -0.2–1.3 in the near, and increase by 0.5–1.9 in the medium and change by -0.3–2.1 in the long term.
- Annual Standardised Precipitation Index (SPI-6) percent change: Projected to decrease by 4.6–15.1 in the near, 3.2–20 in the medium and 4.2–34.8 in the long term. This implies there will be near normal conditions in the region.
- Annual maximum 5-day precipitation percent change: Projected to increase by 2.9–4.5 in the near, 4.4–5.1in the medium and 5.1–10.4 in the long term.
- Annual Consecutive Dry Days change in days: Projected to change by -0.4–1.4 in the near, by -02–2.7 in the medium term and increase by 0.1–7.5 days in the long term.
- Annual change in days for Bias Adjusted Temperature Exceeding 35 °C (SSP 1-2.6, 3-7.0 and 5-8.5): Projected to increase by 7.2–9.2 in the near, 10.8–21.5 in the medium and 11.7–55.3 in the long term, suggesting an increase in heat waves.
- Change in sea level in metres: Projected to increase by 0.1 m in the near, by 0.2–0.3 in the medium and by 0.5–0.7 m in the long term, posing a significant risk to coastal areas and small islands in the region.

Country Context

Antigua and Barbuda

Antigua and Barbuda is highly exposed to a number of climate related hazards, including hurricanes, extreme rainfall, droughts, and rising sea levels. Hurricanes are considered the country's main climate hazard, having faced 15 hurricanes and 14 tropical storms between 1995 and 2021. Additionally, the islands endured 14 drought episodes between 2000 and 2020, resulting in droughts being considered the 2nd major climate threat. Hurricanes pose the most significant threat in Antigua and Barbuda. The country faced 15 hurricanes and 14 tropical storms between 1995 and 2021. Droughts also pose a persistent and growing threat to the islands. Historically, droughts have led to severe water shortages, impacting utilities, agriculture, and even leading to economic crises, such as the need to import water during the drought of 1983-1985. The low-lying geography of Antigua and Barbuda makes it particularly susceptible to land loss due to sea-level rise, which presents a long-term existential threat to Antigua and Barbuda.

Climate change is expected to fuel the intensity of hurricanes in the future by 18% for category 4 and 5 hurricanes over the next 30 years, based on General Circulation Models (GCMs), leading to even more catastrophic events. Projections also indicate a 30%-50% reduction in annual rainfall by 2090. Droughts are expected to become more severe, further straining the already limited water resources. Under the RCP 4.5 scenario, models predict 9 drought years for the period 2040–2069, representing an 8% increase in drought severity. All future scenarios assessed by the Intergovernmental Panel on Climate Change (IPCC) suggest that the country will face rising sea levels and increasing land and sea surface temperatures in the future. The low-lying geography of Antigua and Barbuda makes it particularly susceptible to land loss due to sea-level rise. Antigua could lose approximately 20 km² of land, while Barbuda could lose 15 km² by 2060.

This loss of land, combined with rising sea surface temperatures and increased ocean acidification, threatens not only the islands' ecosystems but also the livelihoods of those who depend on the sea, particularly in the tourism and fishing sectors. Hurricanes in the past have caused widespread destruction of infrastructure and also disrupted essential services such as healthcare, electricity, water, and waste management. The devastation from Hurricanes Irma and Maria in 2017 destroyed nearly 90% of Barbuda's infrastructure, rendering the island temporarily uninhabitable.

The interplay of these climatic hazards creates a highly vulnerable environment for Antigua and Barbuda, where the effects of one event can exacerbate the impacts of another. For example, a severe hurricane can lead to flooding, which disrupts essential services and exacerbates water shortages caused by droughts. The cascading effects of these hazards, coupled with the islands' low-lying topography and concentration of economic activities along the coast, underscore the urgent need for comprehensive climate adaptation strategies.

[82] Iturbide, M. et al., "IPCC WGI Interactive Atlas."

Ecuador

Floods are the most frequent hydro-meteorological disaster in Ecuador and rank second in terms of casualties, with landslides, storms, and droughts also contributing significantly. There has been an increase in both the number of events and deaths over the past 40 years, although with significant fluctuations. Increases in temperature as well as spatial and seasonal variations in rainfall were experienced across Ecuador between the period of 1960–2010. The observed average temperature increase was 1.4°C, with maximum temperatures rising by 1.0°C and minimum temperatures increasing by 1.1°C in the Galapagos Islands.

Climate projections suggest changes in the frequency and magnitude of both average and extreme precipitation and temperature values. By the 2090s, average temperatures in Ecuador are expected to rise significantly, potentially increasing by 3.5°C to 4.0°C under the highest emissions pathway (RCP8.5), compared to the baseline of 1986–2005. Annual precipitation is expected to decrease in the Amazon (by 2–6%) but increase along the coast and in the mountain areas under the highest emissions pathway by the 2090s. Intense precipitation is also expected to rise across the country, especially in the central mountain region, with increases of up to 50 mm for the average largest 1-day precipitation .

Climate change projections indicate significant impacts, including the continued melting of glacier cover on volcanoes, variations in sea surface temperatures, changes in spatial and temporal precipitation patterns, expansion of flood-prone areas, intensification of droughts, reduced water quantity and quality, the spread of disease-transmitting vectors (such as dengue and malaria), and loss of biodiversity. The increased intensity and frequency of both extreme and slow-onset climatic events will continue to cause economic and non-economic losses to goods, services, and human well-being.

Climate change impacts vary across the country's regions and include: (i) approximately 40% loss of glacier cover on the Antisana, Carihuayrazo, Cotopaxi, and Chimborazo volcanoes; (ii) severe droughts affecting 66.7% of agricultural areas and 53.7% of livestock areas (pastures); and (iii) extreme rainfall increasing the fooded surface area by 15.9%, affecting 49.5% of the population. The rise in the intensity and frequency of these extreme climatic events has caused economic damages and losses to goods and services, with annual losses reaching between $927 million and $3.3 billion . Associated non-economic losses include loss of life, health impacts, human mobility, biodiversity, cultural heritage, and indigenous knowledge. In this context, 18 indigenous peoples and 13 nationalities are at risk from the threats and impacts of climate change.

South East Asia (SEA)

Observed Changes in weather/climate and their impacts

Surface temperature has increased in the past century across Asia with large increases and extremes in West and Central Asia, resulting in an increasing trend of growing-season length and strong, more frequent and longer heatwaves in South and East Asia. There is a decreasing trend of the South Asian summer monsoon precipitation during the second half of the 20th century.

Projected changes in weather/climate and associated impacts

An increase in the likelihood of heatwaves is projected across Asia with droughts in arid and semiarid areas of West, Central and South Asia, floods in monsoon regions in South, Southeast and East Asia, and glacier melting in the Hindu Kush Himalaya region. Temperature rise will be strongest in summer in some parts of South Asia where a desert climate prevails. The wet-bulb globe temperature, which is a measure of heat stress, is likely to approach critical health thresholds in West and South Asia under the RCP4.5 scenario, and East Asia, under the RCP8.5 scenario. A sizeable part of South Asia is expected to experience heat stress conditions due to heat waves in the future. Both heavy and intense precipitation are projected to intensify and become more frequent in South, Southeast and East Asia. Monsoon land precipitation is also likely to increase in East, Southeast and South Asia mainly due to increasing moisture convergence by elevated temperature. A large increase in flood frequency in monsoon regions in Southeast Asia is expected in the absence of mitigation efforts, and is likely to increase loss of lives and infrastructure.[83]

Regional projections from the IPCC Atlas[84] based on CMIP-6 model ensemble for the Southeast Asia Region are presented in Annex 2 - South East Asia and the time-series plots are presented in Annex 3 - South East Asia.

Climate projections for the near (2020 to 2040), medium (2040-2060) and long terms (2080 to 2100) and for four SSP scenarios (1-2.6, 2, 4.5, 3-7.0 and 5-8.5) are summarised below.

[83] R Shaw et al., "Asia," in *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Intergovernmental Panel on Climate Change (IPCC) (Cambridge: Cambridge University Press, 2023), 1457–1580, https://doi.org/10.1017/9781009325844.012.
[84] Iturbide, M. et al., "IPCC WGI Interactive Atlas."

- Temperature: Projected to increase between 1.3–1.4°C in the near term, 1.5–2.1 °C in medium term and by 1.6–4.0 °C for the long term.
- Total precipitation percent change: Projected to change by -1.4–0.1 in the near, -0.6–0.5 in the medium and -0.2–1.4 in the long term.
- Annual Standardised Precipitation Index (SPI-6) percent change: Projected to chanbe by -6.8–0.6 in the near, -2.8–2.6 in the medium and -2.6–6.7 in the long term. This implies there will be near normal conditions in the region.
- Annual maximum 5-day precipitation percent change: Projected to increase by 3.8–4.1 in the near, 5.8–7.3in the medium and 6.3–17.1 in the long term, suggesting increased chances of flooding.
- Annual Consecutive Dry Days change in days: Projected to increase by 1.9–2.5 in the near term, 2.5–3.5 in the medium term and 2.1–6.5 days in the long term.
- Annual change in days for Bias Adjusted Temperature Exceeding 35 °C (SSP 1-2.6, 3-7.0 and 5-8.5): Projected to increase by 3.8–4.4 in the near, 6.1–13.3 in the medium and 6.8–52.1 in the long term, suggesting an increase in heat waves.
- Change in sea level in metres: Projected to increase by 0.1 m in the near, by 0.2–0.3 in the medium and by 0.5–0.7 m in the long term, posing a significant risk to coastal areas and small islands in the region.

Country Context

Cambodia

Historically, Cambodia has experienced consistent temperatures that peak above 32°C in early summer and range from 25 to 27°C annually. The summer monsoon from May to November brings the heaviest rainfall to the southeast and northwest regions. Annual rainfall varies from 1,400–2,000 millimetres, with coastal and highland areas receiving higher amounts. El Niño Southern Oscillation impacts monsoons, leading to warmer and drier winters during El Niño and cooler conditions during La Niña.

Under SSP3-7.0, projected precipitation patterns show increased regional variability by mid-century and drier dry seasons nationally. Annual precipitation is expected to rise by 14.48 mm from Cambodia's 1995–2014 reference period over 2020–2039. Conversely, a decrease of 11.27 mm is projected over 2040–2059, with southern and eastern provinces seeing the most significant increases and northern areas experiencing the greatest decreases in annual precipitation.

Climate change is projected to exacerbate flooding and drought risks and decrease Cambodia’s GDP by as much as 10% by 2050 compared to projected GDP in 2050 in the absence of climate change. Agriculture, infrastructure, forestry, human health, and coastal areas are most affected by climate change. The observed impacts of climate change include more intense rains leading to floods, delayed rainy season and longer dry seasons affecting rain-fed and irrigated crops, unexpected dry periods during the rainy season, and untimely rains which affect agricultural planning. Dams and poor river management exacerbate climate change related impacts, increasing vulnerabilities and risks, especially near waterways such as the Mekong River.

Rural communities in Cambodia are highly vulnerable to climate-related shocks. Climate change will likely exacerbate Cambodia's vulnerability to extreme weather events such as floods and droughts, which can damage infrastructure, disrupt agriculture, and lead to food insecurity. Rising temperatures and changing precipitation patterns may affect water resources and biodiversity, threatening ecosystems and livelihoods—additionally, sea-level rise risks coastal areas, potentially displacing communities and impacting the nation's economic stability.

South-West Pacific Ocean (SPO)

Observed Changes in weather/climate and their impacts

In the South West Pacific, tropical cyclones, floods, droughts, sea level rise and ocean acidification have had significant impacts on people, economies and ecosystems. Accounting to the State of the Climate Report for South-West Pacific,[85] the region is influenced by both the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). The mean surface temperature were 0.05 °C to 0.15 °C above the 1991-2000 average for the South-West Pacific and 0.5 °C to 1 °C above 199-2020 average for South Pacific including French Polynesia and New Zealand which had the warmest year on record. The negative temperature anomalies over equatorial Pacific were on account of the prevailing La Niña conditions. Rainfall patterns, also affected by the La Niña conditions, showed above normal in the western part of the region but dry conditions over much of equatorial Pacific. Heatwaves occurred in various parts of the region and sea-level rise rates were higher than the global mean, reaching ≈4mm per year in certain areas. Storms

[85] World Meteorological Organisation (WMO), *State of the Climate in South-West Pacific*, WMO-No. 1324 (Geneva, Switzerland: WMO, 2023).

were the leading cause of death, affecting the largest number of people and causing the most economic damage of all disasters.[86]

Projected changes in weather/climate and associated impacts

Regional projections from the IPCC Atlas[87] based on CMIP-6 model ensemble for ## Region are presented in ## and the time-series plots are presented in Annex 2 - South Pacific and the time-series plots are presented in Annex 3 - South Pacific.

Climate projections for the near (2020 to 2040), medium (2040-2060) and long terms (2080 to 2100) and for four SSP scenarios (1-2.6, 2, 4.5, 3-7.0 and 5-8.5) are summarised below.

- Temperature: Projected to increase between 0.9–1.0 °C in the near term, 1.2–1.6 °C in medium term and by 1.2–3.1 °C for the long term.
- Total precipitation percent change: Projected to reduce by 0.6–0.8 in the near, 0.9–1.4 in the medium and 0.8–3.7 in the long term.
- Annual Standardised Precipitation Index (SPI-6) percent change: Projected to decrease by 8.8–10.0 in the near, 9.4–14.5 in the medium and 7.0–23.4 in the long term. This implies there will be near normal conditions in the region.
- Annual maximum 5-day precipitation percent change: Projected to increase by 3.9–4.1 in the near, 4.8–6.8 in the medium and 5.1–12.7in the long term, suggesting increased probabilities of flooding.
- Annual Consecutive Dry Days change in days: Projected to increase by 2.3–2.6 in the near, 2.5–3.6 in the medium term and 2.3–6 in the long term.
- Annual change in days for Bias Adjusted Temperature Exceeding 35 °C (SSP 1-2.6, 3-7.0 and 5-8.5): No trends were observed.
- Change in sea level in metres: Projected to increase by 0.1 m in the near, by 0.2 in the medium and by 0.4–0.8 m in the long term, posing a significant risk to coastal areas and small islands in the region.

Country Context

Fiji

Fiji has warmed up by 0.7 degrees relative to the pre-industrial baseline of 1850-1900, up to the period of 2011-2020. Observed and projected warming shows that 2°C of global warming corresponds to 1.2 to 1.9°C in Fiji. The temperatures in Fiji have increased at a faster rate in recent decades. The strongest increase has been in daily maximum temperatures (around 0.2°C per decade) and a similar increase in daily minimum temperatures (around 0.1°C per decade). Historical observations also show large year-to-year variability in rainfall with no significant trends since 1960.

Fiji is projected to experience a warming of 0.9°C by 2040-2059 and 1.3°C by 2080-2099 and under the high warming scenario (RCP8.5), the projected warming is 1.3°C and 2.7°C, respectively. Climate Change projections in rainfall are less certain with a high degree of variability which indicates that average annual rainfall may remain the same, but there will be increase in the intensity for extreme rainfall events. Southwest Pacific tropical cyclone activity projection for a 2°C global warming indicates a likely decrease in the total number of cyclones, and a possible increase in the frequency of severe (category 4-5) cyclones. The projected increase in average cyclone intensity, combined with sea level rise and increases rainfall rate would increase the impact of these cyclones.

The impacts of climate change in Fiji include reduced crop production and the need for emergency water and food supplies. Climate change poses a threat to food security, especially in coastal areas impacted by sea level rise and salinity intrusion. Staple crops like rice, taro, and yams are particularly vulnerable to climate change. Natural hazards like tropical cyclones and floods annually push around 25,700 people into poverty, disproportionately affecting communities reliant on subsistence fishing and facing water security challenges. Changing weather patterns also threaten sectors like agriculture and tourism, critical to Fiji's economy, as evidenced by the increasing impact of 124 natural disasters over the past 37 years, with tropical cyclones, floods, and earthquakes being the most frequent occurrences. Fiji's limited capacity to manage and adapt to climate risks contributes to health risks and increased poverty rates.

Reducing the risks associated with climate change impacts through MHEWS

Adverse impacts of climate change and resulting risks are cascading across sectors and regions through multiple pathways that impact human health, water stress, food systems, economic resilience, infrastructure, and security, as

[86] Centre for Research on the Epidemiology of Disasters (CRED), "EM-DAT - The International Disaster Database" (https://www.emdat.be/, 2024).
[87] Iturbide, M. et al., "IPCC WGI Interactive Atlas."

well as ecosystem structure, species ranges and phenology at a global level.[88] The direct impact on food security,[89] as well as insecurity, conflicts over rights and access to natural resources and water, particularly for pastoral communities, is of concern. New exposure to climate-related hazards and vulnerabilities of rural communities, as well as of rapidly growing informal settlements due to urbanisation, are likely to increase significantly under climate change scenarios.[90] In the case of small islands, geopolitical and political, environmental, socioeconomic and cultural factors are interconnected and are likely to increase exposure and vulnerability to the impact of climate change induced sea level rise, increasingly intense cyclones coastal flooding and coastal erosion.[91]

Climate change has a disproportional impact on the poor and vulnerable who lack assets and access to information and resources and are therefore less able to anticipate, adapt or mitigate these impacts.[92] Often these communities are reliant on livelihoods linked to climate sensitive sectors such as agriculture, or are located in regions more exposed to climate risks, including on small islands, along coastlines and in flood and land-slide prone regions. Furthermore, vulnerable groups within communities, including women, women-headed households,[93] households with infants, children and elderly, people with disabilities,[94] often lack the means to receive information and respond to climate related disasters. Reduced agricultural productivity in these regions is driving agricultural expansion with consequent impacts on biodiversity and ecosystems, diminished natural resources and conflict over productive land. In some areas, this is triggering conflict between farmers and herders. Declining productivity of crop and pasture lands in Eastern Africa have driven up the costs of food and increased the number of food insecure people. The number of internally displaced persons has increased, with conflict in some regions adding to the number of refugees and asylum seekers. Disaster impacts in countries with high risk and high poverty can negatively affect welfare and cause major setbacks in human and economic development, with long-term consequences to resilience building and well-being.[95]

Climate change and natural disasters also exacerbate inequality. Poorer countries, regions, and people are more exposed to climate change and natural disasters, they suffer greater losses in proportion to wealth when climate shocks hit, and they have fewer resources with which to recover from climate shocks. The disproportional effect of climate shocks on poor households, exacerbates inequality by pushing them into poverty, leaving them in a worse starting position when the next climate shock hits.[96]

About 13 million people lose their lives annually due to climate-related impacts on health through pollution, extreme weather events, forced displacement, food insecurity and pressures on mental health.[97] The IPCC report highlights the acute food insecurity, malnutrition, displacement and insecurity faced by communities in LDCs, who are disproportional affected due to poverty, governance challenges, limited access to basic resources and high levels of climate-sensitive livelihoods.[98]

Climate change can have unprecedented and potentially catastrophic outcomes on societal wellbeing.[99] By 2050, the world economy may lose up to 14% ($23 trillion) on account of climate change, unless decisive action on reducing greenhouse emissions is taken.[100] Global warming is on track to cross the 1.5 °C threshold, even if greenhouse gas

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[88] Hans-O. Pörtner et al., *Climate Change 2022: Impacts, Adaptation and Vulnerability* (IPCC Geneva, Switzerland:, 2022).
[89] C. Mbow et al., "Food Security," in *Climate Change and Land: IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*, ed. Intergovernmental Panel on Climate Change (IPCC) (Cambridge: Cambridge University Press, 2022), 437–550, https://doi.org/10.1017/9781009157988.007.
[90] BRACED, "Building Climate Resilience in Fragile Contexts: Key Findings of BRACED Research in South Sudan," 2018.
[91] Mycoo et al., "Small Islands."
[92] Aleksandra Kosanic et al., "An Inclusive Future: Disabled Populations in the Context of Climate and Environmental Change," *Current Opinion in Environmental Sustainability* 55 (April 2022): 101159, https://doi.org/10.1016/j.cosust.2022.101159.
[93] Yvonne Corcoran-Nantes and Snighda Roy, "Gender, Climate Change, and Sustainable Development in Bangladesh," ed. Janet McIntyre-Mills, Norma Romm, and Yvonne Corcoran-Nantes, *Balancing Individualism and Collectivism*, Contemporary Systems Thinking (Cham: Springer International Publishing, 2018), http://link.springer.com/10.1007/978-3-319-58014-2_8.
[94] Paul S. Davies and Jeffrey Hemmeter, "Supplemental Security Income Recipients Affected by Hurricanes Katrina and Rita: An Analysis of Two Years of Administrative Data," *Population and Environment* 31, no. 1-3 (January 2010): 87–120, https://doi.org/10.1007/s11111-009-0093-1.
[95] UNDRR, "Words into Action: A Guide to Multi-Hazard Early Warning Systems," Engaging for Resilience in Support of the Sendai Framework for Disaster Risk Reduction 2015-2030, 2023.
[96] Busso and Messina, "The Inequality Crisis."
[97] WHO, "Health and Climate Change," COP24 Special Report (World Health Organisation, 2018).
[98] Pörtner et al., "Summary for Policymakers."
[99] Luke Kemp et al., "Climate Endgame: Exploring Catastrophic Climate Change Scenarios," *Proceedings of the National Academy of Sciences* 119, no. 34 (August 2022): e2108146119, https://doi.org/10.1073/pnas.2108146119.
[100] Swiss Re Institute, "The Economics of Climate Change: No Action Not an Option," 2021.

emissions are substantially reduced in the near-term.[101] Local to regional changes in the intensity and frequency of weather and climate extremes generally scale with global warming[102] and new evidence suggests that even relatively small incremental increases in global warming cause significant changes in extremes on the global scale and for large regions.[103]

Differences in regional climate between the present day and warming of 1.5 °C and between 1.5 °C and 2 °C are expected to be widespread across temperature increases and extremes, heavy precipitation events, significant increases in runoff and flood hazard, increased probability of extreme drought, precipitation deficits, and risks associated with water availability, global mean sea level rise between 0.04 – 0.16 m and an overall increase in multiple and compounded risks.[104] There is a 66% likelihood that the annual average near-surface global temperature between 2023 and 2027 will be more than 1.5 °C above pre-industrial levels for at least one year and it is possible that we have already exceeded the 1.5 °C levels.[105]

The historical and projected impacts of climate hazards show a clear increasing trend on lives, livelihoods and economies, particularly in countries with a high dependence on climate sensitive sectors. Table 5 summarises the impacts different climate hazards have had in the countries participating in this multi-country project. Effective, timely and end-to end MHEWS can allow communities to prepare and act ahead of disasters, to adopt appropriate adaptation and disaster avoidance measures. MHEWS can help governments design and invest in disaster response strategies and social protection measures to support communities and their livelihoods in the face of climate change.

Table 5. Summary of impacts of climate change in participating countries. Source: EMDAT and country feasibility studies

S/N	Climate Hazard	Scenario / Period	Affected Persons	Losses (USD)	Other Impacts
1	Antigua & Barbuda				
	Tropical Cyclones	2000–2024	1 death, 32,600 affected	315.393 million	
	Hurricanes, cyclones, typhoons	Historic event		451 million	Barbuda lost 90% of infrastructure in 2017
		RCP 8.5 1:100 year event		4.03 billion	
		RCP 8.5 Maximum credible event		9.4 billion	
		GCM			18% increase in category 4 and 5 hurricanes
	Droughts	By 2090			30-40% reduction in annual rainfall
		RCP 4.5 2040-2069			9 drought years
	Sea-level rise	By 2060			Loss of land. Antigua: 20 km^2, Barbuda 15 km^2
2	Ecuador				

[101] Amy McNally, "FLDAS Noah Land Surface Model L4 Global Monthly 0.1 X 0.1 Degree (MERRA-2 and CHIRPS)," 2018, https://doi.org/10.5067/5NHC22T9375G.
[102] IPCC, "IPCC — Intergovernmental Panel on Climate Change."
[103] Sonia I. Seneviratne et al., "Weather and Climate Extreme Events in a Changing Climate," 2021.
[104] Valérie Masson-Delmotte et al., eds., *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2021), https://doi.org/10.1017/9781009157896; Ove Hoegh Guldberg et al., "Impacts of 1.5 C Global Warming on Natural and Human Systems" (Panel Intergubernamental sobre Cambio Climático, 2018).
[105] Malcolm T. McCulloch et al., "300 Years of Sclerosponge Thermometry Shows Global Warming Has Exceeded 1.5°C."

S/N	Climate Hazard	Scenario / Period	Affected Persons	Losses (USD)	Other Impacts
	Droughts	2000–2024	110,665 affected	2.319 million	
		1960–2010			Affecting 66.7% of agricultural area
		1960–2010			53.7% of livestock areas
	Flash flood	2000–2024	20 deaths, 11,200 affected	12.194 million	
	Flood (general)	2000–2024	163 deaths, 254,782 affected	57.881 million	
	Landslide	2000–2024	122 deaths, 8,944 affected		
	Mudslide	2000–2024	30 deaths, 180 affected		
	Riverine flood	2000–2024	196 deaths, 563,115 affected	1.384 billion	
	Extreme climatic events	1960–2010		927m–3.3 billion	18 indigenous peoples and 13 nationalities are at risk
	Increased temperature (avg. 1.4°C)	1960–2010			40% loss of glacial cover on Antisana, Carihuayrazo, Cotopaxi, and Chimborazo volcanoes
	Extreme rainfall/Floods	1960–2010			increasing the floodable surface area by 15.9%, affecting 49.5% of the population
3	Fiji				
	Drought	2000–2024	67,000		
	Coastal flood	2000–2024	4 deaths		
	Flash flood	2000–2024	5 deaths, 600 affected	9.88 million	
	Riverine flood	2000–2024	32 deaths, 31,225 affected	215.509 million	
	Tropical cyclones and floods	Historical		500m (F $)or5\|\ \ \|Fluvialfloods$) or 20% of GDP	
4	Chad				
	Drought	2000–2024	8,822,162		
		1981-85	1.5 million		
		2009-2010	2.4m		
	Floods	2022	2.1m		121,088 people rendered homeless
	Flash flood	2000–2024	100 deaths, 175,763 affected	1.653 million	
	Flood (general)	2000–2024	57 deaths, 1,406,766 affected		

S/N	Climate Hazard	Scenario / Period	Affected Persons	Losses (USD)	Other Impacts
	Landslide (wet)	2000–2024	52 deaths, 37 affected		
	Riverine flood	2000–2024	117 deaths, 958,575 affected	12.747 million	
	Storm	2000–2024	14 deaths, 145 affected		
5	Ethiopia				
	Drought	2000–2024	74,705,679 affected	2.369 billion	
		1 in 5 years		1 billion	
		1 in 100 years		>3 billion	
	Flood	1 in 25 years		3.3% of GDP	
		1 in 100 years		7% of GDP	
		2000–2024	163 deaths, 1,953,785 affected		
	Flash flood	2000–2024	889 deaths, 1,030,358 affected	13.937 million	
	Riverine flood	2000–2024	713 deaths, 1,048,512 affected	2.764 million	
	Landslide	2000–2024	93 deaths, 186 affected	42,000	
	Heat stress	Current annual situation		700 million	Impact on labour productivity, livestock yields and infrastructure damage
6	Somalia				
	Drought	2000–2024	20,023 deaths, 27,535,624 affected	1.072 billion	
		2015 – 2022	6.1 million affected, 1.2 million displaced		
		2023	Additional 468,000 impacted, 247,000 displaced		
	Deyr flood	2023	188 deaths, 2.48 million affected, 1.2 million displaced	49.5 million	
	Flash flood	2000–2024	112 deaths, 1,133,285 affected	30 million	
	Flood (general)	2000–2024	173 deaths, 5,298,732 affected		
	Riverine flood	2000–2024	157 deaths, 1,791,500 affected	93.237 million	
	Tropical cyclone	2000–2024	230 deaths, 524,380 affected	2.513 million	
7	Cambodia				
	Drought	2000–2024	4,050,000 affected	61.826 million	
	Flash flood	2000–2024	59 deaths,601,950 affected	2.472 million	
	Flood (general)	2000–2024	27 deaths, 643,812 affected		
	Riverine flood	2000–2024	910 deaths, 9,784,258 affected	1.698 billion	
	Lightening/thunderstorms	2000–2024	14,100 affected		
	Severe weather	2000–2024	1 death, 501 affected		
	Storm surge	2000–2024	16 deaths		
	Tropical cyclone	2000–2024	63 deaths, 943,751 affected	113.077 million	

Well-functioning Multi Hazard Early Warning Systems (MHEWS) allow people, institutions and businesses to prepare for and respond to multiple hazards, including those occurring simultaneously or cumulatively over time, and their

potential interrelated impacts.[106] MHEWS are a proven, effective and feasible climate adaptation measure that saves lives and provides at least a tenfold return on investment.[107] The socio-economic benefits of weather prediction are about US$160 billion per year and improvements in forecasting and early warning systems could provide additional annual benefits of US$30 billion.[108] Economic assessments in several countries have found strong positive cost-benefit ratios for investment in weather and climate services to the tune of between 1:4 to 1:36 from reduction in weather-related economic losses, reduced humanitarian relief costs and maladaptive risk-coping strategies.[109]

This project will target communities whose livelihoods depend on climate sensitive sectors, those with greater physical exposure to climate hazards, with clear emphasis on including women, poor and vulnerable groups within these communities. It will lead to the enhanced production of actionable multi-hazard early warnings and impact-based forecasts to inform and trigger preparedness, early and anticipatory actions . It will strengthen multiple channels of communication to ensure timely and effective dissemination of these warnings and information to the last mile. The project will also prepare disaster management and supporting agencies at national and the sub-national level as well as communities to make effective use of these early warnings and advisories for early and anticipatory action which allows them to adapt to, avoid and facilitate recovery from climate change hazards. Table 6 describes how for each hazard there are a set of hydrometeorological indices which can be monitored and forecasted to provide early warnings. It further describes the types of early warning or use that such forecasts and monitoring can be used for, and how these early warnings further support adaptation and disaster response mechanisms.

Table 6. Summary of how hydrometerological observations and MHEWS can support adapting, mitigating and responding to climate change induced weather anomalies and hazards

Hazard or Weather Anomaly	Hydrometerological Observations and indices	Type of Early Warning	Adaptation, Disaster Preparedness and Response
Drought	Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), soil moisture content	Drought monitoring, seasonal forecasts, anticipatory/early action triggers, impact based forecasts	Water conservation, drought-resistant crop varieties, emergency response plans
Heat Wave	Temperature and humidity indices (e.g., Heat Index, Wet Bulb Globe Temperature), urban heat island intensity	Heat wave warnings, heat health watch/warning systems	Urban green spaces, cooling centres, public awareness campaigns, emergency medical services
Shortened Growing Season	Growing Degree Days (GDD)	Phenological models, pasture availability assessments	Crop variety selection, planting date adjustments, agricultural extension services, crop insurance
Flood	River stage, discharge, rainfall intensity, soil moisture	Flood forecasting, flood warning systems, flood inundation mapping	Floodplain zoning, evacuation plans, flood insurance
Flash Flood	Real-time rainfall intensity, radar-estimated rainfall, streamflow	Flash flood warning systems, nowcasting	Emergency response plans, public education, land use planning, infrastructure resilience
Extreme Precipitation Event	Rainfall intensity, duration, return period	Extreme precipitation forecasting, landslide monitoring	Storm water management systems, evacuation plans, infrastructure resilience
Rainfall Variability	Precipitation time series, trend analysis	Climate change projections, seasonal precipitation forecasts	Water storage infrastructure, diversified cropping systems, agricultural extension services

[106] WMO, "Climate Services for Supporting Climate Change Adaptation Supplement to the Technical Guidelines for The National Adaptation Plan Process," Provisional Edition, 2021.
[107] The UN Global Early Warning Initiative for the Implementation of Climate Adaptation, "Early Warnings for All - Executive Action Plan 2023-2027x" (World Meteorological Organization (WMO), 2023).
[108] World Meteorological Organization (WMO) and World Meteorological Organization (WMO), *SOFF Series, 04. The Value of GBON: Exploring the Insurance Sector* (Geneva: WMO, 2020); SOFF, "The Value of Surface-Based Meteorological Observation Data: Costs and Benefits of the Global Basic Observing Network," Information Brief (Systematic Observations Financing Facility, October 2020).
[109] WMO, "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services" (World Meteorological Organization, 2015).

Hazard or Weather Anomaly	Hydrometerological Observations and indices	Type of Early Warning	Adaptation, Disaster Preparedness and Response
Thunderstorm	Radar reflectivity, Doppler velocity, lightning detection	Severe thunderstorm warnings, nowcasting	Lightning protection, public awareness campaigns, emergency response plans, building codes
Tropical Cyclone	Satellite imagery, wind speed, atmospheric pressure	Tropical cyclone track and intensity forecasts, storm surge models	Coastal zone management, evacuation plans, building codes
Storm Surge	Tide gauge data, wind speed, atmospheric pressure	Storm surge forecasting, warning systems	Coastal protection measures, evacuation plans, disaster recovery planning
Sea Level Rise	Tide gauge data, satellite altimetry, coastal inundation models	Sea level rise projections, coastal vulnerability assessments	Coastal retreat, infrastructure elevation, ecosystem-based adaptation,

The need for global coverage of MHEWS is clear,[110] including response systems which allow preparedness activities and preventative actions and anticipatory action to attenuate the impacts of climate-induced shocks. Timely and targeted early warnings for these hazards combined with appropriate adaptation, preparedness and response can reduce these impacts significantly and help communities recover more quickly and completely from them.

How MHEWS can support adaptation and disaster response

Early warnings systems are characterised by the types of hazards and potential impacts of these hazards. MHEWS need to be contextualised to the local situation, including the level of preparedness and types of responses that are available to first responders and local communities. Table 7 presents a summary of key hazards, their impacts and main stakeholders. It also tries to summarise the types of EWS and the corresponding preparation and responses that could be appropriate. Refer to Table 6 for the types of hazards, how they are observed and associated types of MHEWS.

Table 7. Summary of hazards, their impacts and affected stakeholders and types of early warnings and response strategies

Impact	Stakeholders	Adaptation	Preparedness	Response
Droughts, rainfall variability and shortened growing season				
Prolonged periods of below-average precipitation; delayed onset and/or shortened growing season; reduced pasture and pasture quality; drying and depletion of water points, streams and rivers; food insecurity; migration and conflict over resources	Farmers (crop and livestock), pastoralists, water managers, communities, extension services - agriculture, veterinary and health	Climate resilient agriculture; soil and water conservation; watershed restoration	Response and recovery plans; conserve water; stock food	Drought relief; social protection measures; trucked water
Heat waves				
Prolonged periods of high temperatures; temperature spikes affecting crops, health of vulnerable people and livestock;increased disease; livestock weight loss and	Elderly people, children, people with health conditions, livestock and crop farmers, pastoralists, schools, tourism sector	Afforestation/tree-planting; insulated buildings; urban green spaces	Emergency medical services; water points	Avoid exposure, stay in shaded areas or indoors, increase water intake

[110] World Meteorological Organisation (WMO), "Statement of Antonio Guterres, Secretary-General of the United Nations," March 2022.

Impact	Stakeholders	Adaptation	Preparedness	Response
death; drying of water sources				
General floods				
(Prolonged) inundation of poorly drained, low-lying areas; stagnating water, pollution of water sources, disease vectors, damage to infrastructure; drowning of people and livestock; migration and conflict over resources	Urban and peri-urban areas, unplanned settlements, crop and livestock farmers, pastoralists	Watershed/drainage restoration; zonation maps; design and layout of settlements	Flood maps; evacuation plans; insurance; recovery plans	Evacuate to higher ground, elevate belongings, protect property from flooding; social protection and relief measures
Riverine Floods				
Inundation (sometimes prolonged) of floodplains and river courses; stagnating water bodies; crop loss; damage to infrastructure; pollution of water sources; disease vectors; drowning of people and livestock	Farming communities and settlements in flood plains, crop and livestock farmers, pastoralists; dam/water resource managers	Restoration of watersheds, riparian buffers and wetlands; zonation maps; town planning	Floodplain zoning maps; evacuation plans; insurance; recovery plans	Evacuate to higher ground, elevate belongings, protect property from flooding; social protection and relief measures
Flash floods				
Rapid inundation and washing away of land and infrastructure, erosion and gully formation; drowning of people and livestock	Communities resident along streams and rivers	Restoration of watersheds, riparian buffers and wetlands; zonation maps; town planning	Flood maps, evacuation plans; awareness generation	Move away from water courses; catchment restoration; flood-proofing infrastructure; relief measures
Hurricanes				
High winds; heavy rain; storm surge; coastal inundation; salinisation of aquifers; damage to fishing gear and craft; damage to coastal infrastructure; injury and death	Coastal communities; municipalities; communications, tourism and transport sector	Coastal zone management; building codes	Evacuation plans; stock food, water; cyclone shelters	Evacuate to higher ground and cyclone shelters; secure property
Coastal floods, sea level rise				
Inundation; salinisation of farmland and aquifers; damage to infrastructure	Coastal communities; municipalities; communications, tourism and transport sector	Coastal habitat restoration (dunes, mangroves, shelter-belts); coastal zone management; building codes	Coastal protection; evacuation and disaster recovery plans	Evacuate to higher ground, secure property from flooding
Hailstorms				
Damaging to property, infrastructure and crops; loss of livestock; injury and death	Farming communities; pastoralists	Building codes; afforestation/canopy preservation	Evacuation plans and shelters	Take shelter indoors; protect livestock, vehicles and property from hail
Lightening, thunderstorms, extreme rain events				
Damaging to property and crops; loss of livestock; injury and death; damage to fishing and other craft	Farming, pastoral and fishing communities	Building codes, storm-water management systems	Lightening protection; emergency response plans	Seek shelter indoors; avoid open water and tall objects
Avalanche				

Impact	Stakeholders	Adaptation	Preparedness	Response
Damage to infrastructure; erosion of productive land; alteration of water courses; loss of human lives and livestock	Settlements in hilly/mountainous areas; transport and other infrastructure	Building codes and plans; afforestation and watershed restoration; stream/drainage restoration	Evacuation and emergency response plans; insurance; designated safe areas	Evacuate to designated safe areas; soil and water conservation and afforestation of uplands; protective infrastructure
Wildfires/veldfires				
Biodiversity loss; atmospheric pollution; loss of pasture and forest resources; increased human-animal conflict; migration and conflict over resources	Forest dwellers and settlements adjacent to forests, pastoralists, forest and wild-life authorities	Fire restrictions; fire lines and buffers	Fire propensity maps; fire-hazard signs; water points and pumps	Evacuate to designated safe areas

GAPS, NEEDS AND BARRIERS FOR DEVELOPMENT OF INFRASTRUCTURE, PROCESSES AND INSTITUTIONAL CAPACITY TO DELIVER CLIMATE SERVICES, MHEWS AND AA

Barriers to establishing robust and effective end-to-end MHEWSs and anticipatory/early action

The absence of consistent, reliable and robust sources of holistic technical, human, institutional and financial support to and within countries pose challenges to the effective development, generation and use of MHEWS. Global initiatives are necessary for countries to receive consistent, continuous support that meets global standards, allows them to exchange knowledge and sustainably develop and expand MHEWS to cover all vulnerable communities, sectors and businesses. Similarly it is important to strengthen the internal mechanisms and capacities by which institutions at the national level develop and communicate early warning messages, and how these messages are received, understood and utilized by local responders, communities and populations. Some of the root causes and barriers associated with these aspects of MHEWS and that need to be addressed are described below.

Insufficient financial resources and limited capacities to access financing

There is insufficient capital at the global, country and community levels to establish and maintain the networks of observation equipment needed to generate meaningful weather, climate and hydrological forecasts (build funding). Critical socio-economic observations, which are needed to understand multi-hazard exposure and vulnerability and hence risks faced by people and communities, are also difficult to gather in real time because suitable crowd sourcing and other technologies are under utilised. The resources at national, sub-national, and community levels are not enough to translate forecasts into warnings, share these warnings effectively, and prepare communities, especially those at risk and vulnerable, to use and respond to them through mitigative actions that have been proven effective.

Limited financial resources to set up and maintain observation networks that meet the requirements of the WMO Integrated Global Observing System(WIGOS) has led to gaps in data needed to generate early warning products at the regional and global levels. Many countries face similar challenges in operating and maintaining their hydro-meteorological (hydromet) and communication networks.[111] Limited awareness about the value of hydromet and communication networks in reducing climate risks constrains opportunities to raise necessary public budgets often leading to deterioration of existing installations or the use of sub-standard equipment that fails to meet acceptable standards, creating challenges in quality control and interoperability.

Efficiency and efficacy of preparedness and early response efforts is constrained by lack of forecast-based planning and financial resources at the grassroots and municipal levels. This is critical as local governments are often mandated with maintaining local early warning systems, particularly last mile access. The inadequacy of mechanisms through which necessary funds and other resources can be rapidly released before and during emergencies is a significant barrier to early response and anticipatory action to early warnings needed to mitigate disasters. There is a lack of financing to put in place and maintain the mechanisms, systems and capacities that are necessary for anticipatory action (fuel funding). Funding is also needed for the actual implementation of anticipatory action, including within national systems.

[111] Alliance for Hydromet Development, “Country Hydromet Diagnostics,” n.d., accessed April 1, 2024.

Many countries lack a coherent and long-term financing strategy for establishing and/or rehabilitating their soft and hard infrastructure for early warning services. Even fewer have the fiscal frameworks to allow for funding of early warning systems particularly those that are maintained by local actors. Such strategies should explore the possibility of raising resources from private sources and the capacities and resources to develop comprehensive and compelling proposals that would help unlock funding for projects to set up EWS that address different national priorities and vulnerabilities and contexts. The absence of a comprehensive gap analysis at the national level prevents these countries from benefiting from the global and regional support architecture and facilities, such as GCF or GEF, or from global financing campaigns which targets donors across different sectors.

Limited global, regional and national support for country level actions for a comprehensive EW4All

Technical, scientific and institutional barriers prevent the generation and development of reliable, meaningful and actionable weather and climate information, as well as its effective communication and use by people, government, communities and businesses. Absence of such information contributes to the low level of awareness and appreciation of the value of MHEWS and its associated components, including among policy makers. Many LDCs and SIDS fail to leverage regional facilities and partnerships for necessary and sustained technical assistance. Consequently, they are excluded from the knowledge exchange, peer-to-peer learning, coordination and collaboration with key initiatives and frameworks which provide contextual operational support across a wide range of hazards. This is a barrier to access technical support and information services from regional climate centres, regional centres of excellence (including national and regional academic institutions), initiatives and projects. These include the IGAD Climate Prediction and Applications Centre (ICPAC), Fully Optimised User Centric Climate Services Value Chain for Southern Africa (FOCUS-Africa, Caribbean Community Climate Change Centre (CCCCC), Pacific Community (SPC), the EU-horizon project and the Mediterranean and pan-European forecast and Early Warning System against natural hazards (MedEWSa).

Inadequate policies and strategies for inter-agency coordination, data sharing and governance for preparedness and response

Inconsistencies in policies, institutional structure and mechanisms that govern the collection and sharing of data (hydromet, vulnerability and exposure) can pose a barrier to implementation of international agreements and frameworks for EWS and Disaster Risk Reduction (DRR).[112] National policies often fall short of a comprehensive framework to facilitate private financing and fail to provide suitable structures to strengthen inclusive, people-centred approaches to early warnings. Capacity gaps exist in transformational planning for such approaches which would address each country's unique "paradigm shift" needs. There are barriers within regions and countries which prevent the effective use of available climate information and EWS (CIEWS) by line agencies for different sectors, and those responsible for national disaster response, relief and recovery, particularly civil protection organizations at the district and community levels.

In most countries, different ministries or departments with independent administrative structures and procedures are involved in the generation, analysis and use of climate information. There are barriers to the seamless and coordinated access to data, collaboration between sectoral experts and resources that reside in these agencies and are necessary for the development of targeted and Impact based Forecasts (IbF)[113] and scenarios for triggers to inform early and Anticipatory Action[114] and Forecast based Financing.[115] Furthermore, the Information and Communication Technology Ministry and telecommunication regulatory authority and private telecommunication companies are not actively involved or consulted in the design of communications strategies which includes data transmission from

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[112] Jonathan Raikes et al., "The Influence of International Agreements on Disaster Risk Reduction," *International Journal of Disaster Risk Reduction* 76 (June 2022): 102999, https://doi.org/10.1016/j.ijdrr.2022.102999.

[113] Melanie Harrowsmith et al., "The Future of Forecasts: Impact-Based Forecasting for Early Action" (International Federation of Red Cross and Red Crescent Societies; UK Met Office; World Meteorological Organisation, 2020), https://www.climatecentre.org/downloads/files/Impact%20based%20forecasting%20Guide_Final.pdf; Rochelle Campbell, Daniel Beardsley, and Sezin Tokar, "Impact-Based Forecasting and Warning: Weather Ready Nations" (https://public.wmo.int/en/resources/bulletin/impact-based-forecasting-and-warning-weather-ready-nations, November 2018); World Meteorological Organization (WMO) and World Meteorological Organization (WMO), *WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services*, WMO (Geneva: WMO, 2015).

[114] IFRC, "IFRC Operational Framework for Anticipatory Action 2021-2025," 2022.

[115] WFP, "Forecast-Based Financing - Anticipatory Actions for Food Security," *Sdg Integration* (https://sdgintegration.undp.org/forecast-based-financing-anticipatory-actions-food-security, n.d.), accessed February 10, 2023.

observation stations, dissemination of early warnings and advisories and obtaining feedback from targeted stakeholders. Insights from behavioural science about how end-users respond to early warnings are also neither contextualised nor institutionalised in national EWS. Their exclusion results in missed opportunities to take advantage of the growth in networks and services. The NMHS often do not have staff or facilities below the provincial or district level, leading to a disconnect between generation and use of CIEWS. The inadequacies and deficiencies in standard operating procedures (SoPs) is a barrier to the dissemination of CIEW using public and private communications infrastructure. SoPs are often lacking in the development of easily understood, targeted, tailored and actionable CIEWS for different audiences. Sub-national agencies are often excluded from the dissemination or the use of CIEWS. There are very few countries among the LDCs and SIDS where procedures exist for the use of CIEWS by communities, for who they are intended. Institutional structures at the village or community level are often weak, have limited roles in governance and weak linkages with government agencies. Consequently, the mechanisms needed to effectively prepare for disasters and to implement mitigation and adaptive action at the grassroots are not enabled and/or do not exist.

Inadequate technical and scientific capacities

NMHS in developing countries, face a number of technical and scientific challenges and constraints in the generation and delivery of timely, targeted and contextual CIEWS. The transition to IbF, Anticipatory Action and Forecast Based Financing increase the requirement for higher resolution spatio-temporal data, technical and scientific expertise as well as facilities for statistical downscaling, and the ability to develop models and interpreting model outcomes to build scenarios and triggers to activate early and anticipatory action, including through scalable social protection systems.[116]

NMHS often have insufficient training and capacities required to develop and run models locally. There is therefore a need to develop in-house skills in these areas, but also, to have the parallel development of CIEWS through regional and global support arrangements. There is an urgent need for regional centres and relevant academic and research institutions to support weather and seasonal forecasts as much as possible through provision of data to NHMS and other agencies involved in the early warning/early action value chain, who in turn need to use those data in conjunction with other forecasts available through global producing centres, for e.g. the UK MetOffice (UKMO), the European Centre for Medium-Range Weather Forecast (ECMWF), and the National Oceanic and Atmospheric Administration (NOAA). Many countries have a shortage of staff with field data collection, analytical and modelling skills required for the generation of IbF to inform anticipatory and early action. However, due to the localised nature of such CIEWS, there is a greater need to develop national and sub-national systems as they have better access to local information and contexts and are in a position to conduct the local level monitoring and data gathering on factors that are important for impact-forecasting, such as the changing dynamics of hazard exposure, social vulnerabilities and disaggregated distribution of assets, access to services and infrastructure at risk. Nevertheless, regional centres have a role to help make first order estimates, while national institutions undertake more detailed risk mapping and assessments based on both historic loss and damage data as well as risk data that enables outlook and foresight on the possible impacts of climate change. Despite the importance of risk knowledge for MHEWS, the number of countries that have accessible, understandable, usable, and relevant disaster risk information and risk assessments available at the national and local levels represents the lowest of all SFDRR Target G indicators.

Field data required for IbF include multidisciplinary vulnerability assessments and tracking of bio-physical and hydrologic variables such as those pertaining to vegetation (land use and cover), soil properties (saturated conductivity, erosivity) and hydrology (flow-generation/accumulation and discharge). Processing and visualising this data require programming skills and use of programming languages and tools. Skills are also required in analysing spatial data and hydrologic modelling using tools/software and cloud-based tools which leverage large data infrastructure without the costs associated with setting up such systems locally. Capacities to link forecasts with hydrologic models and the use of Artificial Intelligence (AI) tools are also lacking. Barriers exist in the adoption of innovative digital technologies which can enable this transformational shift. This includes the use of IoT based sensors to autonomously measure and transmit data using mobile networks. Generation of timely early warnings often requires installation of specific sensors and systems which are autonomous and "off-grid". Many of these, such as water level recorders, have dual channels for real-time warnings to local communities as well as transmission of data to NMHS for further analysis and interpretation. O&M of these systems creates challenges for NMHS who have a shortage of ground personnel and for communities without the necessary technical skills.

[116] UNDRR, “Analysis of Barriers in Financing and Operationalizing Linkages Between Anticipatory Action and Social Protection Systems” (United Nations Office for Disaster Risk Reduction (UNDRR), 2023).

Gaps in observational data are particularly severe and persistent in SIDS and LDCs. This is a bottleneck at the start of the EWS value chain about which the international community has been concerned about for decades. Many attempts have been made to address the problem. However, substantial investments in observing systems have not translated into increased observational data sharing.

The GCF Sector Guidance note on Climate Information and EWS identifies key barriers for effective EWS ranging from a lack of enabling environments, coordinated interventions, well-managed hydromet operations, to budgetary constraints and resource mobilisation.[117]

Barriers to effective local actions based on MHEWS

Ineffective or absence of dissemination to the last mile

Many countries have significant gaps in telecommunication networks which exclude some of the most climate vulnerable communities in rural areas, especially nomadic and migratory pastoral groups. Access to early warnings and advisories can also be a serious constraint among poor rural communities who may not own phones or have electricity to power radios. Insufficient capacities for translation, contextual rephrasing and packaging of early warning information and advisories for multiples channels can prevent end-users from using such information. Most MHEWS are developed through a centralized process which, in large and diverse countries, fail to sufficiently address local contexts and tailor risk communications to diverse audiences, and tend to use technical terms in major national languages. They are not adequately designed around end-users, are not people-centred and warning messages are often not timely, actionable or understood by local actors. Warning messages and advisories usually lack the local context and are not tailored to the different needs of targeted communities, including the elderly, persons with disabilities and health impairments, female-headed households, and vulnerable children. The design and content of early warnings often fail to address the differential needs of these end users that arise from their differential access to information, resources and representation. This prevents the most vulnerable members of communities to access early warnings or take appropriate action.

Insufficient national and local level disaster preparedness and anticipatory action planning

There are is a major gap in terms of national and/or local plans setting out anticipatory action and development and use of triggers which determine when to act, roles of different actors in the EW value chain, to define the relevant and most appropriate and effective types of anticipatory actions for these actors. Under one third of countries globally have reported into the Sendai Frameowrk Monitor on indicator G4 - percentage of local governments having a plan to act on early warnings . This suggest that more than two thirds of the world's local governments may not have these plans. Furthermore, the percentage of local governments that have a plan to act is very low even among the countries that have reported. Few governments have integrated anticipatory action into their national systems remains , although their number is growing.

There is a significant lack of equitable and meaningful decision-making opportunities and roles for women in the design and management of MHEWS and related areas.[118] There are significant gender gaps in access to information, technology and digital services. For example, the divide in mobile internet use is most stark in South Asia and Sub-Saharan Africa where, more than half a million women are excluded from the mobile connection and the gender gap scores are 41% and 37%, respectively.[119]

Local institutions often lack the resources to lead effective preparedness and responses to follow up warning messages with local action and a coordinated inter-agency response. Barriers that limit effective use of CIEWS by first responders and communities include local conditions such as socio-cultural and economic contexts, infrastructure and services that determine the ability of communities to adopt measures that mitigate the impact of climate-induced disasters. Technical constraints faced by first responders and communities include challenges in accessing CIEWS, their contextual interpretation and the lack of procedures and plans to take anticipatory action or to mitigate impacts of disasters. There is almost a complete absence of information on dissemination and evacuation procedures that

[117] GCF, "Climate Information and Early Warning Systems Sectoral Guide" (Yeonsu: Green Climate Fund, September 2022).
[118] UNDRR, "Inclusive and Accessible Multi-Hazard Early-Warning Systems: Learning from Women-Led Early-Warning Systems in the Pacific," 2022.
[119] GSMA, "The Mobile Gender Gap Report 2022," *Mobile for Development*, June 2022.

consider people with visual or hearing impairments, physical disabilities and those who are illiterate. In the few cases where evacuation procedures and facilities exist, they are male-centred and designed for persons without disabilities.

Country specific barriers to establishing an effective MHEWS

Antigua and Barbuda

Several key areas require urgent attention to strengthen the islands' resilience. The first is the need for improved observation and forecasting systems, particularly for marine hazards. Given the islands' exposure to ocean-related hazards such as storm surges and coastal erosion, there is a critical need for accurate and locally specific advisories to protect vulnerable groups. The built environment is another area of concern, as many buildings are not resilient to high-intensity storms due to the cost of building to code and the existence of outdated infrastructure. An improved understanding of building resilience is crucial for planning emergency responses, including evacuations and sheltering.

There is a need to update and align disaster management legislation and policies with international standards. The Disaster Management Act. needs to be modernised and disaster risk reduction needs to be integrated into sectoral policies. National strategic plans for emergency management agencies need improvement with attention to data-sharing and collaborations. There is a need for public awareness and understanding of hazards and disaster risk, including exposure and vulnerability, Hazard maps and exposure and vulnerability models along with climate change analysis for critical sectors covering both hazards and risks across multiple scenarios are needed. The country requires a comprehensive communication strategy and an online risk data platform which is accessible to stakeholders and the public.

Indigenous knowledge and practices need to be incorporated into the national early warning system and schools need to be targeted as part of the effort to improve disaster knowledge. There are gaps in real-time monitoring of hydro-meteorological data, hydrological and marine monitoring and routine operations and broadcasting activities which need to addressed through investments in infrastructure. Telecommunications and broadcasting infrastructure needs support for which country assessments on network infrastructure resilience are needed. There is need for a National Emergency Telecommunication Plan (NETP) to facilitate adoption of the Common Alert Protocol (CAP). Existing networks need to be re-configured to respond to assistive technologies for people with disabilities. There is also need to accelerate the adoption of the CDEMA Model MHEWS Policy 2020, and integrating CAP procedures and impact-based forecasting into local response systems. Finally, there is need to strengthen or form community disaster response teams, providing training and equipment for first responders, and for support to the government to adopt a dedicated financing mechanisms and structured early action measures for pre-impact actions based on the needs of vulnerable groups.

Ecuador

There is a need to significantly enhance the country's ability to anticipate, prepare for, and respond to various climate-related hazards, such as floods, landslides, droughts and extreme temperatures. Key gaps and areas where support is needed include governance and coordination in the government. A robust regulatory and institutional framework for MHEWS is required which includes coordination with National Gender and Development (GAD) initiatives. There is also need for a National Climate Finance Framework to ensure sustainable climate services. This needs to be accompanied with a comprehensive climate data management strategy with standardised data frameworks, including a climate data centre with a user interface. Standard operating procedures across hazards need to be formulated and adopted in order to enhance governance capacities.

Gaps in disaster risk knowledge and observations need to be addressed by developing methodologies for risk assessments and implementing these assessments to create a robust data collection and risk database. The observations and monitoring networks in Ecuador need to be strengthened by rehabilitating and integrating existing monitoring systems and improving data management and telemetry capabilities. This needs to be coupled with strengthening of MHEWS forecasting capacity, enhancing now-casting, improving assimilation processes, and adopting ensemble forecasting techniques. Impact-based forecasting systems need to be developed for specific hazards such as floods, landslides, droughts, and extreme temperatures.

There is also need to strengthen the existing warning dissemination systems through mapping stakeholders and focal points for receiving and disseminating alerts, establishing a multi-level and inter-institutional communication protocol,

and generating binding documents to ensure effective communication. Permanent operational mechanisms and protocols are needed for warning dissemination and triggering adaptation measures and early and anticipatory action. Priority alert mechanisms need to be identified along with implementation fo cell broadcasting, strengthening alternative communication means, and developing a warning platform using the CAP. An inclusive strategy needs to be implemented for generating aerts and notices in various languages. There is also a need for increased awareness about climate hazards both at the national and local levels which systematically integrates Indigenous Knowledge Systems (IKS) into MHEWS. Preparedness protocols need to be developed and regulatory frameworks and standardised methodologies for Community Emergency Plans need to be developed and implemented.

Chad

Chad urgently needs to strengthen and build capacities of institutions engaged in the observation of weather and climate and in the formulation of forecasts, advisories and early warnings. There is an acute need to better understand vulnerabilities and risks through gathering of data and knowledge management. Governance arrangements and inter-agency coordination needs strengthening, especially between institutions responsible for disaster preparedness and management, particularly at sub-national levels. These steps are critical in order to meet the information needs of communities in the face of climate change and altered weather patterns which are affecting their lives and livelihoods. These institutions, particularly at the level of communities, need to be equipped to plan and prepare for disasters. Support and resources are needed to help agencies that are engaged in supporting communities through early and anticipatory actions in order to ensure inclusive, need-based and people centred disaster preparedness, resilience and long term adaptation to climate change.

Ethiopia

There are significant gaps in all three pillars of MHEWS. There is no national risk database which houses multi-hazard data and risk analysis. Impact based disaster risk profiles are needed at the woreda (district) level across all critical sectors. There are also significant gap in the coverage of the observation network, particularly in the East and South East of the country. Challenges in data sharing and the lack of inclusion of women, elderly, people with disabilities and marginalised groups in the design of EWS are also significant. Communications disaster risk remain poor and mechanisms to disseminate advisories, anticipatory action and emergencies are weak.

The governance and coordination of disaster response between sectors and ministries also faces challenges in terms of development of multi-hazard anticipatory action plans and linking them to national financing mechanisms. There is need for agreement on multi-hazard alert thresholds and community based early warning systems in vulnerable regions. Preparations for disasters such as stockpiling and preposition of essential emergency stock at national level and in identified priority areas (food and non-food) are needed. The latter requires planning, coordination and cooperation, including with the private sector. Ethiopia needs to mainstream anticipatory action as part of emergency preparedness and response planning and integrate anticipatory action with social protection mechanisms.

Somalia

Somalia lacks early warning system infrastructure and the policy and institutional environment needed for the use of climate and weather information to generate and disseminate early warnings or advisories. The extent of MHEWS is insufficient for adaptation or early action by individuals and communities. There are significant gaps in the risk assessment framework and an urgent need for a nation-wide hazard risk assessments down to the local levels. There is limited understanding and knowledge about critical vulnerability factors and the country lacks a database on disaster impact or means of tracking loss and damage due to climate related disasters. The lack of multi-hazard maps that identify specific geographic areas, sectors and groups hinder the development of tailored EWS and DRR plans and local risk management plans. There is an urgent need for awareness generation, capacity development and coordination between agencies for the use of disaster risk knowledge at national and local levels.

There is also a need to strengthen the harmonisation of early warning data collection, analysis and exchange between federal line ministries, sectoral offices and regional bodies, as well as improving data automation, modelling and forecasting of early warning. Interoperability and early warning information exchange between sectors needs to be improved along with accessible nationwide warning dissemination and communication. Early warning communication strategies and SOPs are lacking and governance, functions, roles and responsibilities for dissemination of early warnings are weak. There is an urgent need for comprehensive infrastructure networks and early warning

dissemination services and equipment to support CAP adoption. Agreements with telecommunication service provider are needed to set up automated system and adopt protocols for AA and communication strategies and feedback mechanisms. There is an urgent need for inclusive, people-centred MHEWS which involve communities by establishing local networks to receive and disseminate information and last mile connectivity. There is also a need to enhance preparedness for timely responses and early actions by improving response and recovery disaster preparedness measures at the community level through participatory, gender-responsive disaster preparedness measures and plans. At the policy level, there is a need to develop legislation and strategies to integrate AA and preparedness, forecast based plans and protocols and SOPS.

Fiji

Fiji needs to strengthen its early warning systems in order for communities to better prepare for and adapt to climate related hazards. There is need for enhancing communication, governance and coordination mechanisms amongst national stakeholders relevant to EWS in Fiji. The risk assessments methods for historical data, climate knowledge and local knowledge need consolidation and strengthening. Weather, climate and hydrometeorological observations and networks need to be upgraded and expanded and the capacities to use this data to generate warnings for severe weather, localised flooding and droughts as well as impact based forecasts needs to be improved. Specific attention is needed for drought early warnings and forecasting systems to support food security. Systems need to be put in place to use this information for disaster preparedness and planning. In terms of dissemination, there is a need to implement the National Emergency Telecom Plan which includes automation of a geo-targeted, location-based messaging through the CAP and cell broadcasting. There is also the need for expansion of Starlink network and maritime radio to achieve 100 % EWS coverage in Fiji.

Fiji requires a robust tracking system for assessing hazard impacts and future risks. Forecasting needs to be expanded to all areas are affected by hazards and challenges in accessing and sharing disaster data need to be addressed. Risk assessment methodologies and parameters need to be standardised and a centralised database system is needed to store risk information across sectors and disaggregated by gender, age, and disability. There are gaps in the infrastructure to collect and analyse data for climate projection applications, including a number un-gauged rivers. Observation networks including AWS installations need upgrading and means to utilise historical climate data need to be made available in order to enhance EWS and expand location-specific predictions.

There is need to strengthen governance and coordination to enhance collaboration and legal frameworks by developing and implementing protocols and relevant mechanisms, including protocols and SOPs for data sharing among MHEWS agencies. Inter-agency working groups need to be formed for data exchange, to analyse laws related to data exchange, establish MOUs between authorities for early warnings, and create protocols for data sharing. Coordination among stakeholders in developing MHEWS plans and establish collaboration mechanisms among government, non-government, and community levels needs to be strengthened.

Community focused communication strategies need to be developed based on risk perception studies. These need to improve upon translation and interpretation of early warning messages using technologies which facilitate and where possible automate translation, caption generation and text to speech capabilities. These dissemination systems need to be inclusive and specifically target individuals with disabilities and elderly. There is need for training of ground actors, government officers, extension officers and those involved with the Red cross on how to respond to early warnings. Community awareness campaigns are needed and the reach and effectiveness of disaster preparedness campaigns needs to be improved. Local contingency plans need to be developed which are informed, inclusive and community driven and national and sub-national trainers need to be trained and supported in creating and strengthening of community disaster management committees. Community based disasters management plans need to be developed to respond to early warnings and localised community based early warning systems. Traditional and local knowledge needs to be incorporated into the these local early warning systems.

Cambodia

Cambodia needs interventions at various levels in order to be better prepared for climate related disasters. There are significant challenges in governance and coordination between agencies critical in the early warning value chain which need to be addressed. Significant gaps in weather information needs exist, including in the monitoring of river levels and droughts. Capacity gaps need to be addressed in the Ministry of Water Resources and Meteorology (MoWRAM)

for both observations and development of early warning products. There are challenges in data sharing between agencies and the need for a standardised information management system which implements and integrated and cross-pillar approach while focusing on on gender and inclusion in early warning systems and early and anticipatory action. Sectoral MHEWS need to be improved in agriculture and health and efforts need to be made to reinstate the multi-sectoral monsoon forum, and focusing on Impact Based Forecasting (IBF).

There are significant gaps in the public knowledge about climate change and climate risks which need to be addressed, with emphasis on knowledge coordination strengthening the Cambodian Disaster Damage & Loss Information System. Youth in Cambodia need to be involved in developing community-based EWS, and the capacities of the National Disaster Management Committee (NDCM) and the National Adaptation Plan for Disaster Risk Reduction (NAP-DRR) at national and sub-national levels need to be enhanced.

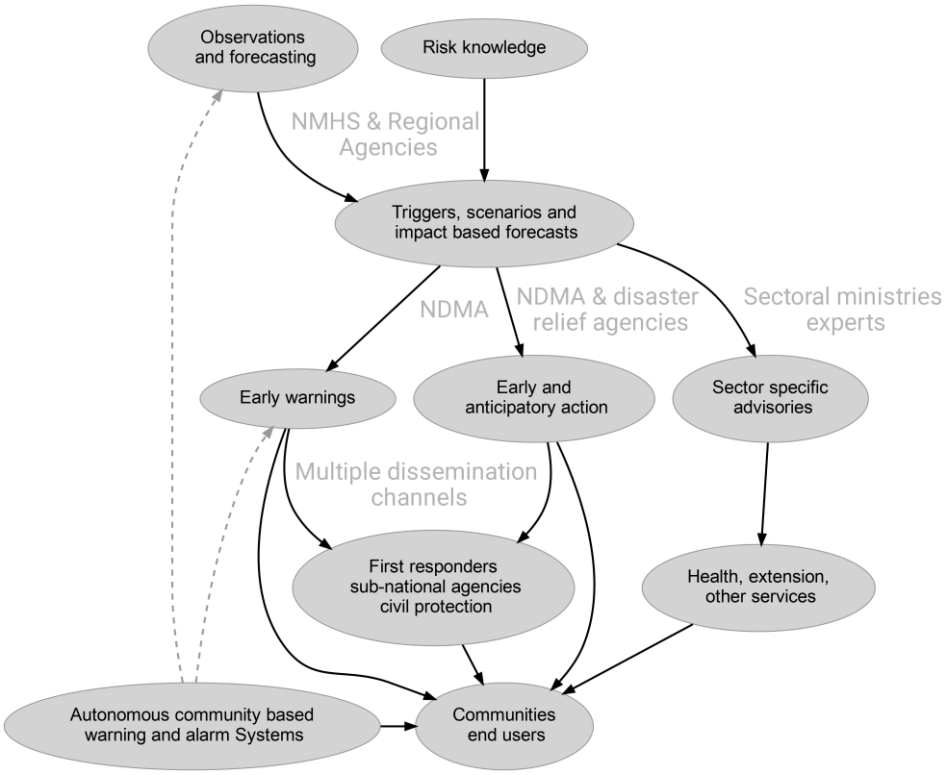
The dissemination of early warnings remains a significant challenge in Camobodia. There is need to raise awareness of emergency alert systems for which coordination between mobile network providers, and upgrading online presence and dissemination channels is critical. Capacities of local authorities need to be developed on early action and for implementing community-based early warning systems. The authorities need to supported in providing shock-responsive social protection for preparedness and anticipatory action in target provinces, specifically emphasising support to vulnerable communities, including women, people with disabilities, children, and youth.

INNOVATIVE APPROACHES TO ADDRESS GAPS AND BARRIERS

Addressing the barriers to effective end-to-end MHEWS require engagements at different levels of organisation, governance systems and across multiple institutions. The project will need to operate at different scales and leverage new and innovative technologies while ensuring the interventions engage meaningfully with local communities, their own knowledge, understanding and coping strategies for climate related disasters.

Key to the success of the project will be the understanding of gaps in the MHEWS value chain (Figure 2) and tailoring interventions to the country and local context. Some of the considerations used to design the project interventions are:

1. Technological interventions are affordable, both in terms of initial costs of purchase and set up, but also in terms of O&M and running costs including data transmission, electrification and security.
2. Investments made in observations are cost effective and contribute to the generation, dissemination and use of MHEWS. Collaborations and co-finance from other agencies and programmes investing in the GBON and observation network such as SOFF and CREWS will therefore be critical.
3. A mixed approach is used in terms of observations which caters to both the national observation network and local EW needs. Thus a mix of networked systems and locally operated autonomous systems for alarms and warnings will be tailored to each country and its local requirements.
4. Sustainable arrangements are made to ensure private agencies are fully involved in data transmission and dissemination. This is particularly relevant for the telecommunications sector where such arrangements can offset costs and serve as an incentive for private sector involvement.
5. Linkages between institutions operating at the community levels and higher up along the administrative hierarchy are established with a clear identification of focal persons and definition of roles they play along the MHEWS value chain.
6. Institutional collaborations, both at the global and regional level (for technical inputs for pillar 2) and with grassroots organisations and NGOs for pillar 3 and 4 are leveraged to the full. This will be particularly important in countries that lack fully operational NMHS and NDMA, often on account of fragility and conflict.
7. Strategies for gender inclusion and involvement of marginalised groups are designed to fit the political, social and cultural contexts of each country and region, most importantly for pillar 3 and 4 activities.



A simplified diagram of the MHEWS value chain and its key players (pillars)

Innovative technologies and approaches

The project will leverage available innovative technologies in both the production and dissemination of early warnings and innovative approaches to maximise the use of disaster knowledge and preparedness. This will be done through collaboration and partnerships with development agencies engaged in technology development, universities and research agencies as well as agencies and service providers among corporations and the private sector. The following technologies and partnerships will be explored:

Pillar 1: Disaster Knowledge

The project design process has utilised available hydromet diagnostics. Tools that facilitate such diagnostics and assessments such as the digital tool developed by the CADRI Partnership capacity diagnosis tool will be used for the gap analysis as may be required as part of Output 2. Additionally the country projects will utilise available tracking tools to track loss and damage.

The development phase of this proposal included disucssion with a number of agencies with whom partnerships will be explored. These include SDG-AI, WFP VAM, Microsoft AI for Good, Google Flood Hub, PRISM, and Planet Labs which capture very high resolution satellite imagery for disaster applications. These will allow the project to leverage advances made in AI applications in vulnerability mapping and real time tracking and forecasting of floods. These systems typically use cloud computing infrastructure with complex machine learning algorithms and AI to process multiple criteria and channels of data including satellite remote sensing and remote sensing derived indices, very high resolution imagery and a range of socio-economic datasets.

Pillar 2: Observations

Networked and centrally managed systems and technologies

The project will explore the use of alternative observation systems in sites where other conventional systems are difficult to set up or operate due to constraints such as costs and security. Among these are the relatively inexpensive and innovative sensor systems such as those used by the TAHMO group and lightning detection systems such as those sensors developed by private agencies such as Ubimet which have a small form factor and can be installed on transmission towers or other small locations to provide critical information on extreme events such as thunderstorms

and extreme rain events. Rain fade technologies[120] will also be explored in collaboration with cellular telecommunication companies as an alternative to rainfall observations.

Autonomous community based early warning and alarm systems

Autonomous systems, designed to measure and transmit data using mobile networks or trigger alarms will be utilised in areas with high exposure to disasters but low or no coverage from national hydromet networks. These "off-grid" systems include water level recorders and landslide sensors. They can also be assembled with telemetry systems to provide real-time warnings to local communities as well as transmission of data to NMHS for further analysis and interpretation. Applications include landslides,[121] floods and flash floods[122]

Pillar 3: Dissemination

The implementation of the CAP[123] will be explored in all countries. This includes technologies such as cellular broadcast, SMS and USSD where feasible. The project will additionally explore the use of multiple channels for dissemination all of which provide opportunities for innovation. These include services such as interactive voice response, AI based generation of captions, text-to-speech and translation. Discussions on utilising these services have been held with agencies such as Viamo. In addition, more conventional community radio services will be explored using interactive call-in programmes which target specific groups such as farmers for disseminating and discussing advisories such as those based on seasonal rainfall forecasts. This will be in addition to social media platforms which have been widely adopted in many countries. User groups and distribution lists will be utilised for targeted dissemination of multimedia messaging and calling.

Pillar 4: Preparedness and response

Innovations in pillar four will include co-development of agricultural advisories using approaches such as PICSA[124] and IT based tools such as E-PICSA which facilitate access to relevant and often near real-time climate information which has been packaged in local languages and is contextually relevant.

Citizen science and crowd sourcing approaches will be used to expand risk knowledge capability at all scales. Technologies such as ODK and Kobo will be leveraged to simplify and improve the efficiency and effectiveness of local observations and for monitoring of site specific data as well as indicators designed to measure project progress.

Participatory approaches will be used for disaster planning and mapping. These will combine tools such as drones, GIS and smart-phone based mapping to develop evacuation plans, including those for the most vulnerable households within a community.

Targeted support to vulnerable groups during disasters through social protection programmes such as cash transfers will be explored. Where possible this will be tied to impact based forecasts to ensure vulnerable groups are provided necessary resources to prepare for disaster in advance, for example by African Risk Capacity group in Zambia.

Support and training through national and regional academic and centres of excellence

The project seeks to leverage collaborations and partnerships with local, regional and global centres of excellence as well as IT firms engaged in developing and deploying technologies for MHEWS. The development of support networks comprising regional and national academic institutions and centres of expertise is expected to be more cost effective and ensure longer term sustainability.

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[120] Aart Overeem, Hidde Leijnse, and Remko Uijlenhoet, "Country-Wide Rainfall Maps from Cellular Communication Networks," *Proceedings of the National Academy of Sciences* 110, no. 8 (February 2013): 2741–45, https://doi.org/10.1073/pnas.1217961110.

[121] N. Dixon et al., "An Acoustic Emission Landslide Early Warning System for Communities in Low-Income and Middle-Income Countries," *Landslides* 15, no. 8 (August 2018): 1631–44, https://doi.org/10.1007/s10346-018-0977-1.

[122] Feras Alasali et al., "A Sustainable Early Warning System Using Rolling Forecasts Based on ANN and Golden Ratio Optimization Methods to Accurately Predict Real-Time Water Levels and Flash Flood," *Sensors* 21, no. 13 (January 2021): 4598, https://doi.org/10.3390/s21134598.

[123] WMO, "Guidelines for Implementation of Common Alerting Protocol (CAP)-Enabled Emergency Alerting" (Geneva, Switzerland, 2013).

[124] Graham Clarkson et al., "Stimulating Small-Scale Farmer Innovation and Adaptation with Participatory Integrated Climate Services for Agriculture (PICSA): Lessons from Successful Implementation in Africa, Latin America, the Caribbean and South Asia," *Climate Services* 26 (April 2022): 100298, https://doi.org/10.1016/j.cliser.2022.100298.

By working with NDAs, DAEs and regional coordinating bodies (SPC, SPREP, SADC, IGAD, CCCCC, CAF etc) investments will be able to target the most critical gaps and ensure the full MHEWS cycle is achieved, reaching as many people, businesses and communities as possible. These collaborations and partnerships are expected across a range of activities and technologies which will support a range of applications include those described in the section on innovations.

This is a key element of the strategy to ensures long term technical support to the NMHS and NDMAs. It will also ensure access to cutting edge technologies and developments in the fast changing landscape of cloud computing with machine learning and artificial intelligence applications in hydrometeorological disaster research.[125]

Regular capacity building and knowledge exchange under the project will emphasise making the best use of regional centres of excellence and investing in skills in newly emerging technologies such as AI and remote sensing capacities, for e.g. the UK MetOffice (UKMO), the European Centre for Medium-Range Weather Forecast (ECMWF), and the National Oceanic and Atmospheric Administration (NOAA).

Activity 3.1 seeks collaborations with academia in the process of impact assessments. This would include assessing the socioeconomic outcomes of climate products and advisories at the level of institutions and communities. The collaborations will also serve to review and evaluate climate information products and facilitate their incremental improvement and development.

Activity 3.2 on disaster risk knowledge and observations will leverage collaborations to access technologies in impact based forecasting across a range of hazards as well as vulnerability assessments and mapping at unprecedented levels of detail and accuracy.

Activity 3.3 on dissemination and preparedness will build on developments in the use of AI in translations, text to voice applications and interactive voice messaging. It will support countries in developing effective communication strategies for contextual and actionable alerts to end users.

Regional programme-provided support

Continuous regional support to the project through support networks comprising regional and national academic institutions and centres of expertise is another mechanism that will be used to ensure cost effective and sustainable access to technical and financial resources and to advanced facilities for computation and software. These support networks will be strengthened and forged by working with NDAs, DAEs and regional coordinating bodies. These include IGAD Climate Prediction and Applications Centre (ICPAC), Fully Optimized User Centric Climate Services Value Chain for Southern Africa (FOCUS-Africa, Caribbean Community Climate Change Centre (CCCCC), Pacific Community (SPC), the EU-horizon project and the Mediterranean and pan-European forecast and Early Warning System against natural hazards (MedEWSa). Investments and support flowing through the network will target the most critical gaps and ensure the full MHEWS cycle is achieved, reaching as many people, businesses and communities as possible.

In addition, the project will build on existing plans and initiatives such as the Flash Flood Guidance System (FFGS) or the Hydrological Status and Outlook Systems (HydroSOS) initiative.

THEORY OF CHANGE AND COST-EFFECTIVENESS

Theory of change

The objective of this multi-country proposal is to accelerate the design and implementation of EW4All through coordinated global support involving all the key actors across the EW4All value chain. The underlying assumption for the theory of change of the project is:

IF generation, delivery and adoption of multi-hazard early warning information is improved for effective early and anticipatory action, **THEN** avoidance of and adaptation to climate induced natural hazards will be enhanced and the loss of lives and disruption of livelihoods, services and productive assets will be reduced **BECAUSE** of improved,

[125] Mandeep Kaur, Pankaj Deep Kaur, and Sandeep K. Sood, "Analytical Mapping on Trends of Information Technology in Hydrometeorological Disasters Research," *Geocarto International* 37, no. 26 (December 2022): 14171–97, https://doi.org/10.1080/10106049.2022.2087006.

effective and timely disaster mitigation and response by national and sub-national governments, communities and businesses supported by multilateral agencies and private entities.

Figure 2. Diagram of the theory of change for the project

This project addresses the four key elements of MHEWS, i) disaster risk knowledge; ii) observations, monitoring and forecasting systems; iii) warning dissemination mechanisms; and iv) preparedness and response capability.[126]

Effective MHEWS depend on coordination with and across different sectors and at multiple levels and require feedback mechanisms which allow for their improvement.[127] The involvement of both national and local institutions and communities in dissemination of warnings and response is a critical component of successful MHEWS.[128] Addressing persistent gaps in establishing and managing an end-to-end MHEWS at the country level is a key requirement. The proposal recognises that there are multiple on-going initiatives and mechanisms that aim to enhance countries' climate information and EWS, and that an effective end-to-end MHEWS can only be built on timely and long-term support for critical baseline capacities such as: i) robust scientific risk information and analytics on weather, hydrology, environmental conditions, climate hazards and socio-economic, infrastructure and other dynanmic vulnerabilities; ii) optimised internal coordination among various government entities that are responsible for managing different elements of a national EWS value chain; and iii) a long-term financing plan to maintain the necessary hydromet infrastructure, and community level capacities to receive, understand and respond to EWS through risk-informed preparedness and response actions. These baseline capacities in many countries, especially in LDCs and SIDS, can be built only through long-term support; the project will therefore strengthen the existing architecture and create the environment in which countries can better utilise timely, long-term, uninterrupted support.

Additionally, there is recognition that the scale and speed required to deliver universal early warning coverage by 2027 requires an “all-hands-on-deck” approach which utilises support available from all partners and leverages different funding windows and mechanisms. Achieving this will require sustained assistance to maintain effectiveness and sustainability. Furthermore, the support architecture described above cannot be solely dependent on a single project or programme and this project will include activities in which a long-term financing and management strategy is developed. The sustainability of such an architecture with adequate financing, is critical so that countries can establish a pathway for developing a national MHEWS.

Targeted countries will be provided global and regional assistance to mobilise financial and technological resources for upgrading and sustaining their MHEWS. A comprehensive assessment of climate-related risks required improvements in capacities for early action, which includes local level disaster planning, will be conducted in all countries. National policies, procedures and mechanisms will be instituted to coordinate and collaborate between NMHS, NDMAs, government ministries (including agriculture, water and health) and non-government agencies. Mechanisms for creating contingency funds and their timely release to relevant first responders in anticipation of hazardous events will be put in place and capacities of critical agencies and institutions at all levels along the EW/AA value chain will be enhanced.

The project is structured so that it addresses the need for accelerated investments into MHEWS for countries.

Output 1 ensures much needed investments at the regional and global levels to set up, scale up and accelerate technical and operational support to countries with the ambition to enhance their MHEWS coverage and capacities. This output will catalyse regional and global collaboration among actors active in EWS support, including through regular coordination, joint action, and exchanges to reduce duplication, save scarce resources, and better leverage the comparative advantage of diverse actors to deliver benefits aligned to the EW4A call to action. By enhancing enabling conditions, both globally and regionally it will promote country-level actions towards the EW4All goals. This output will address barriers pertaining to both support for country level actions as well as gaps in global, regional and national policies and inter-agency coordination to scale up coherent national strategies for end-to-end MHEWS. The output will improve access to technical expertise, operational support, collaboration, knowledge sharing and the

[126] UNDRR, “Early Warning System” (https://www.undrr.org/terminology/early-warning-system, 2007).
[127] UNDRR and WMO, “Global Status of Multi-Hazard Early Warning Systems: Target G” (United Nations Office for Disaster Risk Reduction, 2022).
[128] Matthew L. Collins and Naim Kapucu, “Early Warning Systems and Disaster Preparedness and Response in Local Government,” *Disaster Prevention and Management: An International Journal*, 2008.

existing global support architecture and will be led by the EW4All Pillar Leads in collaboration with global and regional organisations.

Finally, Output 2 ties together the four key components of the EW4All EAP by addressing barriers in observations, risk knowledge, dissemination and disaster preparedness and response at the country level. Activities under Output 2 address gaps at the national level, these are designed to ensure effective use of MHEWS for disaster preparedness and response. Hence the investments in observations will be guided by the vulnerability analysis and specifically seek to facilitate development of impact based and actionable early warnings for early and anticipatory action by national actors on the ground. Engagements with the governments will also seek strengthening of institutional mechanisms and governance for more effective preparedness and response to attenuate the scale of recovery needs. Dissemination systems will be improved to ensure usable multi-hazard risk information is transferred to end-users, including women and vulnerable groups within communities, along with guidance on effective mitigation actions to reduce impacts (loss and damage). Finally, the work with communities will ensure disaster planning and preparedness as well as community-based systems that hybridise new technologies and local knowledge. Output 2: Accelerating actions towards EW4All goals, will design national level projects which implement priority investments listed under the four pillars in the EAP based on the context of each participating country. This will be led by the respective country NDAs and supported by the UNDP Country Offices in collaboration with national and regional centres and societies of WMO, UNDRR, ITU and IFRC and other key partners.

Coherence between the global and country proposals

There is a one-to-one correspondence between the log-frames of the global funding proposal (GFP) and the seven country funding proposals (CFPs) in order to ensure coherence in the overall theory of change and budgets of the GFP. This is illustrated in Figure 5. The country proposals are designed to deliver on Output 2 of the GFP. Thus, the activities under Output 2 correspond to the outputs under the CFPs and the GFP sub-activities correspond to the activities under the CFPs. The CFPs will diverge at the sub-activity level as these will be aligned to the respective contexts and theory of change of each of the seven countries.

Figure 3. Correspondence between the log-frames of the GFP and the seven CFPs

Technical, logistic and administrative support and oversight will be provided to all the project outputs at the global level through a global PMU as well as technical experts from the Pillar Leads and partners. In addition, country specific coordination and oversight to Output 2 by country level PMUs who will recruit additional international and local experts as needed. This approach will ensure cost effectiveness in project implementation as vetted technical experts from the UNDP roster, Pillar Leads and partner agencies will support multiple countries.

Criteria used to select countries

Selection of seven countries for Output 2 on accelerating actions towards EW4All

The seven countries selected for accelerating actions towards EW4All under this multi-country proposal are Antigua and Barbuda, Cambodia, Chad, Ecuador, Ethiopia, Fiji and Somalia. These countries represent some of the most climate vulnerable regions of the world. They have been selected due to their exposure to climate variability and change, including in some cases from multiple hydrometeorological climate-related impacts. The selected countries have also been in part selected because of their varying levels of economic development, diversity of livelihoods, range of climate hazards and varying levels of fragility and insecurity. Encompassing a range of geographies, social and economic systems within the 1st phase, will allow the multi country project to benefit from the diverse set of best practices and lessoned learned within these countries. This will provide an opportunity to develop multiple solutions that address the gamut of barriers that prevent the delivery of effective MHEWS, which support communities in adaptation and disaster response. These experiences will in turn help to develop a set of foundational approaches, on which the pipeline for additional projects can be developed, as well as clearly defining the roles of different agencies and partners in shaping and supporting the implementation of these projects.

Besides the requirements to sample a diverse set of contexts, as noted above, the following three considerations were used in the selection process:

Partner priorities

Partner priority refers to the priority assigned to countries by the EW4All partners. All seven selected countries were in the initial list of 30 priority countries put forward by the Secretary General when launching the EW4ALL initiative. This was considered to be a starting point for identifying priority countries, to allow for delivery of the SG commitment under EW4All. Of these 30, the seven selected countries where further prioritised by the Pillar Leads (UNDRR, WMO,

ITU and IFRC) based on existing and planned work under the four pillars for MHEWS. These existing initiatives and capacities can therefore be leveraged to a) build on current investments already being undertaken in these countries, thereby leveraging already committed co-financing activities; and b) explore and make use of some of the innovative approaches being tested and piloted, thereby providing the opportunity to leapfrog existing technological barriers.

Regional representation

The seven selected countries represent some of the most vulnerable regions of the world and a diversity of climate-related hazards, namely: i) the Sahel and Central Africa (Chad, drought and floods); ii) East Africa and the Horn of Africa (Ethiopia and Somalia, drought, disease and floods); iii) South East Asia (Cambodia, flooding, drought, heatwaves and coastal inundation); South Pacific (Fiji, flooding and Cyclones); the Andean/Amazonic and Caribbean regions within the LAC region (Ecuador and Antigua & Barbuda, Hurricanes, flash flooding and coastal inundation). Antigua & Barbuda are also representative of SIDS which, with African States are considered the most vulnerable to the impacts of climate change, while Ecuador suffers from multiple climate hazards due to its location and variety of micro climates.

Countries with prior or planned investments from CREWS and SOFF

The seven countries were also prioritised based on current or planned investments from the CREWS and SOFF programmes. These programmes have already completed, or are preparing, a comprehensive diagnostic of hydromet capabilities and/or investments in basic hydromet infrastructure, as well as the capacity of countries to operate and maintain (O&M) that infrastructure. All seven countries have completed SOFF assessments and benefit from CREWS investments (except Ecuador), thereby simplifying and reducing the number of required assessments and investments, needed for the design and implementation of the EW4ALL programme in these countries.

Cost-effectiveness and efficiency of options to address theory of change

Cost effectiveness and efficiency has been ensured in project design through a the following ways.

The selection criteria used for the seven countries under Output 2 and the ten countries for pipeline development included an evaluation of existing work on MEHWS. This specifically included prior and proposed support by SOFF and CREWS. This ensured that baseline investments in hydromet infrastructure were in place in most of the selected countries, and that detailed diagnostics on technical and institutional capacities and gaps in hydromet and, in some cases, communications infrastructure had taken place. This allowed for an accelerated development phase of the country-specific proposals. It also ensured ensured that the proposed investments focus on critical gaps in observations and communications infrastructure and capacity which allows an emphasis on developing holistic and end-to-end MHEWS where last mile dissemination and preparedness for disaster response at the level of communities remains a key priority.

This project ensures a cost-effective alternative to reactive approaches to climate-related hazards that focus on ad-hoc recovery and investment. It will significantly enhance the risk knowledge and early action capabilities of sectors and communities and will contribute to the capacity building of relevant stakeholders. The enhanced risk knowledge will enable stakeholders, particularly local communities and first responders, to take pro-active action based on timely and accurate information, thereby reducing the impacts of both slow and fast onset disasters on lives, livelihoods and assets. The project will ensure a larger spatial coverage of impact-based forecasts for vulnerable regions and establish protocols, supported by national policies and procedures, for communities to prepare for and take pre-emptive action against disasters.

The sizeable and multi-year investment to addresses gaps in the value cycle will ensure that actionable warnings reach the last mile and those at risk being able to respond. A high expected benefit-cost ratio (BCR) on investments in strengthening the hydrological and meteorological agencies and all partners in the MHEWS value cycle can only be achieved through such improvements in MWEWS and in preparedness. These investments make it possible to limit losses from hydromet disasters. This project will ensure the sustained and informed use of constantly improving meteorological, hydrological, social, behavioural and related information by leveraging additional co-finance, as well as ensuring country ownership by governments that are able to fund the ongoing costs of maintaining all elements of the MHEWS cycle.[129]

[129] WMO, “Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services.”

MHEWS are a public good and for under-developed countries and SIDS, the financial and technical barriers that prevent the implementation of a reliable, robust, widely accessible and effective MHEWS for disaster preparedness and planning can only be removed by public investment financed by grant resources from international development institutions. The project does not entail revenue generation or cost recovery during its duration and cannot be expected to attract investments from the private sector, which is nascent in many of the targeted counties. However, the project does plan to engage the private sector by stimulating demand for climate information-based value added products and services, by engaging with the private sector particularly in telecommunications, agri-businesses, tourism and transport – with a focus on aviation and financial services such as insurance. The level of engagement and the type of industry will be determined by the national context. These engagements may generate some revenue and cost sharing or co-financing in the future and could support the project's financial sustainability beyond its proposed duration.

On the other hand, there is overwhelming evidence of substantial benefits of investing in weather and climate information and disaster risk reduction. Reported benefit to cost ratios are four or higher,[130] the socioeconomic benefits are estimated to be at least US$ 160 billion per year[131] and the net benefit of investing in the resilience of infrastructure in developing countries would be $4.2 trillion over the lifetime of new infrastructure.[132] The return on investment from disaster risk reduction offer "triple dividends" from avoiding direct impact, enhancing economic potential and generating sustainable development co-benefits.[133]

Efficiency and effectiveness will be ensured by building on existing national capacities and infrastructure across the MHEWS value chain and leveraging investments from other donors, particularly from SOFF and CREWS. Existing institutional capacities and linkages will be effectively used at all levels across government, non-government, private sector – particularly telecommunications and among community based organizations. This will minimize time and costs and provide a foundation to strengthen and enhance MHEWS to the community level.

Synergies between ongoing government initiatives and projects, including those supported through vertical funds will be used to co-finance and share costs. Coordination with ongoing initiatives will prevent duplication of effort while optimising investments and operation and maintenance of observation infrastructure. Technical support from regional facilities, multilateral agencies and the private sector will be used to minimise costs of analysis, technology transfer, training and data acquisition. Costs of hiring technical staff and their training and capacity building within NMHS, NDMA and other relevant partners will also be reduced through collaborations with regional and national technical and research agencies.

The choice of technologies for observation, networking and dissemination for each country are governed by a scientific gap analysis and consideration of operation and maintenance costs and capacities. An optimal mix of technologies will be used, including gridded and remotely sensed datasets from other agencies to complement and supplement expensive observation infrastructure. Conformance to WMO and international public standards for data and communication and the use of open source software and IoT devices for local observations will further ensure inter-operability and reduce costs.

The development of support networks comprising regional and national academic institutions and centres of expertise is expected to be more cost effective and ensure longer term sustainability. By working with NDAs, DAEs and regional coordinating bodies (SPC, SPREP, SADC, IGAD, CCCCC, CAF etc) investments will be able to target the most critical gaps and ensure the full MHEWS cycle is achieved, reaching as many people, businesses and communities as possible.

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[130] WMO; World Bank, "World Bank Data: Malawi," 2023, https://data.worldbank.org/country/malawi; United Nations International Strategy for Disaster Reduction (UNISDR), "Costs and Benefits of Disaster Risk Reduction" (Geneva, Switzerland, May 2007).

[131] SOFF, "The Value of Surface-Based Meteorological Observation Data: Costs and Benefits of the Global Basic Observing Network."

[132] Stéphane Hallegatte, Jun Rentschler, and Julie Rozenberg, "Lifelines: The Resilient Infrastructure Opportunity" (World Bank Group, 2019).

[133] Tanner Thomas et al., "The Triple Dividend of Resilience: Realising Development Goals Through the Multiple Benefits of Disaster Risk Management" (Overseas Development Institute (ODI), International Bank for Reconstruction and Development / International Development Association or The World Bank., 2015).

Recommendations for funding (and associated costs) given gaps, current efforts and scalability

Recommended activities

Output 1: Enhancing enabling conditions globally and regionally to promote country-level actions towards the EW4All goals

Output 1 aims to scale up and accelerate global and regional support for national efforts to increase Multi-Hazard Early Warning Systems (MHEWS) capacity and coverage. This includes three key components: Output 1.1 focuses on enhancing coordination and providing technical support for the implementation of Early Warnings for All (EW4All); Output 1.2 emphasizes the strengthening of monitoring and evaluation (M&E) processes to support EW4All implementation; and Output 1.3 aims to reinforce knowledge management and the dissemination of lessons learned. Together, these efforts are designed to improve the effectiveness and reach of early warning systems, ensuring that more communities are better prepared for multiple hazards.

The output will support the global and regional coordination and support architecture for EW4All that will be sustained beyond the project implementation period. Activities through this output will help the EW4All pillar leads build on CREWS and similar coordination mechanisms to achieve; i) substantive synergies with other partners providing similar support towards the EW4All target; and ii) to help unlock required funding for sustaining such a support architecture. The latter will target conventional and emerging donors such as bilateral donors, multilateral financing institutions, and philanthropists. The work will be guided by a long-term financing strategy that is in turn informed by detailed needs assessment from developing countries.

The output will augment on-going support for synthesis of knowledge, experience and lessons by providing operational and technical assistance aligned with international standards and best practices towards the effective implementation of the EW4All initiative. This will involve the development, dissemination and application of comprehensive normative guidance, tools, and methodologies across all four pillars of EWS and at the inter-pillar level. Specifically, this includes the development of detailed guidelines, strategic orientation documents, and AI-based tools designed to improve processes along the entire early warning value chain and the provision of tailored technical assistance to strengthen national EWS capabilities. National and regional DAEs, as well as sectoral representatives and associated ministries will be included in the knowledge exchange to ensure they can contribute to discussions on practically implementing MHEWS within different contexts and sharing lessons on past experiences.

In addition, this output will support the integration of early warning systems into national priorities, roadmaps, and financing strategies, including governance and legal frameworks. Technical support will also be provided to facilitate simulations and testing of national EWS operational effectiveness, develop coordinated funding requests, strengthen the global EW4All MEAL framework and develop a knowledge management system to document and disseminate key learnings. Further, capacity-building efforts will enable Direct Access Entities to fast-track access to GCF financing for early warning initiatives. Collectively, these activities aim to establish robust, sustainable, and effective early warning systems globally, ensuring that countries are well-prepared to respond to and mitigate the impacts of disasters. This component will be led by EW4All Pillar lead agencies and will aim to support enabling conditions at both the global, regional and national levels, so that countries receive suitable and timely assistance to meet the universal coverage target of EW4All.

Activity 1.1: Enhanced Coordination and Technical Support for EW4All Implementation

Activity 1.1 focuses on enhancing coordination and providing comprehensive technical support to ensure the effective implementation of the Early Warnings for All (EW4All) initiative. This involves the development and application of normative guidance, tools, and methodologies that span across all four pillars of early warning systems (EWS) and integrate these efforts at the interpillar level. The four Pillar lead agencies will collaborate to create detailed and standardized guidelines, training materials, and strategic orientation documents. The goal is to provide countries and partners with the necessary resources to align their national EWS initiatives with international standards and best practices. This includes integrating early warning systems into national priorities, roadmaps, and financing strategies, as well as supporting governance and legal frameworks for EWS. Furthermore, the development and application of AI-based tools will be emphasized, ensuring that advanced technologies are used responsibly to address gaps and improve the effectiveness of the entire early warning value chain. Activity 1.1 further aims to accelerate technical support to countries by providing operational assistance and facilitating simulations and testing of national EWS

operational effectiveness. Coordinated funding requests, including Green Climate Fund (GCF) submissions, will be developed to secure necessary financial resources. Capacity-building efforts will also be undertaken to enable Direct Access Entities to fast-track access to GCF financing for early warning initiatives.

Sub- Activity 1.1.1: Develop normative guidance and tools across all four pillars & at the interpillar level

This sub-activity will result in the development of pillar and interpillar guidelines, tools, training and methodologies, building on what exists and accounting for regional and national contexts. Strategic Orientation and Policy Guidance will be developed and provided to countries and partners. The sub-activity will also support the application of AI-Based tools by providing guidance and support to countries on the responsible use of AI for effective EWS across the entire EW value chain to address gaps and needs leveraging the AI for EW4All sub-group. The guidance and tools will include:

- A catalogue of existing AI solutions, with a toolkit of high maturity solutions to be deployed by countries as a function of their demand.
- Strengthening national capacity to quantify loss and damage from climate-related shocks and disasters, including through national accounting systems, standards, and SOPs across multiple sectors to improve the quantification of direct and indirect loss and damage costs.
- Technical assistance on diagnostics of status of risk knowledge in EWS at the national or local level (using tools such as EW4All Gap Analysis); assessment of maturity of risk data production, management and use (including historic losses and damages / disaster data along with risk, i.e. hazard, vulnerability, exposure and coping capacity, as well as data ecosystem capacities such as data storage, interoperability and sharing protocols, APIs, processing power, etc.); Data maturity scoping (sources, types, formats, quality)
- Technical assistance/capacity building to strengthen national capacities to collect, produce, share, manage and analyze granular hazardous events and disaggregated (sex, age, disability, income, sector, geographic & hazard, etc.) disaster losses, damages and impact data, ensuring alignment with the Sendai Framework
- Technical assistance/capacity building in national data collection, sharing and quality assurance mechanisms/arrangements, data (e.g. hazard classification and hazard definitions) and metadata standards
- Technical assistance/capacity building to develop roles, responsibilities and workflows on data collection, sharing and analysis are codified into local, sectoral and national policies, plans and SoPs
- Technical assistance for the establishment of standardized national risk assessment protocols and tools tailored to the country and local context
- Capacity development for national and local stakeholders on risk assessment methods and tools, including risk and hazard identification, vulnerability, coping capacities and exposure mapping and assessment
- Technical assistance in the development of national risk maps and tools to consolidate and manage risk information effectively across sectors and administrative units
- Introducing/socializing use of Artificial Intelligence (AI) tools for risk analytics
- Promotion of crowdsourcing methods to support losses and damages data collection/production

In addition to this, WMO will undertake a review of its guidance across hazard types and update as needed to enable the use of multi-model ensemble and probabilistic forecast to issue warnings and communicate uncertainty. As part of the review and update emerging technologies and the role of AI will be addressed. Work will also be done to ensure that the guidance is packaged and disseminated with WMO Members to enable their uptake and use.

Sub-Activity 1.1.2: Accelerate Technical Support to Countries for EWS implementation

Activity 1.1.2 focuses on accelerating technical support for countries implementing Early Warning Systems (EWS). It involves providing operational and technical assistance to countries, supporting the development and implementation of EW4All national roadmaps, supporting countries to test the capacities of the MHEWS, and support the financing elements that underpin MHEWS systems and capacities.

Efforts will be focused on scaling up and enhancing the work of the Tropical Cyclone Programme (TCP), the Severe Weather Forecasting Programme (SWFP), Impact-Based Forecasting and Warning (IBFW), and the Common Alerting Protocol (CAP). Regional Associations, aiming to reach more countries will be supported to address a broader range of hazards, and provide better support to WMO Members. Under this sub-activity operational and technical assistance will be provided to countries, ensuring alignment with international standards and best practices outlined in sub-activity 1.1.1. Pillar leads, WMO Regional Climate Centres, together with other global, regional and national agencies will co-design and implement analytic frameworks and models for national adoption to scale-up use of data related to critical multi-hazard exposure, vulnerability , loss and damage, and effective mitigation action to provide the basis of impact based forecast warning services (IbWFS). Alignment will also be sought with existing regional and global initiatives around early warning early action. This will include providing and helping to design systems for data sharing,

archiving and access and open-source software and scripts for data cleaning, analysis, visualisation and modelling. Regional centres will also be responsible for developing models which can be used by the NMHS together with the NDMAs, for IbWFS, scenario building and triggers to inform early/anticipatory actions. Wherever feasible, the regional centres will explore co-production of AA protocols involving the NMHS, NDMAs together with research agencies and grassroots organisations. The capacity of WMO, UNDRR, ITU and IFRC will be augmented to enhance the quality of support to countries via Outputs 1 and 3. In particular, the existing WMO supportive frameworks such as WIGOS, WIS, and GDPFS/WIPPS will be expanded geographically to provide real time operational support to more countries and also cover a wider range of hazards to match country needs.

The sub-activity will support the integration of early warning systems into national priorities, roadmaps, and financing strategies. Technical support and coordination across all pillars of the EAP which relat to governance and legal frameworks for EWS and their dissemination will be provided to participating governments. A sustainability strategy for the global support architecture will be developed by implementing global financing campaigns and consultations with various partners and donors that will take place throughout the implementation of the project. The sub-activity will also develop methods to facilitate simulations and testing of national EWS operational effectiveness. It will develop coordinated funding requests, including GCF submissions, across pillars and at the interpillar level and provide capacity-building and support to Direct Access Entities to fast-track access to GCF financing on early warnings. A global strategy will be developed to unlock financing at the global level to deepen or expand support to countries towards the EW4All target. Countries will be supported in sourcing financing from international financial institutions, international organisations and vertical funds and corporate donors seeking to support climate adaptation, such as those participating in the UN Global Compact. Countries will also be facilitated in supporting grant financing for women-led and women only initiatives.

Activity 1.2: Strengthened M&E to support EW4All Implementation

A global M&E framework for EW4All, including the EW4All Maturity index will be developed and rolled out, including a dashboard to track progress of the initiative globally and at country levels across all four pillars. The framework will include annual reporting on progress on the EW4All initiative at the conference of parties (COP). The activity will replicate/ scale up the experience from South Asia on the development of a "women's resilience index" to measure country capacity for how women and socially excluded/hardest hit groups are considered in disaster and hazard risk. The activity will also support countries on Sendai Monitor reporting, particularly target G.

Sub-Activity 1.2.1: Operationalising the EW4All maturity index

This sub-activity will develop and implement the EW4All maturity index system for benchmarking global progress across all pillars and at the interpillar level. It will update and validate assessments and score cards to track country progress and provide diagnostics support to countries on monitoring systems effectiveness. This sub-activity will enable WMO to complete the rapid assessment of Pillar 2 for new countries entering the initiative. WMO will also track progress on completed assessments and ensure that country score cards are updated regularly. Moreover, WMO will undertake the task of updating the methodology for Country Hydromet Diagnostic to align with priority hazards identified. These activities will strengthen global information and reporting systems on MHEWS capacities for informed action.

Sub-Activity 1.2.2: Strengthen global EW4All MEAL and reporting to enable regular progress updates

This sub-activity will strengthen and consolidate the EW4All monitoring and evaluation framework across pillars, considerate of inter-pillar elements, It will conduct data collection and related monitoring actions on field and develop and publish studies, reports, other knowledge materials to showcase outcomes of framework monitoring, including annual EW progress report.

Sub-Activity 1.2.3: Regular update of EW4All Dashboard

Sub-activity 2.2.3 will improve integration of EW4All implementation progress and country capacities data into the EW4All dashboard. It will improve analytical and visual functions and maintain the dashboard, including the creation of a database covering the entire EWS value chain and its pillars. It will ensure country-level tracking and updates to the global database respecting measurable improvements in national capacity in areas such as risk assessment, risk data use and governance for EWS, application of hazard-specific exposure and vulnerability data to improve IbF, and progress on avoiding and minimizing loss and damage through EWS. In addition the sub-activity will ensure regular reporting by participating countries on the Sendai Monitor, particularly for target G reporting.

Activity 1.3: Strengthened knowledge management and lessons learned

The activity will support knowledge exchange among countries at different stages of implementation of the EW4All EAP across all Pillars and implementing partners. Countries will be assisted in developing plans to improve their MHEWS and AA approaches and systems, ensuring that each approach takes a people-centric view with ensured last-mile communications and including all stakeholders (DAEs, humanitarians, financial organisations and sectoral representatives – both government and NGOs).

Sub-Activity 1.3.1: Development of knowledge management framework that guides learning and exchange

This sub-activity will develop a knowledge management framework to systematically capture, document, and disseminate lessons learned. It will establish processes and protocols for knowledge sharing among stakeholders and develop a repository that is open access and online for the dissemination of knowledge products. A UN global knowledge bank for EWS will be created as a common digital public good to improve easy access by country-level actors to robust tools, guidance, peer-learning, and reliable technical guidance from multiple UN and non-UN sources on themes cutting across EWS.

Sub-Activity 1.3.2: Documentation and dissemination of good practices and lessons learned

The identification and documentation of good practices, challenges, innovations and solutions encountered in early warning programming will be done under this sub-activity. Post-disaster forensics will be conducted to learn lessons related to early warning systems. Lessons learned on EWS functioning will be integrated in post-disaster needs assessments (PDNA), and the reinforcement of functional EWS will be included in Recovery Frameworks. The sub-activity will also disseminate early warning knowledge products, in support of peer-to-peer learning and continuous improvement and informed decision-making. Under this sub-activity, WMO will develop and maintain an enhanced section on the WMO website which centralizes information, tools, and guidance materials dedicated to providing resources for the implementation of Early Warnings for All (EW4All) initiatives.

Sub-Activity 1.3.3: Development of technical expert working groups

This sub-activity will establish technical expert groups for countries implementing mobile EWS using digital networks. It will facilitate the sharing of implementation expertise and best practices, provide capacity building and technical support for mobile EWS and assist countries in accessing life-saving alert technologies through standardization and negotiation.

Output 2: Accelerating actions in select countries towards EW4All

As per the UNDRR[134] MHEWS have four interrelated key elements, referred to as the four pillars of early warning: 1) disaster risk knowledge based on the systematic collection of data and disaster risk assessments; 2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; 3) dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and 4) preparedness at all levels to respond to the warnings received.

Effective EWS require these four interrelated components to be coordinated within and across sectors and across multiple levels and institutions. In order to do so, the project must address the critical gaps and barriers identified in the participating countries. This analysis of barriers has been presented in the section on barriers.

This component will roll out national level investment activities in seven countries to address country and local level needs to achieve the EW4All target. All seven of these countries are from the list of the 30 focal countries identified under the global EW4All initiative for 2023 and the criteria used for these selection were discussed earlier. Concrete investments will focus on EWS hardware and software, risk knowledge, disseminating and communicating early warnings and preparedness for local-level actions that reduce vulnerability of communities. These will be based on a comprehensive analysis of capacities and gaps in each country, presented in their respective feasibility studies.

[134] UNDRR, "Early Warning System."

Concerted efforts will be made to close gender gaps in access to, control over, and use of MHEWS technology, communications and services. This includes considerations of needs and challenges facing rural women, ethnic minorities, men and women who are illiterate, people with disabilities, elderly and households with infants and children. It will support women's equitable decision-making opportunities, including in design and management of EWS areas, laws, policies and operational procedures. Lessons from other countries such as Cambodia will be incorporated to ensure women play meaningful roles in MHEWS and early action.

Each country has unique opportunities and barriers to implementing effective EWS. However, there are some common needs, particularly in LDCs and SIDS. This component will fulfil those needs and leverage available opportunities by executing time bound investment activities and allowing for measuring the impacts on ground. The implementation of the national investment activities will be supported by WMO, UNDRR, ITU, IFRC, and other partner agencies, depending on the capacity of the host government and in-country presence and capacities of these agencies. All activities will coordinate with and be designed to complement existing work being undertaken by DAEs, NGOs (IFRC, Care, Christian Aid etc.) and other multilateral (World Bank, GFDRR, FAO, WFP) and bilateral (GIZ, FCDO, SIDA, NORAD etc) donors. This Output is designed to mirror the structure of the EAP so that activities within this Output will be fully aligned to it.

The first activity under the output seeks to address the issue of governance and coordination which is a critical requirement for effective and sustainable MHEWS to be designed and delivered. Its sub-activities will specifically address the unique challenges of Fragile and Conflict Affected States (FCAS),[135] building on lessons from climate adaptation projects in such countries.[136] Activity 2 of the output will address barriers and gaps in disaster knowledge (Pillar 1) and Observations (Pillar 2) while activity 3 will address gaps in dissemination (Pillar 3) and disaster response (Pillar 4).

Activity 2.1: Strengthened Governance and Coordination

The activity will focus on legislation and policies governing the exchange of information to facilitate coordinated dissemination of warnings between different actors. It will establish clear functions, roles and responsibilities of agencies in the national warning dissemination process with associated updating of the WMO Register of Alerting Authorities (RAA). Alert dissemination and feedback channels will be expanded to reach end users with targeted and actionable information by leveraging community-based institutions, civil society and faith-based organisations. Considerations of differential access to information and resources by women and vulnerable groups will be included in the dissemination strategy. Partnerships with intermediaries will be established and training provided to local authorities and relevant agencies for interpretation and dissemination of alerts to ensure delivery of clear and actionable warnings to end users. This will include extension officers and other government staff in line departments and journalists. This activity will also establish or strengthen existing local early warning committees or equivalent grassroots organisations with representatives from elected/traditional leaders who are linked to govt. development or DRR structures in each country. Meaningful involvement and representation of women and vulnerable groups in these institutions will be ensured. Each EWC will seek to be a registered entity under the relevant national provisions and will seek to have a formal structure of office bearers and a bank account. A clear coordination and reporting structure will be instituted between sub-national agencies from the lowest level of governance up-to the district level. Each EWC will have direct access to focal persons in the relevant government agency at the district, NMHS and NDMA. Capacities of these local institutions, from district down to village level will be enhanced through regular engagements and training programmes that strengthen institutional structures and procedures.

Sub-Activity 2.1.1: Strengthened coordination mechanisms

The sub-activity will advocate for enabling policies, laws and strategies for effective early warning, earl yaction and preparedness. It will support the development of a strategy and action plan and associated legislation to mainstream early warning and anticipatory action, while ensuring alignment with best practices and a supportive framework and legislation to mainstream early warnings and anticipatory action from national to local scales. This will be done through a comprehensive review of existing disaster risk management policies, laws and strategies as well as climate

[135] Laura Jaramillo et al., *Climate Challenges in Fragile and Conflict-Affected States* (International Monetary Fund, 2023).
[136] Adaptation Fund, "Addressing Climate Change Adaptation in Fragile Settings and Conflict-Affected Countries: Lessons Learned from the Adaptation Fund's Portfolio," January 2024.

plans. The establishment of national liability frameworks that hold stakeholders accountable for not acting on warnings will be explored as mechanism for strong legal incentives for accountability .

Mechanisms to incentivize non-government and private agencies in contributing to the national EWS will be explored. This includes available options for incorporating financial incentives (e.g., tax breaks, access to subsidies) which could be effective incentives, for example for telecommunications.

Data sharing between and within agencies at the national and sub-national levels will be strengthened and a formal delivery mechanism will be provided for government agencies to engage with and financially support national and local authorities, first responders and other stakeholders involved in early warning on the ground and to better align and activate their respective response plans to reduce the impact of the hazard (Sub-activity 2.4.2). Targeted groups include national and local authorities, businesses, communities, National Red Cross Red Crescent Societies, NGOs, the United Nations (UN) and community groups.

This activity will additionally ensure policy and financial support for mainstreaming of early earning, early action and preparedness in government frameworks, systems and plans based on local needs and priorities and using local knowledge. Committed financing will be critical to anticipatory action and response in the event of a crisis. Contingency funds will be sourced through activities under components 1 and 2 and will be made available ahead of an expected impact. The success of the work in this activity hinges on committed financing for disaster preparedness and anticipatory actions ahead of a crisis. The activity will embed the principles of anticipatory action into social assistance through enhancing shock-responsive social protection system at the grassroots level .

Sub-Activity 2.1.2: Enhanced governance capacities

This will include: i) a clear assignment of roles and responsibilities at the national and subnational level for services; ii) strategic plan and organizational structure; iii) periodic process to assess and evaluate its services; iv) coordination platform(s) – such as the NFCS – established; v) inter-institutional arrangements are in place for data sharing, inter-operability of systems, co-design of services; vi) communication, competency framework, cooperation, studies, quality system and financial resources. Development and updating of national plans, strategies and legislation for NMHS and DRM agencies in each country will lead to forecasting and warning services being installed for all priority hazards and meeting Sendai Target G Indicator 4: All countries' local governments have a plan to act on early warnings.

- Strengthened governance, collaboration and inclusion. Governance arrangements, particularly for disaster preparedness and response, will be strengthened to include clear provisions, protocols, roles and responsibilities for early warning and early action, and will include an emphasis on inclusion of women and vulnerable groups within communities. Collaboration will be strengthened between grassroots organisations including government agencies, traditional and religious leaders, local schools and health centres and civil society organisations.
- Capacity building and creation of enabling conditions for better integration of relevant ministries and entities concerned with gender, with the work of NDMAs and NMHS in order to more efficiently use existing capacity within government structures.
- Raising awareness on crucial intersections of gender inequality, social exclusion with success of MHEWS uptake and use.
- Strengthened collaboration between key ministries, academia and the private sector, including at the community level. It will support countries in defining their roles, responsibilities and identify ways of working which prioritise collective action between the different agencies and institutions. The activity will strengthen risk knowledge capability in these institutions by combining local, traditional, Indigenous, generational and scientific knowledge that can enable resilience under a range of future risk scenarios. Building on existing approaches, it will strengthen locally led, people-centred and citizen science-based approaches. It will use innovative approaches to leverage new and existing technologies to expand risk knowledge capability at all scales, including continuous monitoring / crowdsourcing of important vulnerability metrics as a basis for responding to and anticipating emerging crises and disasters.

Sub-Activity 2.1.3: Monitoring, Evaluation and Learning

Sub-Activity 2.1.3 ensures continuous monitoring of other project activities and sub-activities based on quantitative and where possible spatially explicit indicators and means of verification to track project progress and support adaptive management decisions. This is expected to result in improved monitoring, evaluation and learning systems integrated within project and national structures to provide up to date status of activities and emerging risks, as well as promoting adaptive approaches to the implementation of MHEWS. It will promoting institutional arrangements to ensure capacity and resources (e.g. staff, budget, etc.) to implement, monitor, and report gender-responsive actions

and will enhance capacities of countries to monitor the availability and effectiveness of EWS, to use this to update their approaches and to report better on Sendai Framework Target G and custom indicators. Specific actions will be taken to set up a formal mechanism for feedback on the EWS from end-users and communities. This will leverage mobile phone based technologies (surveys, forms) where available combined with regular consultations for feedback from focal persons in communities, specifically including representatives of women and vulnerable groups. This will require assessments and data collection for which digital technologies will be leveraged where possible. The activity will also undertake regular impact evaluations to capture use and socioeconomic outcomes of climate products and advisories at the level of institutions and communities. The activity will establish formal linkages with academia and institutions at the national and regional level for collaborating on the impact assessments and also for reviews and evaluations of the products themselves for their incremental improvement and development. The proposed actions under Sub-Activity 2.1.3 include: i) M&E survey design, implementation and analysis of results for feedback into project reporting, management and impact evaluation. This will be split into monitoring visits undertaken at quarterly intervals and impact evaluation surveys done annually; ii) Product evaluation which will involve accuracy assessments through field measurements and validation with target stakeholders, both institutions and communities, with disaggregated analysis which captures feedback on EWS and its impacts on women, men, youth and vulnerable groups such as elderly and people with disabilities; iii) M&E and impact evaluation of communication and dissemination strategies. This will cover: a) monitoring of data sharing and integration protocols at the institutional level, specifically between agencies involved in observations and those engaged in development of sector specific products using this data; b) monitoring of reach and c) effectiveness across different channels of dissemination and across both institutions and communities. The latter including the different vulnerable group; iv) M&E of the gender strategy, assessing the gender indicators for reporting on a quarterly basis and updating the strategy on an annual basis; and v) M&E of environmental and social safeguards as per the country specific safeguard plans and strategies on a quarterly basis.

Activity 2.2: Disaster risk knowledge and observations

This activity will result in the systematic collection of risk data, information and analysis leading to improved awareness about hazards, exposure populations, services, infrastructure, vulnerabilities of communities, and improved loss and damage accounting. Existing data collection and repository systems in countries will be strengthened for increased data production, aggregation and use of risk information to support impact-based forecasts. Relevant authorities such as NDMA, NMHS and other stakeholders, including sector ministries, sub-national government, will benefit from capacity building. The countries will strengthen their disaster loss accounting systems and monitoring of Sendai Target G Indicator 5:1 All countries have accessible, understandable, usable and relevant disaster risk information and assessment available to people at national and local levels. The activity will also establish collaborations with relevant academic institutions to develop effective communication strategies for contextual and actionable alerts to end users.

Sub-Activity 2.2.1: Develop disaster risk knowledge systems

The sub-activity will increase production and access to risk information and effective application of risk information at national, sub-national and local levels. It will result in improved capability of each country to produce quality, timely and contextually relevant risk information for EWS which integrates community knowledge through a comprehensive stakeholder engagement plan. This will result in improved generation of national, sub-national and local risk information to a minimum defined level of vulnerability, exposure and risk across major climate-related hazards. Capacities of relevant agencies in data access, metrics and analysis to support decision-making will be built to facilitate access to updated risk information in standardised, inter-operable formats. Finally, the sub-activity will build institutional capacities to incorporate risk knowledge into EWS. This will result in high resolution vulnerability (hazard, exposure) datasets for each participating country and high resolution, forecast linked models for specific risks (floods, dry-spells, heatwaves, drought, thunderstorms, landslides, GLOF).

Sub-Activity 2.2.2: Broaden observation and monitoring networks

This sub-activity will focus on the strengthening and/or establishment of meteorological, hydrological and climate forecast and monitoring systems for each participating country. Capacities of NMHS will be enhanced to fill gaps in hydromet data acquisition through institutional and staff capacity development, installation of hardware and software leading to improved observations for developing forecasts which in turn feed into the generation of accurate and timely early warnings. Additionally, the NMHS will adopt a quality management system for regular review and reporting on the accuracy and timeliness of their services leading to compliance with GBON. The activities will build on implementation plans of existing programmes such as the Flash Flood Guidance System (FFGS) or the Hydrological Status and Outlook Systems (HydroSOS) initiative. The sub-activity will result in enhanced national capacities for

observations and data exchange by enhancing data sharing and information exchange infrastructure to support EWS. Implementation of the WMO Information System 2.0 (WIS 2.0) will be accelerated to enable timely and sustained data access and develop technical capabilities. This will be coupled with policy advocacy and development to enable sharing of critical data required for early warnings, based on the WMO Unified Data Policy. Existing efforts on observation, monitoring and forecasting for EWS led by multilateral agencies will be optimised through data sharing and sharing of forecasting products.

Data sharing within the country, i.e. between ministries and actors involved in the generation of impacts and understanding how to interpret forecasts for communities and people will also be enhanced through both improved infrastructure as well as capacity building. A gap analysis on early warning needs will be conducted at national and regional levels to expand the cataloguing of hazardous events (WMO-CHE) to all weather and climate driven hazards and their monitoring requirements; the catalogue will also be deployed to track loss and damage. Timely access to and use of in-situ observing networks, satellite observation, radar, lightening detection and other advanced technologies will be used to build detection and forecasting capabilities. The activity will help close the observed gaps to meet data needs for monitoring hazards by implementing the GBON as well as hydrological, meteorological and hydrological networks responding to national requirements for early warning. It will close gaps in ocean and cryosphere data in hot spots such as coastal areas and high mountains and will accelerate the implementation of the WMO action plan for hydrology by establishing regional hydrological status systems. An assessment of interoperability of different EWS systems will be done to identify and address gaps in communication and data exchange. This will ensure seamless data integration and communication between the different components of the EWS in the country as well as with external systems.

Sub-Activity 2.2.3: Strengthen MHEWS forecasting capacity

The sub-activity will strengthen capabilities for data processing, forecasting and analysis. The network of Regional Specialised Meteorological Centres and associated National Meteorological and Hydrological Centres will be supported to meet region specific needs for severe weather forecasting, flood and flash-flood forecasting, sand and dust storm forecasting, marine weather forecasts, high resolution weather predictions, now-casting, tropical cyclones and IbF. Additionally, WMO supportive frameworks (WIGOS, WIS and GDPFS/WIPPS) will be expanded to provide real-time operational support for a wide range of hazards.

Activity 2.3: Warning dissemination and preparedness

This Activity, corresponding to the third and fourth pillar of the EAP, seeks to ensure that clear, understandable and actionable warning messages reach everyone at risk, in line with the Sendai[137] Targets G Indicator G-3 (All people will be covered and can receive early warning information through local governments or through national dissemination mechanisms) and Indicator G-6 (All people will be covered and can receive early warning information through local governments or through national dissemination mechanisms). This will be achieved by developing and taking advantage of last mile connectivity and by establishing multi-channel EWS using radio, TV, the Internet, mobile and satellite networks, sirens etc. Early warning messages will be developed in a multitude of accessible formats and languages, including for persons with disabilities in their full diversity, illiterate persons, etc. Information will be disseminated in a manner which ensures that risks and warnings are understood,are clear and actionable by their target audience. The activity will also ensure that participating countries have updated registries of authorities responsible for alerting communities and are issuing warnings that are compliant with the Common Alerting Protocol (CAP[138]) whilst being understandable in culturally appropriate formats and media and being cognisant of data protection and privacy concerns.

The activity will support a spectrum of actions, including integrating clear protocols for early warning and early action in disaster management/ preparedness plans. It will support actions based on early warnings before disasters hit, such as evacuation, strengthening of infrastructure, pre-positioning of essential stocks and supplies. This activity will strengthen the preparedness capacities, systems and procedures of local governments, responders and vulnerable communities through training and equipping them to respond based on integrated community and national EWS and communications.

[137] UN, “Sendai Framework for Disaster Risk Reduction 2015 - 2030” (United Nations, 2015).
[138] WMO, “Guidelines for Implementation of Common Alerting Protocol (CAP)-Enabled Emergency Alerting.”

Sub-Activity 2.3.1: Strengthen EW dissemination systems

The Sub-Activity will lead to expanded and strengthened communication network and services by supporting the implementation of multi-channel systems for communicating and disseminating early warnings and alerts to the last mile. Infrastructure and network services will be strategically strengthened by targeting the most efficient, trusted and preferred communication channels, with at least one channel as backup where feasible. Geo-located mobile early warning services based on cell-broadcast or location-based SMS systems will be implemented and strengthened by working with mobile network operators, ICT regulators in countries and GSMA the global association of mobile network operators. Best practices for data privacy will be put in place. Countries will receive technical assistance to set up and implement mobile early warning systems. This will be further strengthened by supporting governments to institute appropriate regulatory approaches and policies that mandate the use of geo-located alerts using satellite in areas where people are at risk, but mobile networks do not exist (e.g. in remote mountainous areas). Here, alternative networks, in particular, satellite-based and radio networks will be exploited as the primary dissemination channel. Funds will be identified to pay for these systems where governments do not have resources to establish a basic satellite/mobile early warning system. Assessments will be carried out to understand how best to reach communities at risk and innovative and emerging technologies will be used to develop "client profiles" to scale up targeted dissemination of actionable early warnings. This activity proposes country piloting of the Disaster Connectivity Map and visualization tool to assess connectivity levels and disaster risks using AI, helping visualise local connectivity, identify risk areas, and enhance national assessments and communication strategies.

At the community level, the activity will promote and support inclusive, people-centered co-development of gender responsive, actionable early warnings by targeted communities in local languages using and extending approaches such as the Participatory Integrated Climate Services for Agriculture (PICSA). Existing community-based systems including Indigenous Knowledge Systems (IKS) and flood and drought warning systems set up through other agencies such as the IFRC will be leveraged and feedback mechanisms from end users, including women and vulnerable groups, will be established to facilitate improvements in the development and delivery of early warning services. Innovative systems that leverage mobile communications and IoT will be used to set up low-latency autonomous systems (described in activity 2.3.3) with local communities. Communities will be supported in accessing and interpreting forecasts and weather data to better manage their risks.

Sub-Activity 2.3.2: Develop adaptation and preparedness protocols

Actions under this sub-activity will lead to comprehensive procedures and protocols for disaster adaptation and preparedness, with emphasis on supporting communities most at risk in each country. Its actions will build on the strengthened coordination mechanisms and governance (Activity 2.1) and better disaster knowledge and observations (Activity 2.2). Actions under this sub-activity will include: i) Communication protocols and identification of focal persons for each interest group; ii) Protocols for graduated warning levels to have heightened awareness during periods of increased risk exposure; iii) Protocols for evacuation during disasters; and 4) Protocols for relief, extension and health services to deliver appropriate services to communities.

Sub-Activity 2.3.3: Strengthen disaster adaptation and response capacity

This activity will result in the development of disaster preparedness/contingency plans to ensure effective response, including provisions for early warning and early/ anticipatory action. Capacities for preparedness based on risk-informed and impact-based forecasts will be ensured at the local levels to enable local authorities, first responders and communities to act quickly and effectively based on the early warning alerts. Training of local governments and first responders including agencies such as National Red Cross or Red Crescent Societies will be done and their preparedness capacities, systems and procedures will be strengthened based on the integrated community and national early warning system. A National Early Warning Service training programme will be developed and implemented to both enhance capability and develop a sustainable knowledge base. Institutional and operational level capacities will be built by scaling up investments in preparedness, cash systems, supply chains and logistics, as well as enhancing accountability of local responders. Communities will be engaged in developing holistic early warning and anticipatory action in local disasters management, disaster risk reduction and climate change adaptation plans based on feasibility studies, climate information and local knowledge. These will include including evacuation routes and plans for construction and retrofitting of small infrastructure for emergencies. Specific attention will be given to the needs of women and vulnerable groups, specifically accommodating the increased risk of gender based violence during emergencies and of accessibility of facilities to differently abled individuals. As part of CIEWS, communities will be trained on O&M of early warning devices such as water level recorders, rain-gauges and anemometers. Support and oversight will also be provided for small scale infrastructure for emergencies such as installing water storage

tanks, minor improvements to existing, access routes/paths, construction of small shelters or storerooms. Existing preparedness systems and operational protocols should reflect the roles, needs and rights of underrepresented and disadvantaged groups, including women, children, elderly, persons with disabilities, people on the move, minorities, etc. Inclusivity will be central to the approaches adopted in the project across all activities.

Key interventions in participating countries under Output 2

To have an effective MHEWS in place, each country will need to develop and strengthen their existing MHEWS, strategies, policies and protocols to mobilise resources and people. The country specfiic priorities described below are based on an exhaustive engagement with stakeholders across different levels of government, communities and their organisations, multilateral agencies working in-country and regionally, private sector agencies and NGOs. Community consultations engaged women, marginalised and vulnerable groups as has been documented in the country specfic stakeholder engagement plans.

Antigua and Barbuda

The project approach for Antigua and Barbuda (A&B) was developed through an extensive multi-stakeholder engagement process, which culminated in an implementation roadmap for reinforcing a people-centric MHEWS in the country. The roadmap identified several key principles which underpin the approach, focused on: i) strengthening the national governance framework; ii) data-sharing collaborations and consolidation; iii) bridging the gap between technical information and community comprehension; and iv) enhancing capacity for emergency management. Moreover, several key sectors/areas have been prioritized to fill gaps in the existing MHEWS, particularly focused on the marine environment – including ocean conditions and environmental impacts – and the introduction of an EWS for Barbuda that is not wholly reliant on already stretched services in Antigua.

From a governance perspective, interventions in A&B will focus on modernizing the disaster management policy and legislative framework, and integrating DRR considerations into sectoral policies – including for the built environment, land-use planning and urban development. These policy actions will be aligned with existing plans on a national and regional level, and reinforced by a national strategic plan for national emergency management agencies, together providing a solid foundation for the effective functioning and sustainability of MHEWS and ensuring clarity and alignment among all involved parties. A key component of the governance support is the establishment of a Disaster Preparedness and Response Fund. This fund will provide a sustainable mechanism to channel resources toward critical disaster preparedness and response activities. The cross-cutting governance interventions will be underpinned by improved disaster risk knowledge in the country (Pillar 1), focused on creating a seamless information flow between relevant government agencies, supporting organizations and the public to improve coordination and enable more holistic developmental planning, with risk data and information readily available to all stakeholders. This will include increasing the availability of sector-specific risk data, knowledge and best practices for critical sectors such as tourism, energy, agriculture, education, telecommunications and health, as well as added focus the marine environment and social risks. At the heart of this effort is the development of an online risk data platform, designed to centralise and manage critical risk information across all relevant sectors, as well as undertaking comprehensive hazard and risk assessments, addressing significant knowledge gaps, particularly in Barbuda.

Under Pillar 2, a core focus of interventions will be on increasing the operational capacity of the Antigua and Barbuda Meteorological Service (ABMS) – including supporting actions to direct additional budget to the services, hiring and training of technical staff, and improving the hurricane resilience of the ABMS offices through structural enhancements and the installation of backup power and communication systems. In addition, the project will improve existing hydrological observation infrastructure and monitoring systems to enhance flash flood forecast system for urban and rural areas, as well as introducing additional marine monitoring infrastructure for swells and potential environmental changes. The enhancements to these networks will include provisions for real time monitoring and analysis of hydrometeorological data, ensuring interoperability with risk data in place at ABMS through the introduction of a platform to consolidate geospatial hydrometeorological and disaster risk information.

Pillar 3 will focus on simpler warning messages that are easily understandable by the public, ensuring that warning messages are clear, concise, and actionable during emergencies. This will be supported by awareness actions to build trust among communities in the warnings being presented and their associated anticipatory actions. A national emergency telecommunication plan will be developed alongside a common alert protocol that integrates multiple

dissemination platforms, including cell broadcasts, radio and television broadcasting, sirens, among other traditional forms of mass warning.

Finally, interventions under Pillar 4 the project will support the scaling of community-based early warning systems (CEWS) to empower local communities to take an active role in monitoring, disseminating, and responding to potential threats — developing specialized risk-informed response/contingency plans for extreme events based on the needs of vulnerable communities. The plan also emphasizes enhancing community disaster response teams, providing training and equipment for first responders, as well as providing resources for rapid evacuation and shelter services, and strengthening scenario-based planning with impact-based forecasting to improve response capabilities. and establishing dedicated financing mechanisms and structured early action measures for pre-impact actions based on the needs of vulnerable groups. The anticipatory action will be closely linked with the governance support interventions – ensuring that relevant legislation is updated to accommodate the emerging functions of key response institutions.

Cambodia

The EW4AII intervention for Cambodia provides a comprehensive plan for governance and coordination, disaster risk knowledge and coordination, and warning dissemination and preparedness in Cambodia. The plan includes developing a data-sharing protocol, upgrading the Cambodia Disaster Damage & Loss Information System (CamDi), and implementing early warning systems at the national and sub-national levels. It also emphasizes the need for gender and inclusion considerations, as well as the establishment of river gauges and drought gauges in target provinces to address weather information needs. Furthermore, the plan focuses on raising awareness of emergency alert systems and enhancing warning dissemination through various channels, including mobile networks and online platforms.

The governance and coordination aspect of the plan involves establishing a collaborative EW secretariat, addressing gaps in the legal and financial context, and implementing a cross-pillar approach to gender and inclusion. The disaster risk knowledge and coordination section emphasize upgrading the Cambodia Disaster Damage & Loss Information System, preparing preparedness and contingency plans in target provinces, and installing river gauges and drought gauges. Additionally, it highlights the development of a comprehensive human resource plan to meet early warning requirements.

The warning dissemination and preparedness component focuses on raising awareness of emergency alert systems, coordinating mobile network providers, and upgrading online presence and dissemination channels. It also entails equipping local authorities with early action capacity, implementing community-based early warning systems, and providing shock-responsive social protection for preparedness and anticipatory action in target provinces. The plan places particular emphasis on the needs of vulnerable communities, including women, people with disabilities, children, and youth.

Chad

The intervention in Chad will ensure that EW/EA are impact based by building capability to carry out post-disaster needs assessments and loss and damages reporting, promoting longer-term adaptation planning and knowledge management. It will ensure EW systems are functional, by developing a sustainable finance plan with expertise in public financial management in the context of Fragile and Conflict Affected States (FCAS). The project will promote the development of a pipeline of supporting projects, ensuring data collected is transmitted in a timely way, ensuring data governance, and developing rights and protocols for issuing and disseminating warnings. It will move from a siloed approach centered on food security, towards a multi-hazard system, considering wider adaptation challenges. It will be people centered, based on the right to information on risks, advice on preparedness measures, and warnings/advisories that are locally relevant and respond to the needs and expectations of people including women, the elderly, people with disability, refugees and minorities.

The project will develop an offer of audio recordings developed through mobile phones, conduct regular surveys and qualitative community research, and develop national capability for cell broadcasts. It will consider preferences for communication and monitor trust in existing and new communication channels being developed. It will provide end-to-end integration of early warning and early action, ensuring anticipatory action protocols are tested and adapted, providing capability to carry out simulations, lessons learned and post disaster needs assessments, supporting crisis response capacity at devolved levels, while bringing together contingency planning information with a register of responsibilities for disaster management, and defined alerting rights. The project will respond appropriately to the

needs of people concerning transparency, accountability and the management of grievances, and be sensitive to conflict dynamics. Significant stakeholder engagement, and preparatory work on institutional and regulatory frameworks, will ensure that coordination and governance approaches are set in motion to support these activities and outcomes, and address critical institutional, financial and regulatory barriers.

Ecuador

The MHEWS project proposed in Ecuador is designed to significantly enhance the country's ability to anticipate, prepare for, and respond to various climate-related hazards, such as floods, landslides, droughts and extreme temperatures. The impact of these hazards is increasing in Ecuador in the last years due to climate change. The project aims to establish a robust and integrated multi-hazard early warning system that leverages advanced forecasting techniques, standardised climate data management, inclusive communication strategies, community emergency plans and anticipatory actions. The primary activities include the development of a functional legislative framework, the development of a National Framework for Climate Services (NFCS), the establishment of a comprehensive climate data centre, the implementation of national risk assessments for the relevant hazards, the improvement of the hazard forecasting, the integration of Indigenous Knowledge Systems (IKS) into early warning practices, the improvement of the communication strategies and the creation of gender-sensitive disaster preparedness protocols, as it is described further in section 7 of the Feasibility Study.

These activities are strategically aimed at addressing the pressing climate challenges in Ecuador. The country is highly vulnerable to natural disasters due to its geographical location in the Andean region, which is prone to extreme meteorological events, droughts, floods, and landslides, as described in the Feasibility Study. The project's focus on strengthening governance structures and enhancing institutional capacities ensures that early warning systems are effective and sustainable. By improving disaster risk knowledge, enhancing monitoring and forecasting capabilities, and ensuring timely and inclusive communication of warnings, the project will mitigate the adverse impacts of climate-related hazards on vulnerable communities.

Key activities of the project, such as the establishment of a National Climate Finance Framework and the enhancement of data management systems, address specific gaps identified in Ecuador's national climate strategy. These include the need for more robust and sustainable financing mechanisms for climate adaptation, as well as improved coordination among different governmental and non-governmental stakeholders involved in disaster risk management. Furthermore, the project's emphasis on gender-sensitive approaches and the inclusion of Indigenous Knowledge Systems (IKS) aligns with Ecuador's commitment to social inclusion and equitable climate adaptation. By ensuring that early warning systems are accessible and responsive to the needs of women, Indigenous peoples, and other vulnerable groups, the project contributes to a more resilient and inclusive society.

In summary, the MHEWS project addresses the key challenges identified in Ecuador's national climate strategy, including gaps in institutional capacity, financing, and community preparedness. Its activities are specifically designed to strengthen the country's preparedness and resilience in the face of increasing climate variability and extreme weather events, ensuring that Ecuador is better equipped to protect its people and assets from future climate-related risks.

Ethiopia

The project interventions address critical barriers that prevent the effective generation, dissemination and use of early warnings for climate change adaptation, preparedness and response to warnings, through three broad outputs tailored to specific country needs. The project will support the collection and dissemination of multi-hazard and multi-sector risk data through the development of a central National Risk Data Hub managed by EDRMC and accessible to all. This will enable the development and sharing of impact-based disaster risk profiles focusing on highly vulnerable areas especially looking at floods risk and drought. It will support the upgrade of hydro-meteorological observing stations and improve coverage in under-covered areas. An analysis on most relevant communications channels to address EW to vulnerable populations will be undertaken and used to develop a disaster risk, EW linked to mitigation and AA messaging. EW systems will be operationalized at community level in priority high risk locations, linking with AA. An emergency call number and service will be developed.

Multi-sector line ministries will be engaged to agree on sector-specific EW and Emergency Thresholds, and multi-hazard AA plans will be integrated into Preparedness Planning in highly vulnerable areas, linking with a financial support mechanism and a social protection scheme.

A National Risk Data Hub coordinated by EDRMC with contributions from all sector Agencies/Ministries will be formed to collect and develop multi-hazard data and risk analyses and undertake capacity development for expert human resources including IT and connectivity capacities to enable data sharing amongst all actors. Woreda level risk profiles in priority areas will be developed with compilation and analysis of hazard, exposure and vulnerability data. The project will improve data sharing by establishing requisite protocols and procedures and will support the integration of geo-hazards in EWS. A gender based EWS focusing on elderly and children will be developed as part of this exercise which will also lead to the establishment of community-based early-warning systems in priority areas.

A survey will be undertaken to identify most relevant media communications channels according to types of audience, including vulnerability and gender-based issues. This will be used to build capacities of communications specialists to address media, and to journalists to communicate about disaster risk.

Fiji

The proposed interventions in Fiji primarily focus on strengthening and enhancing the existing functions of partner organizations to address well-known priorities for improving understanding and communication and governance and coordination mechanism amongst the national stakeholders relevant to EWS in Fiji. The project aims to unify risk assessment methods in Fiji, focusing on historical data, climate models and local knowledge.

The project will expand or upgrade weather/climate/hydrometric observation network for EWS: Investments will be made to improve monitoring and warning for severe weather, and localized and flash flooding, and droughts.. Data collected will be used to create models and forecasts of, enabling timely warnings and the development of evacuation plans. The project will additionally Strengthen MHEWS forecasting capacity by enhance predication accuracy through integration of AI and machine learning techniques, developing a centralized database/repository and incorporating use of data science, e.g. Artificial Intelligence (AI) to assist in forecasting and early warning. A slow drought monitoring impact-based forecasting system for food security will be established along with Drought Early Warning System.

For warnings dissemination and preparedness, the project will support the implementation of the National Emergency Telecom Plan which includes automation of a geo-targeted, location-based messaging through the CAP and cell broadcasting. This will require a review and revision of the current licensing of the national mobile providers to ensure they upgrade their infrastructure to enable cell broadcasting. The project will also support expansion of Starlink network and maritime radio to achieve 100 % EWS coverage in Fiji.

The project will develop and implement community-focused communication strategies based on findings from risk perception studies. It will improve translation and interpretation of EW messages by incorporating message translation, caption generation, and text-to-speech capabilities in EWS messaging to enhance inclusivity for individuals with disabilities and the elderly. Train-the-Trainer workshops will be run for key stakeholders, such as ground actors, government officers, Red Cross officers, and sugarcane extension officers and Technology Transfer Officer and community-level awareness campaigns will be run on how to respond to early warning information. The project will evaluate the reach and effectiveness of disaster preparedness campaigns, and integrate the lessons learned into revised communications and training. Local contingency plans will be developed which are behaviourally informed, inclusive and community driven and a CBDRM Training Toolkit will be developed used to and run Train of Trainer workshops on CBDRM and early warning messages with inclusion of early actions.

Somalia

The interventions proposed for Somalia under the EW4All project fall predominately within the Country's EW4All Roadmap identified activities and the resourcing requirements for these. During the latter part of 2023, Somalia initiated steps to draft and consult on the national Roadmap for Implementation of Early Warning for All (EW4All) 2024-2027. In collaboration with the UNDP Somalia country office, the EW4ALL Roadmap will be operationalised under the leadership of the National Multi-Hazard Early Warning Center (NMHEWC), which is already operational under the Somalia Disaster Management Agency (SoDMA). Four outputs under the four pillars form the [tentative] interventions proposed for Somalia, which contribute directly to the realisation of Somalia's (draft) National Roadmap

for Implementation of Early Warning for All (EW4All) 2024-2027 through the roadmap-identified activities and the resourcing requirements for these. The activities under the three outputs include the following.

In order to improve disaster risk knowledge and capacities the project will undertake the development of a comprehensive risk assessment framework and database. Disaster risk knowledge materials and communications will be developed for national and local levels and capacity building and coordination provided for the application of improved disaster risk knowledge at national and local levels. The project will also support integrated actions for detection, monitoring, analysis and forecasts of weather and climate. It will harmonise the collection of early warning data, its analysis and exchange modalities among federal line ministries, sectorial offices, and regional bodies. It will support improved data automation, modelling and forecasting of early warning harmonised among sectorial offices and improved interoperability and early warning information exchange between sectors.

The project will support nation-wide warning dissemination and communication access by supporting development and implementation of early warning communication strategies and standard operating procedures for governance, functions, roles and responsibilities for early warning information, communication and dissemination. It will establish comprehensive functional infrastructure networks and early warning dissemination services and equipment and ensure inclusive, people-centred EW4ALL through local networks. Finally the project will enhance preparedness for timely responses and early actions, including at the local level, by supporting improved response and recovery disaster preparedness measures established for early actions and the development of supporting risk management policy, legislation and strategies.

Somalia has a need to accelerate the momentum in building its institutions as a basis for transitioning from fragility to reducing poverty and promoting shared responsibility. However, progress in institutional building has been slow, reflecting the countries context of fragility and conflict. Climate shocks contribute to widespread food insecurity, forced displacement, abandonment of rural livelihoods and perpetuating fragility.

Sustainability and exit strategy

The sustainability for the project will be ensured through a actions, specifically:

Under sub-activity 2.1.2 the integration of early warning systems into national priorities, roadmaps, and financing strategies will be supported. Technical support and coordination across all pillars of the EAP which relate to governance and legal frameworks for EWS and their dissemination will be provided to participating governments. A sustainability strategy for the global support architecture will be developed by implementing global financing campaigns and consultations with various partners and donors that will take place throughout the implementation of the project. The regulatory framework will be enhanced by the development of a national strategic plan for national emergency management agencies, that together with the policy updates will provide a solid foundation for the effective functioning and sustainability of MHEWS and ensuring clarity and alignment among all involved parties.

The targeted scenario would involve long term regional and global support for country level actions towards the EW4All goals, including countries with fiscal and technical constraints and those facing challenges due to insecurity. Long term and continuous investments will be ensured through mechanisms such as SOFF and will result in improved hydromet infrastructure, its O&M and strengthened capacities of NMHS and NDMAs for generation and dissemination of reliable, actionable impact-based forecasts and climate information. Strengthened institutional coordination and collaboration will result in effective use of climate information to trigger and support decisions for anticipatory action.

Deliberate and detailed impact assessments will lead to increased awareness and knowledge targeted at increased political commitment coupled with institutional mechanisms that ensure community involvement in disaster preparedness and planning. The project will create increased opportunities for regional cooperation and up-scaling of climate resilient sustainable development. It will link sectoral and technical government entities, science institutions, civil society and other stakeholders to promote anticipatory actions. This will contribute to an enabling environment where climate risk information is effectively produced and disseminated, in a sustainable fashion, to the most vulnerable groups to safeguard their lives, livelihoods and assets in the long-term. Legal frameworks for DRM and protocols for inter-agency coordination and involvement of local institutions will be strengthened along with regional and international level collaborations and partnerships.

The global support structure

The speed and scale of interventions required to deliver on the EW4All objectives can only be achieved through coordinated global support involving all key actors across the EW4All value chain. The needs of LDCs and SIDS to establish, operate and maintain their national end-to-end early warning systems, effective communication systems and disaster preparedness at the level of vulnerable communities requires multiple funding instruments. These instruments need to bring together complementary mechanisms that maximise country ownership and impact.

There is a need to facilitate national investment planning to achieve EW4All goals around which finance can coalesce to achieve shared value and results. This includes the development of national road-maps and investment pipelines and the communication of a common vision of needs, priorities, and opportunities across all four pillars of EWS. It is necessary to recognise the respective business practices, funding cycles, and operational practices of various financial instruments to accelerate GCF co-finance. This will help address gaps across the continuum of country-specific technical and financial support needs for end-to-end early warning systems, translating country vision into concrete investment.

The absence of a consistent, reliable and robust source of holistic technical and financial support to countries is the essential challenge to the effective generation and use of MHEWS. Support available to countries is fragmented and tends to be driven through project financing. Global initiatives such as EW4All and mechanisms like SOFF and CREWS are therefore necessary for countries to receive consistent, continuous support that meets the global standards, allows them to exchange knowledge and sustainably develop and expand MHEWS to cover all sections of their vulnerable communities.

Recognising that responding adequately to the SG's call for EW4All will require concerted efforts at the global level for a sustained period of time, developing a strong exit strategy for this project will become one of the critical deliverables of this GCF project. In particular, the global support architecture supported by the project will continue to finance itself through various channels including bilateral or multilateral public financing, philanthropists, private sector financing, or other innovative financial instrument. Sustainability and replicability of the project will be facilitated and supported through key partnerships and its alignment with key frameworks and strategies at the global and regional level. The project is aligned with the WMO Global Framework for Climate Services (GFCS), designed to facilitate delivery of best practice climate services.

This project is designed to address existing root causes and barriers to sustainable climate information services, MHEWS and AA in the most vulnerable countries among the LDCs and SIDS. The following strategy is proposed to ensure sustainability beyond the project's lifespan.

Institutional strengthening

The project will strengthen the existing institutions and governance at the global, regional and national levels, rather than creating new parallel structures. Sustainability will be supported by the establishment of holistic national and regional frameworks, with associated institutional coordination mechanisms such as road-maps, strategies and SoPs to ensure effective governance, coordination and management of national climate services. The project will support integration of climate services in key policies, strategies, plans and budgets which will provide a foundation for uptake of climate information in decision-making and facilitate sustainable service provision in the long term. The identification of funding modalities for climate information products and anticipatory action including by integration in the national/regional budget/pools will also contribute to sustainability.

State of the art hydromet monitoring equipment and tools for observations, monitoring, modelling and prediction will be integrated in the existing hydrological and meteorological institutions, based on available data management infrastructure. Institutional capacity will be further strengthened through upgrading relevant IT and communications equipment. Special attention will be given to building capacities for O&M of both equipment and data infrastructure. The project will also help NHMS and NDMAs in developing and implementing long-term sustainable strategies for O&M through financial arrangements such as SOFF, for which it will provide support. NHMS will be supported in designing and disseminating a suite of tailored climate information products for national ministries, departments and agencies and the private sector to ensure some cost recovery.

In order to ensure long term technical and capacity support, the project will support NMHS and NDMA to participate in networks based on regional and national centres of expertise. This will ensure long-term and sustainable engagement with governments and policy makers. It will allow network actors to apply to a wide variety of other funding sources, including utilising academic grants to support research as part of MEAL. This national and regional technical capacity will furthermore benefit DAEs, regional institutions and national government by increasing access to technically rigorous support and their capacity to submit transformative proposals in the future. By including DAEs and NDAs in the development of proposals, this programme will also expose them to new ideas and enhance their proposal development capacity.

Community level capacity strengthening

The project will adopt a broad multi-stakeholder approach and bring on board government agencies, multilateral and international agencies and NGOs, Red Cross and Red Crescent network, private sector actors and communities as users of climate information, early warnings and anticipatory actions as well as front-line agencies in climate adaptation and disaster response. When possible, this will be done through existing government led coordination mechanisms. Institutional linkages will be strengthened by enacting enabling policies and procedures that improve effectiveness of delivery and use of CIEWS. Local, community-based institutions, in particular, will be strengthened to effectively access CIEWS, interpret and co-develop anticipatory action, adaptation and response strategies and plans.

This will go hand-in-hand with participatory exercises leading to detailed maps and plans and simulation exercises which ensure the different elements of communication and response are well understood and internalised. Capacity building plans and exercises will deliberately focus on inclusion of women and most vulnerable groups such as households with elderly, women with infants, children and people with disabilities.

Programmatic alignment

This multi-country project will unlock opportunities for coordinated action and serve as an accelerator and amplifier for EWS support co-financed through complementary instruments. It will work closely with other important programmes such as CREWS and SOFF, and other mechanisms for funding such as from GEF and multilateral donors. This will be achieved by building on multilateral mechanisms such as CREWS and the GCF, which mobilizes a significant number of diverse national entities ranging from Ministries to national NGOs operating through a collaborative and partnership-based business models. This will ensure scaling up of projects supported by these agencies, particularly under SOFF and CREWS.

Financing

Establishing a financing strategy in each participating country is one of the deliverables of the project to address the critical challenge of financial sustainability. The strategy will assess the feasibility of various possible sources of finance, including both public and private sources, to expand and maintain end-end-to end MHEWS in the selected countries, based on their specific needs. This includes the national hydromet monitoring network including public and private financing sources. The financing strategy will include financial mechanisms that ensure the sustenance of: i) the national hydromet monitoring network; ii) development of climate products including impact based forecasts, models for scenario and trigger development; iii) support to anticipatory actions including ex-ante forecast-based financing and resilience bond or ex-post climate risk transfer mechanisms; and iv) support disaster preparedness and response capabilities down to the level of communities. These mechanisms will be operated at multiple levels and tailored to each countries fiscal policies and capacities for effective and efficient fund transfer for DRR. Contingency funds will thereby be released to targeted agencies and communities to take early action and avoid and/or mitigate the impact of disasters through effective action built on CIEWS. The financing plan will explore public-private partnership on data usage, analysis and dissemination. It will develop and implement implement campaigns and consultations with various partners and donors and coordinate funding requests, including GCF submissions, across pillars to unlock financing at the global level. The project will support Direct Access Entities to fast-track access to GCF financing on early warnings. Countries will be supported in sourcing financing from international financial institutions, international organisations, vertical funds and corporate donors seeking to support climate adaptation.

Policy strengthening

Project activities will fill gaps in policies and governance arrangements to strengthen national level EWS coordination among government actors at the national and local level across sectors. Relevant national strategies and plans will be updated or developed for NMHS and NDMA agencies in each country contributing to Sendai Target G Indicator 4: All

countries' local governments have a plan to act on early warnings. The project will strengthen legislation and policies governing coordination, exchanging of information, coordinated dissemination of warnings and establishing DRR structures for preparedness and response. This will mainstream early warning and anticipatory action and will leverage supportive framework and legislation within the respective countries. The strategy will be linked to social protection and DRM based on local priorities and will address assignment of roles and responsibilities at the national and subnational level for government agencies, communities and local institutions as well as other actors such as NGOs. Coordination platform will be established and inter-institutional arrangements will be specified for data sharing, inter-operability of systems, co-design of services.

Impact Potential

Globally, 3.3 to 3.6 billion people are highly vulnerable to climate change.[139] Between 2015 and 2021, 1.05 billion people were affected by disasters and $330 billion USD in economic losses of 145 countries reporting to the Sendai Framework. Yet, only 4.1% of disaster-related development assistance was allocated to ex-ante prevention and preparedness, of which the majority was for emergency response.[140] As of 2022 half the countries in the world, less than half of LDCs and less than a third of SIDS had a MHEWS.

The project contributes to the achievement of GCF strategic-level impacts through increased resilience and enhanced livelihoods of the most vulnerable people and communities globally through a programmatic approach which accelerates access to early warning systems for the most critical climate hazards. It does so by investing in technologies and finance for generation, dissemination of climate information and in its effective use through preparedness and anticipatory action. It will enhance and increase the impact and long-term sustainability of these investments both at the national and regional levels. It responds to the update of the GCF strategic plan 2024-20271 which contributes to the EW4All call of the Secretary Generation with a dedicated target result on EWS.

Seven countries will receive holistic investment and technical assistance to establish an effective end-to-end EWS in accordance with the actions proposed in the EW4All Executive Action Plan. A particular focus will be placed on improving last-mile communication of and community-level capacities to receive, understand and act on climate information and early warnings by ensuring each country prepares and updates disaster response plans and ensures communities have access to communications, the capacities and knowledge and the preparation to react to warnings. These activities will directly contribute to improving the resilience of people potentially at risk from climate-related extreme events and hazards in LDCs and SIDS where communities are highly vulnerable to climate induced disasters on account of socio-economic vulnerabilities and physical exposure.

Actionable climate information products for agriculture, energy and water management will increase resilience across sectors, particularly agriculture, reducing the risks from climate-related hazards and thus reduce losses and damage to crops, infrastructure and other assets. By the end of the project, it is expected that these target countries are well on track to achieve the target of universal early warning coverage and hence the total population of the countries will be receiving adaptation benefits from the project.

The project will support existing WMO frameworks such as WIGOS, WIS, GDPFS/WIPPS and is aligned with existing initiatives around early warning and early action such as CREWS and REAP which aims to make one billion people safer from disasters by 2025. The project will facilitate knowledge exchange, coordination and collaboration with key initiatives such as the Alliance for Hydromet Development, Anticipatory Hub, CREWs and SOFF, and with UN agencies and IFIs to ensure that they collectively strive towards meeting the EW4All target. The project will contribute to the achievement of the GCF indicator of reduction in the number of people affected by climate-related disasters and will deliver climate change adaptation benefits by:

1. Improving the resilience of people potentially at risk from climate-related extreme events and hazards in LDCs and SIDS where communities are highly vulnerable to climate induced disasters on account of socio-economic vulnerabilities and physical exposure. It will provide early warnings to communities who are susceptible to cyclones, coastal flooding and sea-level rise, floods, landslides and droughts.
2. Enhancing regional and national MHEWS with targeted and timely last mile communication, impact based forecasts which help communities take effective measures to secure their lives, assets, and livelihoods during

[139] The UN Global Early Warning Initiative for the Implementation of Climate Adaptation, “Early Warnings for All - Executive Action Plan 2023-2027x.”
[140] UNDRR and WMO, “Global Status of Multi-Hazard Early Warning Systems: Target G.”

climate-related hazards and triggers to inform early and anticipatory actions, including forecast based financing so that resources are made available to at-risk communities ahead of disasters.

3. Increasing the safeguarding of assets and infrastructure from climate-related hazards through accurate, timely and actionable early warning services. Actionable climate information products for agriculture, energy and water management will increase resilience across sectors, particularly agriculture, reducing the risks from climate-related hazards and thus reduce losses and damage to crops, infrastructure and other assets.
4. Strengthening NMHS and NDMAs in participating countries through regional and global collaborations which enhance their access to sustainable finance and technical knowledge. This will result in up gradation and improved O&M of hydromet infrastructure, access to innovative and state of the art tools and techniques and streamlined protocols which increase institutional effectiveness leading to more reliable impact-based forecasts and targeted, actionable climate information products for early and effective on-ground action.
5. Strengthening national DRM legal frameworks and financing mechanisms as well as coordination, collaboration, and knowledge sharing from the local to the international level leading to an effective DRM cycle and increased opportunities for regional cooperation and up-scaling of climate resilient sustainable development.

Paradigm shift

This project will help shift the emphasis of DRM in countries from response to preparation and anticipatory action by strengthening MHEWS, impact-based forecasting. It will facilitate the generation and dissemination of critical climate risk information and the design and implementation of evidence-informed transformative policies and plans which reduce the exposure and strengthen the capacities of communities to prepare for, and take pre-emptive action against disasters. It will thereby reduce the vulnerability of communities and critical infrastructure and strengthen the resilience of vulnerable sectors to climate-related hazards and their impacts of climate change. It will ensure the needs of most vulnerable population groups during extreme events such as women, children, elderly and persons with disabilities will are reflected in relevant policies, procedures and processes.

The global support architecture that the project establishes a sustainable mechanism to support countries both technically and financially in rolling out a comprehensive EW4All value chain. It will support aims to catalyse learning and impact beyond one-off, project-based investments, which characterises investments in the CIEWS sector in many developing countries. Elements that contribute to the paradigm shift potential of this project include the emphasis on supporting and fostering synergies with other initiatives with complementary objectives. These include the Alliance for Hydromet Development, CREWs and SOFF, which will lead to support towards knowledge generation; knowledge synthesis and sharing among countries; and long-term financing strategy for both countries and for the global support architecture.

Finally, this project will foster an unprecedented level of cooperation and collaboration among key actors across the EWS value chain, from global to regional, national and even sub-national levels. This will leverage multi-institutional partnerships at the regional and global level coupled with national frameworks and road-maps which ensure multi-sectoral collaborations within government ministries and multi-level implementation mechanisms for disaster preparedness and response. The mechanism will enhance partnerships between government and non-government agencies, including societies and circles of Pillar Leads, iNGOs and national entities and mechanisms such as CREWS and SOFF.

Potential for scaling-up and replication:

The design of this project, where Output 2 focuses on comprehensive country-level investments in select countries will ensure the roll-out of EW4All beyond the initial seven countries to future countries looking ot invest in MHEWS. The support architecture created through the project will allow to catalyse scale-up and replication to other countries who look to mimic the project's approach. Substantively, the establishment of selected impact-based forecasting schemes and AA initiatives have a high potential for replication within and across the target countries. The use of appropriate technologies and innovations will also contribute to scaling up and replications. For example: i) The implementation of the CAP and use of multiple channels for dissemination, but those specifically leveraging on the cellular networks will facilitate uptake by different telecommunication companies; ii) Successful applications of AI in for development of EW products and vulnerability assessments; iii) Co-development of agricultural advisories using PICSA and E-PICSA; and iv) Community based autonomous early warning and alarm systems.

Potential for knowledge and learning:

The enhancement of MHEWS and production of IbF which utilise and combine traditional indigenous knowledge with modern and scientific techniques will facilitate adoption of adaptation and responses to early warnings, facilitate anticipatory actions for disaster preparedness and response by DRM institutions and grassroots communities. This will catalyse wider acceptance and lead to safeguarding of lives, livelihoods and assets. It will support regional and country level dialogues, knowledge exchange, coordination and collaboration with key initiatives such as on-going projects and programmes of the UN, the Alliance for Hydromet Development, CREWs and SOFF.

Contribution to the creation of an enabling environment:

The project will support enabling conditions at regional and global level promoting country-level actions towards the EW4All goals. It will improve the hydromet infrastructure of participating countries and strengthen capacities of NMHS and NDMAs to improve the generation of risk and vulnerability information and O&M of the infrastructure. It will streamline national and local protocols to improve institutional effectiveness of coordinating with multiple actors in the dissemination of reliable, actionable impact-based forecasts and climate information to trigger and support decisions for anticipatory action. It will strengthen national DRM legal frameworks as well as coordination, collaboration, and knowledge sharing from the local to the international level leading to an effective DRM cycle and increased opportunities for regional cooperation and up-scaling of climate resilient sustainable development. It will help link sectoral and technical government entities, science institutions, civil society and other stakeholders to promote anticipatory actions. All of these will ultimately contribute to an enabling environment where climate risk information is effectively produced and disseminated, in a sustainable fashion, to the most vulnerable groups to safeguard their lives, livelihoods and assets in the long-term.

Contribution to the regulatory framework, policies and financial mechanisms:

The project will catalyse a systemic change in the operational procedures and processes of participating countries in the generation and use of early warnings. It will facilitate the integration of climate information services in key decision making, planning and operational processes by: i) revising institutional frameworks to optimise coordination between hydrological and meteorological organisations with other governmental institutions by embedding early warnings, impact based forecasts and anticipatory action into government contingency plans and DRM budgets; ii) advocating for and providing links to international financing opportunities for long-term funding arrangements for hydrological and meteorological institutes to provide tailored climate information services on climate change threats; iii) linking with initiatives such as SOFF to ensure funding for the installation and O&M of hydromet infrastructure as per WMO standards; and iv) delivering fine grained and updated vulnerability assessments to assist in long-term disaster mitigation and adaptation planning.

Overall contribution to climate-resilient development pathways:

The development and dissemination of timely, tailored and targeted climate information products will be transformational in building the long-term resilience of key economic sectors such as agriculture, tourism and health, to climate risks. Delivered through a suite of outreach, learning and knowledge management activities, information products will increase efficiency and provide more detailed and better-informed approaches and response actions to climate risks.

Beneficiaries

This projects emphasis is on reducing the impacts of climate change on the lives, livelihoods and property of communities most vulnerable to climate change and on the services, infrastructure and critical sectors of the economy of countries in which they live. To do this, its activities are aimed at communities, regions and sectors most at risk from slow and rapid onset climate disasters.

Proposals for each of the participating countries have been designed to maximise the impact of the project on these communities, regions and sectors. This has been done though a comprehensive vulnerability analysis coupled with gap assessment to ensure the project meets the needs of undeserved communities and regions.

IMPLEMENTATION ARRANGEMENTS AND SUPPORT

Coordination and Oversight

Global

This project will be implemented under the Direct Implementation Modality (DIM) with UNDP as the senior supplier. The nationally designated authorities of the GCF will be the senior beneficiaries and the Director, Bureau for Policy and Programmer Support in UNDP will be the executive.

For Output 1, , the four Pillar Leads will be provided a budget based on the budget and work-plan for this output and will disburse their respective budgets to partner agencies for implementation of activities, as per the detailed budgets and work-plans.

For Output 2, the UNDP will provide technical, logistical and administrative support and the overall monitoring, evaluation, learning for the project, communications support and support and oversight to ensure adherence to UNDP and GCF social and environmental safeguards, gender safeguards and considerations as well as inclusion of marginalised groups. The global office will be responsible for regular reporting to the GCF in accordance to the work-plans for each of the countries and will also support the work-planning process. Annual audits of accounts will also be coordinated through the Global PMU as per the mandated procedure.

The global implementation arrangement will comprise of a Project Board or Project Steering Committee (PSC) comprised of representatives of the seven countries – their respective National Designated Authorities as the Senior Beneficiaries. The Executive will be a senior official from the UNDP. UNDP will also play the role of Senior Supplier. Pillar Focal Points (WMO, UNDRR, ITU and IFRC) will support the Project Board through a Coordination Group and will attend the Board meetings. In addition, technical experts from the four pillars will provide project support to the Global PMU. The Pillar Leads will also be Responsible Parties (RPs) in the implementation of Output 1. PSC meetings will be held virtually, twice times a year. In addition, the members of the committee will meet physically every other year (three times in the five years) for a knowledge sharing meeting. Three such meetings will be held during the implementation of the first seven country projects. These meetings will be attended by the EW4All Pillar Leads, GCF, UNDP and two representatives from each of the country projects, including at least one from the relevant national governments.

The Project Board is responsible for making, by consensus, management decisions when guidance is required by the Project Manager. Project Board decisions will be made in accordance with standards that shall ensure management for development results, best value money, fairness, integrity, transparency and effective international competition. In case a consensus cannot be reached within the Board, final decision shall rest with the UNDP Executive Coordinator.

A global Project Management Unit (PMU) will be constituted within UNDP for the overall project coordination, oversight and monitoring. The PMU will also provide technical support help the country PMUs in accessing regional and international resources through networking. The PMU will ensure the EW4All pillar leads are kept abreast of the project progress for their inputs and support. The proposed structure of the global PMU is provided in Figure 6. It comprises of six full time staff - a Project Manager, a Finance Analyst, a Monitoring Evaluation and Learning Officer, an Operations Associate a project associate and a Communications expert. The administrative team will support the acquisition and procurement of specialised equipment during the project for the specific country needs, in an effective manner that also responds to national capacities. It will also look into developing Long Term Purchasing Agreements that would ensure the efficient use of project resources. The PMU will be provided part-time technical support through a team of advisors who specialise in climate change adaptation, climate information and early warning systems, a Gender, Social and Environmental Safeguards expert, a Communications Expert and other subject experts brought in on an as needed basis.

The Project Manager will run the project on a day-to-day basis on behalf of the Project Board within the constraints laid down by the Project Board. The Project Manager function will end when the final project terminal evaluation report and other documentation required by the GCF and UNDP has been completed and submitted to UNDP. The Project Manager is responsible for day-to-day management and decision-making for the project. The Project Manager's prime responsibility is to ensure that the project produces the results specified in the project document, to

the required standard of quality and within the specified constraints of time and cost. The project Logic Framework (indicators, means of verification, assumptions) will be reviewed and the quarterly and annual plans will be refined based on the progress made in each country as well as at the regional and global level.

Figure 4. Global project implementation arrangements

National

The project will be implemented under Direct Implementation Modality. Implementation arrangements have been vetted and approved by the government via the relevant NDA and other Government Partners who will also be on the board of the country project steering committee (Figure 7).

UNDP Country offices will provide funds to the relevant RP in coordination with and through the explicit approval of the respective country NDA. The seven UNDP COs will provide oversight and coordinate the project through the national PMU. In addition the UNDP CO may provide additional logistic, administrative or technical support solicited by the respective government. The RPs will include relevant MDAs, including the NDMA, the NMHS and relevant sectoral Ministries, local chapters or societies of the Pillar Leads, NGOs and other research and development agencies.

The Project Board at the national level will be comprised of the Disaster Risk Management Agencies and the NDA for GCF. As the Senior Beneficiary, the implementing partner will be part of the board. Furthermore, as the Senior Supplier, UNDP will provide quality assurance for the project and ensure adherence to the guidelines for the implementation modality. The Project Board will be responsible for making, by consensus, management decisions when guidance is required by the National Project Manager. Project Board decisions will be made in accordance with standards that shall ensure management for development results, best value money, fairness, integrity, transparency and effective international competition. In case a consensus cannot be reached within the Board, final decision shall rest with the UNDP Programme Manager. The Project Board will meet three times a year.

The Implementing Partner (IP) for the project will be UNDP, and will have the support of the relevant ministries housing the NDMA or the NMHS. These will take on a role as lead Responsible Parties.

Other Responsible Parties will be identified by the NDMA and based on their comparative advantages and core competence in supporting in the successful delivery of project outcomes. The RPs will be directly accountable to UNDP as per the terms of an agreement which they will enter into. RPs will be engaged at both national and sub-national levels.

The National Project Manager will run the project on a day-to-day basis on behalf of UNDP within the constraints laid down by the National Project Board. The Project Manager function will end when the final project terminal evaluation report and other documentation required by the GCF and UNDP has been completed and submitted to UNDP. The Project Manager is responsible for day-to-day management and decision-making for the project. The Project Manager's prime responsibility is to ensure that the project produces the results specified in the project document, to the required standard of quality and within the specified constraints of time and cost.

Project Support comprises stakeholders including relevant government ministries and departments at national level and local government with local offices in the districts (NMHS and NDMA and ICT ministries/regulators), the community members from targeted districts, the civil society and other local and international NGOs. Staff from the pillar leads will be appointed as technical advisors based on their role in each of the country projects.

Sub-national coordination of project activities will be done through relevant district agencies, and where needed, through local units of international agencies such as IFRC societies. Sub-national planning, particularly at the village level will be informed by village level institutions for social and civil protection. Community members will play a critical role in the implementation and monitoring of project activities. Extensive stakeholder engagements have been undertaken at the community level in all countries in the formulation of their respective Stakeholder Engagement Plans. These plans inform the roles, functions and responsibilities by which communities can be fully engaged in the project.

The project Logic Framework (indicators, means of verification, assumptions) will be reviewed and the quarterly and annual plans will be refined engaging the communities from the targeted districts. The stakeholders will also be engaged during the mid-term and final evaluations to assess the progress of the project and enable adaptive project management in response to the needs and priorities of the communities targeted. Community participation will be tracked through tools developed by the project management, leveraging, where possible the existing decentralised government structures to implement the project and the role and views of the community members. Community representation in the Board will be through the decentralised structure of the Implementation Partner in each country.

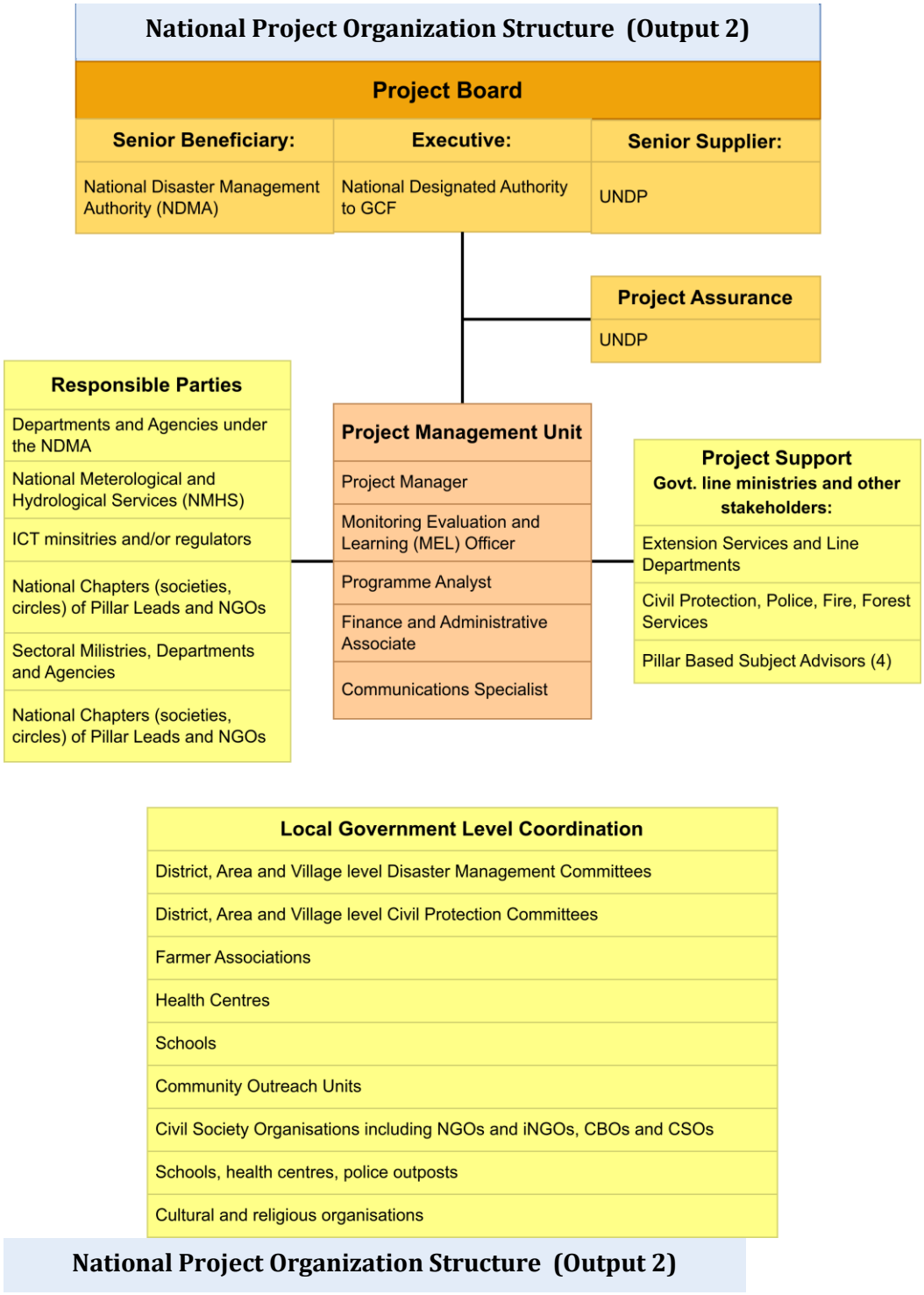

Figure 5. National project implementation arrangements

Technical support provided at the global level

Technical support at the global level will be provided by a team of specialists who will support the implementation of Output 1 (coordination) and Output 2 by the seven countries. This arrangement will significantly reducing the costs of hiring such expertise for each country. This approach will also allow the on-boarding of experts for a wider range of specialisations, adding to the richness and technical depth. Furthermore, it will result in increased capacities at each country through the multiple engagements and workshops that will be organised during the pipeline development of ten countries and implementation of the seven country projects.

Table 8.

For Output 1

The pillar leads will, through the activities described under the output, will support enabling conditions at both the global, regional and national levels, so that countries receive suitable relevant and timely assistance to meet the universal coverage target of EW4All. Its activities will augment synthesis of knowledge, experience and lessons by providing operational and technical assistance aligned with international standards and best practices towards the effective implementation of the EW4All initiative. Tools and methodologies will be developed and disseminated and tailored technical assistance will be provided to countries to strengthen national EWS capabilities. National and regional DAEs, as well as sectoral representatives and associated ministries, will be included in the knowledge exchange to ensure they can contribute to discussions on practically implementing MHEWS within different contexts and sharing innovations, lessons, and evidence of national EWS effectiveness.

For Output 2

The activities for Output 2 are organised along the Country Funding Proposal (CFP) log-frames which are based on Output 2 of the Global Funding Proposal (GFP) Figure 5. The total cost of the activities per country will be about 500,000 USD for five years, or about 100,000 USD per country per year. This will cover the costs of about four to five experts each year in addition to retreats, workshops and field missions to countries over the five years of implementation. The implementation of the seven country projects will be supported by a global team of experts and a global PMU, the former for technical activities and the latter for administration and reporting.

Technical expertise

The international expertise will span the technical elements of all the four pillars as well as cross cutting issues including social and environmental safeguards, gender mainstreaming, inclusion and disability. The experts will be directly engaged in design and implementation of activities, supported by national project staff and local experts from the seven countries. Most of the international experts will be hired on a part-time basis and will support activities identified and approved by the national governments for which local expertise is not available. This arrangement will ensure access of all countries to a wide range of specialised expertise on a cost-sharing and therefore, cost-effective basis. Expertise in the following areas is being considered - note that the experts will be hired based on country needs:

1. Vulnerability mapping: Use of AI with multiple data streams across disciplines, including census, field assessments such as FEWS and USAID supported country vulnerability assessments, remotely sensed data and climate data products.
2. Hazard mapping and hazard zonation across multiple hazards including floods, droughts, coastal hazards and landslides utilising machine learning and AI based algorithms with data inputs from remote sensing and other gridded products from climate centres, including regional centres.

3. Forecasting: Use of satellite data, AI and data integration from multiple streams into modelling. Deliverables will include impact based forecasts for drought, floods, landslides and trigger development for critical, country specific hazards. These products will be developed in collaboration with regional facilities/resources and local teams with training of relevant staff in updating and refining the products.
4. Community based early warning systems: Autonomous sensors equipped with warning and alarm systems for floods and landslides. The experts will support the installation and training of trainers on the O&M of the systems in country.
5. Hydrologist to help design a strategy and train staff in the collection and analysis of field observations across a range of scenarios to support flood modelling as well as streamflow models for water resource management for irrigation.
6. Communications of EW and establishing protocols and SOPs tailored to country needs and tailored to national policies and institutional arrangements.
7. Financial expert to support setting up of investment plans, costing plans and strategies.
8. Expertise in social and environmental safeguards, gender mainstreaming and stakeholder engagement will be provided to support the national teams in developing and updating relevant plans as well as the design and implementation of appropriate monitoring and reporting systems on these as per GCF and UNDP requirements.
9. An Inclusivity expert will support the design of national plans, strategies and project work-plans to ensure they incorporate best practices in accessibility and inclusion of people with disabilities and those with increased vulnerability due to age and with chronic illnesses. The expert will also help set up an appropriate monitoring and reporting structure for this.
10. Experts in Fragile and Conflict Affected States (FCAS). Regional and international experts will be engaged to support the implementation of activities through appropriate strategies in FCAS and set up appropriate monitoring and reporting systems.

Technical oversight, coordination and support

Technical advisors will provide continuous support by reviewing the work-plans and the concept notes, strategies and plans that describe the approach, budgets and indicators for monitoring the work plan. In addition, the following plans and strategies which are to be updated on an annual basis will be reviewed and supported:

1. O&M Plan
2. MEAL plan
3. Safeguard documents/plans as per ESMF
4. Gender strategy and action plan
5. Social inclusion strategy
6. Communication strategy
7. KM strategy

Monitoring Evaluation and Learning (MEAL)*

The global PMU will track and consolidate the MEAL systems implemented in each of the countries. Monitoring will cover both physical and financial progress on deliveries, associated indicators and means of verification. This will directly feed into the global communications and knowledge management effort which will include support for impact evaluations in all the seven countries. Collaborations with local and regional research facilities will be leveraged to further develop and publish interesting lessons and experiences, ensuring high quality knowledge management products from the project. Datasets from the monitoring activities and impact evaluations will be hosted on a global project dashboard and shared with partners for input into relevant dashboards of the Pillar Leads and partners. The following specific activities will be undertaken:

1. Monitoring of indicators and updating of means of verification as needed
2. Monitoring of delivery (down to the level of actions and specific RP focal persons/staff
3. The design, implementation and analysis of data from impact evaluation baselines and follow up surveys
4. Collation and analysis of datasets from the MEAL system and sharing with partners for integration with existing dashboards
5. Integration with UNDP mandated digital project management systems and maintenance of a dashboard to track project progress

6. Facilitating applied research through collaborations with local/regional/global agencies
7. Documentation and publications of lessons learned on available on-line platforms and peer reviewed journals

Mandatory Monitoring and Reporting

The technical advisors and global PMU will support critical monitoring and reporting requirements of the project. This includes financial reporting. Support provided will include updating and tracking of indicators used to measure project progress and the design of reporting templates and forms, terms of references to hire the relevant experts (locally or internationally) and in writing and reviewing of the reports. The mandatory reports include

1. Inception Reports
2. Annual Performance Reports
3. SES reporting based on ESMFs and local requirements
4. Gender action plan updated annually
5. Communication strategy and plan
6. Stakeholder engagement plan updated annually
7. O&M manuals and plans
8. Project Completion Report

Mandatory Evaluation

The GCF mandates that each project undergoes an interim and a final evaluation of the project. These evaluations will need to be done nationally as well as globally and will be supported by international as well as local (national) consultants. The design of the ToR and procurement of the global consultant will be done by the Global PMU while the Country PMU will procure the local consultants and provide logistical support for the missions and stakeholder engagements of the consultants.

In addition, an impact evaluation of project impacts will be designed and implemented by the Global Team. This impact evaluation will require multi-disciplinary baseline, mid-line and end-line surveys in each of the countries, using statistically and scientifically rigorous techniques, drawing from prior assessments. The impact evaluations will support project reporting, but more importantly, will support adaptive management and allow a robust measure of the project's impacts.

Learning and Knowledge Management

This project provides a unique opportunity in capturing lessons and experiences to develop practical tools and products which span a range of technical as well as administrative processes. This will be done in a participatory manner with inputs from different project stakeholders, including validation of the outputs. As part of process documentation and learning, the following will be developed:

1. Guides to stakeholder engagement across key institutions and the four pillars of EW. These will be based on documenting how key stakeholder and their roles are identified and the types of institutional arrangements and mechanisms that are required to ensure free flow of data, information and resources between key stakeholders, across sectors and vertically between different levels of government; i.e. national to local to community based institutions. The guides will include samples of MoUs, SoPs, strategies and plans that are developed during the project. It will document the processes and procedures followed, including prior road-maps and structures and how they were leveraged to implement the activities of this project. Detailed questionnaires, question lists and survey tools will be part of the package developed.
2. Resources for disaster simulations which include local government institutions, first responders and community based organisations. The tools developed will include means (observations tools) to identify and assess gaps in EW communications and response across different agencies and institutions.
3. Tool kits on engaging with communities on disaster preparedness and response including participatory methods for settlement level vulnerability assessments, development of disaster plans including evacuation plans and routes that incorporate needs of people with disabilities and those most exposed and vulnerable to hazards.

Reviews and annual planning workshops

A critical input of the G-PMU will be to support the project planning process in the seven countries. Technical advisors from the G-PMU will participate in the annual review and planning workshops which will be organised by the National PMUs (N-PMU) in each of the seven countries. These workshops will involve the Responsible Parties and critical institutional stakeholders involved in project implementation and will serve as a multi-stakeholder platform to present

the Annual Progress Report draft for the GCF, RP level progress and challenges in implementing activities, discuss lessons and formulate strategies and the way forward. This process is summarised in Figure 8. The global team will host annual technical workshops that to provide an opportunity for country teams to engage with and access the technical experts listed above. These workshops will be critical in the following:

1. Facilitating country teams to access the most relevant technical experts and to design and coordinate with them for their deployment technical missions to countries.
2. The workshops will be held in different host countries among the seven partners. This will ensure cross learning between countries through sharing of experiences and expertise and participating in field visits in host countries.
3. Presentations by each country of annual progress and work-plans for the succeeding year.
4. Technical working group meetings which include technical experts from each of the four pillars, facilitating the interaction of the country teams with experts and representatives of the pillar leads. This will specifically include a review of the learning and knowledge management products described above.
5. Global steering committee meetings.

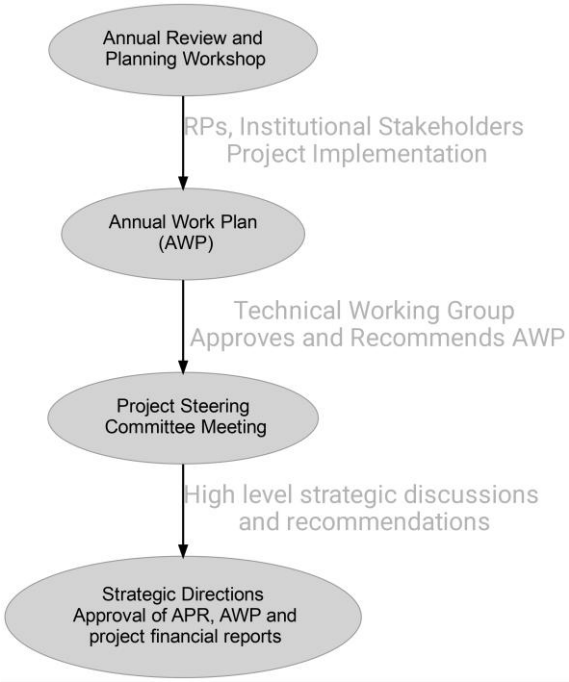

Figure 6. Summary of the annual review and planning process to be conducted at each country by the Country PMU

1. Formal discussion and approval of the APR.
2. Drafting of a detailed AWP for the project which is fully owned by the project partners.
3. A technical discussion on key challenges and strategies to address them by the Technical Working Group resulting in recommendations to the Project Steering Committee (PSC) for the approval of the APR and AWP. The TWG will also make high level recommendations for consideration by the PSC.
4. A discussion of high level strategic issues and recommendations made by the TWG followed by a formal approval of the APR and AWP.

In addition to the annual review process, the G-PMU will convene annual review and planning meetings for all the seven country project teams, modelled on the annual planning process described above.

The representatives of the RPs of each country project will form the institutional stakeholders who present their countries progress and work plans during the global annual review and planning workshop. The technical advisors and specialists will form the Global Technical Working Group who will review and make technical recommendations to the work-plans and strategies. Each workshop will culminate in the Global Project Steering Committee meeting for the approval of the APR, AWP and high level strategic inputs to the project.

Three of these events will be held at retreats in one of the participating countries, and will be attended in person. The retreats will provide critical platforms for project planning, coordination and knowledge sharing.

Administrative and logistic support

A global Project Management Unit (G-PMU) will be constituted for the overall project coordination, oversight and monitoring. This will be paid from the PMU fee of 5% charged to the overall project budget and will not reflect in the partner country budgets. The PMU will also provide technical support help the country PMUs in accessing regional and international resources through networking. The PMU will ensure the EW4All pillar leads are kept abreast of the project progress for their inputs and support through monitoring of both physical and financial progress. The Global PMU will provide administrative support through procurement of international expertise, innovative technology firms and provides for equipment and services and the design of Terms of References for the same, including ToRs for the use and Establishment of Long Term Agreements (LTAs) for technical equipment, training on its operation and, where possible long terms O&M support. A global procurement fee for the MPSU of 10,000 per year per country, or 50,000 for five years will be charged. Apart from this, the G- PMU will manage the Interim and Terminal Evaluations along with Country UNDP offices, and coordinate the mandatory financial and activity reporting discussed earlier.

Technical support in the reviews and drafting of documents will be provided on an ongoing basis to all the C-PMUs. This will include:

1. Concept notes and supporting documents for international and regional procurement and activities
2. Terms of References for international consultants and firms
3. All international procurement
4. Interim and end of project evaluations and impact assessments
5. Audits

Additionally the G-PMU will support and oversee the reporting which is to be done at country level and collated and summarised at the global level. This includes

1. Annual workplans at start of year and updated quarterly
2. Independent interim (mid-term) and terminal (end of project) evaluation
3. Annual Performance Reports
4. Accounting and financial report, including mandatory audits.

Liaison

The G-PMU will serve as a liaison between the participating countries and the Pillar Leads and their global, regional and national facilities. Collaborations between centres of excellence which include academic institutions and technology firms and private entities will also be supported by the Global PMU.

SUMMARY AND CONCLUSIONS

This Multi-country Project (MCP) proposal is part of a global initiative to advance Early Warnings for All as announced by the United Nations Secretary General in March 2022[141] and articulated in the EW4All Executive Action Plan. The project will target seven countries for the roll-out of the EAP, namely Antigua and Barbuda, Cambodia, Chad, Ecuador, Ethiopia, Fiji, and Somalia. It will accelerate the delivery of EAP priority actions in these countries by stimulating the design and funding of multiple regional delivery mechanisms to support the financial and technical needs of the targeted countries. National projects tailored to each participating country's needs will establish Multi-Hazard Early Warning Systems and their effective use by the most vulnerable communities. It will also establish a pipeline of proposals for an additional ten countries, ensuring additional progress towards the EW4All goals through multiple funding instruments and mechanisms.

The project will help establish MHEWS which support informed, long term decisions that help avoid otherwise crippling damages and losses to communities and livelihoods. Effective, end-to-end MHEWS that will be supported will warn against impending shocks and enhance climate resilience of governments and communities by providing critical

[141] United Nations Secretary-General, "Secretary-General's Message on World Meteorological Day," *United Nations* (https://www.un.org/sg/en/content/sg/statement/2022-03-23/secretary-generals-message-world-meteorological-day, March 2022).

information to guide risk management, anticipatory action and disaster avoidance and preparation. It will improve technical support mechanisms and financial flows to meet the needs of countries (particularly LDCs and SIDS) to establish, operate and maintain their national end-to-end MHEWS. It will establish regional and national collaborations, multiple funding instruments and complementary mechanisms that maximise country ownership and impact. The project will facilitate national investment planning into the MHEWS value chain, including the development of national road-maps, investment pipelines, and approaches to sustain national EWS through state and private sector resources, and innovative finance. This will help address gaps across the continuum of country-specific technical and financial support needs for end-to-end MHEWS, translating country visions into concrete investments.

The project interventions, delivered through two Outputs, intend to assist vulnerable countries in making continuous strides towards meeting the EW4All visions. This will be achieved not only through supporting concrete investments in the seven countries in Output 2 and by establishing a sustainable architecture at the global and regional levels to continuously support more countries in promoting country-level actions towards EW4All (Output 1). The project addresses critical barriers that prevent the effective generation, dissemination and use of early warnings for climate change adaptation, preparedness and response to warnings. The three outputs will work in tandem to accelerate the delivery of the EW4All EAP and provide long-term and uninterrupted support to critical baseline capacities on which MHEWS are built (Figure 8). These are: i) robust scientific information and analytics on weather, water and climate hazards and vulnerabilities within NMHS, NDMAs and relevant sectors to support greater and more diverse understanding of disaster risk and its underlying factors, with greater impact based forecasting to inform decision-making and planning; ii) effective internal coordination among various government entities that are responsible for different elements of managing a national EWS; and iii) a long-term financing plan to maintain the necessary hydromet infrastructure, and community level capacities to receive, understand and respond to EWS thus enhancing adaptive capacities at national levels to protect lives and livelihoods.

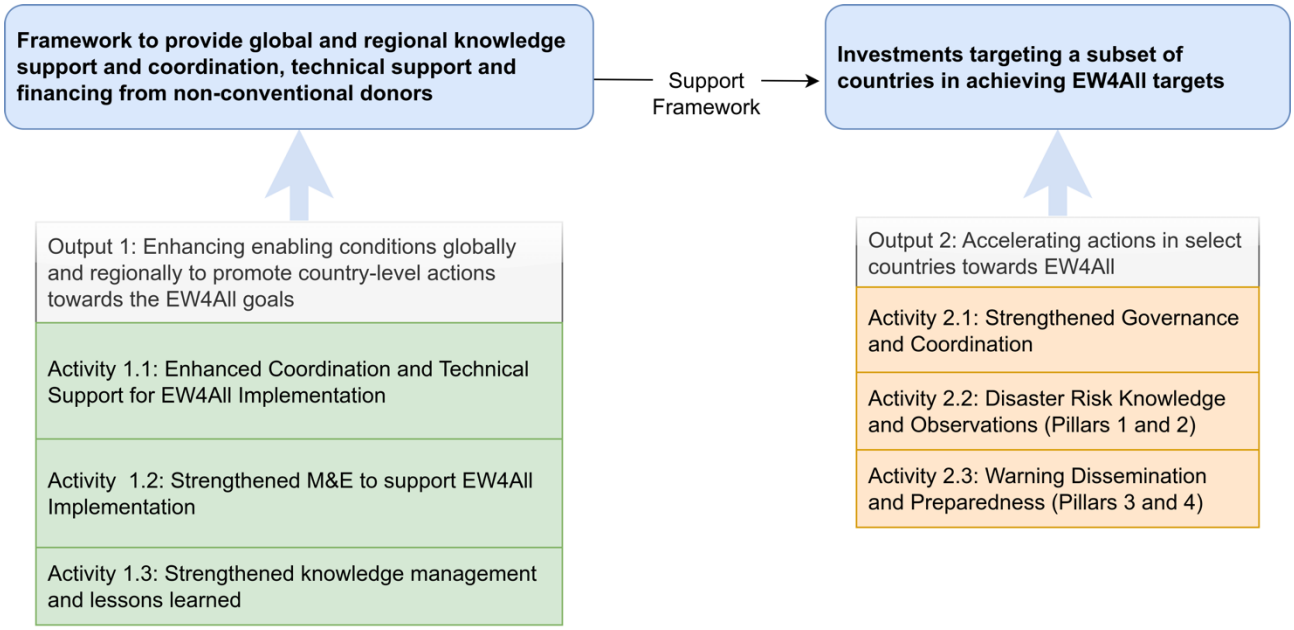

Figure 7. Interactions between the three proposed outputs

Output 1 aims to accelerate and scale up national access to global and regional technical and operational support for countries to develop comprehensive MHEWS and capabilities for a comprehensive EW4All. Recognising the need for continuous and significant efforts to achieve the goal on universal access to early warnings, enabling conditions will be enhanced globally and regionally to promote country-level actions toward a global coordination and support architecture for EW4All that will be sustained beyond the project implementation period. The output will be led by WMO and UNDRR. This output will address barriers pertaining to both support for country level actions as well as gaps in global and regional policies, standards and inter-agency coordination to scale up coherent national strategies for end-to-end MHEWS. The output will improve existing global support architecture to scale-up access to technical expertise, operational support, collaboration and knowledge sharing and the existing global support architecture and will be led by WMO and UNDRR in collaboration with global and regional organisations.

Output 2 addresses barriers that prevent the implementation of a comprehensive and end-to-end MHEWS in the seven countries including: 1) Gaps in policies, inter-agency coordination and lack of coherent strategies; 2) Inadequate technical and scientific capacities; 3) Missing observations particularly in Small Island Developing States (SIDS) and Least Developed Countries (LDCs); and 4) Barriers that prevent effective local actions. The activities will mirror the four pillars of the EW4All EAP and will be implemented through the national governments with support from UNDP, the EW4All pillar leads (WMO, UNDRR, ITU, IFRC) and their in-country national offices and other partner agencies where relevant. The output will implement priority investments listed under the four pillars in the EAP based on the context of each participating country. This will be led by the respective country NDAs and supported by the UNDP Country Offices in collaboration with national and regional centres and societies of WMO, UNDRR, ITU and IFRC and other key partners.