# Building Resilience of Vulnerable Communities to Climate Variability in Rwanda's Congo Nile Divide Through Forest and Landscape Restoration


## Annex 2: Feasibility Study

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## *1. INTRODUCTION*

### *1.1. General description of the feasibility study*

This feasibility study is designed to support the Green Climate Fund (GCF) Funding Proposal (FP) "Building Resilience of Vulnerable Communities to Climate Variability in Rwanda's Congo Nile Divide Through Forest and Landscape Restoration" by presenting additional information that is central to the development of the proposal and by providing access to the models, data and assumptions underlying the proposed project approaches and targets.

The Feasibility Study documents provide analyses of the current and projected impacts of climate change on the land use and forests of Rwanda's Congo Nile Divide (CND) and the vulnerable populations that live in the region. The documents also provide evidence for the effectiveness and responsiveness of the project's selected approaches to address the resilience and adaptation needs of beneficiary populations while achieving reductions in GHG emissions as co-benefits.

### *1.2. Outline of subsequent sections*

To facilitate the use of this Feasibility Study by reviewers, it is divided into the following sections, which, in the full proposal, will be presented as independent documents with associated appendices.

2. **Country Profile & Climate Change Vulnerability Assessment:** The Country Profile provides a brief overview of the geographic, population, land use, and socio-economic and ecological characteristics of Rwanda and the CND. Information is also presented on tenure issues and current management practices in forests in the CND region. The Climate Change Vulnerability Assessment (CCVA) is a comprehensive description of Rwanda's current climatic conditions, projected climate change impacts, and an assessment of the target populations' vulnerability to climate change. The CCVA uses a combination of spatial and statistical analyses of time series data to determine the climate change vulnerability of forest ecosystems and different sectors within the CND.
3. **Policy and Institutional Framework:** This section provides a summary description of national strategies and plans on development, climate change and natural resource management relevant for the project. It highlights how the project will contribute to national priorities and targets. It further provides a description of the main actors and institutions for the governance of climate change.
4. **Project Approach:** This section provides an overview of the design of the project, an analysis of other adaptation and restoration projects, a description of the Theory of Change underpinning the paradigm shift that the project seeks to achieve, and an outline of the project components.
5. **Options Analysis and Justification:** This section provides an overview of the barriers to adaptation (i.e.,forest resilience barriers and social barriers) and an Options Analysis presents primary approaches identified through literature review and consultations with stakeholders that were considered while designing the project interventions. Descriptions of these interventions are presented along with the relative advantages and disadvantages of each.
6. **Feasibility Assessment of Activities:** This section provides a multi-criteria assessment of site locations and methods for forest restoration and afforestation, as well as an analysis and identification of preferred alternatives for energy efficient stoves to reduce wood fuel demand.

The forest restoration feasibility study assesses the current state of forests and agroforestry in the CND, identifies best practice techniques for forest restoration and agroforestry, and produces an initial assessment of project intervention sites. The energy efficient stoves feasibility study analyzes the current baseline cook-stove sector among our target 8500 smallholders' farmer households and evaluates possible alternative energy efficient options for the CND region to reduce fuelwood demand. An assessment of forest monitoring data sources and analytical methods is also presented as Appendix 1.

7. **Program Description:** This section provides a technical analysis of the interventions under each component at the output, activity and sub-activity level. The project's theory of change will present how the activities undertaken address the barriers and contribute to a chain of results that lead to the project's intended outcomes given a number of underlying assumptions. Each intervention is further described in technical studies considering the following aspects: (i) Adaptation benefits; (ii) Barriers addressed; (iii) Implementation sites; (iv) Best practices and lessons learned considered; (v) Detailed description of activities.

## 2. COUNTRY PROFILE: RWANDA

### 2.1. Geography

Rwanda is a small mountainous country, located in east-central Africa, covering an area of 26,338 km$^2$. The country is bordered by Uganda to the north, Burundi to the south, the Democratic Republic of the Congo (DRC) to the west and Tanzania to the east.

The elevation varies 900m to 4,507m from East to West, where the eastern plains lay between 1,000m to 1,500m and the central plateau region between 1,500m and 2,000m.

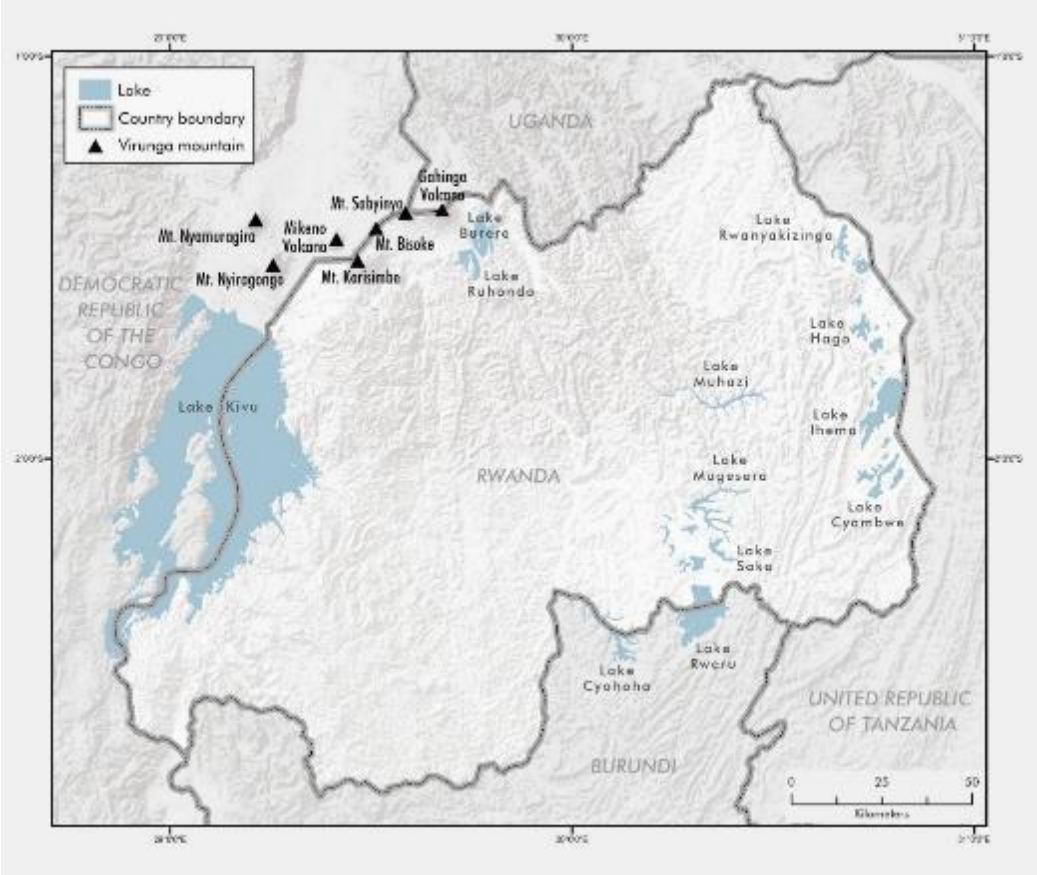


Figure 1- Rwanda topographic map.

Rwanda is divided into four Provinces: Northern, Eastern, Southern and Western, and the capital City of Kigali. These are divided into 30 Districts, which are in turn divided into 416 Sectors, which are divided again into 2,148 Cells, which are sub-divided into 14,837 Villages. The purpose of the districts is to support democracy and socio-economic development, while the goal of the Sectors is to promote good governance and social welfare. The Cells provide basic services and are tasked with meeting sustainable development goals, and the purpose of the Villages includes recording basic statistical data, resolving conflicts to ensure security, and supporting the implementation of government programs, among other goals[1].

1 https://www.gov.rw/government/administrative-structure

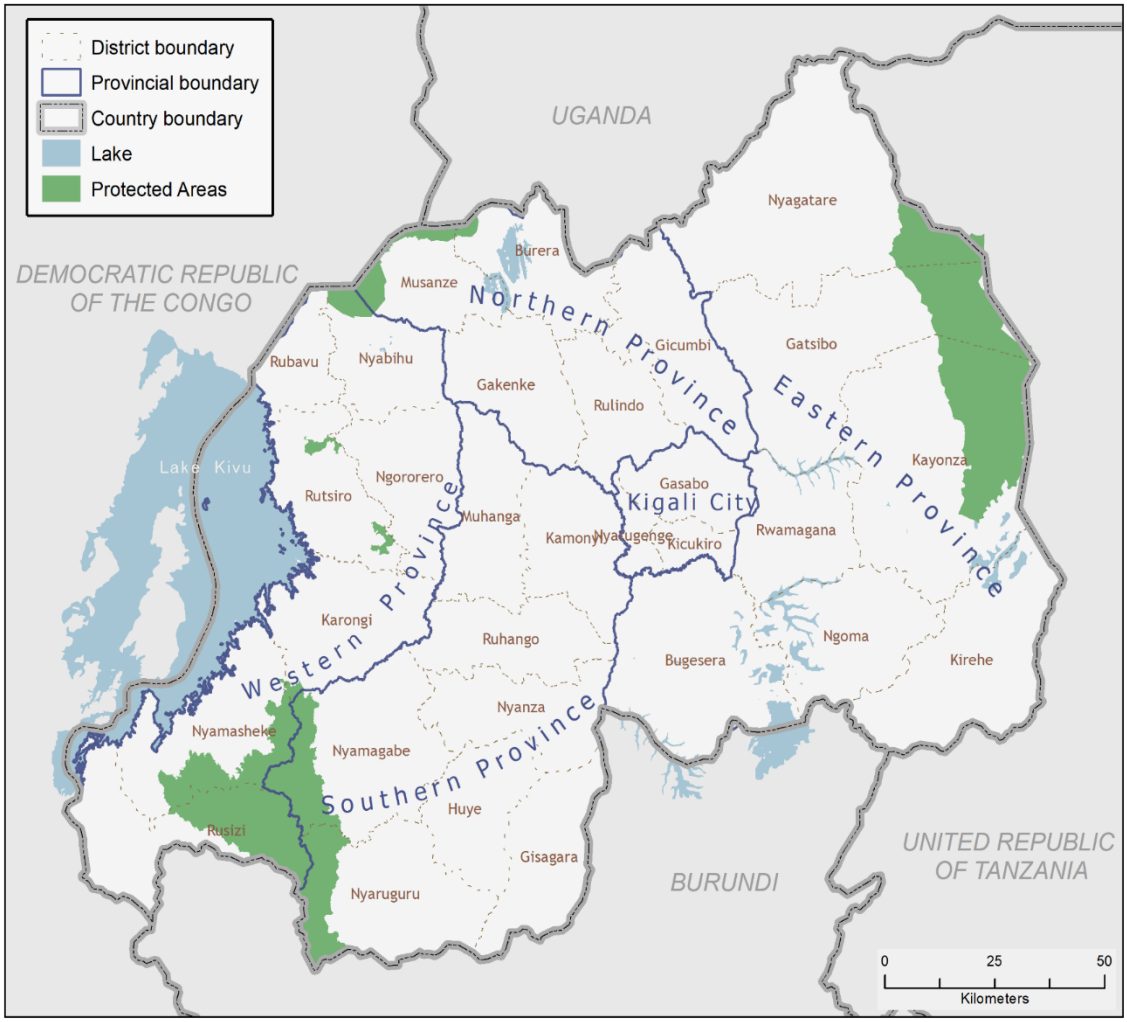


Figure 2- Map of Rwanda's Provinces and Districts.

### *2.2. Geography -- Project Area: The Congo Nile Divide*

The project area, the Congo Nile Divide (CND), an area of 4,446 km$^2$, separates the drainage basins of the Congo and Nile rivers. The Rwanda portion of the CND runs from the Virunga Mountains and Volcanoes National Park (VNP) on the border with Uganda in the North, down through Gishwati Mukura National Park (GMNP), to the south end of Lake Kivu and Nyungwe National Park (NNP) on the southern border with Burundi. These three national parks contain the country's only remaining montane forests. The boundaries of the CND landscape are defined as all areas greater than 1900m in elevation.

Administratively, the CND overlaps three Provinces (Western, Southern, Northern) and ten Districts (Karongi, Musanze, Ngororero, Nyabihu, Nyamagabe, Nyamasheke, Nyaruguru, Rubavu, Rusizi, Rutsiro).

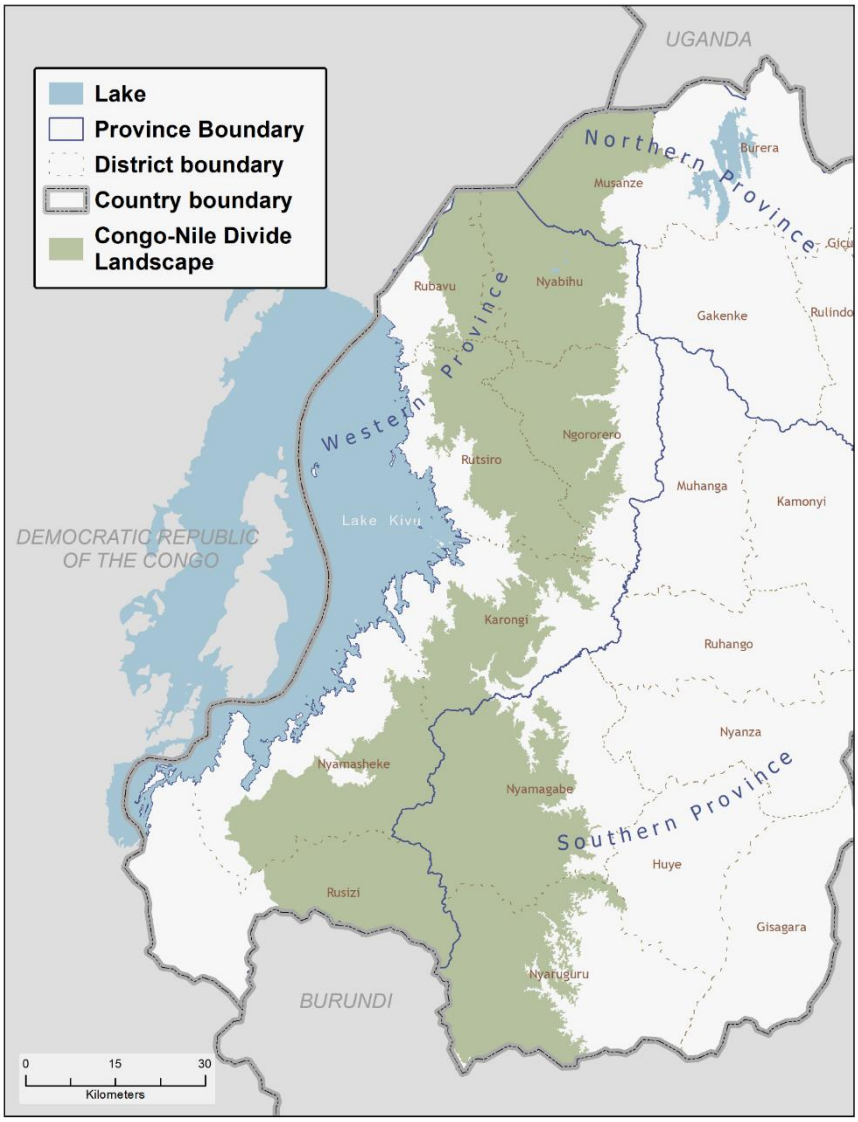


Figure 3- Map of CND Landscape.

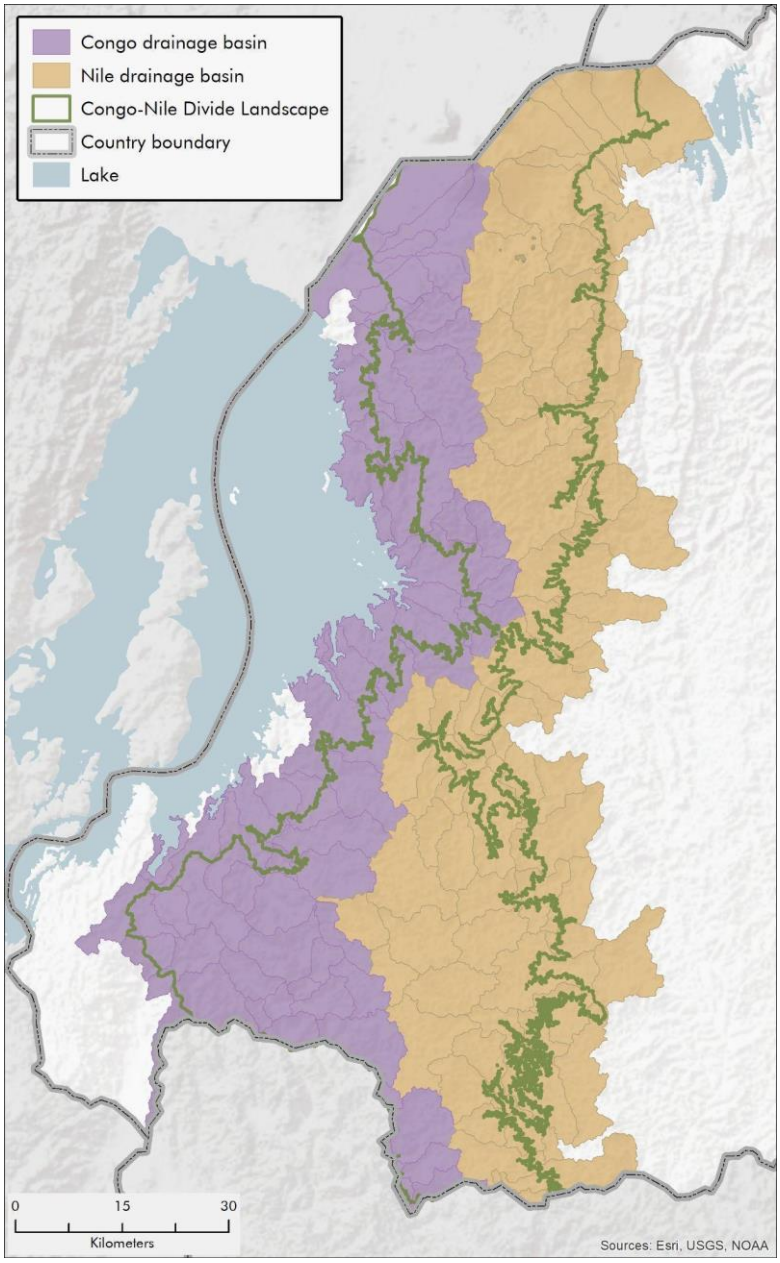


Figure 4- Map of CND Landscape drainage basins.

### *2.3. Population -- Rwanda*

The population of Rwanda is 12,952,209[2], with almost 500 people per km$^2$. Rwanda is generally characterized by a young population, with half of the population less than 19 years of age. With a current annual growth rate of 2.4%, Rwanda's population may reach 25.8 million in 2050, with gross density approaching 1000p/km$^2$, the highest in Africa.

[2] The World Bank https://data.worldbank.org/indicator/SP.POP.TOTL?locations=RW

### *2.4. Population -- CND*

In the CND, the Southern Province is the most populated followed by the Western Province and the Northern Province. The districts of the CND region contain about 32.4% of the country's population and have some of the highest population density in the country including Musanze, Nyabihu, Ngororero, Rubavu and Rusizi (Figure 5). The average population density in the CND is 474 people/km² above the national average of 416. Rwanda's rural population in 2032 is projected to be 70%, between 10,782,054 and 11,812,599[3]. This population increase will undoubtedly affect the land use as the population density will increase from 518 population per sq.km to 887.2 population per km² in 2050[4]. Already some districts of the CND have reached a population density of 1,036 population/km². The increasing population density will lead to more land fragmentation, greater demand for forest products (such as firewood, charcoal etc.) and conversion of protected forests into agricultural land.

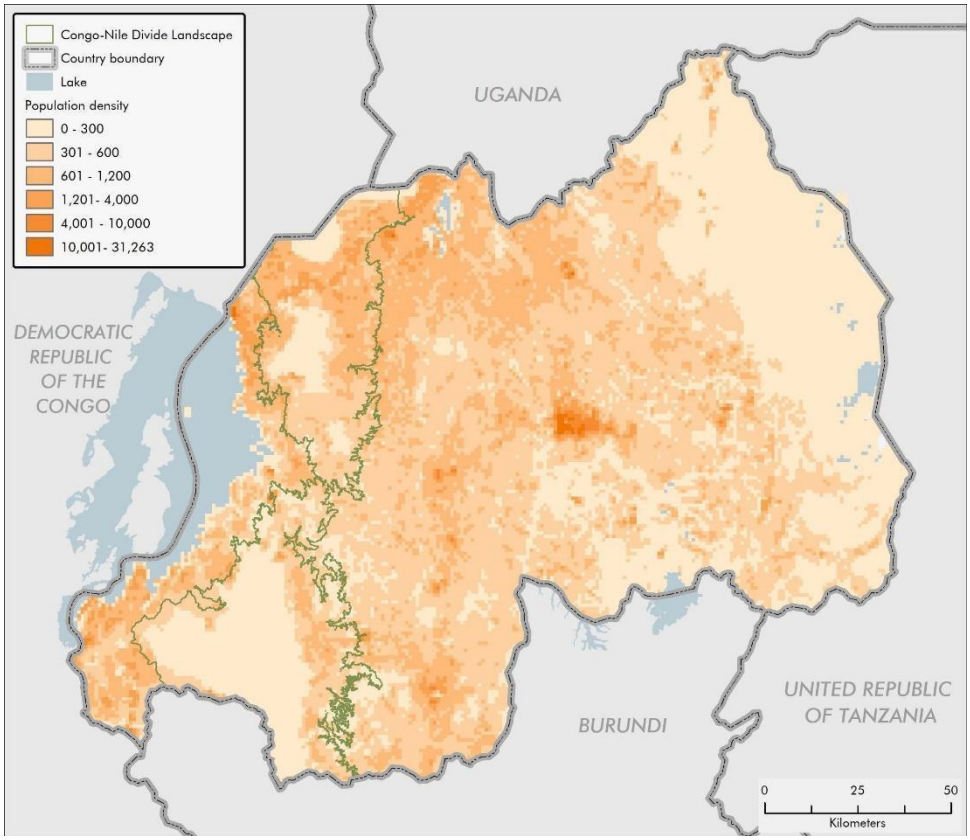


Figure 5 - Rwanda population density. Data: WorldPop 2020[5]

3 National Land Use and Development Master Plan (2020-2050)

4 Idem

5 https://www.worldpop.org/project/categories?id=18

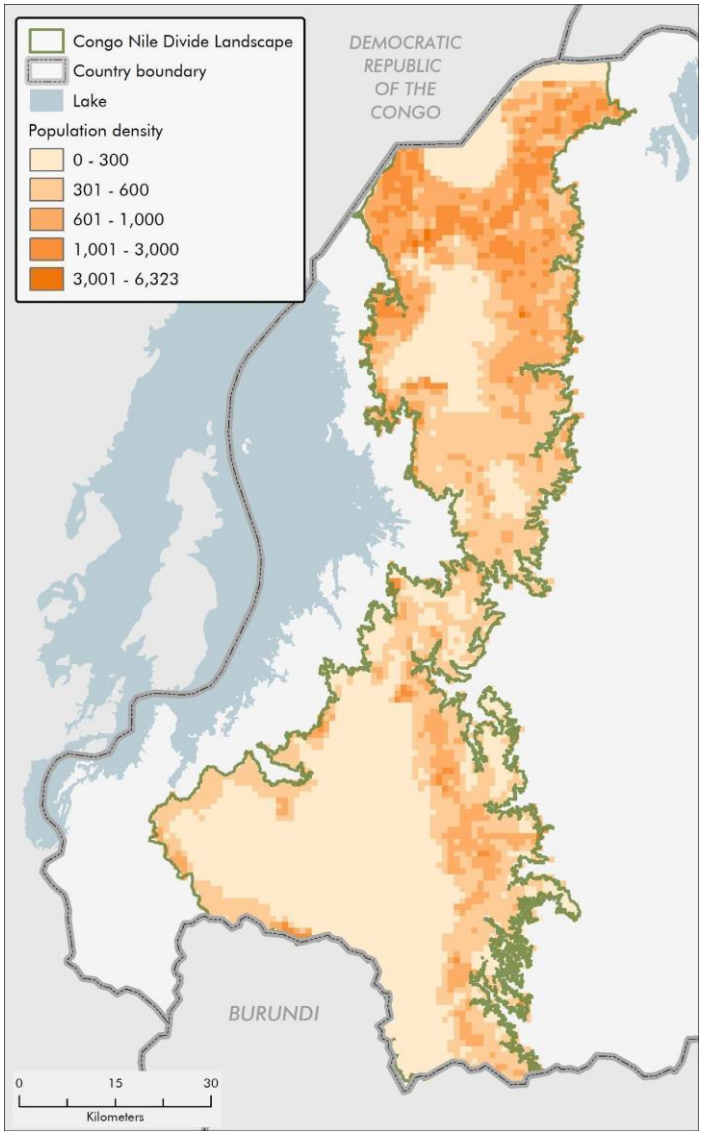


Figure 6 - CND Landscape population density (people per $km^2$; data: WorldPop 2020).

Table 1 provides an overview of population distribution in the CND by district. Population density ranges from 281 people per $km^2$ in Rutsiro to 1,039 people per $km^2$ in Rubavu.

**Table 1- Population distribution in the CND by district (National Institute of Statistics, 4th Census, 2012).**

| Area | Population (2012) | Population density (2012) | Male (2012) | Female (2012) | % of total population (2012) |
|---|---|---|---|---|---|
| Whole Country | 10,537,222 | 416 | 5,074,942 | 5,462,280 | 100 |
| CND (Total) | 3,477,128 | 474 people/km$^2$ (mean) | 1,643,392 | 1,832,402 | 32.4 |
| Musanze | 368.267 | 694 | 174.399 | 193.868 | 3.4 |
| Rusizi | 400,858 | 418 | 192,528 | 208,330 | 3.8 |
| Rutsiro | 324,654 | 281 | 154,044 | 170,610 | 3.0 |
| Nyamagabe | 341,491 | 313 | 161,219 | 180,272 | 3.2 |
| Nyabihu | 294,740 | 555 | 137,799 | 156,941 | 2.7 |
| Karongi | 331,571 | 334 | 155,887 | 175,684 | 3.1 |
| Ngororero | 334,413 | 493 | 154,827 | 179,586 | 3.1 |
| Rubavu | 403,662 | 1039 | 194,989 | 208,673 | 3.8 |
| Nyaruguru | 294,334 | 291 | 139,279 | 155,055 | 2.7 |
| Nyamasheke | 383,138 | 325 | 178,421 | 203,383 | 3.6 |

Source: NISR, 2012

### *2.5. Socio-economic status -- Rwanda*

Rwanda has undergone several development phases starting from the aftermath of the genocide against the Tutsi in 1994 which focused on recovery; the early 2000s, when the Vision 2020 was elaborated and gave a blueprint for a new Rwanda embarking on economic development aspirations, and, post-2010, a period that intensified efforts to lay foundations for sustained growth by investing in human capital, developing basic infrastructure, and expanding access to various services.

Since 2000, Rwanda has experienced a rapid socio-economic and demographic transformation. The real gross domestic product (GDP) during the period 2007-2017 rose from RWF 3.26 trillion to RWF 6.69 trillion, or by an average of 7.45% per year[6]. Poverty declined from 77% in 2001 to 55% in 2017, while life expectancy at birth improved from 29 in the mid-1990s to 69 in 2019. The maternal mortality ratio has fallen from 1,270 per 100,000 live births in the 1990s to 290 in 2019. The official inequality measure, the Gini index, declined from 0.52 in 2006 to 0.43 in 2017[7]. Also, in 2015, the NISR reported the working population (16 years and above) in Rwanda to be 6.4 million, with females representing 54% and males 46%.

Agriculture is an important sector of the Rwandan economy and contributed 26% to the national GDP in 2020[8] with almost 90% of households practicing traditional subsistence agriculture, mainly on narrow plots of land exhausted by continuous utilization. This sector employs over 64% of the working population and is characterized by low productivity and low economic value[9]. The majority of Rwandan households are reliant on agriculture for food and income.

The services and tourism sector is a major driver of economic growth in Rwanda, contributing 15.1% to GDP in 2019. Key growing service areas include banking, insurance, and transport. Services exports grew by 10% per annum between 2009 and 2014. The travel sector (including tourism) has steadily increased its share of total services exports in recent years. In 2019, tourism revenues amounted to US$498 million (17% increase from 2018) constituting 50.1% of all service exports.

Despite solid progress since 2000, poverty remains widespread and pervasive. Overall, 38.2% of the population lives in poverty and 16% in extreme poverty[10]. Rwanda's poverty profile indicates that women are more affected by poverty than men, with 47% of female-headed households poor compared with 44.9% of all households. As in many countries, poverty has important geographical dimensions. Rural households are more than twice as likely to be in poverty and extreme poverty than urban households. Table 2 shows the percentage of population living in poverty and extreme poverty conditions for 2016/2017.

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6 NISR, 2018

7 https://www.worldbank.org/en/country/rwanda/overview

8 NISR, 2021

9 Idem

10 National Institute of Statistics (NISR), 2017. The Fifth Integrated Household Living Conditions Survey (EICV5), 2016/2017.

| Location | Poor [%] | Extreme poor [%] |
|---|---|---|
| Nationally | | |
| Country-wide | 38.2 | 16 |
| Area of residence | | |
| Urban | 15.8 | 5.9 |
| Rural | 43.1 | 18.1 |
| Province | | |
| Kigali city | 13.9 | 4.2 |
| Northern Province | 42.3 | 17.4 |
| Southern Province | 41.4 | 16.9 |
| Eastern Province | 37.4 | 15.3 |
| Western Province | 47.1 | 21.6 |

**Table 2- Poverty and extreme poverty in Rwanda**[11]

### *2.6. Socio-economic status -- CND*

Districts of the Western and Southern Provinces in the CND region have the highest rates of poverty and extreme poverty in the country (Figure 7). Some of these districts also have high levels of stunting prevalence.[12]

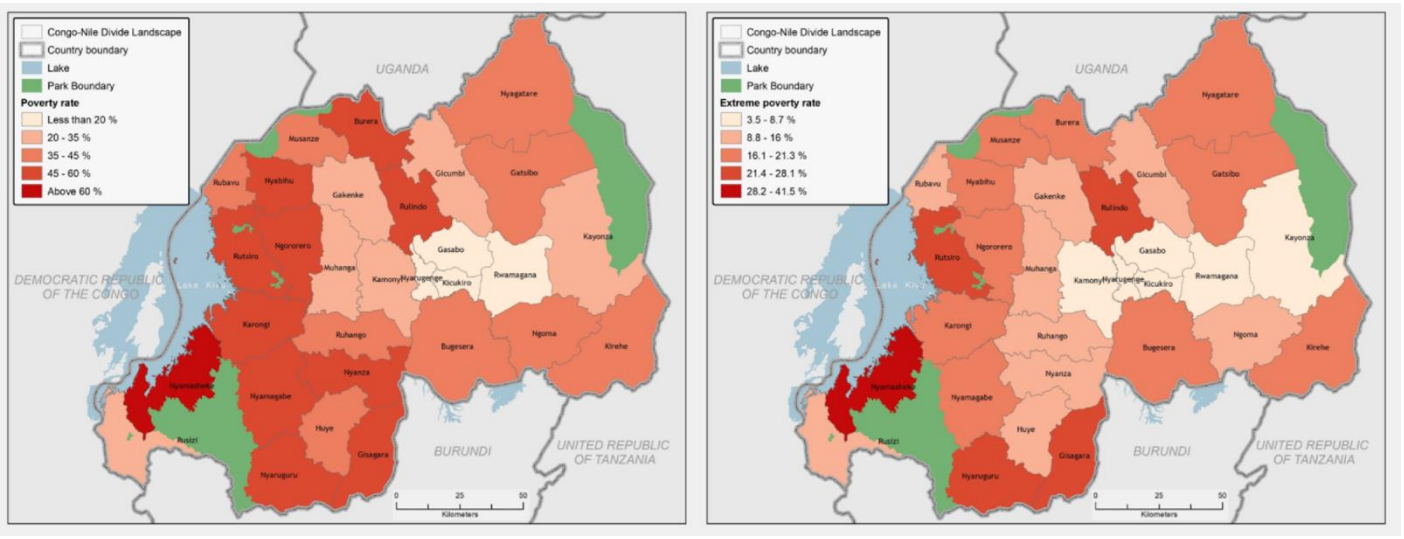


Figure 7- Poverty and extreme poverty rates by district 2017[13]

11 National Institute of Statistics (NISR), 2017. The Fifth Integrated Household Living Conditions Survey (EICV5), 2016/2017.

12 Rwanda Nutrition Situation Analysis and Policy Implications

13 National Institute of Statistics of Rwanda (NISR), EICV5_Environment and Natural Resources Thematic Report,

Major economic activities in the CND region include tourism, agriculture and mining. Major crops include coffee and tea, banana, maize, beans, cassava and sweet potatoes. Most rural households are smallholder subsistence farmers growing beans, maize, Irish potatoes, and sweet potatoes in higher altitudes and sorghum, banana, cassava, and beans at lower altitudes. Primary cash crops include tea and coffee; cultivation of crops for export is increasing and tea plantations are in expansion. Some commercial enterprises, such as the tea industry, engage local farmers through out-grower schemes. Farmers also form cooperatives to collect, wash and sell coffee, including specialty Arabica Bourbon coffee. Climate model projections suggest that suitable areas for production of Arabica coffee in Rwanda are likely to decline by as much as 50%. Livestock as an alternative source of household income and food is kept by more than 80% of households in the CND region. The livestock consists mainly of cows, goats, pigs, sheep, poultry, and rabbits.

### *2.7. Land tenure and land use*

The Constitution of the Republic of Rwanda recognizes state and private property and grants every citizen the right to private property, whether held individually or in association with others. The state has the authority to grant rights to land, including private ownership rights, and to establish laws governing land acquisition, transfer, and use. State land is classified as public or private; public land cannot be alienated. Customary land (and collective customary land) is no longer recognized in Rwanda, which makes it unique among sub-Saharan African countries. Instead, land is held by individuals and families (GOR Constitution 2003, rev 2015).

In 1999, the Government of Rwanda adopted the Succession Law, which established equal inheritance rights for women and men[14]. Following adoption of the 2004 National Land Policy, which laid the foundation for land tenure reform, the 2005 Organic Land Law (OLL) outlined procedures for land tenure and titling, registering land and administering land titles, and guidance for land use and development[15].

The Rwanda Land Dashboard (https://rwandalanddashboard.rlma.rw/o45@d) is an interactive national land data visualization platform and provides data on land ownership. Rwanda is primarily used for farming and/or livestock development. Based on the National Land Use and Development Master Plan 2020-2050, 41.6% of the country's land area is used for agriculture, although only 31.9% is highly suitable for agriculture. 27.5% of the land cover is forest, however only 19% is natural forest; the remainder is area surface for forestry. The growing population combined with strong reliance on agriculture make land one of the scarcest resources in Rwanda. The majority of Rwandan households cultivate at least one parcel of land, and most of them are directly reliant on agriculture as their main or only source of income, especially in rural areas (94%) in 2016/17[11].

While the Rwanda Land Dashboard and other surveys of land ownership do not allow for extraction of data to the precise CND boundaries, data is available at the provincial level. Land scarcity is a severe problem in the Western Province (which broadly overlaps with the CND), with average land size per household being only 0.4ha, and over 60% of farmers cultivating an area of less than 0.3ha[16]. Without agricultural productivity improvements (e.g. terracing, agroforestry activities), producing a sufficient

December 2018

[14] Daley, Dore-Weeks, & Umuhoza. (2010). Ahead of the Game: Land tenure reform in Rwanda and the process of securing women's land rights. Journal of East African Studies, 4 (1): 131-152. http://dx.doi.org/10.1080/17531050903556691

[15] Gillingham, P.; Buckle, F. Rwanda land tenure regularisation case study. Evidence on Demand, UK (2014) 40 pp. [DOI: http://dx.doi.org/10.12774/eod_hd.march2014.gillingham]

[16] EICV 5 report 2016/17

amount of food and fuelwood on such small land parcels is extremely difficult, leading to substantial pressure on natural and plantation forests. Similarly, small landowners are highly susceptible to climate-worsened natural disasters such as landslides, as a single event can lead to complete loss of crops for a household.

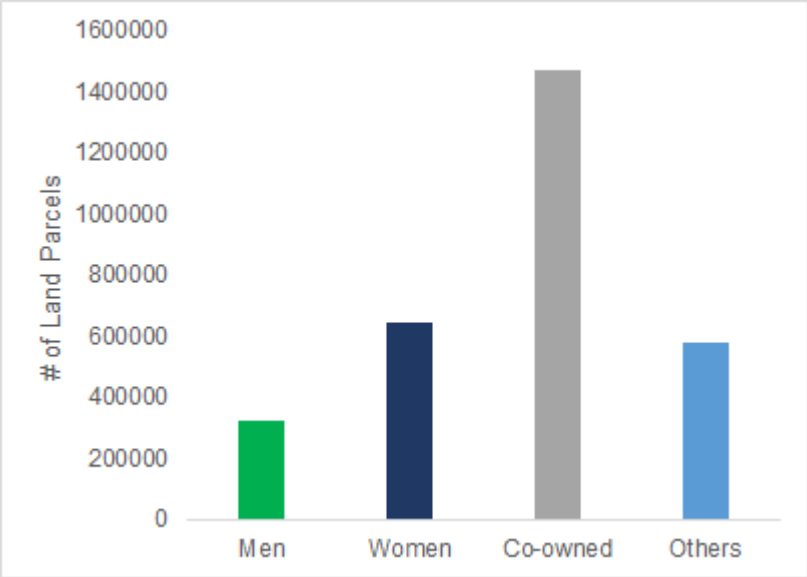


Figure 8. Land parcel ownership statistics in the Western Province. Source: Rwanda Land Dashboard (https://rwandalanddashboard.rlma.rw/o45@d)

In the Western Province, the vast majority of land parcels are co-owned by both men and women (Figure 8). Of parcels owned by a single person, women own around double the number of land parcels compared to men (Figure 8). About 80% of crop growers have ownership rights over their land and can use it as a guarantee for a loan. The Northern Province has the highest percentage with 89% of households having land rights and the possibility to use it as a guarantee. The other three provinces have similar levels of land rights: Southern Provinces: 77%; Eastern Province: 78%; Western Province: 81%.

The Land Law N° 27/2021 of 10/06/2021 classifies land as either individual land or state land. Individual (i.e., private) land can be obtained under principles of customary law or under formal law. State land includes: (1) state land in the public domain (e.g., lake shores, national parks, roads, tourist sites), which generally cannot be alienated; (2) state land in the private domain of the state.

The National Land Policy of 2004 provides that: (1) all Rwandans will enjoy the same rights of access to land; (2) all land shall be registered and land shall be alienable; (3) consolidation of household plots is encouraged; and (4) land administration shall be based on a title deeds registration system (GOR Land Policy 2004).

Land use is largely influenced by a number of factors, the main ones being climate, socioeconomic (culture, and population growth, conflict and resettlement), and government policies. Almost 47.2% of the country's land is used for agriculture, with 12,433 km² under cultivation (NLUDMP 2020-2050). The country has 2,068 km² of wetlands, of which about 62% is cultivated[17]. The trend in recent decades has been the expansion of settlements and infrastructure areas and thus loss of agriculture pasture, forestland, and woodlots[18].

17 National Land Use and Development Master Plan (2020-2050)

18 Rwanda Environment Management Authority (REMA), 2009. Rwanda: State of Environment and Outlook Report 2009.

### *2.8. Land use and degradation in the Congo Nile Divide region -- Project Area*

Major land uses in the CND region include natural forests, planted forests, tea plantations, pasturelands, subsistence agriculture, roads and public facilities and urban and rural settlements. 27% of the project area is protected as Volcanoes National Park (VNP) (163 km²), Gishwati-Mukura National Park (GMNP) (35.58 km²), and Nyungwe National Park (NNP) (1,019 km²). Forest plantations are dominated by species of Pinus, Eucalyptus, Alnus and Acacia. Tea is a high value export commodity and a strategically important industry and vehicle for green growth in the western region of Rwanda. The cool climate of the western highlands of the CND region provides the growing conditions for excellent tea, which is known worldwide for its strength and brightness. The Rwandan government has established an objective to increase tea production from 24,000 ha to 45,000 ha through the expansion of out-grower programmes linked to privately owned tea processing factories[19]. The targeted areas for tea expansion in the CND region are in Nyaruguru, Karongi, and Nyamasheke districts where climate, soil, altitude, rain and other conditions are suitable for tea growing[20]. It has been estimated that 6,300 ha of forest plantations will have to be established to meet the energy needs of 21,000 ha of tea plantations[21]. The targeted growth in tea production, increasing population, land scarcity and competing demand for land by various industries are likely to put additional pressure on forest ecosystems and the services they provide in the CND.

Also, given the fact that targeted areas for tea expansion overlap with priority areas for landscape restoration and high biodiversity value, it is obvious that without cross-sector linkages and better land use planning these priorities may be in conflict and dramatically reduce the effectiveness of any one alone. Within the context of a particularly 'human-dominated' landscape, such as Rwanda, it is key to identify large-scale, cross-sectoral opportunities (agriculture, forestry, tourism, and climate change) to safeguard remaining natural ecosystems for their ecological, social and economic benefits.

Kigali: Rwanda Environment Management Authority-Republic of Rwanda

19 Strategic plan for Agriculture Transformation 2018-2024

20 https://naeb.gov.rw/index.php?id=47&type=rss

21 Personal communication from the Director of Nyabihu Tea Factory

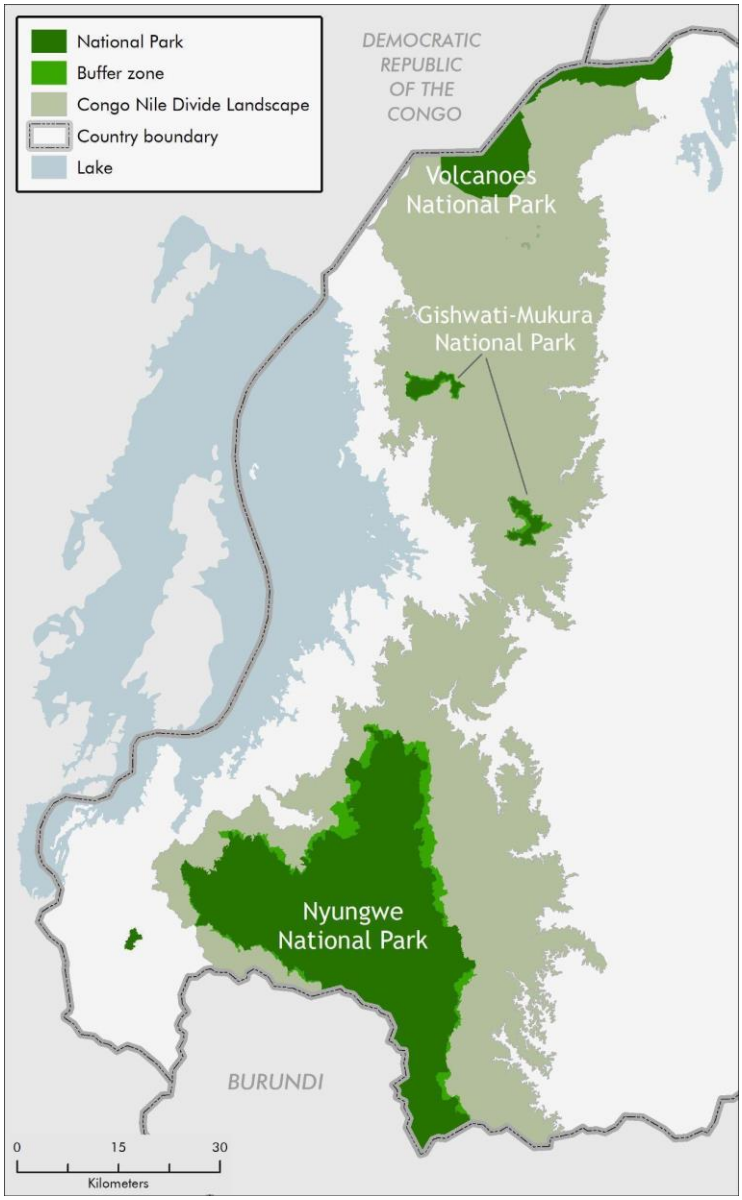


Figure 9- Map of national parks and their buffer zones within the CND Landscape.

The Upgraded Seasonal Agricultural Survey (USAS) in 2020 estimated that the area of agricultural land in the 10 districts of the CND is 385,000 hectares (52% of total land area). In the 2019/2020 agricultural year, the total physical crop area under cultivation was estimated at 328,000 hectares. The area under permanent crops increased from 123,000 ha in season A to 133,000 ha in season B. These estimates include the total area of all CND districts, rather than the precise CND boundaries, as data is collected at the district level. However, the patterns are likely to be very similar within the CND boundaries.

Smallholder farming is the dominant form of land use in the project area. Most rural households grow beans, maize, Irish potatoes, and sweet potatoes in higher altitudes and sorghum, banana, cassava, and beans at lower altitudes. Most smallholders keep livestock, primarily for manure, although livestock is also used for meat and dairy products, especially around Gishwati-Mukura National Park. The project area has distinct characteristics of land fragmentation. In 10 districts of the CND region in the Western, Northern, and Southern provinces, 40-50% of farmers have farmland covering less than 0.2 ha.

Extremely small farms are concentrated in the Western Province (31% of national total). In Rubavu district, Western Province, almost 70% of farmers have plots smaller than 0.2 ha[22].

Cultivation takes place in some very steep hills and many areas of the CND are affected by land degradation and are suffering soil loss. The National Land Use and Development Master Plan 2020-2050 prioritizes forest conservation, rather than agriculture, on slopes >55%, and these areas should be reforested or afforested to increase ecosystem services.

The highest soil erosion risk in Rwanda is concentrated in the CND[23]. Figure 10 below shows that the CND has predominantly high erosion risks with the top three categories most represented. (i) High erosion risk with 25-50 t/ha/year, (ii) Very high erosion risk with 50-100 t/ha/year, and (iii) Extremely high erosion risk with more than 100 t/ha/year. The extremely high erosion risk category covers 33,154 ha, the Very high risk covers 65,922 ha, while the high covers 61,472 ha. Table 3 below shows the risk categories and their corresponding areas per district in the CND.

**Table 3 - Soil erosion risk categories per district in the CND[16]**

| Soil Erosion Risk | Extremely high (ha) | High (ha) | Very high (ha) | Total (ha) |
|---|---|---|---|---|
| KARONGI | 2,900 | 7,946 | 5,761 | 16,607 |
| MUSANZE | 1,033 | 2,728 | 2,548 | 6,309 |
| NGORORERO | 5,665 | 10,102 | 10,829 | 26,596 |
| NYABIHU | 2,271 | 8,989 | 6,733 | 17,993 |
| NYAMAGABE | 4,447 | 10,686 | 12,729 | 27,863 |
| NYAMASHEKE | 2,831 | 3,152 | 3,448 | 9,432 |
| NYARUGURU | 4,996 | 8,121 | 8,444 | 21,560 |
| RUBAVU | 1,598 | 2,206 | 2,243 | 6,047 |
| RUSIZI | 7 | 379 | 55 | 441 |
| RUTSIRO | 7,406 | 7,163 | 13,132 | 27,701 |
| Grand Total | 33,154 | 61,472 | 65,922 | 160,548 |

22 NISR, EICV4 2013/2014

23 MOE (2020). Rwanda Erosion Control Mapping

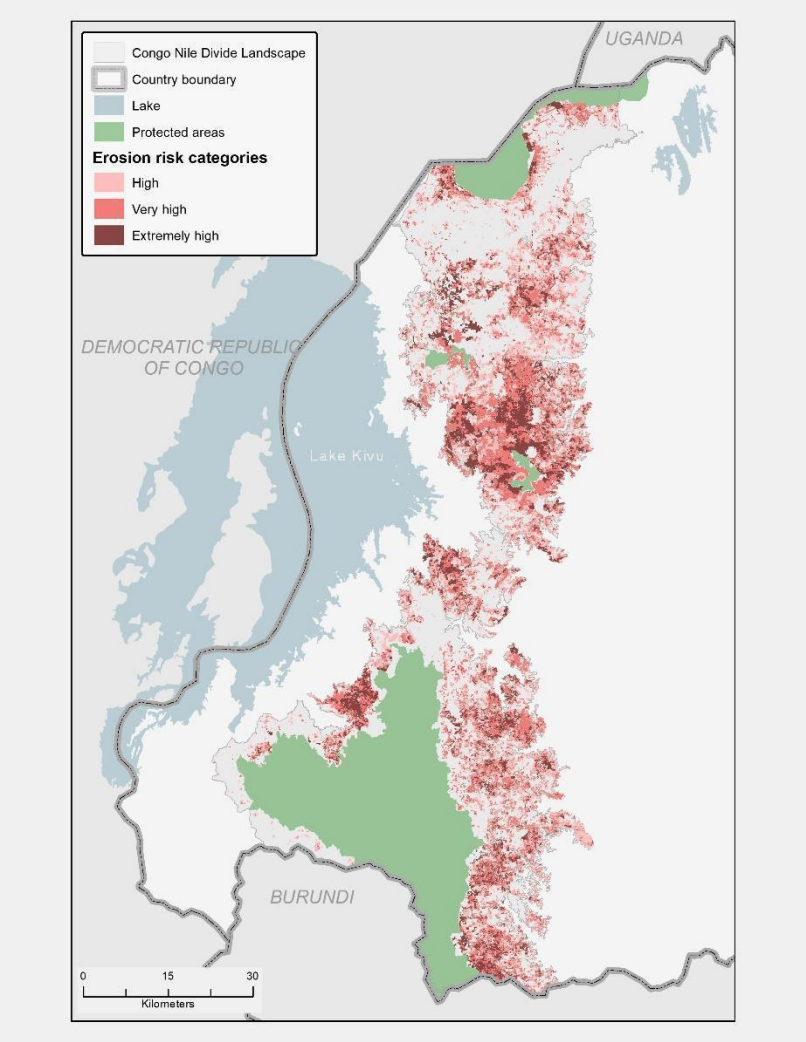


Figure 10 - Top three erosion risks categories in the CND (High: 25-50 t/ha/year; Very high: 50-100 t/ha/year; Extremely high >100 t/ha/year). Source: Erosion Control Mapping Report 2020.

### *2.9. Forest status in the Congo-Nile Divide*

The natural forests of Rwanda's CND are critical for the ecosystem services and products they provide for both the region's vulnerable communities and the national economy. They have been identified as an essential tool for ecosystem-based adaptation (EbA) in Rwanda's Green Growth and Climate Resilience Strategy[24]. Most importantly, they regulate Rwanda's climate by capturing and enhancing rainfall[25], which is crucial for Rwanda's rain-fed agriculture. These also recharge aquifers; regulate water flow; control flooding; retain soil; provide wood fuel energy and timber; underpin the country's tourism, which provides the largest contribution to Rwanda's foreign exchange earnings[26]; and provide wider benefits of

[24] Republic of Rwanda. 2011. Green Growth and Climate Resilience National Strategy for Climate Change and Low Carbon Development.

[25] Seimon, A. 2012. Climatology and Potential Climate Change Impacts of the Nyungwe Forest National Park, Rwanda. WCS Technical Report, Wildlife Conservation Society, New York, USA

[26] RDB 2017

atmospheric pollution control that sustain the country's economy and the wellbeing of its people[27].

However, over the past 45 years, the CND's natural forests have been depleted and degraded, primarily through land conversion for agriculture and over harvesting of fuelwood. Since 1962, VNP has lost nearly half of its natural forest; NNP has lost more than 13%, mainly from catastrophic wildfire; GMNP has lost 95%[28]. In 2019, forests of any type covered around 27% of the CND (169,197 ha), an increase from 23% (144,792 ha) in 1986. While overall forest cover has increased since the mid 1980s (Arakwiye et al. 2021), almost all of this gain is made up of patchy monocultures of *Eucalyptus* and *Alnus* species, valued for timber and wood by-products but with relatively low potential to provide other ecosystem services compared to native tree species. This situation highlights the need for an integrated approach to afforestation and reforestation to ensure the sustainable provision of diverse ecosystem services[29].

In the CND, around 54% of forest is now contained within national parks, with the remaining 46% made up of forest plantations. Despite covering a large total area, more than half of these plantations are smaller than 0.25ha, and over 70% are smaller than 0.5ha. The vast majority of plantations in the CND are made up of Pinus patula and Eucalyptus spp., representing 45% and 38% of all plantations, respectively[30]. Around 60% of these plantations are owned by private smallholders, and the majority of these are extremely degraded, with average stocking rates of 37 $m^3$/ha (compared to >200$m^3$/ha in well managed forests)[31]. District owned forests are also very degraded, while state forests and those owned by private institutions are generally well-managed and productive (Table 4). One of the major reasons behind such severe forest degradation in the CND is that most forests are owned by individual smallholders, who do not have investment capacity or access to microfinance facilities in order to renew degraded plantations. This, coupled with an extremely high demand for woodfuel, means that existing plantations are heavily exploited and often harvested far too early, further driving degradation. While forests managed by private institutions are generally much more productive, the average size of smallholder owned plantations is too small to be financially attractive for sale/concession to forestry institutions (NB - a more detailed analysis of forest status in the CND is provided in section 6).

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27 Stainback A. and M. Masozera. 2010. Payment for ecosystem services and poverty reduction in Rwanda. Journal of Sustainable Development in Africa. 12(3).

28 Weber, Masozera, & Masozera, 2005.Biodiversity Conservation in Rwanda. Collected works of the Protected Areas Biodiversity Conservation Project.

29 Arakwiye, Bernadette, John Rogan, and J. Ronald Eastman. "Thirty Years of Forest-Cover Change in Western Rwanda during Periods of Wars and Environmental Policy Shifts." Regional Environmental Change 21, no. 2 (March 8, 2021): 27. https://doi.org/10.1007/s10113-020-01744-0.

30 Rwanda National Forest Inventory 2015

31 Rwanda National Forest Inventory 2015

**Table 4. Characteristics of forest ownership categories in the CND.**

| Ownership Category | % of Forest Cover | Characteristics |
|---|---|---|
| State Forest | 26.9 | State forest plantations are large (average size of 31ha), and generally well managed in the CND, with average stocking rates of 193 $m^3$/ha. This is the highest productivity for forests across all of Rwanda. |
| District Forest | 2.2 | Average size of district forests is 2.2 ha in the CND. They are generally degraded and extremely under-stocked (around 5.84 $m^3$/ha, compared to an ideal rate of 60-80$m^3$/ha). Boundaries of district forests are poorly delineated, and they are frequently subject to pruning and early harvesting due to high demand for wood fuel in surrounding communities. |
| Private - Smallholder | 67.6 | Small-holder private plantations have average size 0.25 - 2 ha. They are under-stocked (around 35 $m^3$/ha49) while the average standard for small private plantations dominated by a coppicing regime should be around 70 $m^3$/ha. Small holders individually don't have investment capacity and don't have access to micro-finance facilities, explaining why plantations are not renewed and over time become less productive. |
| Private - Institutional | 3.3 | Institutional private plantations are well managed in the CND, with average stocking rates of 193 $m^3$/ha. |

Beyond forest plantations, many farmers in the CND also incorporate agroforestry trees on their cropland. Farm woodlots are often the only viable option for farmers with steep and highly degraded land and given that the CND is mainly characterized by such land, the majority of on-farm trees are present in woodlots. On more gently sloping land, planting trees on hedgerows enables farmers to control soil erosion, as trees are planted along contour lines. However, agroforestry trees are often subject to the same issues as district and privately owned forest plantations, driven primarily by overharvesting for fuel wood. Approximately 86% of primary energy in Rwanda comes from biomass, and modelling conducted as part of Rwanda's Biomass Energy Strategy shows that demand for wood fuel was 6.5 million tons higher than available sustainable production in 2018[32]. Similarly, the United Nations Framework Convention on Climate Change (UNFCCC) estimates the non- renewable fraction of the biomass at 98% in Rwanda, pointing to a very high unsustainable harvest of biomass[33]. This level of demand results in overharvesting of both natural and planted forests, which leads to deforestation and forest degradation as well overexploitation of trees and shrubs on agricultural land.

[32] Rwanda Biomass Energy Strategy 2019

[33] Word Bank Documents and Reports, Rwanda Improved Cook stoves Project, The World bank Project, 2016 Project ID P158411

### *2.10. Forests and climate vulnerability in the Congo-Nile Divide*

The forest fragments outside national parks in the CND are too small and functionally inadequate to provide the regulating, provisioning, and supporting services that are essential for vulnerable communities in the CND. Climate change is now further degrading Rwanda's fragmented forests by changing their species composition, structure, functional processes, and disturbance regimes and, as a result, is diminishing the ecosystem services these forests provide[34] to vulnerable communities. The resilience of forests, i.e., their ability to withstand environmental and climatic shocks, is directly related to their size and connectivity.

Climate change is therefore endangering the forest ecosystems and landscapes that are critical for building climate resilience for the 2.3 million people in the CND region. Most of the people in the CND are smallholder farmers living on steep slopes without access to irrigation. Their adaptive capacity is low because their crop yields and livelihoods are vulnerable to rainfall variability and because high population density severely limits their options for relocation in the event of disaster. This is particularly true for women who, until very recently, had fewer land rights than men. The increasing frequency of extreme rainfall events due to climate change – combined with forest loss and degradation - is increasing the loss of lives and property from landslides[35]. The CND is the part of Rwanda most vulnerable to floods and landslides[36], and the risk is now escalating due to climate change. For example, a dramatic increase in heavy rains and landslides occurred from 2000-2018 that affected more than 30,000 people in the CND, killing at least 502 and destroying homes of more than 29,750 people. Twenty-nine of these landslides dammed rivers, resulting in loss of fertile soils and pollution of rivers with agrochemicals. The CND loses an average of 1.5 million tons of fertile soil per year from heavy rainfall due to climate change, landslides and erosion[37].The risk of this damage is expected to increase with climate change unless actions are taken to decrease vulnerability of CND forests and communities.

Climate change – i.e., changes in the timing of seasonal precipitation, increased extreme rainfall events and droughts - is responsible for a series of cascading effects that negatively impact the physical structure and functioning of forests, substantially reducing critical ecosystem services, and ultimately diminishing the resilience of vulnerable communities. More intense and prolonged droughts significantly increase the vulnerability of forests to catastrophic fire, further degrading the integrity of remaining forests. For example, during prolonged droughts, wild honey collection, a traditionally important activity, has caused catastrophic forest fires, further degrading the integrity of remaining forests in Nyungwe National Park. The natural forests that burn are susceptible to invasion of often non-native plants (e.g., ferns) that dramatically inhibit natural forest recovery processes. If burned areas don't recover to forest, this further dries out the forest, creating negative feedback loops that increase the risk of more fires, insect damage and soil erosion. Warmer temperatures are also decoupling the relationship between insects and their pollination of flowering plants.

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34 FAO 2017

35 Bizimana and Somnez. 2015. Landslide Occurrences in The Hilly Areas of Rwanda, Their Causes and Protection Measures. DISASTER SCIENCE AND ENGINEERING p. 1-7, 1(1), 2015

36 MIDIMAR 2012. Republic of Rwanda: Disaster high risk zones on floods and landslides. *Available online: http://www.preventionweb.net/files/28208_highriskzonesreportfinalpublication.pdf*

37 Nsengiyumva et al. 2018. Landslide Susceptibility Assessment Using Spatial Multi-Criteria Evaluation Model in Rwanda. https://www.researchgate.net/journal/International-Journal-of-Environmental-Research-and-Public-Health-1660-4601

Pollination is an ecosystem service provided by natural forests that positively benefits adjacent agricultural production. As forests and associated pollination services decline, smallholder agricultural production, and associated livelihoods, in adjacent areas will be negatively impacted. In addition, as already limited forests decline from these drought-associated impacts, during extreme rainfall events, adjacent communities are increasingly at risk from flooding, landslides, and soil erosion. Loss of soil fertility through drought and flooding on steep slopes, forces farmers to convert more forests to farmland in order to maintain crop yields. To disrupt the cascading impacts of climate change on vulnerable communities, interventions must be designed to both manage existing forests for climate resilience and to restore natural and protective (plantation) forests.

### *2.11. Climate Change Vulnerability Assessment for the CND*

See Annex 2.1

## *3. POLICY AND INSTITUTIONAL BACKGROUND*

### *3.1. Legal and policy framework*

Rwanda has positioned itself to be a global leader in green growth and climate change adaptation. The government has invested significantly in developing an institutional and policy-enabling environment for climate change adaptation through both national and sectoral development strategies, including: Vision 2050; National Adaptation Plan (2006); National Strategy for Community Development and Local Economic Development (2013–2018); Economic Development and Poverty Reduction Strategy (EDPRS) 2013–2018; Green Growth and Climate Resilience Strategy: National Strategy for Climate Change and Low Carbon Development (2011); Environmental and Climate Sub-Sector Strategic Plan (2013/14 2017/18); Water Resources Management Sub-Sector Strategic Plan (2011-2015); Water, Climate and Development Program (2013); National Decentralization Policy (2012); National Land Use and Development Master Plan currently under revision; Strategic Plan for the Transformation Agriculture in Rwanda (2009); Biomass Energy Strategy (2019); Forestry Sector Strategic Plan (2018), National Agroforestry Strategy and Action Plan (2018); National Sustainable Tourism Master Plan (2015); Forest Investment Program for Rwanda; National Forestry Policy (2018); and individual District Development Plans, District Forest Management Plans, and Integrated Development Program (IDP) Village Model.

Rwanda has been committed to addressing the challenge of climate change since 1995 when it ratified the United Nations Framework Convention on Climate Change (UNFCCC) and later the Kyoto Protocol in 2004. Rwanda submitted its National Adaptation Programmes of Actions to Climate Change (NAPA) in 2006. Rwanda NAPA is articulated on six priority adaptation options to climate change. Key priorities related to this project include:

- Promotion of non-agricultural income generating activities;
- Introduction of species resistant to environmental conditions;
- Development of firewood alternative sources of energy.

In line with the Paris Agreement, Rwanda submitted its Intended Nationally Determined Contribution (INDC) in 2015 which became its first NDC in 2016; the latest updated NDC for Rwanda was submitted in 2020. The current updated NDC seeks to accelerate Rwanda's socio-economic growth by holistically addressing sector specific vulnerabilities and unlocking and directing domestic and external investments to adaptation for effective climate action. Key priority adaptation interventions under the NDC related to

this project include promotion of afforestation / reforestation of designated areas, improvement of forest management for degraded forest resources, integrated approach to planning and monitoring for sustainable land management, development of a harmonized and integrated spatial data management system for sustainable land use management. Dissemination of modern efficient cook stoves to 80% of the rural population and 50% of the urban population by 2030, achieving a more sustainable balance between supply and demand of biomass, and reducing firewood and fossil energy consumption for cooking is one the key priority interventions for mitigation measures.

The GoR has invested significantly in developing an enabling policy and institutional framework for a more climate-resilient development pathway. Many of the GoR policies and strategies focus activities on improving climate adaptation planning, increasing overall forest health, and improving the resilience of local communities, including those listed in Table 5.

**Table 5 – Legal and Policy Framework**

| Policy (Lead Institution) | Summary | Specific Relevant Objectives/Targets |
|---|---|---|
| Green Growth and Climate Resilience Strategy<br><br>Lead institutions: Ministry of Finances and Economic Planning and Ministry of Environment | Provides the country's roadmap for becoming a climate resilient, low carbon economy by 2050. GGCRS's strategic objectives include the achievement of sustainable land use and water resource management, and reduced vulnerability to climate change. | Programme 4: Integrated Approach to Sustainable Land use Planning & Management:<br>- Employ integrated approach to planning<br>- Improve use of spatial data<br>- Establish national information sharing policy<br>- Programme 12: Sustainable Forestry, Agroforestry and Biomass Energy:<br>- Promote afforestation/ reforestation of designated areas<br>- Employ improved forest management for degraded forest resources<br>- Promote improved cookstoves |
| National forest policy<br><br>Lead institutions: Ministry of Environment | Highest-level document governing the development and management of Rwanda's forest resources. Sets 7 broad policy statements which identify solutions to forestry issues. | Policy Statement 2 – Forest Establishment & Rehab:<br>- Rwanda's capacity to produce forest tree seedlings to meet forest land afforestation targets, post-harvest reforestation targets, and degraded forest land restoration targets will be fully developed.<br>- Policy Statement 5 – Biodiversity & Ecosystem Conservation:<br>- Biodiversity and ecosystems resources and values will be maintained and enhanced in |

| Policy (Lead Institution) | Summary | Specific Relevant Objectives/Targets |
|---|---|---|
| Forestry Sector strategy Plan<br><br>Lead institutions:<br>Ministry of Environment | The Forest Sector Strategic Plan (FSSP) 2018-2024 provides directions on how to achieve the medium to long-term policy actions presented in the 2018 National Forest Policy (NFP) for the development and management of the forest sector. | Key priority objectives related to this project:<br>1. The capacity of forest institution and actors will be enhanced to match the requirements for Sustainable Forest Management (SFM);<br>2. Ensure Sustainable Forest Management through the establishment and implementation of integrated forest management plans at all levels;<br>3. Biodiversity and ecosystems services and values will be enhanced in accordance with national and international agenda;<br>4. Active participation of stakeholders in Sustainable Forest Management to ensure ownership and proper benefit sharing. |
| National Agroforestry strategy and Action Plan<br><br>Lead institutions:<br>Ministry of Environment and Ministry of Agricultural and Animal resources | The strategy (2018-2027) creates a roadmap for promoting leadership and synergies in agroforestry and engaging coordinated actions to increase the adoption of agroforestry technologies at Rwanda's agricultural landscapes and watersheds. | Priority actions are formulated in six interconnected thematic areas. The ones relevant to this project are:<br>1. Strengthening Communication and Extension for Agroforestry Adoption and Scaling-Up,<br>2. Promotion of priority Agroforestry Practices,<br>3. Empowering Women and Youth through Agroforestry Development in accordance with national and international programmes and targets to which Rwanda is committed.<br><br>Policy Statement 6 – Agroforestry:<br>- Appropriate agroforestry techniques and tree species will be implemented to contribute to increasing overall forest cover and enhancing agriculture land productivity. |

| Policy (Lead Institution) | Summary | Specific Relevant Objectives/Targets |
|---|---|---|
| Rwanda's Nationally Determined Contribution (NDC)<br><br>Lead institution: Ministry of Environment | Rwanda's intended climate change mitigation actions. The full implementation of this strategy rests upon five enabling pillars: Institutional Arrangements; Finance; Capacity Building and Knowledge Management; Technology, Innovation and Infrastructure; and Integrated Planning and Data Management | Puts a strong emphasis on sustainable forestry, agroforestry, and biomass energy as one of the programmes under which specific actions are implemented to achieve direct and indirect mitigation benefits.<br><br>Priority interventions:<br>• Development of Agroforestry and Sustainable Agriculture (control soil erosion and improved soil fertility)<br>• Promote afforestation / reforestation of designated areas<br>• Improve Forest Management for degraded forest resources<br>• Integrated approach to planning and monitoring for sustainable land management<br>• Develop a harmonized and integrated spatial data management system for sustainable land use management<br>• Efficient cook stoves |
| National Land Use and Development Master Plan (NLUDMP 2020-2050)<br>Lead institution: Ministry of Environment | Spatial land-use planning strategy aiming to foster sustainable development and balance land-use tradeoffs while achieving Rwanda's vision 2050 goals | Specific Targets:<br>• Preserve current extent of natural forests (1,389 km²)<br>• Preserve all existing forest plantations (3,873 km²)<br>• Reforesting 1,554 km² of bare land with slope >55% |
| Rwanda Sectoral Analysis - Nationally Appropriate Mitigation Actions (NAMAs)<br>Lead institution: Ministry of Environment | Outlines potential actions Rwanda can take to achieve mitigation goals under UNFCCC agreements. | Land-use & Forestry Sector<br>• Improved management of forest plantations<br>• Establishment of new plantations<br>• Use of efficient cookstoves |
| Rwanda Sectoral Analysis - Nationally Appropriate Mitigation Actions (NAMAs)<br><br>Lead institution: Ministry of Environment | Outlines potential actions Rwanda can take to achieve mitigation goals under UNFCCC agreements. | Land-use & Forestry Sector<br>• Improved management of forest plantations<br>• Establishment of new plantations<br>• Use of efficient cookstoves |

| Policy (Lead Institution) | Summary | Specific Relevant Objectives/Targets |
|---|---|---|
| National Strategy for Transformation (NST)<br>Lead institution: Ministry of Finances and Economic Planning | Implementation instrument for Vision 2020 and for the first four years of the journey under Vision 2050. Outlines government strategy to move towards a green economy and achieve sustainable development goals. | Increasing climate resilience in agriculture and human settlements and targeting public works schemes to areas most at risk from climate change are key areas of focus in the strategy. Sustainably exploiting natural resources and protecting the environment and reducing the dependence on wood as fuel are also priorities. |

Other key Environment and Natural Resources Sector Policies and Strategic Plans include: Urbanization and Human Settlements Policy (2002); The National Land Policy (2004); National Policy for Water Supply and Sanitation (2010); The Mining Policy (2010); National Policy for Water Resources Management (2011); The National Biodiversity Policy (2011); Environmental and Climate Sub-Sector Strategic Plan (2013/14 2017/18); Water Resources Management Sub-Sector Strategic Plan (2011- 2015); Water, Climate and Development Program (2013); National Decentralization Policy (2012); National Land Use and Development Master Plan (2020); Strategic Plan for the Transformation Agriculture in Rwanda (2009); National Sustainable Tourism Master Plan (2015); Strategic Plan for the Environment and Natural Resources Sector 2018-2024; and individual District Development Strategies (DDS) and Integrated Development Program (IDP) Village Model.

### *3.2. Institutional framework*

Rwanda has a comprehensive and progressive institutional framework and has established agencies to work cross-sectorally to support natural resource management, notably the Rwanda Environment Management Authority (REMA), Rwanda Forestry Authority (RFA), Rwanda Meteorology Agency, National Land Authority (NLA) and the Rwanda Water Board (RWB) within the Ministry of Environment (MOE). In addition, a National Fund for Environment and Climate Change (FONERWA) has been established to address cross-sector financing needs. Rwanda also recognizes the importance of engaging multiple stakeholders and has established mechanisms including regular cross-sectoral planning meetings and the Joint Action Development Forums (JADF), and consultative platforms used for promoting cooperation between the private sector, civil society and the public sector. In addition, in the elaboration of the Environment and Natural Resources (ENR) sector strategic plan, thematic working groups (TWGs) were created to bring together Central and Local government institutions, development partners, the private sector and civil society engaged in the ENR sector. There are five TWGs including Environment and Climate Change, Land, Forestry, IWRM and Mining. Furthermore, Rwanda has established national councils for women and youth which will serve as entry points for engaging these key stakeholders and beneficiaries in the project implementation.

- **National Women's Council (NCW)** -This council is represented at each administrative level from local to national. At each level, there is an executive committee of 7 people. The project activities fall in NCW's mission of building women's capacity and ensuring their participation in national development through advocacy and social mobilization. The mobilization of women is needed in the project activities as they are the majority of beneficiaries of the project in the CND, more largely

involved in agricultural activities than men, as well as cooking and seeking firewood.

- **National Youth Council (NYC)** - This project aligns with NYC's mission of facilitating and encouraging youth to participate in socio-economic development and transformation of a sustainable society, and they are represented at each administrative level from the village to national levels. Rwanda's youths join the agricultural sector as a means of income generation due to the lack of employment opportunities in other sectors, and play a major role as they comprise a high percentage of the Rwandan population.

However, despite the efforts made in recent years, unfortunately, many agencies operate within siloed environments, focusing on limited scopes framed by individual performance plans. The tendency to work independently is a major reason why close coordination is often cited as a key recommendation toward strengthening climate change adaptation measures.

## *4. PROJECT APPROACH*

### *4.1. Project Background*

As detailed in Annex 2.1, predictions for Rwanda from climate models comprising the Coupled Model Intercomparison Project's sixth phase (CMIP6), used in the IPCC Sixth Assessment Report, project an overall temperature increase of approximately 2.6°C by 2040 compared to conditions in 1970. Predictions for precipitation changes are more varied, but most models suggest slowly increasing annual precipitation throughout Rwanda, which would be favorable for helping offset the intensified drying of vegetation and soil moisture yielded by the inexorable temperature increase. Of high concern however, is short-period rainfall, which will continue to intensify due to warming conditions, and exacerbate already severe landslide, flash flood and erosion hazards. A summary of these and other climatic changes, and some associated concerns are shown in Table 6.

**Table 6. Projected climatic changes.**

| Climate component | Character of change | Level of confidence | Near-term concern | Mid-century concern |
|---|---|---|---|---|
| **Temperature** | Upward trend from global greenhouse gas emissions and land-use change | Very high for +2.6 °C net increase 1970-2040 | Elevational range of biota including pests and pathogens increasingly out of balance | Major uphill displacements of biota including cultivars due to ~470 m rise in thermal conditions |
| **Annual precipitation** | Increasing totals | Moderate, but considerable model variation | Low concern, with natural interannual variability still dominant | Moderate concern, with majority of models showing upward trend |
| **Precipitation intensity** | Increasing short-period rainfall and storm totals | Almost certain to occur | Severe landslide hazard already present and increasing, building flash flood potential | Extreme hazard: widespread and frequent landslides and flash floods |
| **Cloud base height** | Rising cloud base and levels of fog immersion in forests | Likely ongoing, will continue with temperature increase | Already significant in deforested highlands with some loss of moisture provision | Of major concern to forest ecology in protected landscapes |
| **Drought/dry spells** | Increasing intensity | Moderate | Some increase in vegetation desiccation potential, possibly enhancing fire risk | Sustained risk of increase in desiccation and fire risk, possibly offset by rainfall increases |
| **Climatic seasonality** | Disappearance of mid-year dry season | | No concern | Increasing convective storm occurrences in June- |

| Climate component | Character of change | Level of confidence | Near-term concern | Mid-century concern |
|---|---|---|---|---|
| | | Low, but explicitly shown in some models | | Aug may eliminate dry season |

The forests of Rwanda's CND are critical for the ecosystem services and products they provide for both the region's vulnerable communities and the national economy. They have been identified as an essential tool for ecosystem-based adaptation (EbA) in Rwanda's Green Growth and Climate Resilience Strategy (GGCRS 2011). Most importantly, they regulate Rwanda's climate by capturing and enhancing rainfall (Seimon 2012), which is crucial for Rwanda's rainfed agriculture. Forests also recharge aquifers; regulate water flow; control flooding; retain soil; limit landslides by stabilizing soils on steep slopes; provide wood fuel energy and timber; underpin the country's tourism, which provides the largest contribution to Rwanda's foreign exchange earnings (RDB 2017); and provide wider benefits of atmospheric pollution control that sustain the country's economy and the wellbeing of its people (Andrew & Masozera. 2010). However, over the past 45 years, the CND's forests have been depleted and degraded, primarily through land conversion for agriculture and over harvesting of fuelwood.

Climate change is now further degrading Rwanda's fragmented forests by changing their species composition, structure, functional processes, and disturbance regimes and, as a result, is diminishing the ecosystem services these forests provide (FAO 2017) to vulnerable communities. The resilience of forests, i.e., their ability to withstand environmental and climatic shocks, is directly related to their size and connectivity. Climate change is therefore endangering the forest ecosystems and landscapes that are critical for building climate resilience for the 2.3 million people in the CND region. Most of the people in the CND are smallholder farmers living on steep slopes without access to irrigation. Their adaptive capacity is low because their crop yields and livelihoods are vulnerable to rainfall variability and because high population density severely limits their options for relocation in the event of disaster. This is particularly true for women who, until very recently, had fewer land rights than men. The increasing frequency of extreme rainfall events due to climate change – combined with forest loss and degradation - is increasing the loss of lives and property from landslides (Bizimana & Somnez 2015, Nsengiyumva et al. 2018). The CND is the part of Rwanda most vulnerable to floods and landslides (MIDIMAR 2012), and the risk is now escalating due to climate change. For example, a dramatic increase in heavy rains and landslides occurred from 2000-2018 that affected more than 30,000 people in the CND, killing at least 502 and destroying homes of more than 29,750 people. Twenty-nine of these landslides dammed rivers, resulting in loss of fertile soils and pollution of rivers with agrochemicals. Recent events suggest the landslide hazard is intensifying: between January and June in 2018, landslides caused more than 200 mortalities (Reuters 2018), and in May 2020, 65 deaths from landslides and flash flooding occurred during a single night of storms focused on the eastern slopes of the CND (Associated Press, 2020). The CND loses an average of 1.5 million tons of fertile soil per year from heavy rainfall due to climate change, landslides and erosion (Nsengiyumva et al. 2018). The risk of this damage is expected to increase with climate change unless actions are taken to decrease vulnerability of CND forests and communities.

The idea for the proposed GCF project arose during stakeholder consultations during development of Rwanda's GCF country programme in 2017. Honorable Dr. Vincent Biruta, Minister of Environment (MOE) at the time, and Ms. Juliet Kabera, DG Climate Change in MOE requested technical support from the

Wildlife Conservation Society (WCS) to develop a project concept and eventually a full proposal to the GCF. The first stakeholder consultation workshop was held in Kigali 24 May, 2017 and numerous consultations and revisions to the initial project idea have been made since the initial discussions.


## Analysis of Prior and Ongoing Adaptation and Forest Resilience Projects

The Project preparation phase enabled extensive consultation and review of past project documentation to ensure lessons from similar or complementary initiatives were embedded in the project design.

A summary of the key projects and their links to the proposed GCF project is provided below.

### Support Program to the Forestry Sector in Rwanda (PAREF) and Forest Management and Biomass Energy project (FMBE)

This 3-phase project (PAREF.be 1/PAREF.be2 from 2008 to 2016 and FMBE from 2017 to 2020), funded by the Kingdom of Belgium and conducted by ENABEL (formerly BTC) in collaboration with RWFA, focused on restoration and concession to private sector of public forests, on management of private woodlots under consolidated Forest Management Units lead by cooperatives of land owners, on participatory roadside plantations and on support of agroforestry through FFS groups. These projects intervened in 7 Districts, of which 4 are in Eastern Province (Bugesera, Ngoma, Kirehe and Ngoma). For these districts, exhaustive forest inventories have been conducted and the District Forest Management Plan (DFMP) has been designed, serving as pilot districts to set the methodology and the forestry database. The developed methodology and standard have been scale-up by RWFA in other 21 Districts to design their DFMPs. National Forest Inventory has been conducted and a national database on supply/demand of wood has been designed under LEAP software to support the revision of the BEST (Biomass Energy Strategy) with the Ministry of Infrastructure. A national standardised and user-friendly database is in process of development to allow easy design, implementation and monitoring of DFMPs. The CND project intends to restore forest plantations, group landowners into PFMUs, and utilize FMES for tracking & monitoring of restored areas. This project will learn from the success of forest management cooperatives at promoting sustainable forest management techniques and knowledge and may adopt a similar approach to build capacity of farmers in agroforestry techniques.

**The "Sustainable forestry, agroforestry and biomass energy management for climate resilience in Gatsibo District" and the "Border to border forest landscape restoration" projects – IUCN/RWFA**

These 2 project funded by FONERWA (The National Fund for Environment and Climate Change) and Germany Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, both jointly implemented by IUCN and RWFA (2016-2018) were focused on landscape restoration in Gicumbi and Gatsibo District, especially implementing a landscape approach through agroforestry promotion, restoration of public and private forests and design of DFMP according RWFA standard (including forest inventories). The CND project took lessons from these projects, particularly on knowledge of local context and technical issues regarding adapted species adopted by farmers. The learning from the two projects will inform the scale up of best practices within the CND landscape. Stakeholder engagement and awareness about landscape restoration have been significantly implemented, political leadership and local government engagement is fully implemented in the project areas, and this will help to fast-track implementation of CND activities.

**Landscape Restoration and Integrated Water Resources Management in Sebeya and other Catchments - SNV/MoE, IUCN**

The project was implemented by Rwanda Water and Forestry Authority (RWFA) in collaboration with International Union of Conservation of nature (IUCN), Netherland Development Organization (SNV)). The project used a community approach towards catchment restoration through Village Land Use planning processes. Communities identified issues facing their landscapes and developed an action plan to address them at landscape level. The project aimed to restore degraded lands in Sebeya and other catchments through agroforestry, afforestation, gullies rehabilitation and river bank protection among other interventions. The project also implemented flood control measures. The design of the CND project has been informed by lessons learned during the implementation of the Sebeya project and will scale up best practices during its implementation in the CND Landscape.

**<u>Other GCF projects in Rwanda</u>**

**Strengthening climate resilience of rural communities in Northern Rwanda (FP073) – FONERWA.**

This recently approved FONERWA GCF funded project is similar in its design to the CND GCF Project and will seek coordination, synergy and to integrate lessons learned. The project will restore and enhance ecosystem services in one of the sub-catchments of the degraded Muvumba watershed, increase the capacity of communities to renew and sustainably manage forest resources and support smallholders to adopt climate resilient agricultural practices. The project will also invest in climate resilient settlements for vulnerable families currently living in areas prone to landslides and floods and support community-based adaptation planning and livelihood diversification.

Many of the project's interventions target those who farm marginal land and are highly vulnerable to landslides, flooding and droughts. The project will specifically target the most vulnerable groups who have less resources to mitigate and adapt to climate change. This includes the extreme poor, as more than a quarter of households in the target area fall into this category and women headed households who tend to be poor and are particularly vulnerable to climate change. A key focus will be on developing the adaptive capacity of farmers and local institutions to ensure that the developed resilience becomes embedded within communities and local structures enabling them to continue adapting to future climate variability beyond the lifetime of the project. The CND project will draw early lessons learned from this intervention.

Particularly, this will integrate early lessons from complimentary activities aligned to the project's three components including objectives around adopting climate resilient practices, sustainable forest management, adoption of fuel-efficient cooking methods.

**Transforming Eastern Province through Adaptation (FP167 TREPA) -IUCN/ENABEL.** TREPA intends to restore over 60,000 ha of drought-degraded landscapes into climate resilient ecosystems through reforestation, agroforestry, restoration of pasturelands, and erosion control measures in 7 districts of the Eastern Province of Rwanda, namely Kirehe, Kayonza, Gatsibo, Ngoma as well as Bugesera districts. This project will promote improved clean and efficient cooking energy technologies to more than 100,000 households in the Eastern Province of Rwanda. It will also develop climate resilient markets and supply chains to incentivize public and private investments in forests, increase the capacity of communities to renew and sustainably manage forests and agroforestry resources, and support smallholder farmers to adopt climate-resilient agriculture.

The CND project will integrate early lessons from complimentary activities aligned to the project's components including objectives around adopting climate resilient practices, sustainable forest management, and adoption of fuel-efficient cooking methods.

These GCF projects will work together in efforts to seek to mainstream and integrate knowledge and capacity developed during implementation at the local and national levels.

**Building resilience to climate change hazards in the Volcano Region of Rwanda – MoE/FONERWA.**
This is a concept note submitted to the GCF. The project focuses on (1) reducing the exposure of the local population to climate hazards, principally through improved water management at catchment level, to reduce surface run-off and its effects of flooding and landslides; and (2) to increase the resilience of the local population through improved housing in zones with reduced risk and economic livelihood options.

**<u>Government and other development partner projects</u>**

**Ecosystem Rehabilitation and Green Village Promotion - FONERWA**
This closed project focused on soil erosion resulting from deforestation with subsequent biodiversity loss which are the major environmental challenges affecting communities in Nyabitekeri Sector of Nyamasheke District. The situation is exacerbated by climate related pressures such as unpredictable rainfall that has in turn led to loss of lives and property. The project thus intends to build community's resilience through provision of environmentally friendly practices that minimize soil erosion while improving livelihoods. The project has four interrelated outputs:

Output 1: Land management and soil erosion control strengthened

Output 2: Alternative renewable energy sources introduced and rainwater harvesting systems installed

Output 3: Sustainable livelihood and food security enhanced

Output 4: Project grant efficiently managed and coordinated

CND will integrate early lessons - particularly from Output 1 and 2. In order to reduce soil erosion on the steep slopes and enhance sustainable soil productivity in the Lake Kivu watershed, the project will develop

progressive terraces on 400 ha. The area will be planted by various agroforestry trees species including *grevillea robusta*, *accacia angussitissina* and *cedrella serrata*, (Soil Nitrogen fixing species) will be planted on 100 ha. Another 200 have been forested by *eucalyptus microcorys*, *callitris robusta* with focus on the ravine area. The CND project will integrate these lessons into the agro-forestry activities under restoration activities of output 2.2 to ensure most effective species are selected to avoid soil erosion and enhance nitrogen fixing.

**Supporting Sustainable Climate Resilience Livelihoods for Poor Farming Households in Bugesera District – FONERWA**

This project is enabling 912 poor households (3,927 people) to reduce their dependence on subsistence cultivation systems increasingly affected by low rainfall, erosion and poor soil quality. Target households will be supported to adopt conservation agriculture including agroforestry to reduce erosion as well as to develop off-farm, climate resilient livelihoods revolving around integrated cropping techniques (using maize, beans, bananas, cassava, mushrooms, etc.) and livestock (rabbit, pigs etc.) production systems to enhance household incomes and reduce vulnerability to climate change. Lessons learnt from this project with inform, community-based tree nursery management as part of the enterprise development as well as promoting farm based value chains.

**Forest Landscape Restoration in the Mayaga Region - UNDP/REMA, Kamonyi, Gisagara, Ruhango and Nyanza Districts**

This GEF project aims to secure biodiversity and carbon benefits while simultaneously strengthening the resilience of livelihoods, through forest landscape restoration and upscaling clean technologies in selected Districts of Southern Province. The project has three interrelated components:

Component 1: Decision support tools for planning of forest landscape rehabilitation

Component 2: Skills and capacity for implementation of Forest landscape restoration plans

Component 3: Implementation of FLR plans secures 555 ha of natural forests, puts 300 ha of forests under participatory forest management, establishes 1,000 ha of plantations under the New Forest Company through co-finance, increases productivity of agriculture and plantation forests on 25,000 ha and reduces wood consumption by at least 25%.

The CND project will collaborate with UNDP through a number of similar and complimentary activities. It will integrate early lessons learned from the forest landscape restoration plans as well as any institutional capacity for planning and implementing forest landscape restoration strategies. The CND Project will also coordinate training programs for extension services, benefiting from the skills and training packages established by UNDP under Output 2.2: Institutional capacity for the extension service and community knowledge.

**Landscape Approach Forest Restoration and Conservation (LAFREC) – Nordic Development Fund (NDF), World Bank and REMA**

This project aimed at rehabilitating forests and biodiversity within Gishwati-Mukura National Park, enhancing sustainable land management on agricultural land, and introducing silvopastoral approaches in the rangelands of central former Gishwati Reserve. It has restored ~600ha of natural forest in Gishwati Mukura National Park, placed ~1000ha of land under agroforestry, and established ~300ha of woodlots.

The CND project will utilise the information generated by the LAFREC project to inform selection of agroforestry & plantation species, as well as determine the need for training around agroforestry, plantation management and support provided to implement tree-based landscape restoration approaches through provision of training, seeds, materials, and through payment for local labour.

The CND project will build upon the work done by the Landscape Approach to Forest Restoration and Conservation (LAFREC) project by the Nordic Development Fund and World Bank.

**Improving the Efficiency and Sustainability of Charcoal and Wood Fuel Value Chains – World Bank and NDF**

Focused on North-Western Rwanda (Gishwarti-Mukura landscape) with a possibility to extend to other parts of the country. An NDF grant will benefit the WB-GEF Landscape Approach to Forest Restoration and Conservation (LAFREC) Project implemented by the Rwanda Environment Management Authority (REMA). NDF will support the National Seed Centre in order to improve and diversify the tree seed pool. The project will also target commercial tea factories' wood consumption and households' cooking needs through analysis and promotion of sustainable alternatives. Some of the key activities implemented by the project include improved woodlot management, improved tree seeds quality, efficient charcoal production and promotion of alternative sources of energy. The woodlot management part of the project will encompass forests in Gishwati-Mukura landscape. Building upon existing plans and training, the NDF-funded activities will initiate local-level planning of existing woodlots to improve management and increase productivity. The project components also include strengthening cooperatives to improve charcoal production techniques as well as the value, quality and marketing of the charcoal produced. The CND project will collaborate with this project through ICS activities under the component 3.

**Building Resilience of Communities Living in Degraded Forests, Savannahs and Wetlands of Rwanda Through an Ecosystem Management Approach - UNDP/REMA, MoE and MINAGRI**

The project aims to increase the capacity of Rwandan authorities and local communities to adapt to climate change by implementing Ecosystem-based Adaptation (EbA) interventions in forests, savannas and wetlands. The project has three components:

Component 1: National and local institutional capacity development for the use of an EbA approach.

Component 2: Policies, strategies and plans for adaptation to climate change.

Component 3: EbA interventions that reduce vulnerability and restore natural capital.

During project design, UNDP/REMA was consulted to ensure that activities involving capacity development for forestry were integrated and complementary to the CND project activities. The CND PMU will work closely with the UNDP/REMA project team to ensure that final lessons learned will be integrated during the CND inception phase.

**Rwanda's Green Fund – FONERWA**

Rwanda's Green Fund set up by the Government to support environment protection and deal with the impact of climate change. The fund acts as the avenue through which development partners can contribute to Rwanda's green growth ambitions. Private sector contributions are considered as grants and project co-financing in the short-term, and investment in the long-term, among others. External capitalization sources include bilateral and multilateral development partners' contributions and access to international

environment and climate funds. FONERWA is implementing several projects from which the Mayaga FLR project design has drawn lessons, and with which implementation will be coordinated. Most of its projects have addressed land management and soil erosion control; alternative renewable energy and improved energy efficiency; rainwater harvesting systems; sustainable livelihood and Food security enhancements. The project will benefit from and coordinate with the following projects.

The just concluded "Integrated Land, Water Resources and Clean Energy Management for Poverty Reduction Project" (2014-2017) supported the sustainable management and conservation of natural resources, more productive agriculture to reduce human pressure on Volcanoes National Park and reduce greenhouse gas emissions. In Gatsibo, FONERWA implemented a project (2015 – 2017) aimed at rehabilitating 500 ha of degraded forests; creating 3,000 ha woodlots for environmental protection, agroforestry on 15,000 ha for soil fertility and promoting improved cook-stoves in order to reduce pressure on forest resources. This project benefitted 19,317 poorest households which represents 17% of the total population. The two projects developed extension and training materials on sustainable land management, improved energy systems and improving household incomes, for all levels of stakeholders that the CND project will build on.

**IMF Resilience and Sustainability Facility**

The Resilience and Sustainability Facility (RSF) provides affordable long-term financing to countries undertaking reforms to reduce risks to prospective balance of payments stability, including those related to climate change and pandemic preparedness.

The RSF arrangement, underpinned by a strong reform package will help advance Rwanda's efforts to build climate resilience. The reforms under the RSF are expected to strengthen and institutionalize monitoring and reporting of climate-related spending, integrate climate risks into fiscal planning, improve the sensitivity of public investment management to climate-related issues, strengthen climate-related risk management for financial institutions, and strengthen disaster risk reduction and management. Establishing guidelines for financial institutions on climate-related risk management and introducing standards for development of markets for sustainable finance products will also support private green investment.The CND project will build synergies and collaboration with this project to identify and establish sustainable financing mechanisms for the CND landscape.

Furthermore, the CND will contribute to the following international developed agenda such as the International Year of Sustainable Mountain Development 2022, UN Decade of Ecosystem Restoration; and the recent The Kunming-Montreal Global Biodiversity Framework (GBF).

**The International Year of Sustainable Mountain Development 2022**

The United Nations General Assembly declared the year 2022 as the International Year of Sustainable Mountain Development, at the proposal of the Government of the Kyrgyz Republic. The resolution titled "International Year of Sustainable Mountain Development, 2022" (document A/76/L.28) encourages Member States, and invites international organizations and other relevant stakeholders, with respect to sustainable mountain development, to reduce and reverse biodiversity loss and the degradation of land and soil, contributing to the achievement of the Sustainable Development Goals. It also recognizes the need to increase the adaptive capacity, resilience and sustainability of food and agricultural production with regard to climate change, notes that sustainable production practices, agroforestry and the conservation of agrobiodiversity in mountain areas ensure food security and nutrition and dietary diversity

and quality, generate income for smallholder farmers and aid conservation and restoration, addressing the particular vulnerabilities of food production systems to the adverse impacts of climate change, and also notes that mountain farmers and pastoralists play a key role in agroecology. The objectives of the CND are aligned with this resolution and will contribute to achieve its objectives.

**The UN Decade on Ecosystem Restoration**:
This is a rallying call for the protection and revival of ecosystems all around the world, for the benefit of people and nature. It aims to halt the degradation of ecosystems and restore them to achieve global goals. Rwanda made a commitment to restore 2 million ha of degraded lands through the Bonn Challenge. This project will contribute towards achieving this goal.

**The Kunming-Montreal Global Biodiversity Framework (GBF):** Parties to the Convention on Biological Diversity (CBD) adopted the Kunming-Montreal Global Biodiversity Framework on 19 December 2022, replacing the CBD's Strategic Plan for Biodiversity 2011-2020 and its Aichi Targets. The framework is made up of 4 global 2050 goals and 23 global 2030 targets, which are broken up into four broad topics in alignment with the goals. This includes, biodiversity conservation and restoration, nature's contribution to people, access and benefit sharing and tools and solutions for mainstreaming and implementation. This project will contribute towards achieving goal A and key targets including:

- Target 2 - Ensure that by 2030 at least 30 percent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.
- Target 8 - Minimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solution and/or ecosystem-based approaches, while minimizing negative and fostering positive impacts of climate action on biodiversity.
- Target 11 - Restore, maintain, and enhance nature's contributions to people, including ecosystem functions and services, such as regulation of air, water, and climate, soil health, pollination and reduction of disease risk, as well as protection from natural hazards and disasters, through nature-based solutions and ecosystem-based approaches for the benefit of all people and nature.

### *4.2. Spatial assessment of existing projects*

As described above, there are a large number of existing development and conservation projects currently underway or planned for the CND. In order to ensure that this project does not target areas that have been, or will potentially be targeted by projects for similar activities (e.g. agroforestry, afforestation), we mapped the spatial extent of all projects for which data was available (Figure 11). Of the current and proposed projects in the CND, there are 5 which potentially conflict with this project, and in response to some of these projects we have revised our overall project area. Existing projects and the rationale for modifications to this project area are described below:

*LAFREC Project* (red areas on map) - This recently completed project (2015-2021) aimed to rehabilitate forests and biodiversity within Gishwati-Mukura National Park, and enhance sustainable land management through agroforestry and terracing in the Gishwati region. Areas targeted for agroforestry and terracing by the LAFREC project have been excluded from the project area of this project.

*EPAFLEC project* (green areas on map) - This proposed project aims to engage the private sector in climate change adaptation through improved forest management in the North-West of Rwanda. Part of the project aims to rehabilitate degraded public forests, and work with smallholders around these forests to restore private woodlots. Because the project is not in the implementation stage, the currently available data maps a large number of areas that will potentially be targeted by the project, rather than a final set of definite project intervention sites. As such, we have not excluded these areas from this project.

*EWMR Sebeya project* (pale blue areas on map) - This currently underway project (2019-2022) us piloting an innovative community participatory - Village Land Use Action Planning processes (VLUAP), in order to facilitate landscape restoration and improved natural resources management in Sebeya catchment. While the EWMR project is implementing activities such as agroforestry and terracing, exact data on the locations of each intervention is unavailable, and activities are mapped at the catchment scale. Because these catchments are very large areas, and it is unlikely that the EWMR interventions covered the entirety of the catchment, we have not excluded these areas from this project.

*Building Climate Resilience by Implementing the Upper Nyabarongo Catchment Restoration Plan in the Mbirurume Sub–catchment of Rwanda* (pink areas on map) - This proposed GCF project aims to improve the climate resilience of the Upper Nyabarongo Catchment through sustainable forest and land management, and by strengthening climate monitoring and early warning systems. Because many of the activities are very similar to this project (e.g. agroforestry, forest restoration), we have excluded the Upper Nyabarongo catchment area from this project.

*Building Resilience to Climate Change Hazards in the Volcano Region of Rwanda* (violet & orange areas on map) - This proposed GCF project aims to increase the resilience of communities around Volcanoes NP to climate hazards by improving water management to reduce flooding and landslides, through activities including establishing radical terraces, promoting agroforestry on farmland, and increasing productivity of existing forest plantations. While this project plans to implement activities such as agroforestry and terracing, exact data on the planned locations of each intervention is unavailable, and activities are mapped at the catchment scale. Because these catchments are very large areas, and it is unlikely that the proposed interventions will cover the entirety of suitable land within the catchments, we have not excluded these areas from this project (Figure 11). Further analysis and explanation on choice of target areas for this project is included in sections 5 and 6.

This project will complement ongoing efforts of RDB and its partners in the management of national parks in the CND. Over the next five years the Nyungwe Management Company (NMC) intends to invest in park management and infrastructure development, law enforcement, tourism and revenue generation, building constituencies for conservation, as well as conservation and habitat management. Assisted natural regeneration funded by the GCF in Nyungwe not only will build resilience of Nyungwe National Park to climate variability but also increase biodiversity that will benefit tourism development. Similarly, RDB envisions to rehabilitate and restore degraded areas of GMNP. This project will support this effort.

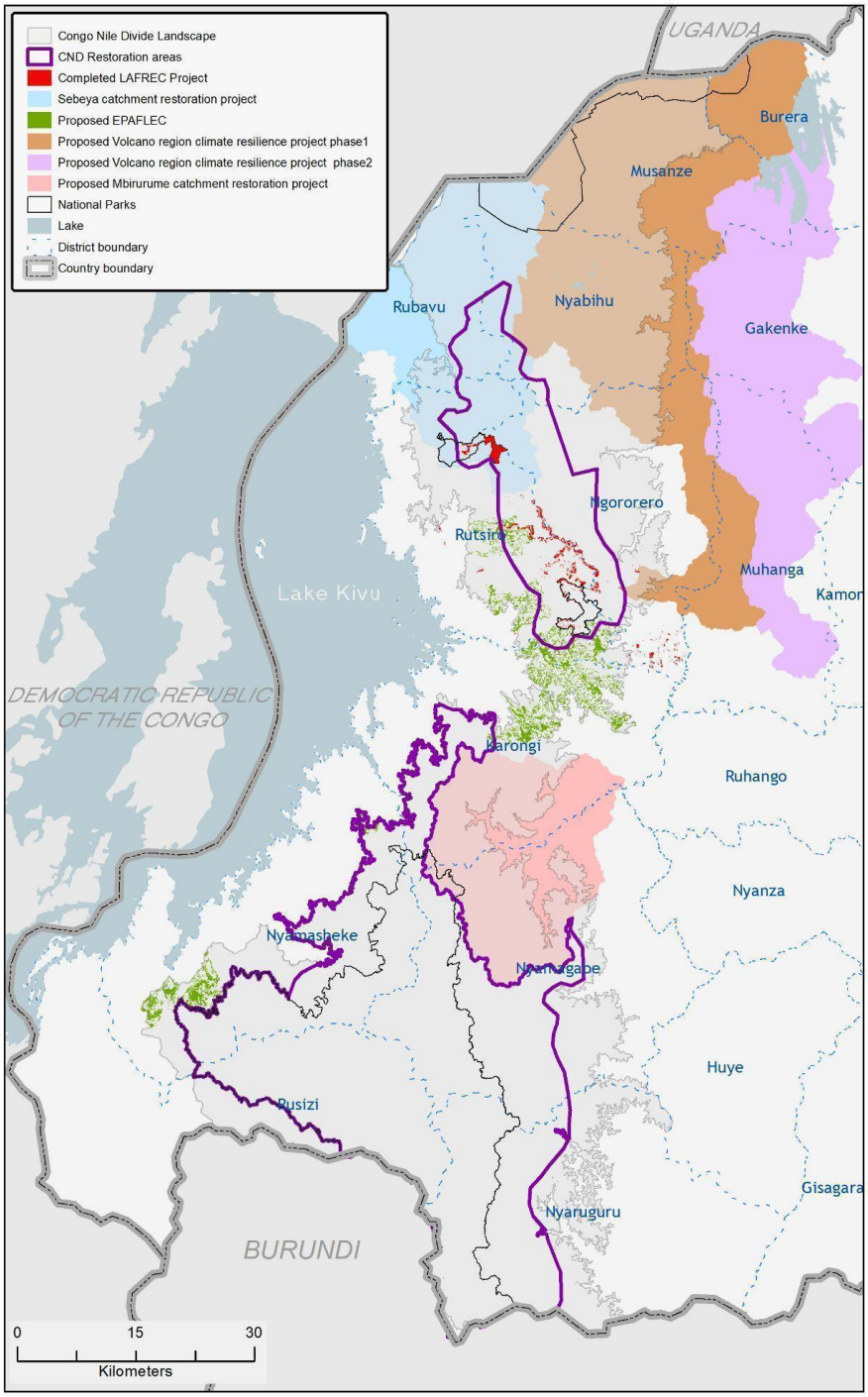


Figure 11: Existing and proposed projects within the CND

### *4.3. Project Overview*

This project provides an opportunity to address the impacts of climate change on forest resilience and on Rwanda's most vulnerable communities in the Congo Nile Divide. The project will demonstrate that the national development of a Least Developed Country – even one like Rwanda with one of the highest population densities in Africa and contending with the challenge of land scarcity – need not come at the cost of extensive environmental degradation. Specifically, the project aims to support Rwanda in achieving its ambitions for a climate resilient, low emission sustainable development paradigm in which:

- The government of Rwanda's commitments to the SDGs, UNFCCC, CBD and UNCCD translate into integrated, cross-sector, aligned policies and programs at national, regional, district and village **scales**;

- The most vulnerable rural communities are trained and develop sustainable livelihoods as indigenous forest restoration workers that restore and maintain natural forest ecosystem function and services;

- The extent and integrity of Rwanda's natural forests are increased; their ability to sustain essential ecosystem services for vulnerable communities is enhanced; and Rwanda's national parks which are essential to the nation's economy are resilient to climate change;

- Smallholder farmers have increased awareness of climate threats and experience fewer losses of crops and economic assets from climate variability and shocks;

- The government's capacity to map, value and monitor forest ecosystems, and to integrate these data into multi-sector spatial planning will be enhanced and will provide a model that can be replicated in other countries and regions in Africa.

The Theory of Change (ToC) diagram (Figure 12 below) illustrates how the project will achieve its goal to improve the resilience of vulnerable communities to climate variability and shocks by increasing the extent and integrity of natural forests and by strengthening the capacity for climate-responsive forest and landscape management. The ToC for this Project is founded on several key principles. Central to all, the CND represents a complex landscape – a geospatial mosaic of forest and farming patches, each dependent on the other. These coupled, biological and socio-economic systems are under great strain due to intense land pressure, which has resulted in a negative cycle of natural resource degradation that undermines the well-being of both natural and socio-economic systems. The advent of climate change is a forceful driver that intensifies this cycle of degradation, with the resultant loss of key ecosystem services that importantly link forests and people. This cycle must be disrupted in order to chart a path toward climate resilience for natural and human systems. The approach to be taken by this Project is therefore based on principles of ecosystem-based adaptation: that healthy and resilient ecosystems form an essential foundation for adaptation to climate challenges[38]. Climate-aware management of both natural and human-dominated ecosystems – interacting and integrated at a landscape level – can break the cycle of degradation and instead lead to a positive sequence of mutually reinforcing, climate-smart, sustainable,

[38] Scarano, F.R. et al, 2017. *Ecosystem-based adaptation to climate change: concept, sustainability and a role for conservation science,* Perspectives in Ecology & Conservation 15(2), 65-73.

and resilient benefits.

In sum, the goal statement of the Project is:
***IF*** *Rwanda's CND landscape of native forests and neighboring farmlands is effectively managed for climate resilience*
***THEN*** *the CND will comprise an interconnected and interdependent set of globally significant, species-rich natural forests in a matrix of sustainable farmlands: assuring vital ecosystem services and improving livelihoods for vulnerable people and the nation at large and contributing importantly to the conservation of biodiversity, the national economy, and mitigation of GHGs*
***BECAUSE*** *building the capacity and management of integrated, climate-resilient forest and farming systems will ensure natural forest perpetuity and break and reverse the climate change-induced intensifying cycles of drought, flooding, and landslides that lead to degradation of livelihoods and resultant increased pressure on forest resources.*

The status and future of the CND's forests and people are tightly intertwined: both heavily dependent on the natural resources and processes that provide a foundation for their ability to thrive. They represent ecological and socio-economic systems that are importantly coupled in a complex landscape, linked in particular by the ecosystem services that flow throughout these systems (hydrological and microclimate regulation, soil conservation, and nature-based tourism). At present these services, and the consequent relationships between forests and people – especially those who are most vulnerable in Rwandan society – are deeply strained[39]. Forests have been reduced in extent, fragmented, and degraded by fire[40], overuse of resources[41], and introduction of exotic species[42]. The sharply sloped rural lands of the CND have been farmed more and more extensively and intensively on steeper and steeper slopes[43,44] and throughout riverine bottomlands, further reducing tree cover outside forest blocks: thereby further compromising the ability of the land to retain soils[45], avoid flooding[46], provide consistent and healthy water[44], ameliorate microclimate[49], store carbon[47], and remain productive. The coupling of these stressed systems has led to a negative feedback cycle of insecurity and constrained the well-being of farmers. Having little access to alternative sources of livelihoods or capital to enable change[48], smallholder farmers have consequently increased pressures on natural forests for land, fuel, and other forest resources[46]. Such pressures in turn cause further forest loss and degradation and decline in biodiversity – reducing their ability to provide essential ecosystem services to people living in the landscape and across the nation, including tourism revenues and employment that are of national import. Thus, these systems are caught in a negative cycle

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39 Bagstad, K.J., 2019. *Towards ecosystem accounts for Rwanda: Tracking 25 years of change in flows and potential supply of ecosystem services.* British Ecological Society.

40 Masozera, A.B., Mulindahabi, F., 2007. *Post-Fire Regeneration in Nyungwe National Park*, Rwanda. Wildlife Conservation Society.

41 Republic of Rwanda, 2011. *Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development*.

42 USAID, 2019. *Rwanda Tropical Forests and Biodiversity Analysis*.

43 Camberlin, P., 2018. *Climate of Eastern Africa*. In Oxford Research Encyclopedia of Climate Science.

44 Seimon, A., 2022. *An Overview of Climate Change and its Impacts along the Congo-Nile Divide in Rwanda*.

45 World Bank, 2019. *Rwanda Systematic Country Diagnostic*.

46 Karamage, F., et al., 2017. *Modeling Rainfall-Runoff Response to Land Use and Land Cover Change in Rwanda (1990–2016)*. Water 2017, 9(2), 14.

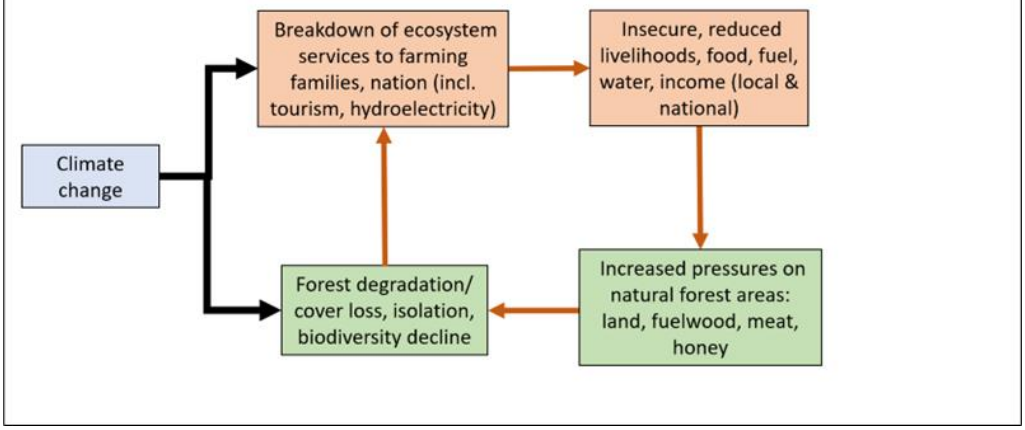
47 Mugabowindekwe et al, in review

48 Clay N., King B., 2019. *Smallholders' uneven capacities to adapt to climate change amid Africa's 'green revolution': Case study of Rwanda's crop intensification program*. World Dev.

that has proven difficult to break, despite significant sector-specific efforts. One such pressure – demand for fuelwood – is quite substantial given that a recent Government of Rwanda (GoR) census found that 77% of Rwandan households use wood as their primary fuel for cooking[49].

With the advent of climate change, these already strained systems are showing clear signs of breakdown. Increased variability in the timing and intensity of rains along with rising temperatures are causing increased landslides[50] and soil erosion[50], increased desiccation and drought[50], and unpredictable timing for agricultural plantings and harvest[51]. This is reducing farm productivity and security, driving even greater pressures on the remaining forested estate, thereby compromising further the essential ecosystem services that are necessary to such well-being. At a larger scale, climate-induced forest degradation and decline of biodiversity in the CND compromise national-level benefits of water provision and quality[1], nature-based tourism[52], the supply of hydroelectricity,[7,53] and carbon storage[10] [see diagram A below].

Diagram A. Climate impacts & risks intensify negative feedback loop for people & forests



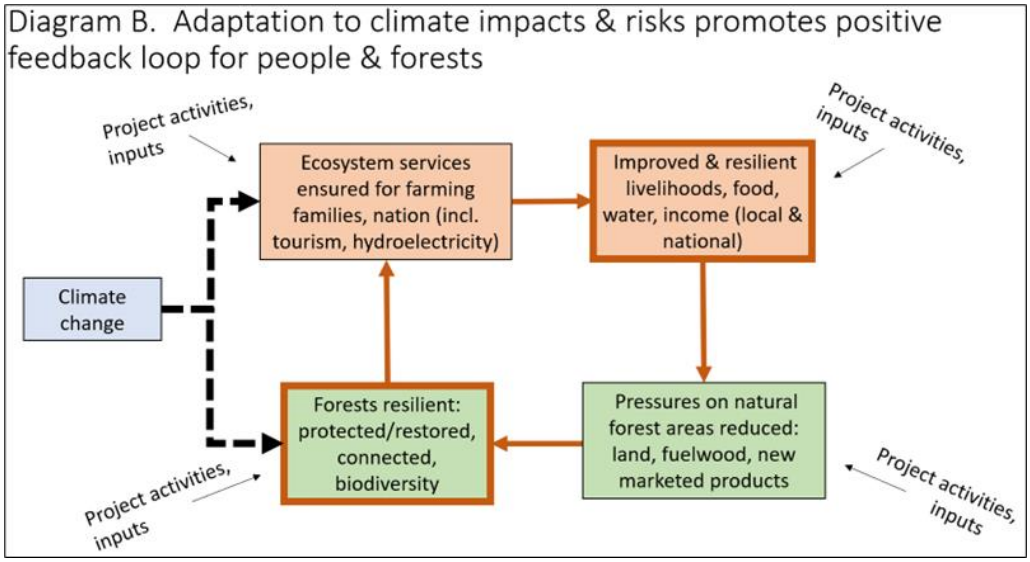

49 Government of Rwanda, 2021. Rwanda Household Survey 2019/2020. National Institute of Statistics of Rwanda.

50 Uwihirwe, J., et al., 2020. *Landslide precipitation thresholds in Rwanda*. Landslides.

51 World Bank; CIAT. 2015. *Climate-Smart Agriculture in Rwanda*. CSA Country Profiles for Africa, Asia, and Latin America and the Caribbean Series. Washington D.C.: The World Bank Group.

52 Rwanda Environment Management Authority (REMA), 2015. *Rwanda State of Environment and Outlook Report.*

53 Rwanda Environment Management Authority (REMA), 2009. *Rwanda State of Environment and Outlook Report*, Chapter 8: Energy Resources.




This context calls for new mechanisms of land-use planning and management that are based on consideration of the CND as a landscape, consisting of an inter-dependent mosaic of forests and farms, the management of each determining the health of the whole. Focusing on this larger scale, with coordination across geographic and sectoral boundaries, while mainstreaming climate risks into management planning will be key – and the foundation for a paradigm shift. Use of this framework to design and apply practical, precedent-setting Project actions in-forest and on-farm is expected to shift mindsets and management systems. This, in combination with establishing durable sources of financing, is thereby intended to shift the natural and human ecosystems themselves toward sustainable climate resilience. [see diagram B above, and the ToC (Theory of Change) diagram below.

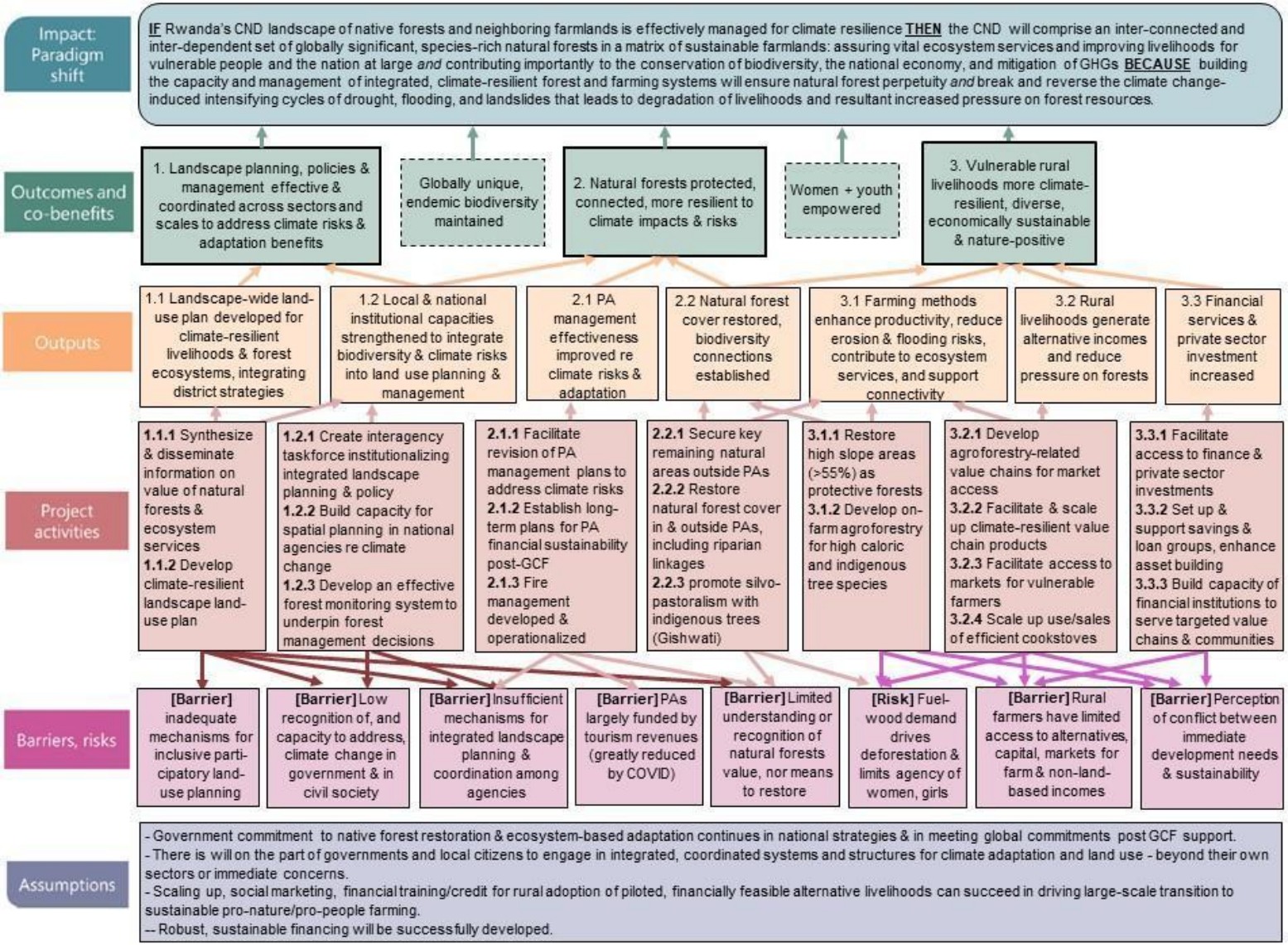



Figure 12: Theory of Change

Here the project components, Outcomes, outputs, and their ability to overcome key barriers are briefly described. In Section 5, more detailed analyses of the options considered for each component are presented.

**Outcome 1. Landscape planning, policies and management effective and coordinated across sectors and scales to address climate risks and adaptation benefits.** Major barriers currently stand in the way of moving in this direction, as outlined in the ToC diagram. ***Awareness, understanding, attention, and action regarding climate risks to natural resources are currently insufficient***. Planning and adaptation to climate impacts are constrained by a lack of information, site-focused modeling, spatial analysis, and real-time monitoring. Where some capacity exists, it ***operates within sector initiatives rather than across them****.* It also proceeds largely within governmental programs, with ***mechanisms for inclusive land-use planning inadequate*****,** not fully engaging rural peoples – particularly women and youth. Because of these barriers, coordination of landscape planning and management is weak across governmental and non-governmental sectors (agriculture, forestry, national parks, economic development), scales (local, district, national), and actors (women, youth, smallholder farmers, commercial businesses, as well as governmental agencies). Activities outlined in **Component 1**, aimed at integrated landscape land-use planning and the capacity for effective management, are intended to help ensure ecosystem services persist, and thereby align the ties between forests and people as they are faced with climate challenges. Activities under this component will provide the government and public with up-to-date information on climate adaptation (1.1.1), build agency capacities for incorporation into land-use planning – particularly spatial analysis and forest monitoring (1.2.2, 1.2.3), establish mechanisms for integrated landscape planning – including public participation and operations of an inter-agency task force (1.1.2, 1.2.1), and facilitate the creation of a climate-smart, integrated CND land-use plan (1.1.2).

**Outcome 2. Natural forests protected, connected, more resilient to climate impacts and risks.** Particular to the CND, another key barrier is that ***natural forests are as yet undervalued and under-resourced*** despite the fact that they play vital roles in stabilizing natural and human CND ecosystems[54,55]. The national parks of the CND (Volcanoes, Nyungwe, and Gishwati-Mukura) are globally significant regarding their outstanding species richness, levels of endemism, and presence of endangered and rare species[56]. Although these are well-recognized for their tourism potential, and strong governmental policy and practice exists to protect them, barriers to their full valuation remains: their ***ecosystem services are yet to be fully recognized*** or financially supported, and their ***support is vulnerable to global tourism trends*** (with COVID-reduced tourism as a current example). As climate change considerations enter into landscape management, the values of these natural forests for fog interception, precipitation infiltration, soil retention, drought mitigation, and hydrological balance are only now becoming more prominent.

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[54] Gatwaza O.C., Wang X., 2021 *Mapping of biodiversity hubs and key ecosystem services as a tool for shaping optimal areas for conservation.* PLOS ONE 16(8): e0253151

[55] Andrew, G., Masozera, M., 2010. *Payment for Ecosystem Services and Poverty Reduction in Rwanda*. Journal of Sustainable Development in Africa (V12, No.3).

[56] This area is also significant for global biodiversity – with the Albertine Rift being one of the most biodiverse regions within Africa, including conservative estimates of at least 980 endemic species, 15 Critically Endangered species, 34 Endangered species, and 99 Vulnerable species. Source: Plumptre, A.J., et al. 2016. *Conservation Action Plan for the Albertine Rift*. Wildlife Conservation Society.

In order to provide such services into the future, Nyungwe and Gishwati-Mukura NPs are in need of restoration and connection[57,58]. Yet the understanding and capacity for recovering their richness and function is nascent at best, particularly in light of climate change. Activities outlined in **Component 2** are therefore designed with forest sustainability at the core. To build climate considerations into forest planning and management, the Project will facilitate revision of park management plans (2.1.1) that enhance dimensions of fire prevention and management (2.1.3), and will support in-park forest restoration (2.2.2). Establishment of restored forest at park boundaries (2.2.2), riparian linkages outside the parks (2.2.2), and forested "stepping stones" that allow for forest species to move between parks (2.2.1, 2.2.3) is intended to enhance biodiversity and forest functions across the CND landscape. Fundamental to forest sustainability as well is sustainable long-term financing, which will be addressed by providing technical support from the Project to RBD and REMA to assess various financial instruments (conservation and/or water funds, bonds, revenue streams) to be employed for revenue generation post-GCF (2.1.2).

**Outcome 3. Vulnerable rural livelihoods more climate-resilient, diverse, economically sustainable and nature-positive.** The sustainability and climate resilience of the agricultural matrix of this landscape is challenged by additional, multiple barriers. Rural agricultural practices and livelihoods are constrained by the very small size of landholdings (avg. 0.3 ha[59]), creating intense pressure to utilize all arable land for food and near-term income-generating products[56], thus creating ***reluctance to incorporate trees or other soil conservation measures on the land***[60]. The resultant ***lack of fuelwood in turn continues to drive deforestation of natural forests***[12]***, and occupies important time of women and youth*** who could instead be engaged in productive and empowering roles. Overall, local communities and extension services[61] have ***limited skills, information and knowledge to design and implement farming methods*** that would enhance their capacity to mitigate the impacts from climate-induced soil erosion, flooding and droughts. Farmers ***also lack access to financial know-how[56] and capital, proven alternative livelihoods, and markets*** that could incentivize and enable change[12]. They are therefore caught in a cycle of immediate need that – without alternatives – forecloses options that could recover and sustain benefits from improved ecosystem services, other forest functions, and new livelihoods. **Component 3** aims to redress these conditions via activities that will demonstrate, incentivize, facilitate, and support actions that maintain and recover ecosystem services, benefit from forest functions and provide alternative on- and off-farm based incomes that reduce pressure on forests. To these ends, the Project will support reafforestation on steep slopes (>55%), on both public and smallholder private lands (Activity 3.1.1). It will develop farm-based agroforestry for climate-resilient species that produce fuelwood and/or market products, while conserving and enriching soils (3.1.2, 3.2.1). The Project will complement land-based production with a scaling-up of alternative value-chain products for smallholders that are nature-

57 Nyandwi, E., Mukashema, A., 2011. *Excessive Deforestation of Gishwati Mountainous Forest & Biodiversity Changes*. Participatory Geographic Information Systems (P-GIS) for natural resource management and food security in Africa.

58 Ordway, E., 2015. *Political shifts and changing forests: Effects of armed conflict on forest conservation in Rwanda*. Global Ecology and Conservation.

59 USAID, 2017. LandLinks Country Profile: Rwanda. https://www.land-links.org/country-profile/rwanda/

60 Rwanda Water and Forestry Authority, 2017. *Forest Investment Program for Rwanda*.

61 Foster & Graham, 2014. *Connectivity and the Tea Sector in Rwanda: Value Chains and Networks of Connectivity-Based Enterprises in Rwanda.*

positive, including but not limited to tourism-based income, beekeeping, and improved cooking stoves (3.2.2, 3.2.4). Central to these activities will be facilitation of access to market chains (3.2.3) and financial mechanisms for establishing and maintaining businesses (3.3.1, 3.3.2, 3.3.3). Given that these activities are designed at the core to be profitable and promote financial sustainability, it is intended that they be replicable, and sustained once GCF funding expires.

**Assumptions**. Success in achieving Project outcomes will depend on important assumptions being met, among them that governmental and non-governmental actors will be willing to work in collaboration across sectoral and geographic boundaries; rural adoption of alternative farming and off-farm revenue generation can be scaled up to drive a landscape-level transition to sustainability; financing and revenue-generating mechanisms will be established that assure continuance of initiated actions; and governmental commitment to natural forest restoration and ecosystem-based adaptation continues in national strategies and in meeting global commitments.

The pathways summarized in this ToC are expected to contribute to the overall goal and outcomes of the Project**: natural forests** and **vulnerable communities** will be more resilient and sustainable despite climate impacts, with effective, **coordinated management** across the CND landscape. In doing so, important co-benefits will accrue. Intentional, inclusive engagement in management coordination will **empower women and youth** in environmental thinking and decision making. Forest conservation and restoration, along with agroforestry, will contribute to greater **carbon sequestration and storage,** while fire management and greater cooking efficiency will **reduce GHG emissions**. The globally unique, endemic **biodiversity** of Rwanda's forests, from great apes to rare orchids, will recover on the basis of healthy, more connected and resilient forest habitat.

The options considered for each of these components and the rationale for those selected are presented in the next section.

## *5. OPTIONS ANALYSIS AND JUSTIFICATION*

The Government of Rwanda (GoR) understands the importance of the country's forests for GHG removals. It also understands that ecosystem services from forests are critical to the welfare of its people and to agricultural productivity, especially in the CND. The GoR is strongly committed to achieving climate resilience and has set and achieved its target of achieving 30% forest cover by 2020. Despite these commitments and achievements, various barriers still prevent Rwanda from achieving the preferred long-term solution of resilient forest ecosystems and resilient livelihoods.

To identify potential solutions to address the barriers described in the section above, we undertook an options analysis based on literature review and stakeholder consultation. This analysis compares and contrasts different approaches to forest landscape restoration and potential financial solutions for the financial sustainability of CND landscape post GCF.

### *5.1. Restoration of Natural Forest in Degraded Ecosystems*

Rwanda's natural montane forest plays an essential role in capturing and creating rainfall to support rain-fed agriculture[62], as native tropical forests are more effective at capturing and storing water than invasive or plantation forests[63]. They also deliver a substantially wider range of ecosystem services compared to plantations[64]. In Nyungwe National Park - the largest block of montane forest remaining in Rwanda - climate change already has altered species composition and fire regimes, reducing EbA value and carbon sequestration[65]. Nyungwe National Park has lost 13% of its natural forest from wildfires since 1997[66], and previously burned areas are more susceptible to drying and recurring fires. One of the key goals of the Government of Rwanda's overall climate adaptation strategy is to enhance the forest ecosystem services needed for climate resilience of vulnerable communities, and Table 7 outlines potential options that could be used to restore natural forest in Rwanda.

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62 Seimon, A. 2012. Climatology and Potential Climate Change Impacts of the Nyungwe Forest National Park, Rwanda. WCS Technical Report, Wildlife Conservation Society, New York, USA

63 Takahashi, Mami, Thomas W. Giambelluca, Ryan G. Mudd, John K. DeLay, Michael A. Nullet, and Gregory P. Asner. "Rainfall Partitioning and Cloud Water Interception in Native Forest and Invaded Forest in Hawai'i Volcanoes National Park." *Hydrological Processes* 25, no. 3 (2011): 448–64. https://doi.org/10.1002/hyp.7797.

64 Yamaura, Yuichi, Yusuke Yamada, Toshiya Matsuura, Koji Tamai, Hisatomo Taki, Tamotsu Sato, Shoji Hashimoto, et al. "Modeling Impacts of Broad-Scale Plantation Forestry on Ecosystem Services in the Past 60 Years and for the Future." *Ecosystem Services* 49 (June 1, 2021): 101271. https://doi.org/10.1016/j.ecoser.2021.101271.

65 Masozera, M., 2008. Valuing and Capturing the Benefits of Ecosystem Services of Nyungwe Watershed, SW Rwanda. Wildlife Conservation Society Report. Colchester, Vermont, USA

66 MINITERE (2005). Biodiversity Conservation in Rwanda. Collected works of the protected areas biodiversity project (PAB).

**Table 7. Options for natural forest restoration in Rwanda**

| Potential Activity | Description | Pros | Cons | Cost |
|---|---|---|---|---|
| Assisted Natural Regeneration - Fern Clearing | Invasive ferns species (*Pteridium aquilinum*) are cleared every three months for 3 years, without clearing other tree species. Removing the hyper-competitive *P. aquilinum* facilitates growth of native trees, which – when tall enough – shade the fern and inhibit its growth. This then facilitates natural regeneration as normal [67] | • Demonstrated to facilitate large increases in trees per hectare (from ~1000-2000/ha to 3000-6000/ha), tree height (from 25cm to 200cm), and species diversity (30-50% increase), in both Nyungwe National Park and Gishwati-Mukura National Park (Masozera 2004)[68,69]<br>• Long-term benefits to vegetation structure and species diversity are higher than under active restoration[70], resulting in greater forest resilience and ecosystem service benefits overall | • Biomass accumulation rates are initially higher in tree plantations compared to natural regeneration areas, though differences diminish over time[71,72,73] | $1985/ ha[74] |
| Active Restoration | A mixture of desirable native forest species are planted, with species choice based on forest type, elevation, slope etc. Non-native species such as *P.* | • Short-term biomass accumulation is somewhat higher than assisted natural regeneration, though | • No clear difference in recovery speed or completeness, when compared to | ~$3000-5000 in *P. aquilinum* dominated areas (cost of |

67 Masozera, A.B., Regeneration of Burned Forested Areas With Periodic Removal of Pteridium aquilinum. Wildlife Conservation Society Rwanda, 2004.

68 Masozera, A.B., Regeneration of Burned Forested Areas With Periodic Removal of Pteridium aquilinum". Wildlife Conservation Society Rwanda, 2004.

69 Arakwiye et al. (in prep). Early ecological outcomes of passive and active forest restoration approaches in Western Rwanda

70 Crouzeilles, R., Ferreira, M.S., Chazdon, R.L., Lindenmayer, D.B., Sansevero, J.B.B., Monteiro, L., Iribarrem, A., Latawiec, A.E., Strassburg, B.B.N., 2017. Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. Science Advances 3, e1701345. https://doi.org/10.1126/sciadv.1701345

71 Arakwiye et al. (in prep). Early ecological outcomes of passive and active forest restoration approaches in Western Rwanda

72 Crouzeilles, R., Ferreira, M.S., Chazdon, R.L., Lindenmayer, D.B., Sansevero, J.B.B., Monteiro, L., Iribarrem, A., Latawiec, A.E., Strassburg, B.B.N., 2017. Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. Science Advances 3, e1701345. https://doi.org/10.1126/sciadv.1701345

73 Meli, Paula, Karen D. Holl, José María Rey Benayas, Holly P. Jones, Peter C. Jones, Daniel Montoya, and David Moreno Mateos. "A Global Review of Past Land Use, Climate, and Active vs. Passive Restoration Effects on Forest Recovery." *PLOS ONE* 12, no. 2 (March 2, 2017): e0171368.

74 WCS Fern Clearing Project – Nyungwe National Park

| Potential Activity | Description | Pros | Cons | Cost |
|---|---|---|---|---|
| | *aquilinum* or *Eucalyptus* are removed. | differences diminish over time[75,76] | passive/natural restoration[77]<br>• Where *P. aquilinum* is established, the cost is very high in comparison to assisted natural regeneration, as fern clearing is still required, and all costs of tree planting are additional | fern clearing + cost of sourcing and planting indigenous species)<br>~$1000-3000 in areas without *P. aquilinum* |
| Passive Restoration | Degraded areas are left to regrow naturally, and may be fenced to prevent cropping, tree harvesting etc. | ● Very low cost | ● Ferns out-compete native tree species, so forest regeneration is very slow where *P. aquilinum* is established, and in many cases does not occur at all<br>● Only suitable in areas with an existent seed bank, or where nearby good-condition forest can facilitate seed dispersal[78] | $0-500 ha |

There are three main options available for restoration of natural forest in Rwanda (Table 7), and the most suitable approach depends on the current state of the land being restored. In areas that are dominated by the invasive fern *P. aquilinum*, such as large parts of Nyungwe National Park, assisted natural regeneration is the most cost-effective way to deliver forest restoration benefits. Multi-year research conducted by the Wildlife Conservation Society (WCS) in Nyungwe National

[75] Arakwiye et al. (in prep). Early ecological outcomes of passive and active forest restoration approaches in Western Rwanda

[76] Crouzeilles, R., Ferreira, M.S., Chazdon, R.L., Lindenmayer, D.B., Sansevero, J.B.B., Monteiro, L., Iribarrem, A., Latawiec, A.E., Strassburg, B.B.N., 2017. Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. Science Advances 3, e1701345. https://doi.org/10.1126/sciadv.1701345

[77] Masozera, A.B., Regeneration of Burned Forested Areas With Periodic Removal of Pteridium aquilinum. Wildlife Conservation Society Rwanda, 2004.

[78] Arakwiye et al. (in prep). Early ecological outcomes of passive and active forest restoration approaches in Western Rwanda

Park has demonstrated that assisted natural regeneration via fern clearing facilitates rapid recovery of natural forest species. Over a period of 2-3 years, fern clearing treatments resulted in 8-fold increases in average tree height, as well as increased species diversity (Figure 13)[79]. Compared to fern clearing alone, very little difference was observed in plots where fern clearing was augmented with tree planting, suggesting it is not necessary for effective forest restoration.

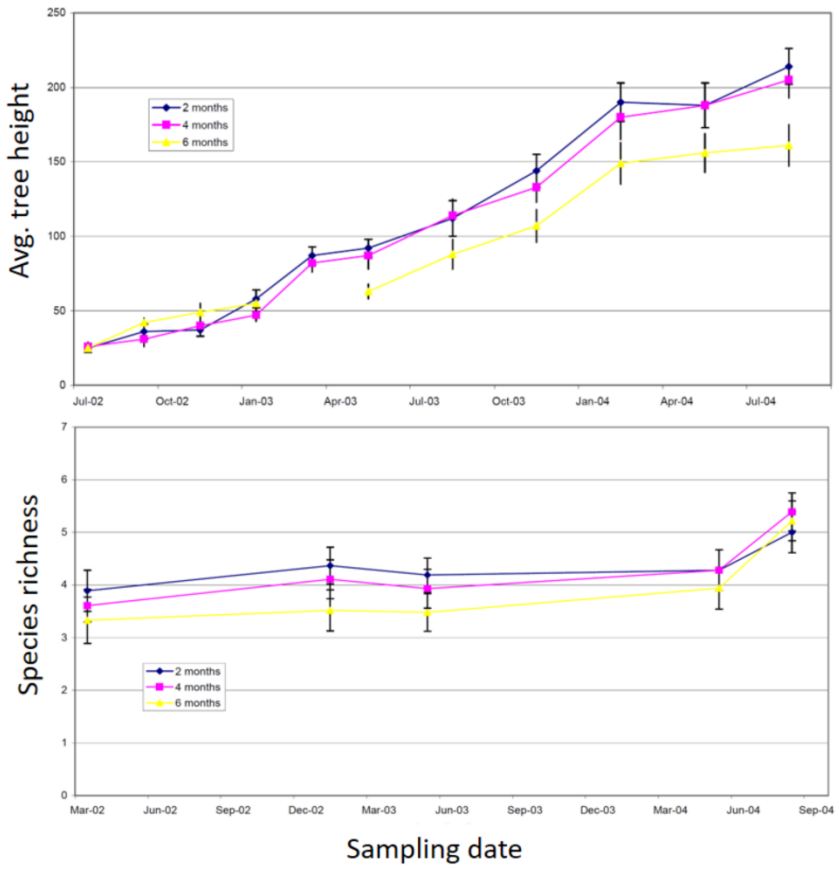


Figure 13. Results of fern clearing treatment in Nyungwe National Park. The top panel demonstrates the effect of fern clearing on tree height, while the bottom panel shows the effect of fern clearing on species richness. Line colours represent different intervals between fern clearing treatments.

In degraded forests where *P. aquilinum* is not established, such as Gishwati-Mukura National Park, a passive restoration approach may be suitable. Evidence from passive restoration sites in Gishwati shows that, after only 7 years, the number of trees per hectare in some sites is approaching levels seen in natural forest fragments (Figure 14)[80]. Non-native species such as *Eucalyptus* and *Pinus* also occur in these sites, so an assisted natural regeneration approach (where exotic species are cut) could be used in these areas also; however, it would be substantially cheaper since *Eucalyptus* and *Pinus* are scattered trees rather than a thick blanket

79 Masozera, A.B., Regeneration of Burned Forested Areas With Periodic Removal of Pteridium aquilinum. Wildlife Conservation Society Rwanda, 2004.

80 Arakwiye et al. (in prep). Early ecological outcomes of passive and active forest restoration approaches in Western Rwanda

like *P. aquilinum*).

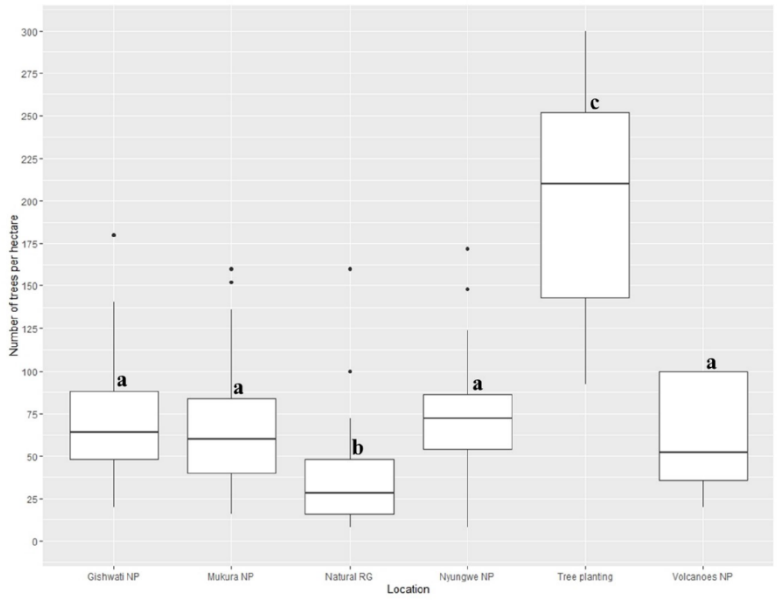


Figure 14. Number of trees per hectare across various forest types in the CND. Natural regeneration sites show tree density levels approaching that of natural forest remnants, despite degrading activities (agriculture, livestock grazing) ceasing just 7 years ago. Acronyms: *NP* - National Park, *Natural RG* - Natural Regeneration Sites, *Tree Planting* - Exotic Plantation Sites

### *5.2. Agroforestry*

The GoR has prioritised agroforestry as a key components of climate change adaptation strategies for the CND[81]. Key goals of the GoR's overall climate adaptation strategy are to: i) enhance the forest ecosystem services needed for climate resilience of vulnerable communities, ii) reduce soil and crop loss from erosion, flooding and landslides (thereby reducing pressure for conversion of forest to agriculture), and iii) increase overall woodfuel supply[82]. The table below summarises agroforestry options that could be used to achieve some or all of these goals.

81 Rwanda Ministry of Natural Resources, 2014. Forest Landscape Restoration Opportunity Assessment for Rwanda. Government of Rwanda, Kigali

82 Rwanda MINILAF, 2018. Rwanda National Forestry Policy 2018. Kigali.

**Table 8: Options for agroforestry in Rwanda**

| Potential Activity | Description | Pros | Cons | Cost |
|---|---|---|---|---|
| Agroforestry - current practices (focus on exotic species) | Farming system with well managed trees on hedgerows and farm boundaries for firewood, fodder and erosion control.<br><br>Silvicultural practices often poorly applied (e.g. over pruning, trees too closely spaced), leading to reduced erosion control benefits. | • Demonstrated to reduce erosion and stabilizes land, without removing area for cropping[83]. Living hedges can reduce erosion from 300 t/ha/yr to 2 t/ha/yr[84]<br>• Increases water infiltration, reducing runoff and erosion. Studies show water infiltration is three times higher under agroforestry compared to control plots[85]<br>• Provides woodfuel and NTFPs[86]<br>• Already widely adopted in the CND[87] | • Many exotic species are used, some of which have negative impacts (e.g. become invasive)[88]<br>• Eucalyptus establishment has been shown to have detrimental effects on soil quality and fertility[89]<br>• Trees on farms are sometimes thought to reduce crop yields[90]<br><br>• Many farmers lack technical knowledge of agroforestry practices[91]<br><br>• Exotic species have high susceptibility to risks such as pests and diseases[92] | USD $700/ha (seed procurement, seedling production, site preparation, planting and maintenance) (source: RFA) |
| Agroforestry - diversified tree species promoted with focus on indigenous species | Farming system with well managed indigenous trees on hedgerows and farm boundaries for firewood, fodder and erosion control. | • Demonstrated to reduce erosion and stabilises land, without removing area for cropping[93]. Living hedges can reduce | • Low demand for indigenous tree species due to limited knowledge | USD 900 per ha for indigenous species including seed procurement, seedling production, site |

83 Fleskens, Luuk. “Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification.” Kigali, 2007.

84 Roose, E., Ndayizigiye, F., 1997. Agroforestry, water and soil fertility management to fight erosion in tropical mountains of Rwanda. Soil Technology, Soil Erosion Processes on Steep Lands 11, 109– 119. https://doi.org/10.1016/S0933-3630(96)00119-5

85 Kuyah, Shem, Cory W. Whitney, Mattias Jonsson, Gudeta W. Sileshi, Ingrid Öborn, Catherine W. Muthuri, and Eike Luedeling. “Agroforestry Delivers a Win-Win Solution for Ecosystem Services in Sub-Saharan Africa. A Meta-Analysis.” *Agronomy for Sustainable Development* 39, no. 5 (September 9, 2019): 47.

86 Kiyani, Pilote, Jewel Andoh, Yohan Lee, and Don Koo Lee. “Benefits and Challenges of Agroforestry Adoption: A Case of Musebeya Sector, Nyamagabe District in Southern Province of Rwanda.” *Forest Science and Technology* 13, no. 4 (October 2, 2017): 174–80. https://doi.org/10.1080/21580103.2017.1392367.

87 District Development Strategies 2018-2024

88 Hagumubuzima, F. 2019. Assessment of Impacts of Removing Eucalyptus Species on Natural Regeneration of Native Species at Gishwati-Mukura National Park. Huye, Rwanda

89 Daba, Mekonnen H. 2016. The Eucalyptus Dilemma: The Pursuit for Socio-Economic Benefit versus Environmental Impacts of Eucalyptus in Ethiopia. Journal of Natural Sciences Research.

90 ICRAF, Rwanda Agriculture and Animal Resources Development Authority, World Vision Rwanda, CSIRO, 2021. TREES FOR FOOD SECURITY-2 PROJECT RWANDA HIGHLIGHTS. Kigali.

91 Uwineza, M.C., Yujun, S., Ndekezi, A., 2019. Farmer’s Perceptions on Importance and Role of Agroforestry Species in Karago, Rwanda. International Journal of Sciences 8, 72–79. https://doi.org/10.18483/ijSci.1882

92 https://www.newtimes.co.rw/section/read/202698

93 Fleskens, Luuk. “Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification.”

| Potential Activity | Description | Pros | Cons | Cost |
|---|---|---|---|---|
| | Farmers applying appropriate silvicultural practices - e.g. appropriate spacing respected, shrub coppicing, tree pruning, and harvest schedule respected, leading to increased availability of tree products, erosion reductions, and optimized crop production. | erosion from 300 t/ha/yr to 2 t/ha/yr[94]<br>• Provides woodfuel and NTFPs[95]<br>• Restored landscape ecological integrity, biodiversity conservation, and enhanced ecosystem services such as pollination [96,97]<br>• Indigenous species are likely to be suited to conditions of the CND, unlike some exotic species | of uses and benefits of farming communities[98]<br>• Lack of access to propagation materials of indigenous tree species[99]<br>• Many indigenous species are perceived to be not as beneficial as exotic in terms of tree products[100]<br>• Farmers perceive complicated management as a constraint[101] | preparation, planting and maintenance. (Source: RFA) |

Kigali, 2007.

94 Roose, E., Ndayizigiye, F., 1997. Agroforestry, water and soil fertility management to fight erosion in tropical mountains of Rwanda. Soil Technology, Soil Erosion Processes on Steep Lands 11, 109– 119. https://doi.org/10.1016/S0933-3630(96)00119-5

95 Kiyani, Pilote, Jewel Andoh, Yohan Lee, and Don Koo Lee. "Benefits and Challenges of Agroforestry Adoption: A Case of Musebeya Sector, Nyamagabe District in Southern Province of Rwanda." *Forest Science and Technology* 13, no. 4 (October 2, 2017): 174–80.

96 Jose, Shibu. "Agroforestry for Ecosystem Services and Environmental Benefits: An Overview." *Agroforestry Systems* 76, no. 1 (May 1, 2009): 1–10. https://doi.org/10.1007/s10457-009-9229-7.

97 Asigbaase, Michael, Sofie Sjogersten, Barry H. Lomax, and Evans Dawoe. "Tree Diversity and Its Ecological Importance Value in Organic and Conventional Cocoa Agroforests in Ghana." *PLOS ONE* 14, no. 1 (November 1, 2019): e0210557. https://doi.org/10.1371/journal.pone.0210557.

98 Uwineza, M.C., Yujun, S., Ndekezi, A., 2019. Farmer's Perceptions on Importance and Role of Agroforestry Species in Karago, Rwanda. International Journal of Sciences 8, 72–79. https://doi.org/10.18483/ijSci.1882

99 Rwanda Ministry of Lands and Forestry. National Tree Reproductive Materials Strategy 2018 – 2027. Kigali, 2018.

100 Ndayambaje, J. D., T. Mugiraneza, and G. M. J. Mohren. "Woody Biomass on Farms and in the Landscapes of Rwanda." *Agroforestry Systems* 88, no. 1 (February 1, 2014): 101–24. https://doi.org/10.1007/s10457-013-9659-0.

101 Liyama, Miyuki, Athanase Mukuralinda, Jean Damascene Ndayambaje, Bernard S. Musana, Alain Ndoli, Jeremias G. Mowo, Dennis Garrity, Stephen Ling, and Vicky Ruganzu. "Addressing the Paradox – the Divergence between Smallholders' Preference and Actual Adoption of Agricultural Innovations." International Journal of Agricultural Sustainability 16, no. 6 (November 2, 2018): 472–85.

Agroforestry is a proven method for erosion control and woodfuel supply in Rwanda and has been adopted across the CND. Agroforestry systems can prevent soil erosion and replenish soil nutrients, such as nitrogen, phosphorus, calcium and magnesium and thus aid in increasing agricultural output[102]. A meta-analysis of 116 agroforestry studies in Sub-Saharan Africa found that runoff control and soil loss were five and nine times lower with agroforestry compared to control areas, and water infiltration was three times higher in agroforestry compared to the control[103]. Average crop yield was almost twice as high in agroforestry as in non-agroforestry systems; and soil fertility was improved by a factor of 1.2. These benefits are recognised by farmers in many areas of the CND. When surveyed in 2017, 84 of 113 respondents (a mix of agroforestry adopters & non-adopters) in Nyamagabe district said that agroforestry has increased soil fertility in the area, 86 said it has reduced deforestation of the natural forests, and 82 agreed that this new technology has reduced soil erosion[104].

While offering many benefits in terms of erosion control and woodfuel supply, business as usual agroforestry in the CND faces a number of issues. The exotic species that are commonly planted (e.g. *Eucalyptus*) are often of very poor genetic quality, which can lead to pest and disease establishment[105], and are also often unsuited to the climatic conditions of the CND[106]. Additionally, common agroforestry species such as *Alnus acuminata* have become established invasive species in the small remaining natural forest patches in Gishwati-Mukura National Park[107].

Given these issues, the most appropriate option for agroforestry promotion in the CND is to focus on indigenous species as much as possible. Beyond providing the erosion control and woodfuel benefits normally associated with agroforestry, using native species can also restore landscape ecological integrity, improve biodiversity conservation, and enhance ecosystem services such as pollination[108,109]. While current farmer preferences lean towards exotic species like *Eucalyptus* & *Alnus*, this is likely because those species have been promoted by agroforestry projects for decades, while the potential benefits of indigenous species have mostly been ignored. As such,

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102 Stainback, G. Andrew, Michel Masozera, Athanase Mukuralinda, and Puneet Dwivedi. "Smallholder Agroforestry in Rwanda: A SWOT-AHP Analysis." *Small-Scale Forestry* 11, no. 3 (September 1, 2012): 285–300.

103 Kuyah, Shem, Cory W. Whitney, Mattias Jonsson, Gudeta W. Sileshi, Ingrid Öborn, Catherine W. Muthuri, and Eike Luedeling. "Agroforestry Delivers a Win-Win Solution for Ecosystem Services in Sub-Saharan Africa. A Meta-Analysis." *Agronomy for Sustainable Development* 39, no. 5 (September 9, 2019): 47.

104 Kiyani, Pilote, Jewel Andoh, Yohan Lee, and Don Koo Lee. "Benefits and Challenges of Agroforestry Adoption: A Case of Musebeya Sector, Nyamagabe District in Southern Province of Rwanda." *Forest Science and Technology* 13, no. 4 (October 2, 2017): 174–80.

105 Unique ltd (Consultant), 2015. Manual of tree plantation establishment and management. Developed for RNRA under the PAREF Be2 project

106 Nef, Danny P., Elisabetta Gotor, Gabriela Wiederkehr Guerra, Marius Zumwald, and Chris J. Kettle. "Initial Investment in Diversity Is the Efficient Thing to Do for Resilient Forest Landscape Restoration." Frontiers in Forests and Global Change 3 (2021): 152. https://doi.org/10.3389/ffgc.2020.615682.

107 Hagumubuzima, F. 2019. Assessment of Impacts of Removing Eucalyptus Species on Natural Regeneration of Native Species at Gishwati-Mukura National Park. Huye, Rwanda

108 Jose, Shibu. "Agroforestry for Ecosystem Services and Environmental Benefits: An Overview." *Agroforestry Systems* 76, no. 1 (May 1, 2009): 1–10. https://doi.org/10.1007/s10457-009-9229-7.

109 Asigbaase, Michael, Sofie Sjogersten, Barry H. Lomax, and Evans Dawoe. "Tree Diversity and Its Ecological Importance Value in Organic and Conventional Cocoa Agroforests in Ghana." *PLOS ONE* 14, no. 1 (November 1, 2019): e0210557.

an education, outreach and promotion program focused on indigenous species and their benefits should increase demand. In addition, to incentivize smallholder farmers to adopt indigenous species, the project will provide seedlings free of charge. Farmers will only invest their labor in maintaining and managing trees on the farm.

### *5.3. Protective Forests*

The CND is extremely vulnerable to floods and landslides[110], and the risk is now escalating due to climate change. These impacts cause crop failures and decreasing crop yields, causing farmers to convert more forests to farmland to maintain yields[111,112]. Farmers that lost crops or cannot maintain sufficient yields may also obtain fuelwood and non-timber forest products (NTFPs) from forests, further driving forest degradation. In the Government of Rwanda's overall climate adaptation strategy, one of the key goals is to reduce soil and crop loss from erosion, flooding and landslides (thereby reducing pressure for conversion of forest to agriculture), and also to increase overall woodfuel supply[113]. The table below summarizes options that could be used to achieve some or all of these goals.

**Table 9. Options for protective forests in Rwanda**

| Potential Activity | Description | Pros | Cons | Approximate Cost |
|---|---|---|---|---|
| Protective forests - monoculture of exotic species | Forests are planted on steep slopes to reduce erosion and landslide risk, and provide timber products. In Rwanda, most protective forests are Eucalyptus or Pine species. | • Effective at reducing erosion and stabilising land. Average soil erosion rates in forests are 6 times lower than in cropped areas[114]<br>• Well-managed exotic forests can provide 100-250 cubic metres of wood per hectare[115] | • Plantation forests exhibit 24% lower soil fertility when compared to natural forest, suggesting overall soil loss & degradation[116]<br>• Monocultures are on average 26-66% less productive than mixed indigenous forests worldwide[117] | USD $1100/ha[120] |

110 Rwanda Ministry of Disaster Management and Refugee Affairs, 2012. Disaster High Risk Zones on Floods and Landslides. Kigali, Rwanda

111 Arakwiye, Bernadette, John Rogan, and J. Ronald Eastman. "Thirty Years of Forest-Cover Change in Western Rwanda during Periods of Wars and Environmental Policy Shifts." Regional Environmental Change 21, no. 2 (March 8, 2021): 27. https://doi.org/10.1007/s10113-020-01744-0.

112 Drigo, R., Munverhirwe, A., Nzabanita, V., Munvampundu, A., 2013. Update and upgrade of WISDOM Rwanda and Woodfuels value chain analysis. Rwanda Natural Resources Authority, Kigali.

113 Rwanda MINILAF, 2018. Rwanda National Forestry Policy 2018. Kigali.

114 Byizigiro, R. V., G. Rwanyiziri, M. Mugabowindekwe, C. Kagoyire, and M. Biryabarema. "Estimation of Soil Erosion Using RUSLE Model and GIS: The Case of Satinskyi Catchment, Western Rwanda." *Rwanda Journal of Engineering, Science, Technology and Environment* 3, no. 1 (July 10, 2020). https://doi.org/10.4314/rjeste.v3i1.2S.

115 Rwanda Ministry of Environment, 2015. National Forest Inventory. Kigali.

116 Mukashema, A. 2007. Mapping and Modelling Landscape-based Soil Fertility Change in Relation to Human Induction. Enschede, The Netherlands

117 Liang, Jingjing, Thomas W. Crowther, Nicolas Picard, Susan Wiser, Mo Zhou, Giorgio Alberti, Ernst-Detlef Schulze, et al. "Positive Biodiversity-Productivity Relationship Predominant in Global Forests." *Science* 354, no. 6309 (October 14, 2016): aaf8957. https://doi.org/10.1126/science.aaf8957.

120 GCF TREPA Project Budget

| Potential Activity | Description | Pros | Cons | Approximate Cost |
|---|---|---|---|---|
| | | | • Commonly used exotic species are susceptible to disease & pests[118], and often unsuited to specific planting site conditions[119] | |
| Protective forests - mixed indigenous species | Indigenous forests are planted on steep slopes to reduce erosion and landslide risk and provide timber products. | • Effective at reducing erosion and stabilising land. Average soil erosion rates in forests are 6 times lower than in cropped areas [121]<br>• Species richness is consistently positively correlated with forest productivity worldwide. Globally, a 10% loss of species richness is equal to a 3% loss in forest productivity, and monocultures are on average 26-66% less productive than mixed indigenous forests[122]<br>• Mixed plantation forests are often more productive than monoculture, as different species require different ratios of nutrients. Mixed plantations in Central America produced 21% more wood than monocultures[123].<br>• Mixed forest designed with diverse wood densities can provide products in both the | • Supply of indigenous seedlings is limited in Rwanda[126]<br>• Indigenous trees are generally slower growing than commonly used exotics (e.g. *Eucalyptus* or *Pinus*) | $3,300 ha[127]<br>$1500 ha[128]<br>$972 ha[129] |

118 Unique ltd (Consultant), 2015. Manual of tree plantation establishment and management. Developed for RNRA under the PAREF Be2 project

119 Nef, Danny P., Elisabetta Gotor, Gabriela Wiederkehr Guerra, Marius Zumwald, and Chris J. Kettle. "Initial Investment in Diversity Is the Efficient Thing to Do for Resilient Forest Landscape Restoration." Frontiers in Forests and Global Change 3 (2021): 152. https://doi.org/10.3389/ffgc.2020.615682.

121 Byizigiro, R. V., G. Rwanyiziri, M. Mugabowindekwe, C. Kagoyire, and M. Biryabarema. "Estimation of Soil Erosion Using RUSLE Model and GIS: The Case of Satinskyi Catchment, Western Rwanda." *Rwanda Journal of Engineering, Science, Technology and Environment* 3, no. 1 (July 10, 2020). https://doi.org/10.4314/rjeste.v3i1.2S.

122 Liang, Jingjing, Thomas W. Crowther, Nicolas Picard, Susan Wiser, Mo Zhou, Giorgio Alberti, Ernst-Detlef Schulze, et al. "Positive Biodiversity-Productivity Relationship Predominant in Global Forests." *Science* 354, no. 6309 (October 14, 2016): aaf8957. https://doi.org/10.1126/science.aaf8957.

123 Petit, Bryan, and Florencia Montagnini. "Growth in Pure and Mixed Plantations of Tree Species Used in Reforesting Rural Areas of the Humid Region of Costa Rica, Central America." Forest Ecology and Management, Improving Productivity in Mixed-Species Plantations, 233, no. 2 (September 15, 2006): 338–43.

126 Rwanda MINILAF, 2018. National Tree Reproductive Materials Strategy 2018 – 2027. Kigali, Rwanda.

127 Wilderness Safaris Forest Restoration Project - Volcanoes NP

128 Forests of Hope Forest Restoration Project - Gishwati region

129 LAFREC Project Forest Restoration in Gishwati region

| Potential Activity | Description | Pros | Cons | Approximate Cost |
|---|---|---|---|---|
| | | short-term and long-term, reducing the wait time before plantation benefits are realised[124]<br>• Provide wood fuel and NTFPs[125]<br>• Will directly increase extent and connectivity of indigenous forests, enhancing overall forest resilience | | |
| Agroforestry- Increasing trees on farms for soil and water management for soil erosion control (Radical terraces/bench terraces) | Agricultural systems, stabilized with well managed trees on hedge rows, contour lines, radical and progressive terraces. Farmers applying appropriate silvicultural practices. Appropriate spacing respected, shrub coppicing, tree pruning, and harvest schedule respected, leading to increased availability of tree products (firewood, fodder and stakes) and optimized irish potato/bean production.<br>Land slope: 12-54% | • Effectively control erosion up to 90% of soil and nutrient losses (Rutebuka et al. 2020b)[130]<br>• Improve soil health (Kuria et al. 2017)<br>• Restore landscape ecological integrity and enhanced ecosystem services such as pollination (FAO 2017)<br>• Increase availability of tree products such as fodder, firewood and stakes (Mukuralinda et al. 2016) | ● Requires regular maintenance<br>● Farmers might be reluctant in adopting land husbandry technologies like terraces if they are not getting expected optimal yield in the first years because it requires at least four years for restoring soil fertility.<br>● Higher costs of investment and maintenance compared to the farmer's capacity hinders farmers from exploiting established terraces. | 2,200 -2,600 USD per hectare (source: IUCN Sebeya project and MINAGRI) |
| Progressive terraces/hedgerow for soil erosion control | Biological methods for soil erosion control on moderate slopes (2 to 30% of slopes). Right trees are planted on moderate slopes, the | ● Soil erosion control through progressive terraces and underground water recharge progressively (Ndayizigiye et al. 1993) | ● Exotic species are much used due to their fast growth and easy propagation methods | Progressive terraces on 1 ha (USD 813.98 = FRW 500,000 in 2012, Source: Bizoza |

124 Nguyen, Huong, Jennifer Firn, David Lamb, and John Herbohn. "Wood Density: A Tool to Find Complementary Species for the Design of Mixed Species Plantations." *Forest Ecology and Management* 334 (December 15, 2014): 106–13. https://doi.org/10.1016/j.foreco.2014.08.022.

125 Ndayambaje, J.D., Mohren, G.M.J., 2011. Fuelwood demand and supply in Rwanda and the role of agroforestry. Agroforestry Systems 83, 303–320.

130 Rutebuka, J., Munyeshuli Uwimanzi, A., Nkundwakazi, O., Mbarushimana Kagabo, D., Mbonigaba, J.J.M., Vermeir, P., Verdoodt, A., 2020b. Effectiveness of terracing techniques for controlling soil erosion by water in Rwanda. J. Environ. Manage. 277, 111369

| Potential Activity | Description | Pros | Cons | Approximate Cost |
|---|---|---|---|---|
| | trees reduce soil erosion serving as physical barrier for sediments, increasing infiltration through root channels and litter accumulation around trees / shrubs for increasing organic matter for water retention and reduce runoff. Appropriate tree spacing and slopes respected. Trees/ shrubs coppiced and pruned to increase the efficiency of biological methods for soil erosion control. Coppicing and pruning trees provide tree products (Stakes for climbing, firewood, fodder) increase maize, beans and potatoes once green manure is incorporated and if not used as fodder, the manure is returned to field. | ● Improve soil health through green manure incorporation to increase soil organic matter and increase microorganism activities (Kuria et al. 2017 and Leigh and al 2020)<br>● Restore landscape ecological integrity and enhanced ecosystem services such as pollination (FAO 2017)<br>● Increase availability of tree products such as fodder, firewood and stakes (Mukuralinda et al. 2016, Rutebuka et al. 2021)<br>● Increase carbon sequestration (Rusanganwa et al 2021)<br>● Stabilize landscape progressively with reduced risks of landslides (Kagabo et al. 2013, Mukuralinda et al. 2016) | ● Crop production may drop due to poor management of trees planted on hedgerows (Rutebuka et al. 2021)<br>● Soil erosion control is progressive and take time to stabilize soil erosion (Kagabo et al. 2013)<br>● Many farmers have limited knowledge on hedgerows management and tree products utilization (Rutebuka et al. 2021)<br>● Low effectiveness can induce a high redistribution of soil nutrients within individual terraces. (Kagabo et al. 2013, Rutebuka et al. 2021) | and De Graaff 2012) |

There are three main options available for controlling erosion on very steep slopes in the Congo Nile Divide (Table 9). Protective forests - where forests are established on steep slopes to prevent erosion and landslides - are very effective at reducing erosion, and are prioritised in the government's National Forest Policy. Fleskens et al. (2007) synthesized runoff experiments in Rwanda and Burundi to show that soil erosion rates in forests are up to 150 times lower than in cropped areas, and up to 500 times lower than on bare soil (Table 10)[131]. Because protective forests deliver substantial erosion and land stabilization benefits, while also helping provide wood fuel and non-timber forest products, they are a very suitable approach for erosion control in the CND. Although costly and lacking in some of the benefits of natural forests, physical erosion control measures - e.g. terracing - can also provide substantial erosion reductions.

[131] Fleskens, Luuk, 2012. Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification. Kigali.

**Table 10. Synthesis of erosion and run-off values collected on run-off plots in Rwanda and Burundi (Source: Fleskens et al. 2007)**

| ***Land Cover*** | ***Treatment*** | ***Erosion (t/ha/yr)*** |
|---|---|---|
| Bare Soil | Tilled parallel with slope | 300-550 |
| Crops (Manioc, potato, maize, bean or pea) | Traditional hoe tillage | 50-150 |
| Crops + 200 trees/ha | Traditional hoe tillage + agroforestry trees | 30-50 |
| Coffee Plantation | Thick mulch (20 t/ha/yr) | 0-1 |
| Forest | (5-15 t/yr of leaf litter) | 0-1 |

When establishing protective forests, most existing projects in the CND use exotic species such as *Eucalyptus* and *Pinus,* because these species are fast growing, widely available, and low cost. However, most exotic plantations in the CND are very degraded due to a number of factors including: poor genetic quality of available seedlings, poor management of monoculture plantations (e.g. early pruning, no thinning), and unsuitability of chosen species to local conditions[132]. Using indigenous species - which are well-suited to the climatic conditions of the CND - is likely to increase the health and resilience of forest plantations and thus increase the erosion control benefits that these forests provide. A global review found that tree species richness is consistently positively correlated with forest productivity worldwide and that, globally, a 10% loss of species richness is equal to a 3% loss in forest productivity[133]. As such, this project should promote and facilitate the use of indigenous species wherever possible, although this must be balanced against community needs for fast growing species and the higher cost of using indigenous trees.

[132] Unique ltd (Consultant), 2015. Manual of tree plantation establishment and management. Developed for RNRA under the PAREF Be2 project

[133] Liang, Jingjing, Thomas W. Crowther, Nicolas Picard, Susan Wiser, Mo Zhou, Giorgio Alberti, Ernst-Detlef Schulze, et al. Positive Biodiversity-Productivity Relationship Predominant in Global Forests. *Science* 354, no. 6309 (October 14, 2016): aaf8957

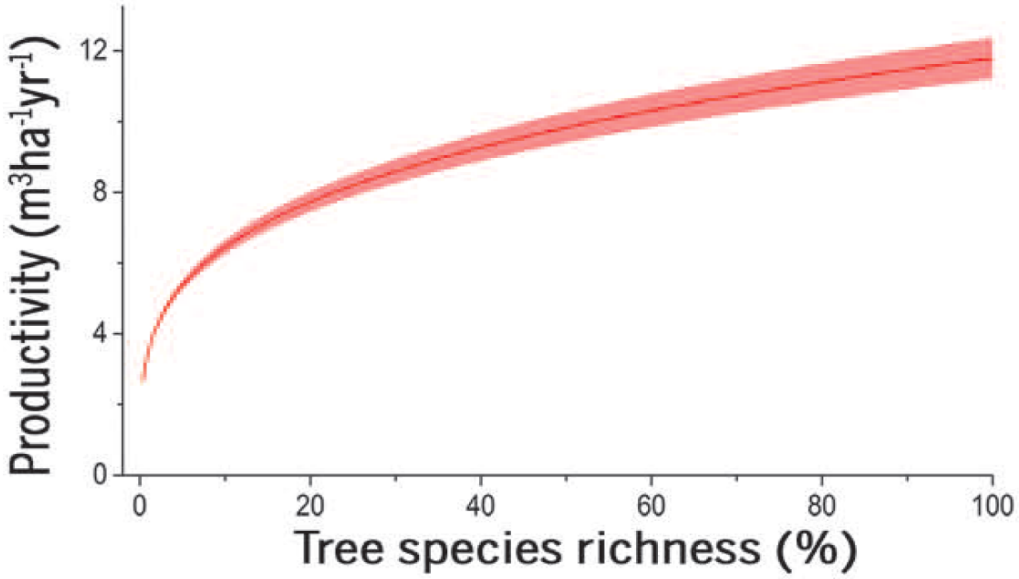


Figure 15. Global relationship between forest species richness and forest productivity, adapted from Liang et al. (2016).

### *5.4. CND financial sustainability post-GCF*

Rwanda has recently developed a Biodiversity Finance Plan[134] through support from BIOFIN. This plan has identified a number of financing solutions that will not only contribute towards improved biodiversity protection in Rwanda, but also aligns with Rwanda's sustainable development and green growth objectives. Table 11 below summarizes options that could be used to achieve some or all of these goals.

[134] BIOFIN Rwanda – Biodiversity Finance Plan, REMA, 2019.

**Table 11: Financing Options**

| Financing Solutions | Description | Pros | Cons |
|---|---|---|---|
| Biodiversity Conservation Fund | The rationale of the finance solution is to establish a dedicated funding window in FONERWA on biodiversity as an opportunity to diversify and expand the sources of financing for the fund and importantly to increase financing for biodiversity. The Biodiversity Conservation Fund window under FONERWA represents the most opportunistic financing mechanism to channel resources directly towards biodiversity conservation efforts. | ● A dedicated fund will elevate the biodiversity focus and status in Rwanda, attracting additional public and private financing for projects directly targeted towards the protection and sustainable use of Rwanda's biodiversity | ● Resistance from institutions may undermine buy-in. Although there is goodwill and a growing positive response to improving and investing in conservation, there is still significant efforts needed to improve coordination among the various institutions to benefit from the opportunities inherent in NBSAP, the nationally endorsed comprehensive approach and a coordinated plan of action to effectively tackle conservation. Considering the current administrative challenges, significant effort will be needed to transform the approach to conservation in a way that provides sufficient support for the Trust Fund as a BIOFIN solution.<br>● Collection of fees and fines as a source of domestic financing is still constrained by regulatory and institutional challenges that must be streamlined and strengthened through cross sector coordination. |
| Water User Fees for Catchment Management | As promulgated under Article 5 of the Water Law, Rwanda adheres to the principles of "user-payer and polluter payer" according to which the user of water and the polluter support a significant part of expenses resulting from measures of prevention, of pollution reduction and restoration of the resource in quality and in quantity[135] | ● This finance solution is directly targeted towards improving the management of Rwanda's network of wetlands, and securing the financial resources necessary to ensure adequate protection of the biodiversity and ecosystem services provided by these wetlands<br>● The proposed solution offers a mechanism to channel the revenue collected from water users into a dedicated fund for ecological infrastructure investments. | ● Investments in ecological infrastructure (landscape restoration) may not have positive biodiversity benefits if non-native species are utilized. It is imperative to consider the biodiversity co-benefits of restoration options.<br>● Lack of political will to impose wetland user fees<br>● Inability to identify investors in wetland development |

135 Law N°62/2008 OF 10/09/2008 putting in place the use, conservation, protection and management of water resources regulations.

| Financing Solutions | Description | Pros | Cons |
|---|---|---|---|
| Promote biodiversity-friendly enterprises in the transition to a Green Economy | The Finance solution targets growth and expansion of private sector investments in biodiversity conservation, an area that is imperative to Rwanda's green economy transition. | ● This solution will accelerate the transition to a green economy by incentivizing and supporting businesses to adopt sustainable practices and attracting investments in biodiversity conservation business enterprises. This finance solution is meant to accelerate the number of investment-grade green business start-ups and incubator/accelerators opportunities, especially among young Rwanda entrepreneurs. | ● A wide range of institutions are involved and the right convener may not be forth coming to gain consensus<br>● Challenges of coordinating the multiple areas to consistently focus FS on Biodiversity<br>● Effective capacity needed to promote biodiversity business may take long to be realized |
| Strengthen the Tourism Revenue Sharing (TRS) Scheme to Improve Conservation Outcomes | This finance solution aims to build on the evidence supporting the need to improve community-based conservation efforts, particularly through investments in integrated conservation-development projects such as the TRS program. | ● Increased community participation in protected area management, resulting in improved protection of national parks. By strengthening the TRS program, it is believed that communities will improve their perceptions of protected areas and conservation efforts, and more actively engage in their protection. | ● Insufficient buy-in from institutions<br>● Inability to identify strong livelihood-conservation linkages for TRS programs<br>● Low participation from community associations |
| Wildlife Conservation Bond | WCB is a payment for performance-based financial instrument that channels investments to achieve conservation outcomes | ● WCB taps a new source of financing by engaging new private and institutional investors rather than investors alone, thereby transferring project outcome risks from donors to investors.<br>● The model is anchored in metrics and evidence, which encourages investors to accept project outcome risks in return for a potential payout in case the project is successful. | ● Increased conservation costs and funding shortfalls once the bond matures. |

Rwanda has recently conducted a Forest Carbon Market Readiness Assessment aimed at evaluating the country's forest mitigation potential and the required elements for the country's participation in carbon markets. This study looked at Rwanda's status of REDD+ elements, Nationally Determined Contributions (NDCs) targets and progress in securing results-based financing from different sources; assessed the country's appetite to apply different carbon standards and evaluated the prospect of emissions reductions credit uses in the country.

The study identified key requirements that for Rwanda to qualify for REDD+ payments under the UNFCCC Framework, including:

1. Development of a Safeguard Information System (SIS) that includes a summary of how all seven Cancun Safeguards are addressed and respected. There are many policies, laws and regulatory frameworks in Rwanda with provisions that would enable Rwanda to comply with the Cancun |Safeguards.

2. Development of a Monitoring, Reporting and Verification (MRV) tools and systems for monitoring emissions for the five REDD+ activities proposed in the FRL. These are (i) reducing emissions from deforestation, (ii) reducing emissions from forest degradation, (iii) conservation of carbon stocks, (iv) sustainable management of forests, and (v) enhancement of carbon stocks. A robust National Forest Monitoring System (NFMS) is also needed. Rwanda has an opportunity to build on the current National Forest Monitoring Evaluation System (NFMES) which already has a MRV function but does not monitor activity data related to reducing emissions from deforestation and forest degradation.

3. Development of a REDD+ policy framework or guidelines for carbon rights, benefit sharing and conflict resolution and Feedback Grievance Redress Mechanism (FGRM).

4. Development of a national forest reference emission level and/or forest reference level.

## *6. FEASIBILITY ASSESSMENT OF ACTIVITIES – SPATIAL BIODIVERSITY ASSESSMENT TO IDENTIFY SITE LOCATIONS AND METHODS FOR FORESTATION AND AFFORESTATION.*

### *6.1. Executive Summary of Spatial Biodiversity Assessment*

The majority of Rwanda's remaining montane forests are restricted to the national parks, which support a variety of threatened and endemic species. A few fragmented forest patches are situated outside of the National Park boundaries. Landcover change (especially for widespread smallholder agriculture), fuelwood harvesting, and human-induced fires, coupled with climate change impacts, especially landslides, erosion and downstream flooding, have compromised the delivery of critical ecosystem services derived from these forests. A detailed spatial analysis of biodiversity in the Congo Nile Divide was conducted to delineate priority areas for the long-term conservation and restoration of forests, and the sustainable management of landscapes, in order to secure the ecosystem services needed to improve the resilience of vulnerable communities to climate change impacts.

This spatial biodiversity assessment for Rwanda's Congo-Nile Divide (CND) is based on a rapid systematic conservation plan, using MARXAN decision-support software. The key analyses involved identifying and mapping the remaining areas of natural forest and other ecosystem types, modeling bioclimatic change and identifying climate change refugia, a Condatis landscape connectivity and bottlenecks analyses, and evaluating ecosystem threat and protection levels. The analyses thus build in landscape connectivity, climate change refugia, biodiversity values, ecosystem services and social costs.

The final outcome of the MARXAN and Condatis connectivity analyses split the CND domain into four major landscape categories with a set of priority implementation areas, each with their own place-bound project interventions. Interventions range from the restoration of natural forest, establishment and improvement of protective forest on steep slopes and along riparian areas; and to implement biodiversity-friendly agroforestry to reduce landslides, erosion and downstream flooding. Over and above these place-bound interventions are a variety of other mechanisms for promoting the sustainability of rural livelihoods and protecting montane forest in Rwanda's CND landscape.

This study was a rapid assessment to support project proposal development and does not replace a full conservation planning process. There are significant additional steps which are required to develop a product that is useful for land use planning during project implementation. These changes include a robust stakeholder engagement process, at a national, district and local scale; incorporation of issues relating to land use rights, both of landowners and farm tenants; incorporation of issues relating to social safeguards, especially for marginalized groups; inclusion of issues related to planning processes and strategies, at a national and local scale; finer scale planning (ideally at a 1:50 000 scale); and improved biodiversity data, including revised data on forest degradation, validation of the ecological condition map, and specific species data where possible.

### *6.2. Overall approach*

The spatial biodiversity assessment for Rwanda's Congo-Nile Divide (CND) is based on a rapid systematic conservation plan, using MARXAN decision-support software. See Section 2.2. and 2.3 of the full report (Annex 2.2) for further details.

**The core planning domain** is Rwanda's CND landscape (Figure 16). It extends from the Volcanoes National Park (VNP) and Virunga Mountains in the north, to Gishwati-Mukura National Park (GMNP) and then further southwards to Nyungwe National Park (NNP), with a portion of Lake Kivu at the western boundary. For the climate change and landscape connectivity analysis, however, a broader landscape was assessed including areas beyond Rwanda, the CND and the MARXAN planning domain. See Section 2.1 of the full report (Annex 2.2) for further details.

The biodiversity and landcover data that was used in the MARXAN analyses was based on existing data; and new spatial data derived from key ecological analyses performed for this project. The key analyses involved identifying and mapping the remaining areas of natural forest and other ecosystem types, modelling bioclimatic change and identifying climate change refugia, a Condatis landscape connectivity and bottlenecks analyses and evaluating ecosystem threat and protection levels (Section 6.3). The analyses thus build in landscape connectivity, climate change refugia, biodiversity values, ecosystem services and social costs (in terms of avoiding, where possible, areas with highest population density, agriculture etc).

**The systematic conservation plan analyses covered a range of biodiversity features sourced from existing data and new spatial data derived from key ecological analyses performed for this project, including:**

- Terrestrial ecosystems, including their IUCN Redlist threat status and protection level. The analysis focused on identifying priority remaining intact areas, based on the development of a map of ecological condition (See Section 6.3.1 and 6.3.4).
- Climate change refugia based on projected changes in bioclimatic envelopes under a range of climate change scenarios (See Section 6.3.2).
- Key landscape linkage areas and bottlenecks (See Section 6.3.3).
- Protected Areas, Protected Forests and Protected Wetlands. All the identified ecosystems to be gazetted for protection are included (See Section 4.1.1 of the full report, Annex 2.2).
- Hydrological process areas – Rivers and Streams, including buffers (See Section 4.1.2 of the full report, Annex 2.2).
- Hydrological process areas – Wetlands and Lakes, including buffers (See Section 4.1.3 of the full report, Annex 2.2).
- Landscape process areas - Steep slopes (over 55%) which are most important for minimizing erosion and landslide risk (See Section 4.1.4 of the full report, Annex 2.2).
- Hydrological process areas – Areas with high rainfall (See Section 4.1.5 of the full report, Annex 2.2).

**The final outcome** of the MARXAN and Condatis connectivity analyses split the CND domain into four major landscape categories (Core Protected Area Nodes and their Buffers, Stepping Stones, Landscape Linkages and the Broader Farming Mosaic) with a set of **priority**

**implementation areas** (Section 6.4.2), each with their own **place-bound project interventions** (Section 6.5). Interventions range from the restoration of natural forest, establishment and improvement of protective forest on steep slopes and along riparian areas; and to implement biodiversity-friendly agroforestry to reduce landslides, erosion and downstream flooding (Wildlife Conservation Society, 2022). Over and above these place-bound interventions are a variety of other mechanisms for promoting the sustainability of rural livelihoods and protecting montane forest in Rwanda's CND landscape (Section 6.4.5).

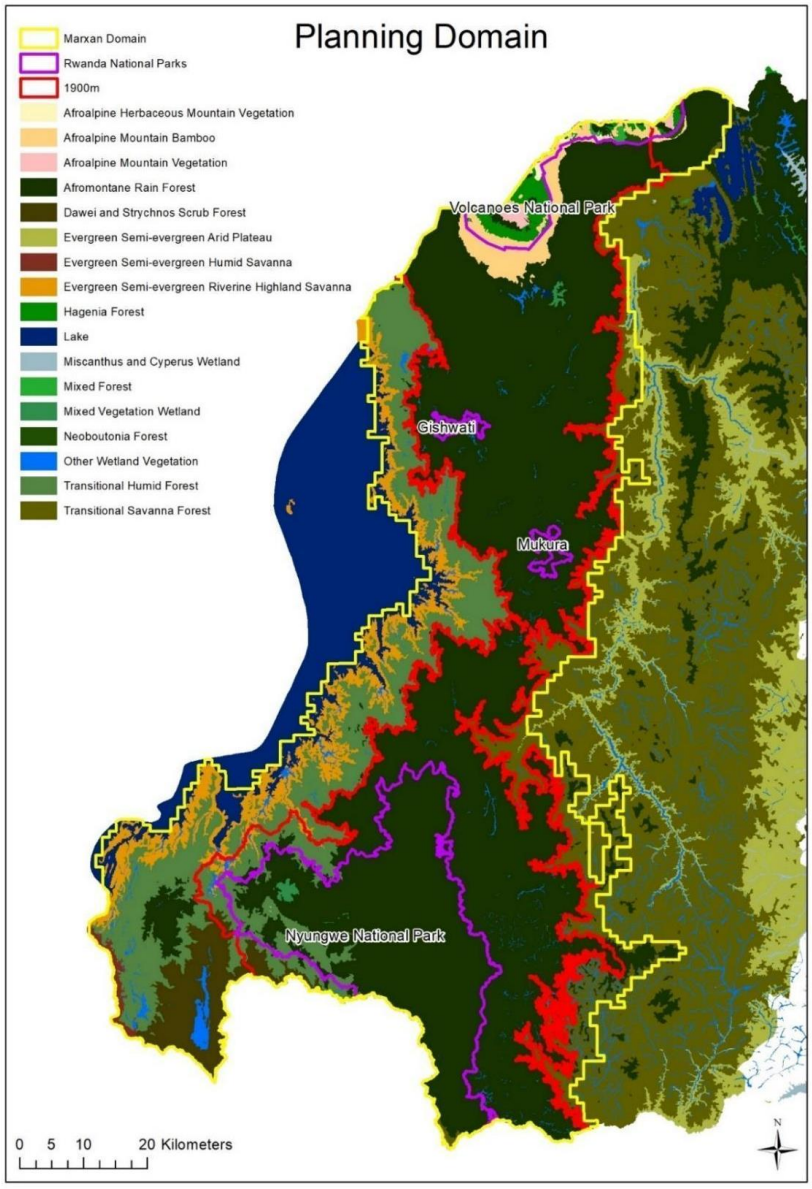


Figure 16. The MARXAN planning domain, in relation to key ecosystems, altitude divides and protected areas.

### *6.3. Key Ecological Analyses*

The spatial biodiversity assessment included key spatial analyses that generated new biodiversity and landcover data for the CND region, summarized in Sections 6.3.1 to 6.3.4 below. The new data was used in the MARXAN analysis (Section 6.4.1). Detailed explanations can be sourced from the full report, Section 3 (Annex 2.2).

#### *6.3.1. Remaining Intact Areas of Natural Forest and Other Ecosystems – Ecological Condition*

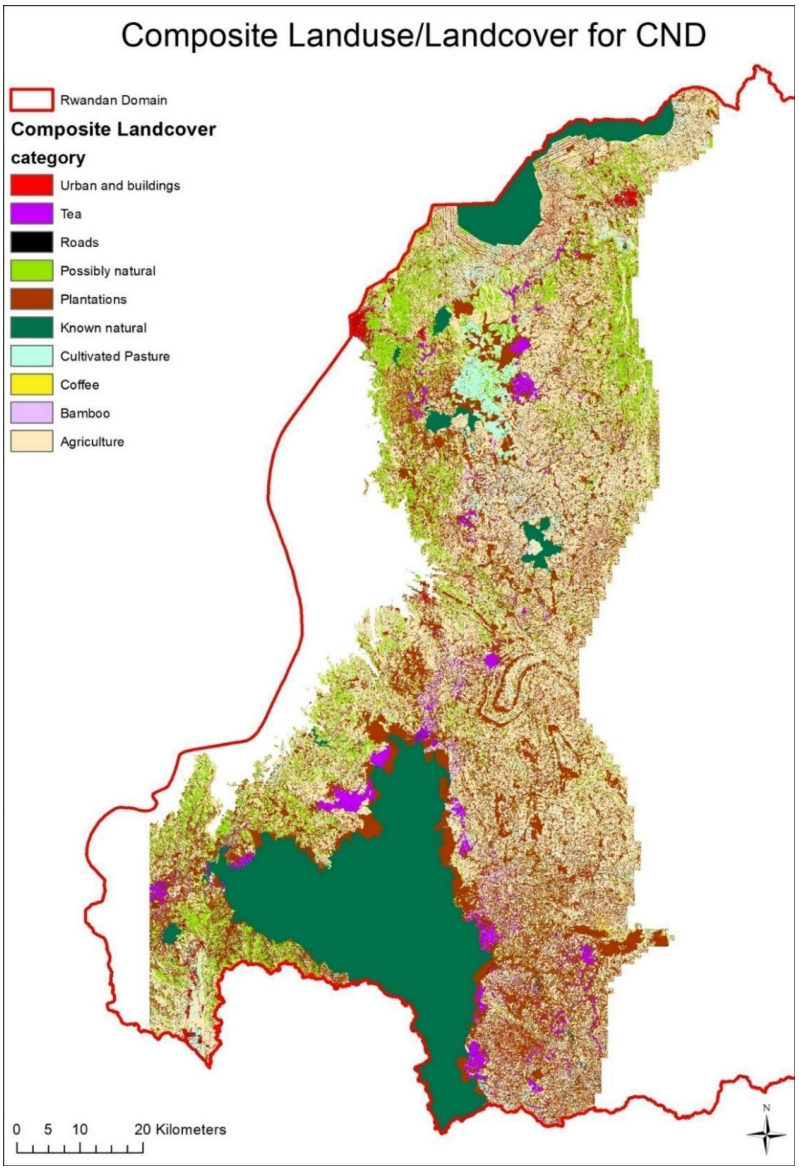


Figure 17. A composite land use and landcover map was developed for the core Congo Nile Divide (CND) landscape.

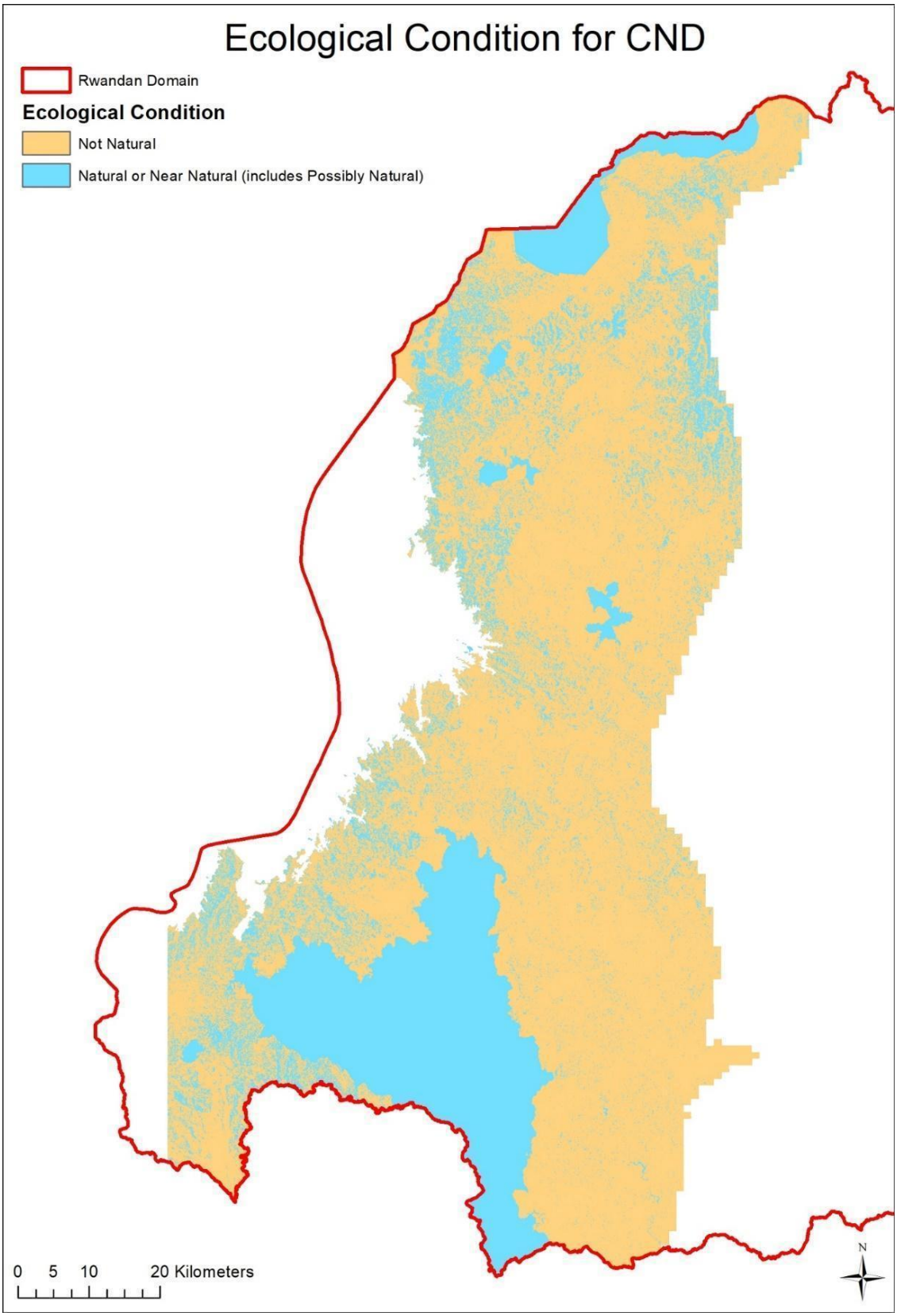


Figure 18. Ecological condition map prepared for the Congo Nile Divide (CND) landscape

An ecological condition map (Figure 18) that shows the remaining intact areas of natural ecosystems (2), was developed based on the land use/ land cover map (Figure 17). The purpose of the map is to determine the amount and location of natural habitat that remains available for achieving biodiversity targets. The impact of different drivers of ecosystem change (such as land cover change, forest loss and overharvesting of resources) are combined and presented into a single map. Refer to Section 3.1.1 of the full report for the methodology regards the development of the new land cover map for the CND. Using the classification set out in Table 12, the composite land use / land cover map (Figure 17) was converted into the map of ecological condition (Figure 18). The areas (hectare and percentage) are summarized in Table 13. The map of ecological condition, with landcover classes summarized below, were incorporated via the systematic plan cost surface, with higher costs associated with the "Not Natural" classes (See the Cost Surface Section of the full report in Annex 2.2 for further details).

**Table 12: Classification scheme used for allocating land use or land cover categories to ecological condition categories for the Congo Nile Divide.**

| Ecological Condition | Land Use or Land Cover |
|---|---|
| Natural or Near Natural | Known natural |
| | Possibly natural |
| Not Natural | Agriculture |
| | Bamboo |
| | Coffee |
| | Cultivated pasture |
| | Plantations |
| | Roads |
| | Tea |
| | Urban and buildings |

**Table 13. Summary of ecological condition and specific landcover classes across the Congo Nile Divide.**

| Ecological Condition and Landcover | Area (ha) | Area (%) |
|---|---|---|
| **Natural or Near Natural** | **213 338** | **29,5%** |
| Known natural | 127 400 | 17,6% |
| Possibly natural | 85 938 | 11,9% |
| **Not Natural** | **508 711** | **70,5%** |
| Agriculture | 259 022 | 35,9% |
| Bamboo | 135 | 0% |
| Coffee | 546 | 0,1% |
| Cultivated Pasture | 36 520 | 5,1% |
| Plantations | 163 093 | 22,6% |
| Roads | 22 132 | 3,1% |
| Tea | 16 673 | 2,3% |
| Urban and buildings | 10 590 | 1,5% |
| **Grand Total** | **722 049** | **100%** |

### *6.3.2. Modelling Bioclimatic Change and Climate Change Refugia*

One of the key activities of the spatial analysis is to map current and future biodiversity priorities of the Congo Nile Divide (CND), especially in relation to predicted climate change. This should be based on, as far as possible, the current and predicted distributions of key ecosystems (vegetation types) and species (endemic and threatened large mammals, birds and plants). Additionally, identifying areas and gradients in abiotic conditions which are likely to support a diverse set of habitat types, today and under future climate change. The modelling focused on core biomes and ecosystems rather than individual species, as the key species of the CBD are all closely associated with specific Afromontane and Afroalpine ecosystems, primarily various natural forest types.

The underlying data from the Spatial Planning for Area Conservation in Response to Climate Change (SPARC) project(3,4) was used; and a Global Environmental Stratification (GEnS) process was then applied, to map three scenarios:

- A baseline scenario (1961-1990) (Figure 21).
- A moderate (or more honestly a minimum plausible, given current climate responses) scenario based on the RCP 2.6 pathway for 2060-2080 (Figure 22).
- A higher change scenario based on the RCP 8.5 pathway for 2060-2080 (Figure 23).

Figure 19 and Figure 20 indicate the format and legend of the three maps. Refer to Section 3.2 of the full report (Annex 2.2) for the detailed methodology.

The data show how the climate envelope for the CND rainforests is likely to become more limited and migrate upslope, with hotter and drier climate envelopes replacing the rainforest envelope. This aligns with the broad scenario set out in the climate change report (5) and implies that the rainforest will be under pressure, rather than being immediately replaced by other ecosystems.

It will be critical to:

- Reduce other pressures on forest systems (alien species, fire, edge effects).
- Maintain and expand core forest areas, especially ensuring that some of the smaller areas around Gishwati and Mukura NPs, to avoid edge effects and optimize the retention of forest microclimates.
- Ensure landscape connectivity to allow species to migrate, to allow for optimal adaption to changing climates by the range of forest species.

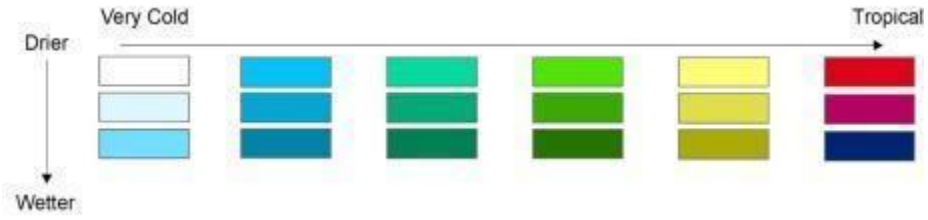


Figure 19. Generalized legend for climate envelope maps.

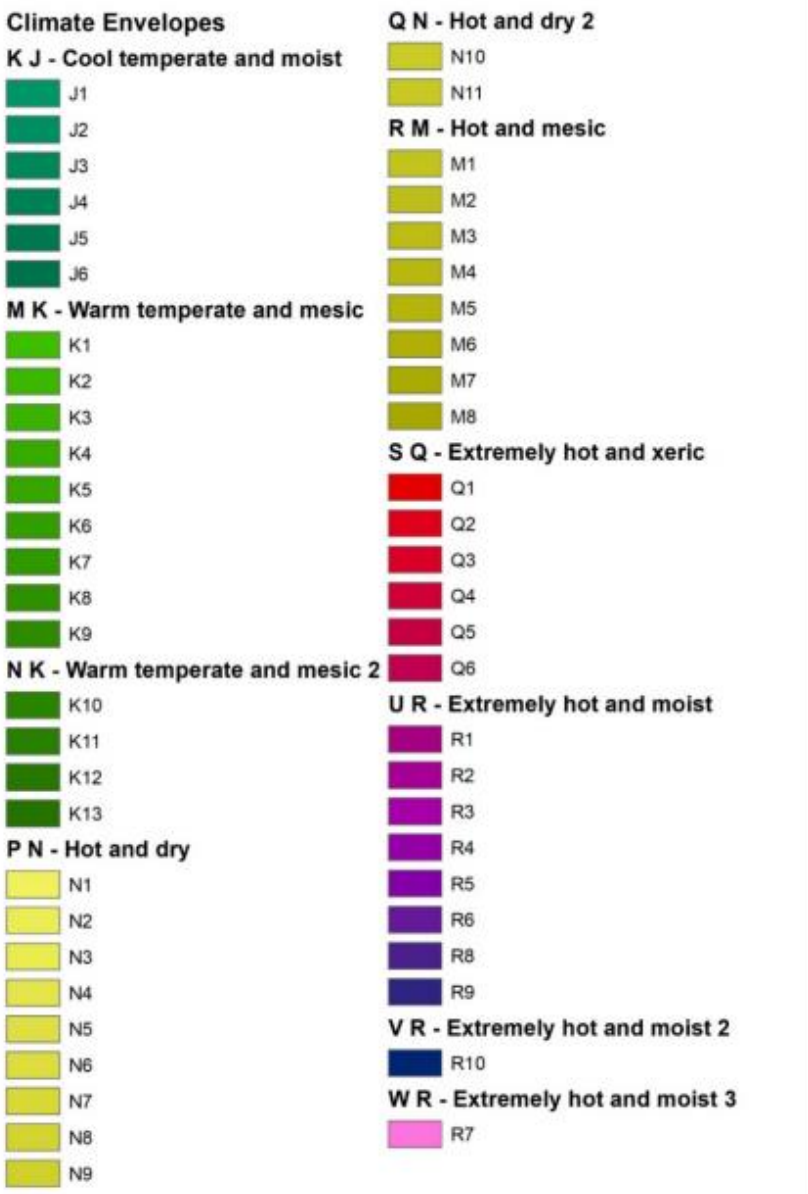


Figure 20. Specific legend categories for the climate envelope maps.

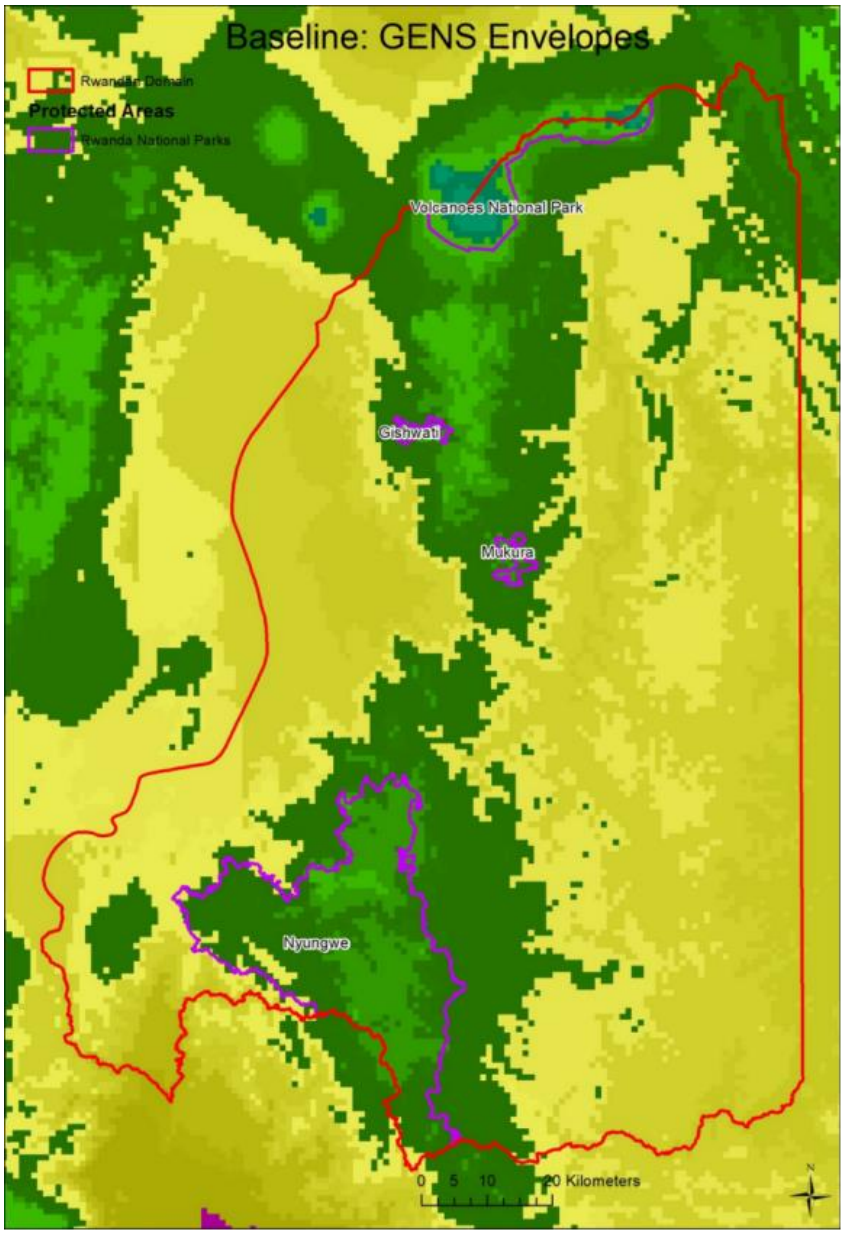


Figure 21. Baseline bioclimatic envelopes scenario (1961-1990) were categorized using the specific Global Environmental Stratification (GEnS) approach (6).

This process classifies climate types based on a combination of temperature, precipitation and environmental variability statistics. The analysis used the climate variable data produced by the Spatial Planning for Area Conservation in Response to Climate Change (SPARC) project (3,4) using the Worldclim 2 dataset (7). Each discrete colour represents a unique climate class that approximates an ecosystem type. The approach closely models the distribution of the key Montane Rain Forest woodland types of the CND as well as the Afroalpine ecosystems (typical of Volcanoes NP). The legends are given in Figure 19 and Figure 20.

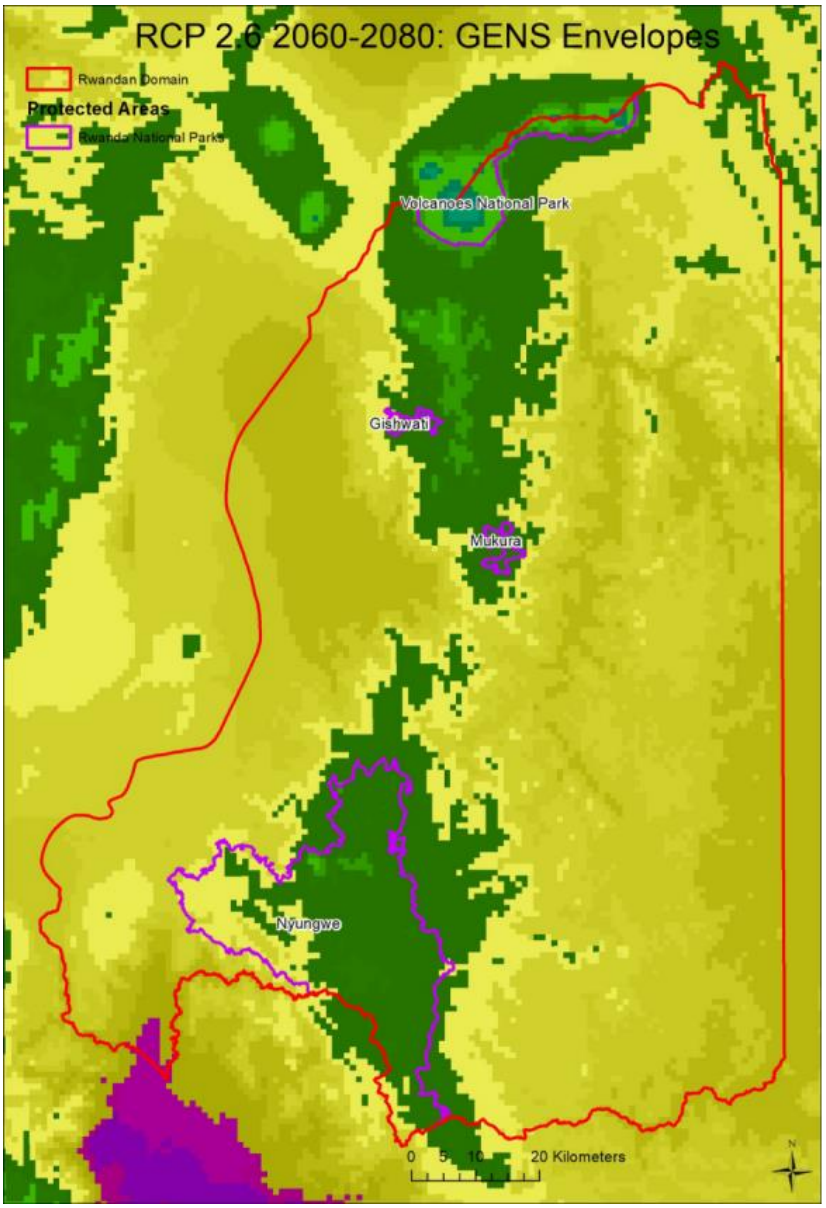


Figure 22. Projected bioclimatic envelopes for a moderate (RCP 2.6) scenario (for 2060-2080).

Projections are based on underlying climate data collated by the Spatial Planning for Area Conservation in Response to Climate Change (SPARC) project based on a robust ensemble integration process (i.e. it used the range of feasible models and results rather than a single model). The subsequent bioclimatic envelope analysis process classifies climate types based on a combination of temperature, precipitation and environmental variability statistics. The maps show how the specific Global Environmental Stratification (GEnS) categories for a moderate (RCP 2.6) scenario (for 2060-2080) differ from the baseline (1961-1990). The data show how the tropical montane rain forest of the CND are likely to retreat upslope.

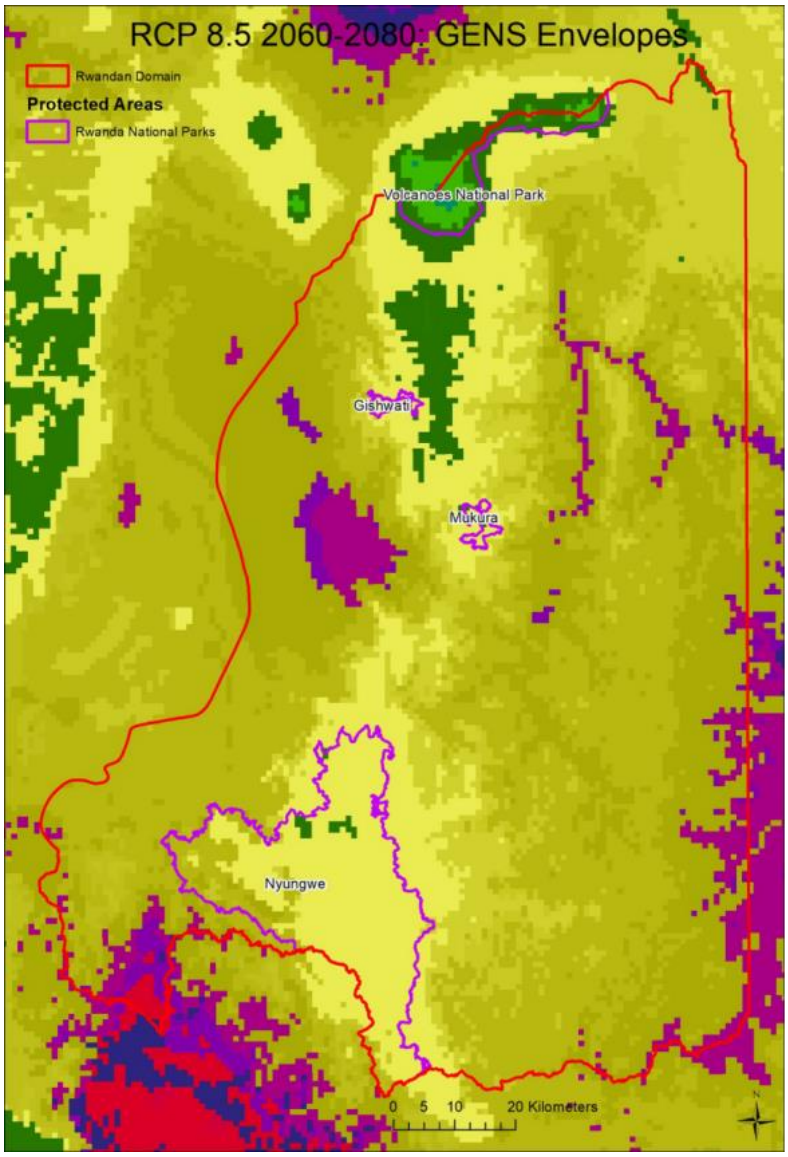


Figure 23 a. Projected bioclimatic envelopes for an extreme (RCP 8.5) scenario (for 2060-2080).

Projections are based on underlying climate data produced by the Spatial Planning for Area Conservation in Response to Climate Change (SPARC) project based on a robust ensemble integration process (i.e. it used the range of feasible models and results rather than a single model). This process classifies climate types based on a combination of temperature, precipitation and environmental variability statistics. The maps show how the specific Global Environmental Stratification (GEnS) categories for an extreme (RCP 8.5) scenario (for 2060-2080) differ from the baseline (1961-1990). Each discrete colour represents a unique climate class that approximates an ecosystem type. The data show how under more extreme scenarios relatively small areas of the CND retain the climate envelopes characteristic of current tropical montane rain forests.

The GEnS envelope maps were then used to delineate **climate change refugia**, which represent the persistence of core forest types under the two climate change scenarios, moderate (short term) and extreme (long term), as described above. Figures 23a and 23b shows the potential

short and long term climate change refugia under the moderate (RCP 2.6) and extreme (RCP 8.5) scenarios respectively, showing the potential climate envelopes where core forest and Afroalpine ecosystems are likely to persist. The remaining intact areas of these refugia are presented in Figure 24, which is limited to the intact areas from the ecological condition map (Figure 18).

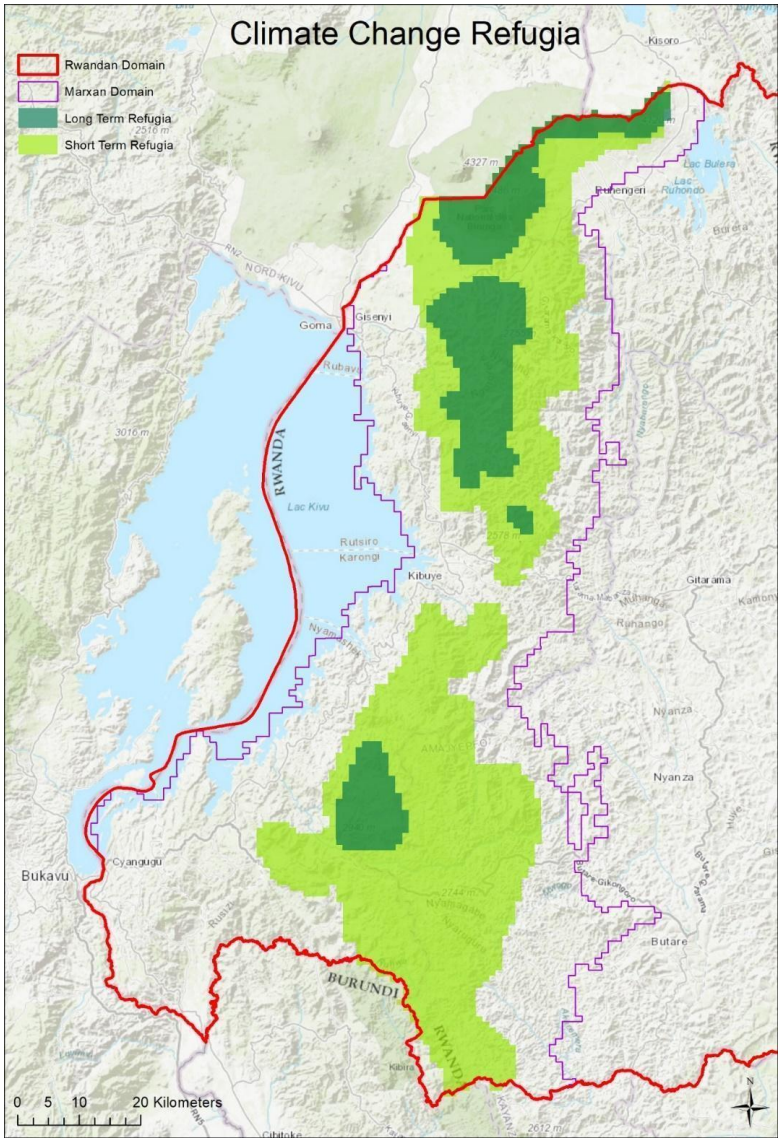


Figure 23 b. Long-term and short-term climate change refugia as outputs of the MARXAN analysis based on the two climate change scenarios, for a moderate (RCP 2.6) scenario (for 2060-2080) and an extreme (RCP 8.5) scenario (for 2060-2080) – showing the potential climate envelopes of core forest and Afroalpine ecosystem types.

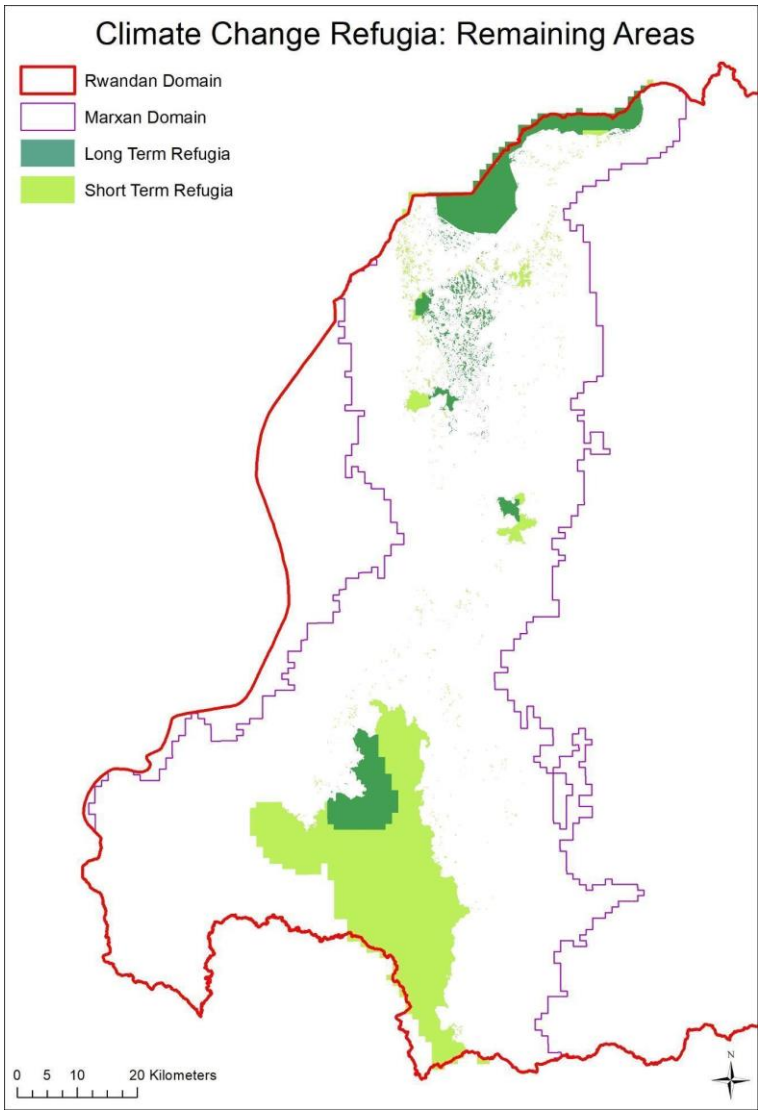


Figure 24: Long-term and short-term climate change refugia as outputs of the MARXAN analysis based on the two climate change scenarios, for a moderate (RCP 2.6) scenario (for 2060-2080) and an extreme (RCP 8.5) scenario (for 2060-2080) – showing the remaining intact areas of potential climate envelopes of core forest and Afroalpine ecosystem types.

### *6.3.3. Condatis Landscape Connectivity Analysis*

Condatis is a software modelling programme designed to aid conservation planning by evaluating the connectivity of an existing habitat network and prioritising potential restoration opportunities(8–11). It was developed to deal with the dual challenges of habitat fragmentation and climate change. It works particularly well for habitats that are well-defined and patchy, and hence it is ideal for examining connectivity between remnant patches of montane forests within Rwanda's Congo Nile Divide.

Figure 25 to Figure 27 below present the montane habitat suitability map, key landscape bottlenecks and landscape connectivity pathways in the CND.

Effectively, the bottlenecks (Figure 26) represent areas for project intervention within the corridor pathway identified in Figure 27, such as restoration and biodiversity-friendly agroforestry. Figure 28 delineates the higher value landscape connectivity pathways shown in Figure 27 more specifically. This allows the pathways to be included as features in the MARXAN analysis.

Refer to Section 3.3.1 for the "Analysis Approach" in the full report (Annex 2.2).

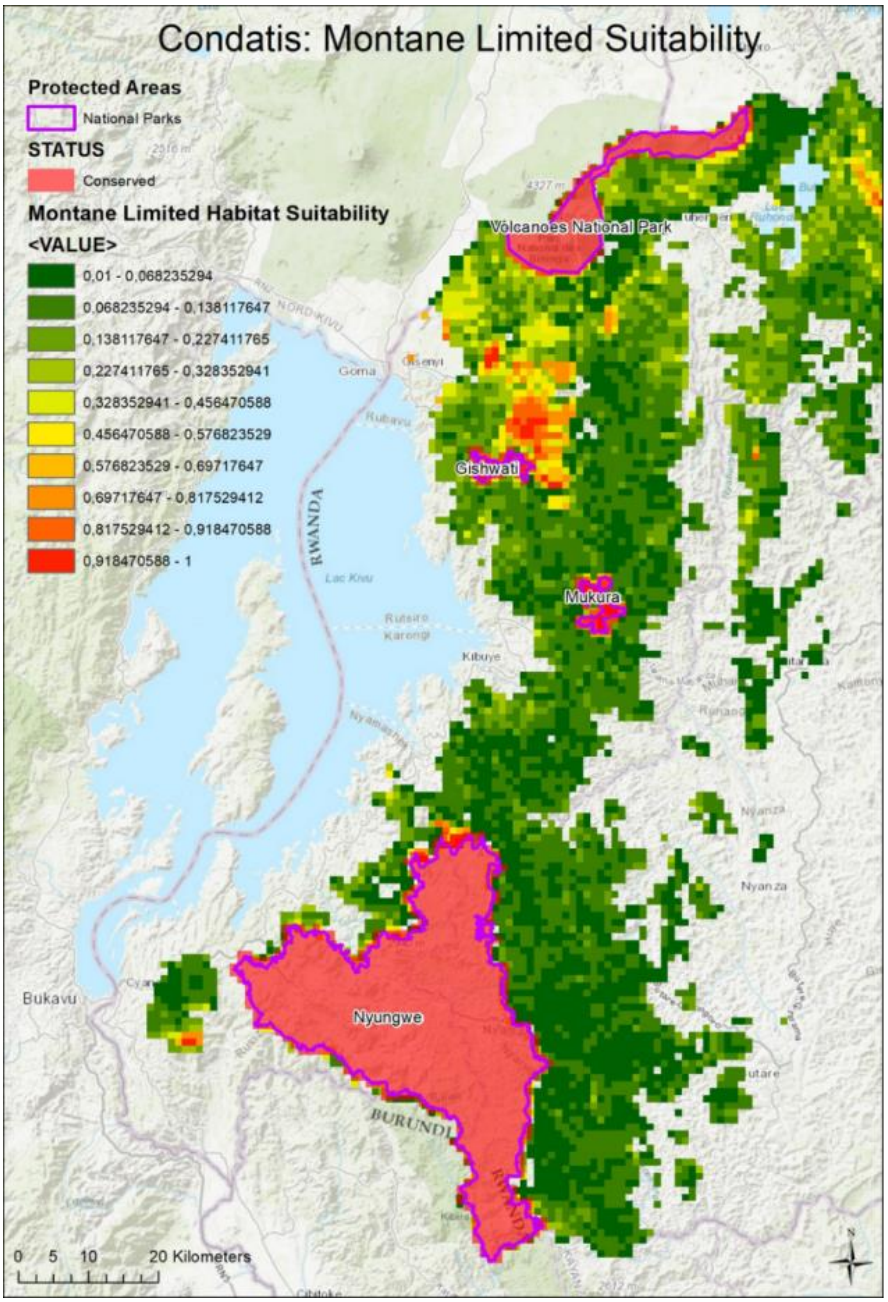


Figure 25. The montane habitat suitability map was developed as an input into the Condatis analysis. This was based on the percentage of remaining intact montane forest types (i.e. effectively the CND landscape) within each square kilometre planning unit. The layer preferentially values fully intact forest ecosystems, and strongly avoids intensively used ones (e.g. farmland, tea, urban). Intermediate values are given to open areas and pasture (as these have reasonable potential for restoration) and plantations (where increased native tree species could be introduced to improve connectivity value).

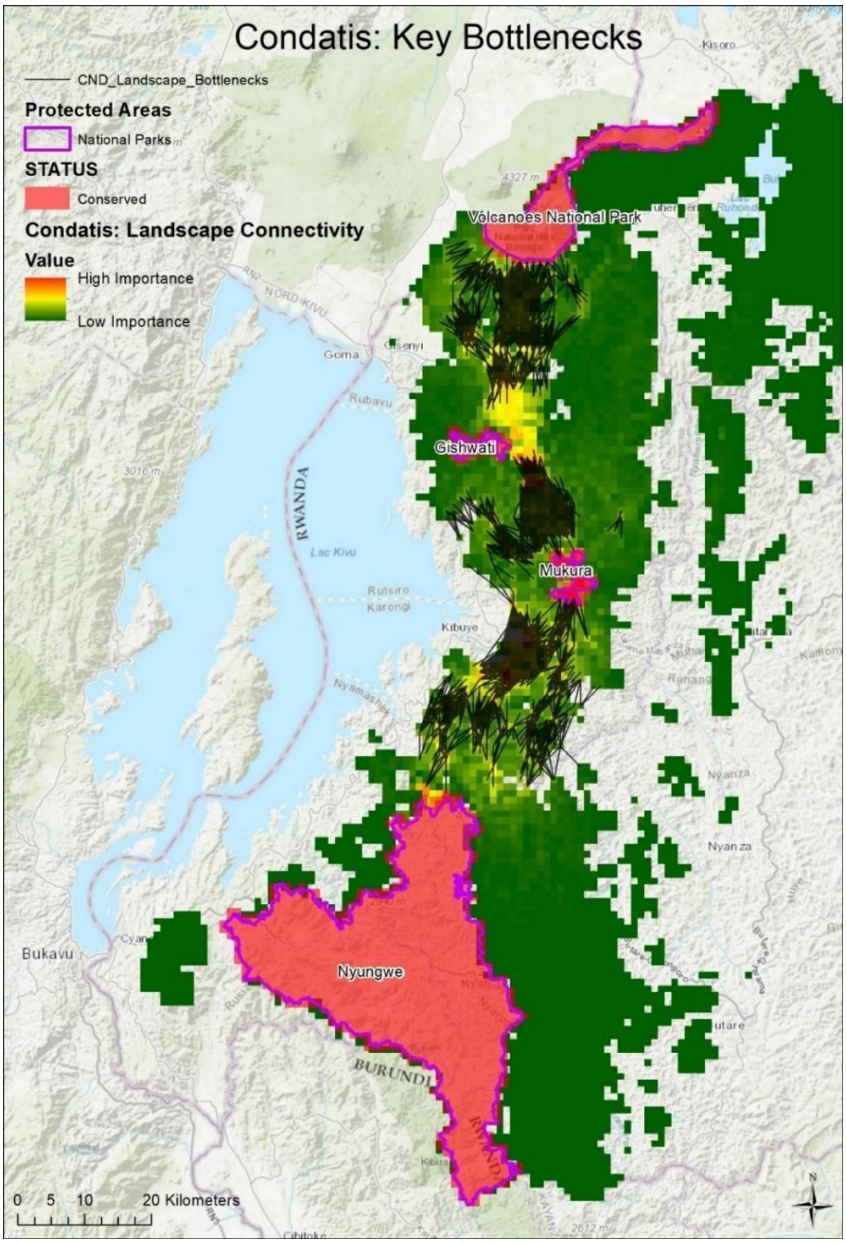


Figure 26. Key landscape connectivity bottlenecks in the Congo Nile Divide landscape, Rwanda.

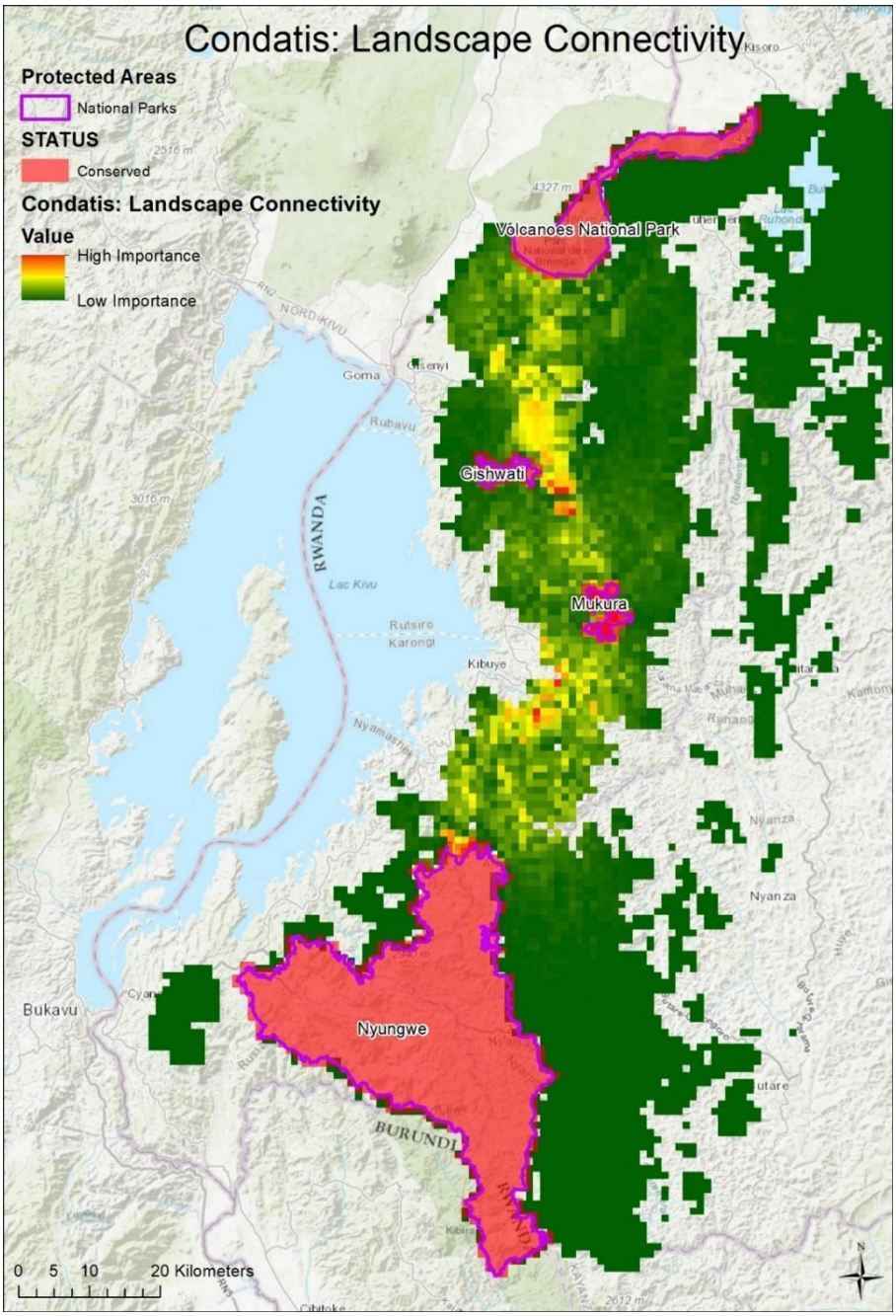


Figure 27. Key areas for landscape connectivity within the Congo Nile Divide identified in the Condatis assessment.

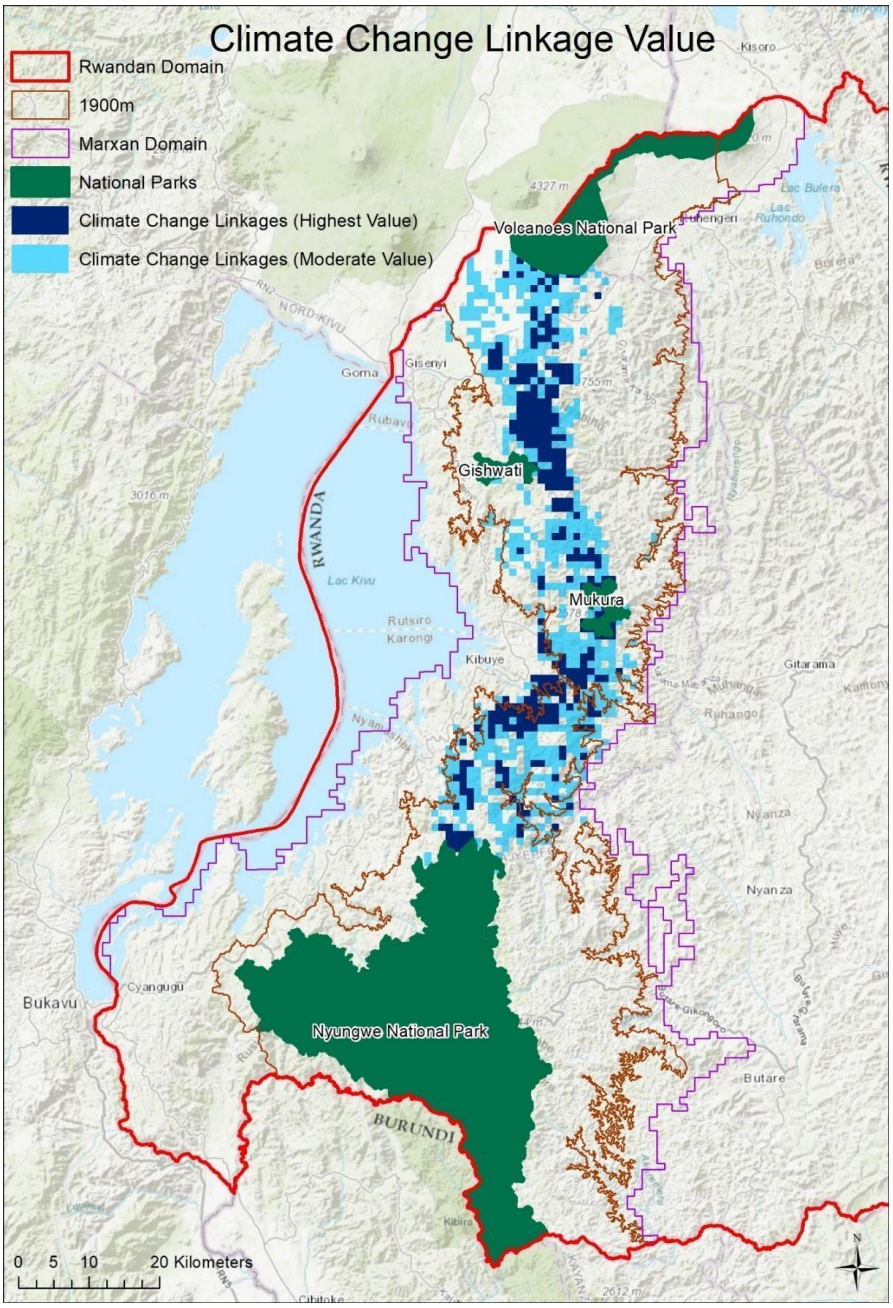


Figure 28. High and moderate climate change linkage values (based on the three quantiles) generated by the Condatis analysis.

### *6.3.4. Ecosystem Types, Threat Status and Protection Levels*

The draft vegetation map for Rwanda was developed in 2020 and is at a suitable scale for use in the Congo Nile Divide (CND) planning process. Figure 30 presents the seventeen (17) vegetation types that occur in the broader MARXAN planning domain, showing the remaining intact habitat (based on the map of ecological condition). The ecological condition map is used to show the remaining or current extent of natural and semi-natural areas (Figure 30), which is then used to determine **ecosystem threat status** (Figure 31). Threatened ecosystems are ecosystems close to collapse; and are referred to as Critically Endangered, Endangered, and Vulnerable. Near Threatened ecosystems are not yet threatened but are close or may qualify in the near future. Least Concern ecosystems are still intact or in a relatively healthy state (Figure 29).

Refer to Section 3.4.2 of the full report (Annex 2.2) for a detailed explanation of ecosystem threat status.

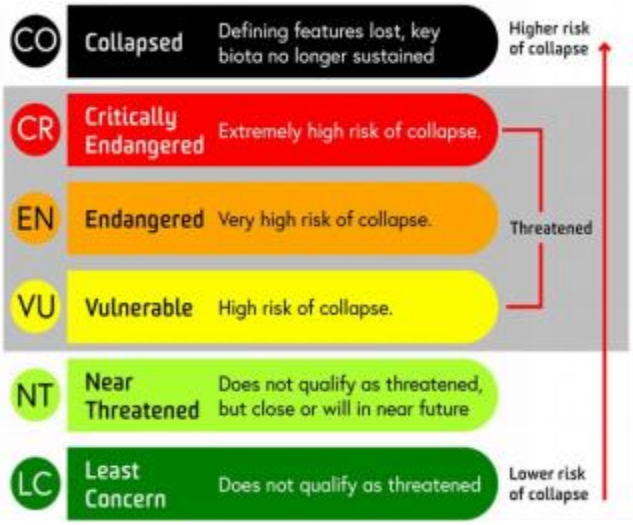


Figure 29. IUCN Red List of Ecosystems categories (Adapted from Keith et al., 2020).

**Ecosystem protection level** indicates whether ecosystems are adequately protected (Well Protected) or are under-protected (Moderately Protected, Poorly Protected, Not Protected) (Table 14). This is computed by overlapping the remaining natural areas in the ecosystem type map (Figure 32) with the protected areas map. Protection level for each ecosystem is then categorised based on the proportion of percentage target for each ecosystem type that is included within protected areas. Refer to Section 3.4.3 of the full report (Annex 2.2) for the detailed methodology used to determine protection level.

**In Rwanda's Congo Nile Divide**, the ecosystem types, threat status and protection levels are indicated in Table 14 and Table 15, as well as original and current extent (hectares and percentage) of the vegetation types. The core ecosystem is the Afromontane Rain Forest, it is classified as Endangered and is Moderately Protected, while very little habitat remains in an intact state outside of the PAs. It is therefore critical to protect and restore what little montane forest is remaining in the CND, to at least approach the 30% post 2020 CBD target as closely

as possible.

**Table 14 Ecosystem types of the Congo Nile Divide (CND), showing key metrics of original and remaining extent.**

| Biome | Ecosystem Type | National Extent | | | | | CND Extent | |
|---|---|---|---|---|---|---|---|---|
| | | National Extent (Original Extent) (ha) | Intact Extent (ha) | % Loss | Intact in PA (ha) | % of National PA Target | Extent in CND (Original Extent) (ha) | % of National Extent in CND |
| **Core CND Ecosystem** | | | | | | | | |
| Montane Woodland | Afromontane Rain Forest | 550 967 | 126 413 | 77.1 | 96 403 | 58.3 | 418 524 | 76 |
| Afroalpine Mountain | Hagenia Forest | 6 318 | 6 185 | 2.1 | 6 130 | 323.4 | 6 202 | 98.2 |
| Humid Savanna | Evergreen Semi-evergreen Riverine Highland Savanna | 37 295 | 5 228 | 86 | 104 | 0.9 | 36 676 | 98.3 |
| Humid Savanna | Evergreen Semi-evergreen Humid Savanna | 2 254 | 551 | 75.6 | 0 | 0 | 2 222 | 98.6 |
| Afroalpine Mountain | Neoboutonia Forest | 972 | 933 | 3.8 | 629 | 216.1 | 972 | 100 |
| Humid Savanna | Transitional Humid Forest | 102 736 | 17 475 | 82.9 | 9 213 | 30 | 102 736 | 100 |
| Afroalpine Mountain | Afroalpine Mountain Bamboo | 14 020 | 6 214 | 55.6 | 4 864 | 116 | 14 020 | 100 |
| Afroalpine Mountain | Mixed Forest | 546 | 542 | 0.5 | 535 | 327.4 | 546 | 100 |
| Afroalpine Mountain | Afroalpine Mountain Vegetation | 1 537 | 1 532 | 0 | 1 530 | 332.7 | 1 537 | 100 |
| Humid Savanna | Dawei and Strychnos Scrub Forest | 22 365 | 4 270 | 80.8 | 99 | 1.5 | 22 365 | 100 |
| Afroalpine Mountain | Afroalpine Herbaceous Mountain Vegetation | 606 | 603 | 0 | 584 | 323.2 | 606 | 100 |
| **Peripheral to CND** | | | | | | | | |
| Wetland | Miscanthus and Cyperus Wetland | 110 182 | 92 078 | 16.4 | 42 199 | 127.7 | 9 | 0 |
| Highland Plateau | Evergreen Semi-evergreen Arid Plateau | 128 739 | 7 824 | 93.9 | 23 | 0.1 | 1 194 | 0.9 |
| Wetland | Mixed Vegetation Wetland | 14 932 | 6 673 | 55.3 | 1 660 | 37.1 | 1 393 | 9.3 |
| Highland Plateau | Transitional Savanna Forest | 421 785 | 11 589 | 97.3 | 828 | 0.7 | 53 214 | 12.6 |
| Lake | Lake | 144 352 | 143 399 | 0.7 | 15 364 | 35.5 | 20 184 | 14 |
| Wetland | Other Wetland Vegetation | 43 745 | 8 239 | 81.2 | 1 439 | 11 | 10 910 | 24.9 |

**Table 15. Redlist threat status and protection level of ecosystem types of the Congo Nile Divide (CND).**

| Biome | Ecosystem Type | Extent in CND (Original Extent) (ha) | IUCN Redlist of Ecosystems Threat Status | Protection |
|---|---|---|---|---|
| **Core CND Ecosystem** | | | | |
| Montane Woodland | Afromontane Rain Forest | 418 524 | Endangered | Moderately Protected |
| Afroalpine Mountain | Hagenia Forest | 6 202 | Least Concern | Well Protected |
| Humid Savanna | Evergreen Semi-evergreen Riverine Highland Savanna | 36 676 | Endangered | Not Protected |
| Humid Savanna | Evergreen Semi-evergreen Humid Savanna | 2 222 | Endangered | Not Protected |
| Afroalpine Mountain | Neoboutonia Forest | 972 | Least Concern | Well Protected |
| Humid Savanna | Transitional Humid Forest | 102 736 | Endangered | Poorly Protected |
| Afroalpine Mountain | Afroalpine Mountain Bamboo | 14 020 | Vulnerable | Well Protected |
| Afroalpine Mountain | Mixed Forest | 546 | Least Concern | Well Protected |
| Afroalpine Mountain | Afroalpine Mountain Vegetation | 1 537 | Least Concern | Well Protected |
| Humid Savanna | Dawei and Strychnos Scrub Forest | 22 365 | Endangered | Not Protected |
| Afroalpine Mountain | Afroalpine Herbaceous Mountain Vegetation | 606 | Least Concern | Well Protected |
| **Peripheral to CND** | | | | |
| Wetland | Miscanthus and Cyperus Wetland | 9 | Least Concern | Well Protected |
| Highland Plateau | Evergreen Semi-evergreen Arid Plateau | 1 194 | Critically Endangered | Not Protected |
| Wetland | Mixed Vegetation Wetland | 1 393 | Vulnerable | Poorly Protected |
| Highland Plateau | Transitional Savanna Forest | 53 214 | Critically Endangered | Not Protected |
| Lake | Lake | 20 184 | Least Concern | Poorly Protected |
| Wetland | Other Wetland Vegetation | 10 910 | Endangered | Poorly Protected |

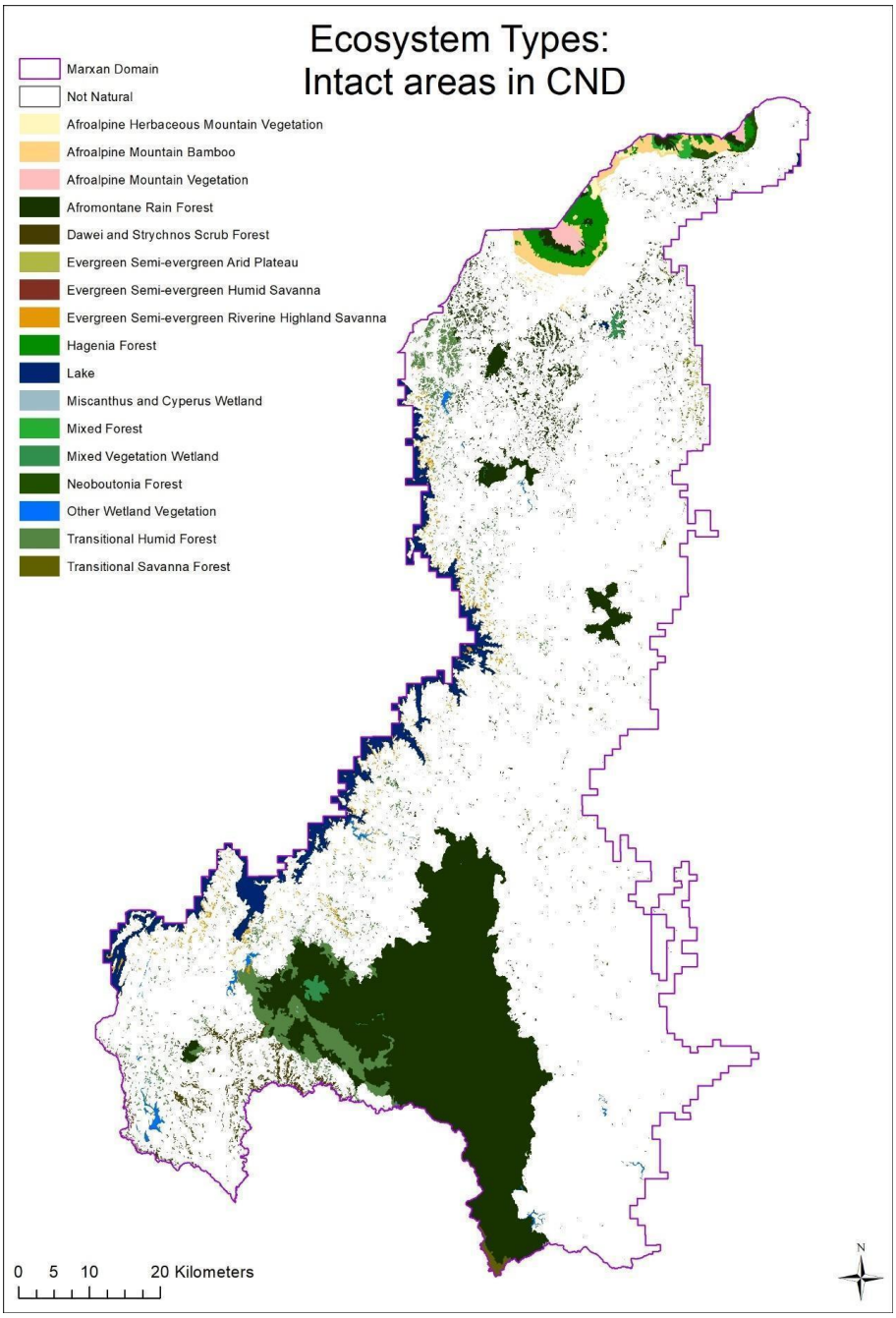


Figure 30. Remaining intact areas of each ecosystem type in the Congo Nile Divide.

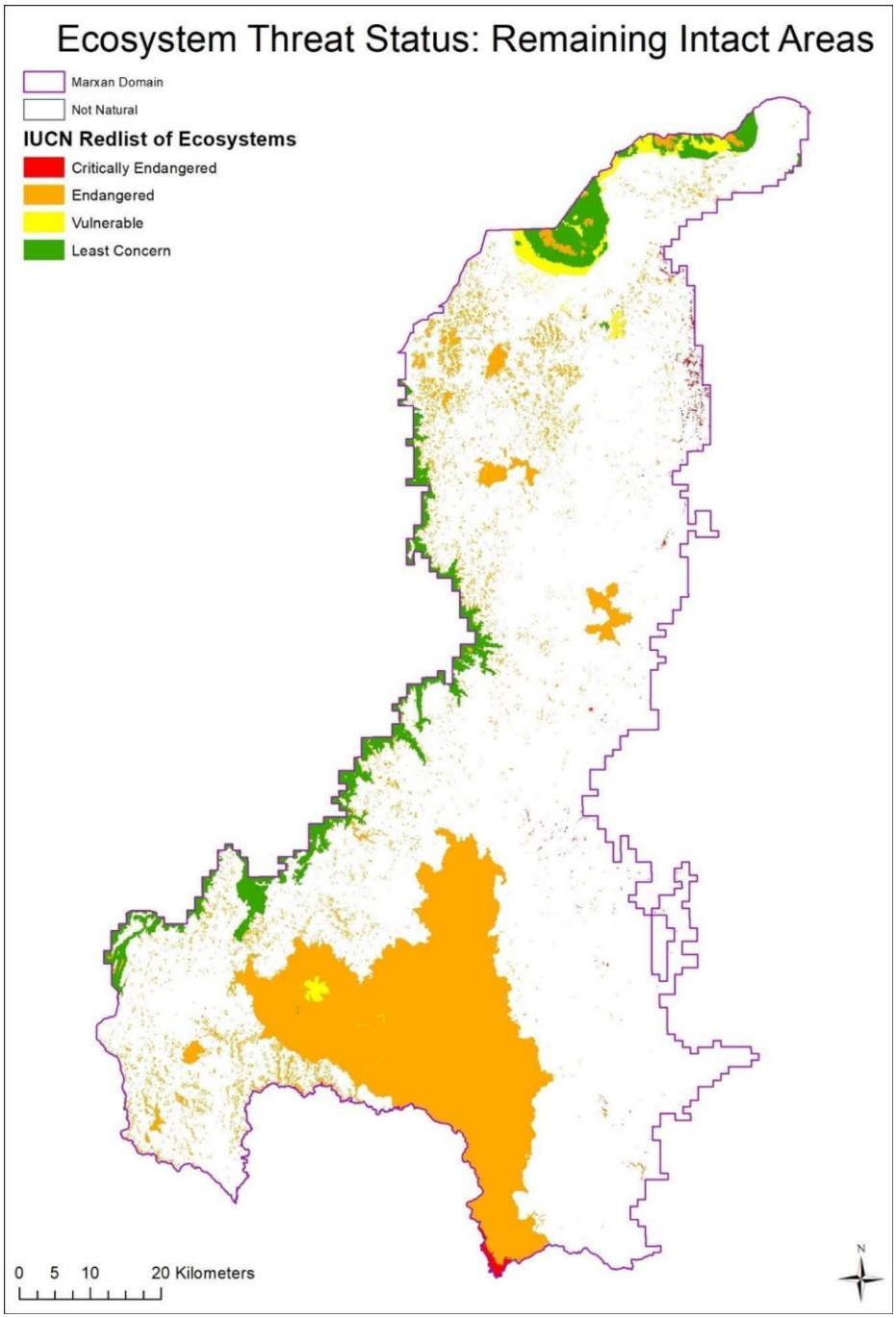


Figure 31. Ecosystem threat status of the different vegetation types in the Congo Nile Divide showing the current extent of remaining intact areas. The “Not Natural” landcover is shown in white.

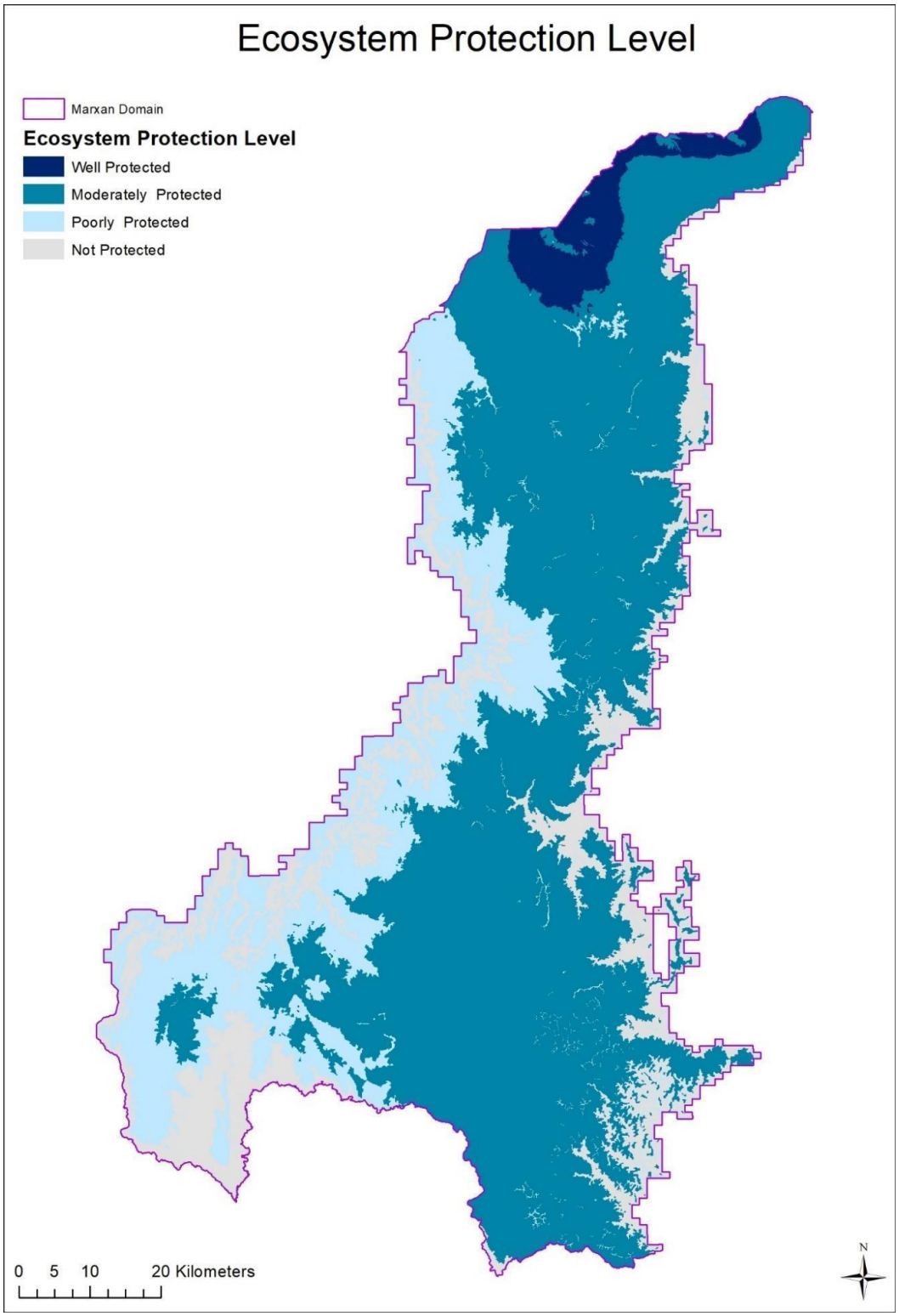


Figure 32. Ecosystem protection levels of the different vegetation types in the Congo Nile Divide. The map shows the original extent of vegetation cover prior to human induced landcover change.

Spatial Prioritization Results

The key spatial results that are outlined in this section include:

- The **MARXAN landscape prioritization**, which builds in landscape connectivity, climate change refugia, biodiversity values, and social costs (in terms of avoiding, where possible, high-density people, agriculture etc) (Figure 33).
- The **four key landscape categories** that splits the Congo Nile Divide into current land use activities for appropriate conservation-oriented measures (Figure 34).
- A **spatial prioritization** foreach project implementation activity (Figure 35).

The key ecological analyses and associated data, as outlined in Section 6.3, and existing spatial data, were used to generate these results.

### *6.3.5. MARXAN Analysis*

The MARXAN irreplaceability analysis for the Congo Nile Divide identifies areas of higher conservation importance (Score close to 10) to areas of lower importance for conservation (Scores closer to 0) (Figure 33). The areas of highest importance (red) are largely driven by climate change refugia, the connectivity analysis, the presence of natural forest patches, wetlands and rivers. The analysis identifies a key high-altitude linkage that connects the National Parks, which support the majority of the remaining montane forest, via smaller isolated forest patches and riparian corridors. As a result, the areas of highest elevation, which link the three National Parks and remaining forest patches (beyond the Parks), are clearly the highest conservation priority.

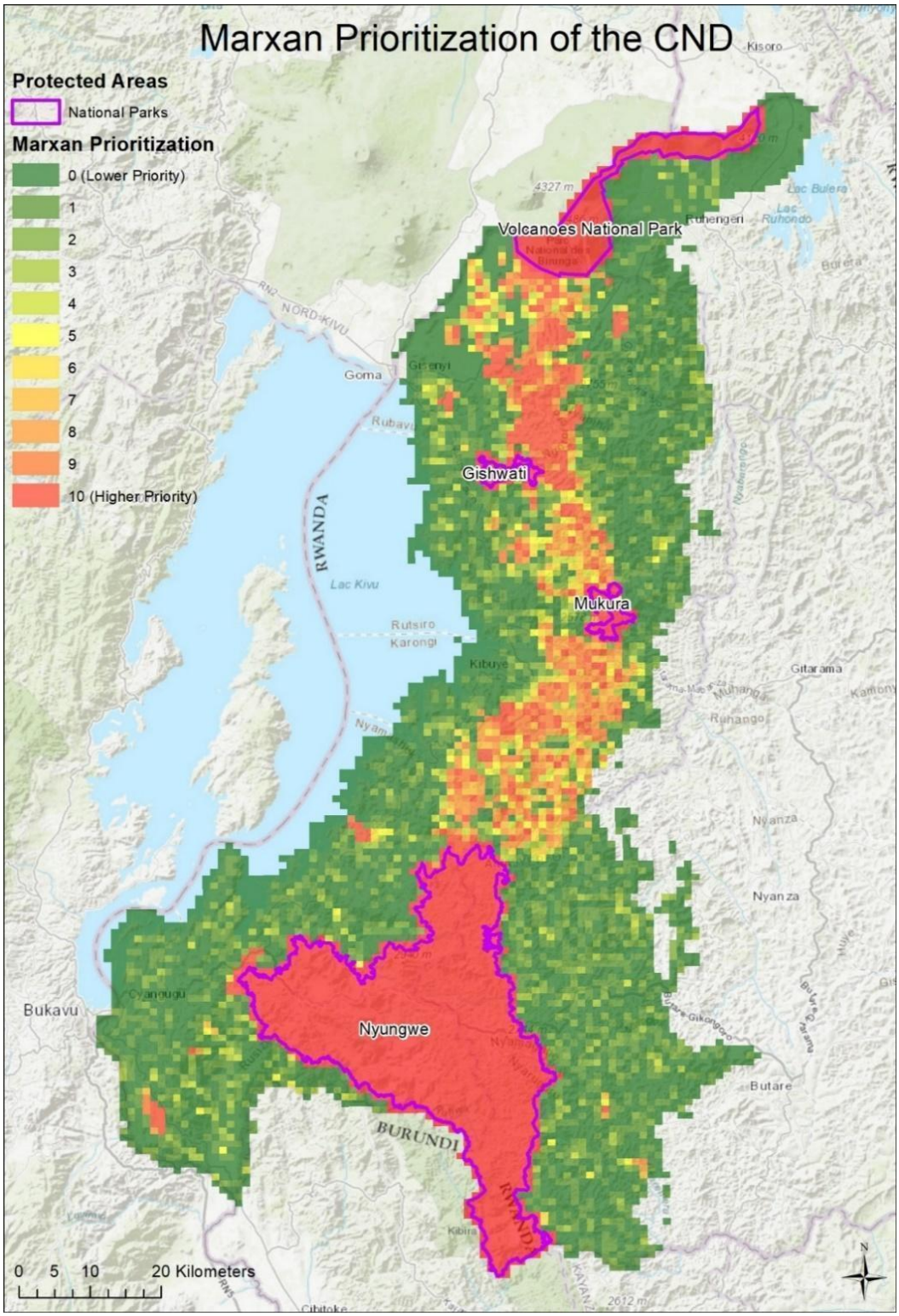


Figure 33. MARXAN irreplaceability analysis for the Congo Nile Divide.

### *6.3.6. Priority Landscapes for Interventions*

#### *6.3.6.1. Landscape Categories and Specific Implementation Areas*

Based on the Condatis connectivity study (Section 6.2.3) and the MARXAN results (Section 6.3.1), the Congo Nile Divide was divided into four major landscape categories (Figure 34), each with their own project interventions (Section 6.4).

Each of the spatial planning categories were further split into areas referred to as "Landscape Implementation Sectors" presented in Figure 35; and summarised in Table 16. Table 17 provides a summary of the landscape categories, along with the associated ideas, required outcomes, core and associated benefits.

The four major landscape categories are:

- **Core Protected Area (PA) Nodes and their Buffers:** National Parks comprise the "Core PA Nodes" that need to be secured and well managed, which include Volcanoes, Gishwati-Mukura and Nyungwe National Parks. These nodes also include buffer areas around the National Parks.
- **Stepping Stones:** These are priority nodes outside of the current National Parks that are critical for maintaining landscape connectivity, comprising of small, isolated patches of forest, at Dutake and Karehe-Gatuntu Protected Forests and the extensive Gishwati Pastures.
- **Landscape linkages:** These are key landscape linkages and knickpoints in the farming landscape that require afforestation on steep slopes and riparian areas to link the CND at a landscape scale.
- **Broader Farming Mosaic:** These are broader areas of moderate priority where conservation interventions can support broader sustainable landscapes and ecosystem service delivery.

Refer to Section 5.2.1 in the full report (Annex 2.2) for more detailed information regarding compatible project interventions within each category. Full detailed project interventions are provided in Section 6.4 below.

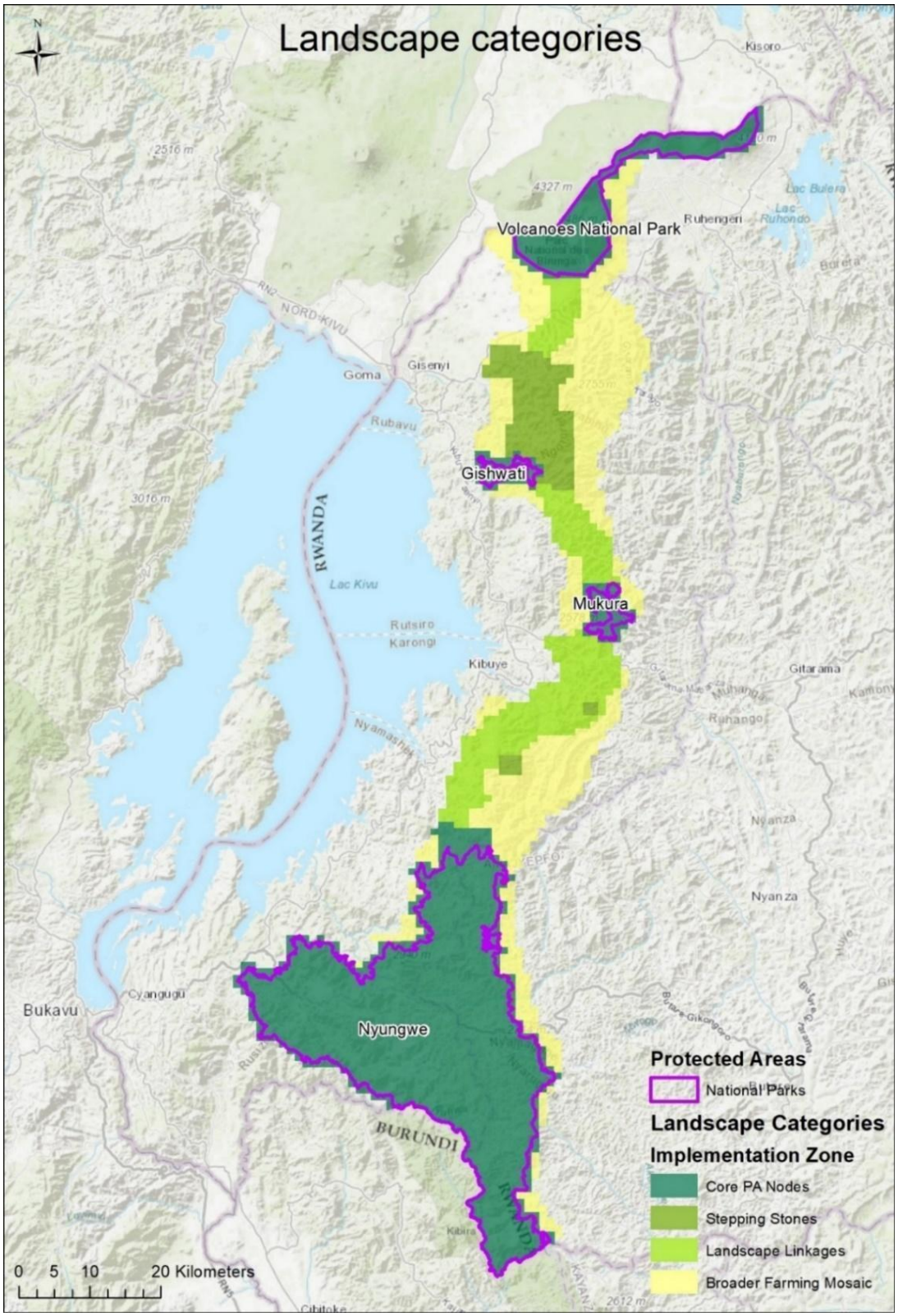


Figure 34. The Congo Nile Divide was divided into landscape categories based on the Condatis connectivity study and the MARXAN results.

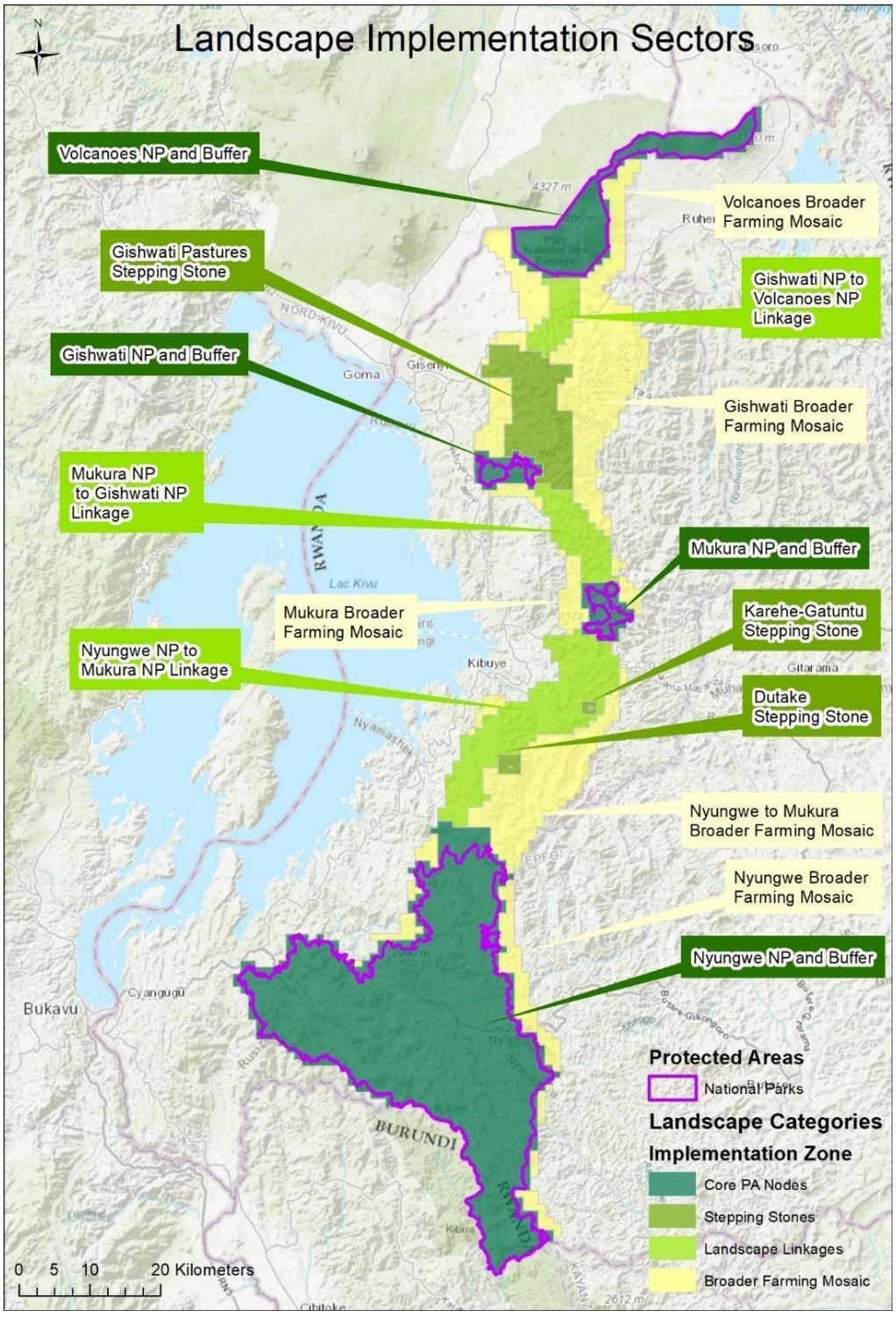


Figure 35. The four major landscape categories (Core PA Nodes, Stepping Stones, Landscape Linkages and the Broader Farming Mosaic) were split into specific areas to aid prioritization and description.

**Table 16. Summary of area and overall MARXAN score (irreplaceability values) for each landscape category and specific sectors. MARXAN scores range from 10 (Highest irreplaceability) to 0 (Lowest irreplaceability).**

| Landscape Category | Landscape Implementation Sector | Area (ha) | Marxan Score (Mean) |
|---|---|---|---|
| Core PA Nodes | Volcanoes NP and Buffer | 19 487,0 | 10,00 |
| | Nyungwe NP and Buffer | 116 794,9 | 9,93 |
| | Mukura NP and Buffer | 4 713,5 | 9,57 |
| | Gishwati NP and Buffer | 4 013,7 | 9,38 |
| Stepping Stones | Gishwati Pastures Stepping Stone | 15 547,4 | 9,00 |
| | Karehe-Gatuntu Stepping Stone | 401,1 | 8,75 |
| | Dutake Stepping Stone | 903,0 | 6,67 |
| Landscape Linkages | Nyungwe NP to Mukura NP Linkage | 23 375,4 | 7,78 |
| | Gishwati NP to Volcanoes NP Linkage | 5 014,8 | 7,64 |
| | Mukura N to Gishwati NP Linkage | 7 823,7 | 6,91 |
| Broader Farming Mosaic | Nyungwe to Mukura Broader Farming Mosaic | 21 164,4 | 5,55 |
| | Volcanoes Broader Farming Mosaic | 11 694,4 | 2,90 |
| | Mukura Broader Farming Mosaic | 4 814,0 | 2,56 |
| | Gishwati Broader Farming Mosaic | 28 433,2 | 1,88 |
| | Nyungwe Broader Farming Mosaic | 11 437,0 | 0,84 |

**Table 17. A description of the four key landscape planning categories and associated ideas, required outcomes, core benefits and associated benefits.**

| **Landscape Component** | **Core PA Nodes** The National Parks | **Stepping Stones** Priority nodes outside of current PAs | **Landscape linkages** Key landscape linkages and knickpoints in the farming landscape | **Broader Farming Mosaic** The broader landscape mosaic | **Institutional issues** |
|---|---|---|---|---|---|
| **Description** | The current core national parks and protected forests. | Critical pieces of biodiversity outside of the PAs required for landscape connectivity, maintenance of biodiversity and delivery of ecosystem services. | The parts of landscape within identified key corridors, where functional connectivity and ability to deliver ecosystem services needs to be urgently maintained or improved. | Remaining farmland areas of the CND. | The non-geographic specific elements of the CND system |
| **Key ideas** | Protect and manage for climate resilience. | Restore and protect to ensure landscape connectivity and ecosystem service delivery. | Functional linked farming landscapes delivering ecosystem services. | Diverse climate change resilient farmland delivering ecosystem services. | Strong, well-capacitated and equitable environmental governance and land use planning. |
| **Required Outcome** | PAs effectively protect and manage natural forests improving resilience to climate change impacts and risks. Natural forests protected, connected, more resilient to climate change impacts and risks. | Critical landscape nodes / stepping-stones are secured and where necessary restored to a natural state. | Priority portions of the farming landscape are specifically managed to improve overall connectivity and ecosystem service delivery. | Sustainably managed farmland landscape is more biodiverse, supports delivery of ecosystem services and is resilient to climate risk. | Government and civil society are well capacitated to ensure robust landscape planning that supports climate resilience. |
| **Core benefit** | Maintain globally significant, | Biodiversity value of critical landscape nodes is maintained. | Improved connectivity of the landscape | Generally improved farmland management | Integrated land use plans, with community participation and |

| Landscape Component | Core PA Nodes The National Parks | Stepping Stones Priority nodes outside of current PAs | Landscape linkages Key landscape linkages and knickpoints in the farming landscape | Broader Farming Mosaic The broader landscape mosaic | Institutional issues |
|---|---|---|---|---|---|
| | species-rich natural forests. Core areas secure best possible source and/or refuge areas for species under climate change. | Landscape connectivity supported through retention of key stepping- stones for species movement across the landscape. | ensures long term climate resilience. Value of core PAs and priority nodes is retained (i.e. the inevitable degradation of sites due to isolation is avoided). | ensures rural sustainability and supports livelihoods. | spatial planning tools/ monitoring |
| **Associated benefits** | Improved delivery of ecosystem services (especially water) and support of rural economies and livelihoods. | Improved delivery of ecosystem services (especially water) and support of rural economies and livelihoods. | Improved delivery of ecosystem services (especially water) and support of rural economies and livelihoods. | Improved delivery of ecosystem services (especially water) and support of rural economies and livelihoods. | Cross sectoral planning and management. |

### *6.4. Priority Areas for Implementation Activities*

#### *6.4.1. Natural Forest Restoration*

Forest ecosystems play a vital role in capturing, storing and releasing water required for rainfed agriculture in the CND. The National Parks support most of the remaining montane rain forest in Rwanda, with the most extensive within the NNP. However, species composition and wildfire regimes have already been altered due to climate change, reducing the delivery of ecosystem services. Additionally, transformation and degradation of forest due to agriculture has resulted in recurring landslides, soil erosion and downstream flooding, which is exacerbated by the steep and mountainous landscape. Target restoration areas will be within the Parks, including within Park buffer zones and the highland corridor to the GMNP. The forest restoration programme will require fern clearing operations to facilitate natural forest regeneration. A community participatory approach will be adopted, with an emphasis on women, which will build on the World Bank's Landscape Approach to Forest Restoration and Conservation (LAFREC) project in the GMNP.

The aim is to implement a forest restoration programme that will include rehabilitating 6 000ha of indigenous forest in the Nyungwe National Park (NNP), restoring 500 ha in the Gishwati-Mukura National Park (GMNP) and restoring isolated forest patches outside of the PAs to

promote connectivity between the Parks. We have used rehabilitation to refer primarily to the removal of invasive plant species to allow for natural forest growth to re-establish native forest. This is primarily in areas which have been burnt and subsequently invaded by ferns. The more active / intensive forest restoration process involves the active planting / establishment of native forest. In both cases, the actions explicitly mean rehabilitating or restoring to a natural state, rather than agroforestry or improved plantations.

Catastrophic fires in NNP during the 1997 drought led to the loss of 13% of natural forest. Following these fires, bracken fern (*Pteridium aquilinum*) rapidly colonized areas, and became dominant due to their fire-resistant rhizomes, large biomass and air-borne spores. Shading and allopathic compounds that inhibit the establishment and growth of tree seedlings and other plant species occurred. Natural regeneration in some areas of Nyungwe Forest has been stalled for over 20 years. Field visits to fern dominated sites demonstrated that average tree height is <30cm, when in healthy forest it is >2m. If burned areas do not recover to forest, this can further dry out the remaining forest, creating negative feedback loops that increase the risk of additional fires, insect damage and soil erosion.

#### *6.4.1.1. Rehabilitation of Natural Forest within National Parks*

The focus of the restoration programme in the National Parks (Figure 36) should consider:
Degraded forest areas due to alien plant infestation or species loss are not shown or delineated within the National Parks. “Sparse forest” from the landcover data could potentially be used, however, this is probably not a valid assumption and is not recommended.
The assumption is that 4,500 ha of rehabilitation through fern clearing is confirmed as reasonable from park management.
The proposal should be flexible and not site specific to allow activities to be conducted in any of the core NPs, as well as the other small Protected Forests i.e. Dutake and Karehe-Gatuntu.

The three National Parks cover a combined area of 120 803 ha, with Nyungwe NP protecting the largest area of montane rain forest habitat. The Protected Forests, Dutake and Karehe-Gatuntu, represent an area of 30 ha (Table18).

**Table 18: Summary table of the extent (ha) of formal Protected Areas in the Congo Nile Divide. Degraded areas within the various National Parks and Protected Forests should be cleared of alien and/or invasive species to allow natural processes to restore native forest. The available datasets do not allow the mapping of precise areas in each PA. This requires a combination of high-resolution remote sensing and ground-truthing.**

| Protected Areas | Area (ha) |
|---|---|
| **Core PA Nodes** | **120 803,6** |
| Gishwati NP | 1 456,2 |
| Mukura NP | 1 995,3 |
| Nyungwe NP | 101 347,8 |

| Protected Areas | Area (ha) |
|---|---|
| Volcanoes NP | 16 004,2 |
| **Stepping Stones** | **30,0** |
| Dutake Protected Forest | 10,8 |
| Karehe-Gatuntu Protected Forest | 19,2 |
| **Grand Total** | **120 833,6** |

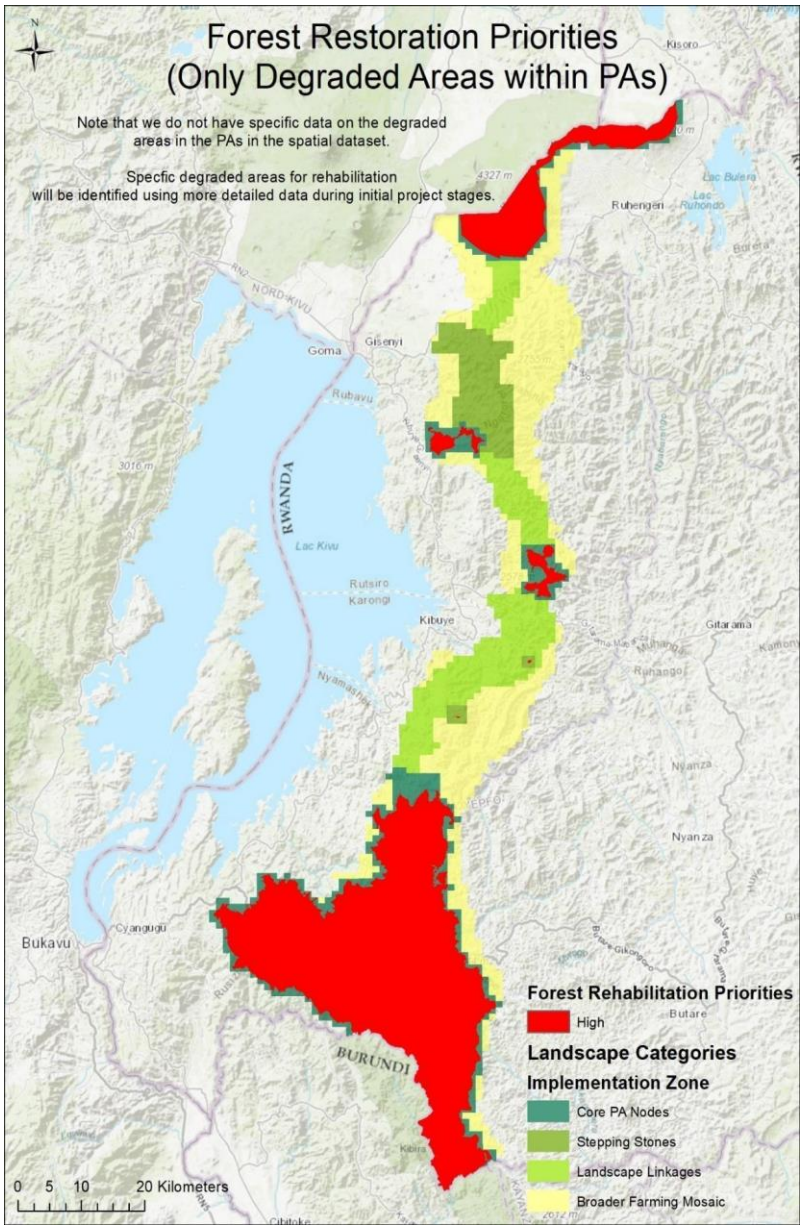


Figure 36. Map showing the extent of high priority areas for natural forest rehabilitation within National Parks and Stepping Stones in the Congo Nile Divide.

#### *6.4.1.2. Restoration of Natural Forest within National Park Buffers and Stepping Stones*

The focus of the restoration programme in the Park Buffers and Stepping Stones (Figure 37) should consider:

The original project proposal aimed for 500 ha of forest restoration around Gishwati-Mukura National Park (GMNP). The spatial analysis confirms that most of the areas suitable for forest restoration are around GMNP (Table 19).

An attempt has been made to prioritise the degraded, steep slopes in the park buffers and the Stepping Stones areas. The Gishwati Pastures Stepping Stone has been excluded as it is the focus of other interventions and does not have a core PA around which to focus the forest restoration.

A total area of 2 492 ha is likely to be available for restoration. It is recommended to target as much of this as possible. This would help ensure the viability of the Protected Areas, important for the major core areas, such as Volcanoes NP[136] and Nyungwe NP; the critical smaller core areas of Gishwati and Mukura NP; and the very small pockets of Dutake and Karehe-Gatuntu Protected Forests.

**Table 19. Priority areas for forest restoration. These areas focus on degraded and steep slopes in the buffers around the Core PA Nodes and in the Stepping Stones. The Gishwati Pastures Stepping Stone is excluded as it is targeted for other interventions.**

| Sector | Area (ha) |
|---|---|
| **Core PA Nodes - Buffer Areas Only** | **2 340,0** |
| Gishwati NP Buffer | 795,7 |
| Mukura NP Buffer | 1 444,3 |
| Nyungwe NP Buffer | 85,9 |
| Volcanoes NP "Buffer" | 14,1 |
| **Stepping Stones** | **152,9** |
| Dutake Stepping Stone | 151,4 |
| Karehe-Gatuntu Stepping Stone | 1,4 |
| **Grand Total** | **2 492,9** |

136 *Although Volcanoes NP does not have a legally designated buffer, the term "Buffer" refers to areas adjacent to the park which need to be managed.*

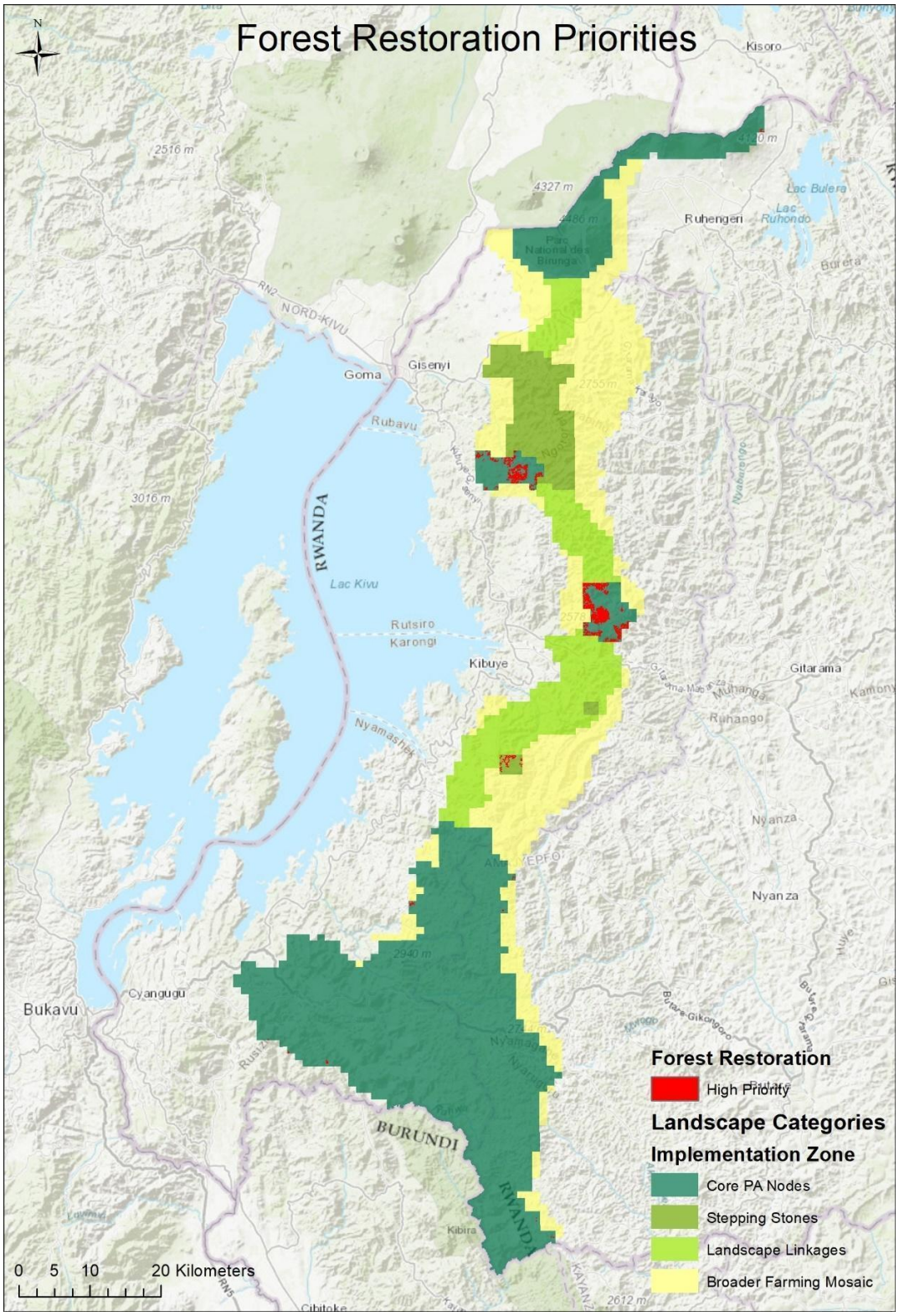


Figure 37. Map showing the extent of high priority areas for natural forest restoration within National Park buffers and Stepping Stones in the Congo Nile Divide.

#### *6.4.1.3. Methods for Natural Forest Restoration*

This project will focus on assisted natural regeneration, which has been shown to be the most effective method for natural forest restoration in the CND, both in terms of biodiversity benefits and cost. Multiple year research within Nyungwe and Gishwati-Mukura NPs has shown that assisted natural regeneration of natural forests is the most appropriate strategy in Western Rwanda. It results in significantly increased tree densities (5 500 trees/ha versus 1 100 trees/ha), higher species richness, and higher average biomass compared with untreated areas (Figure 38).

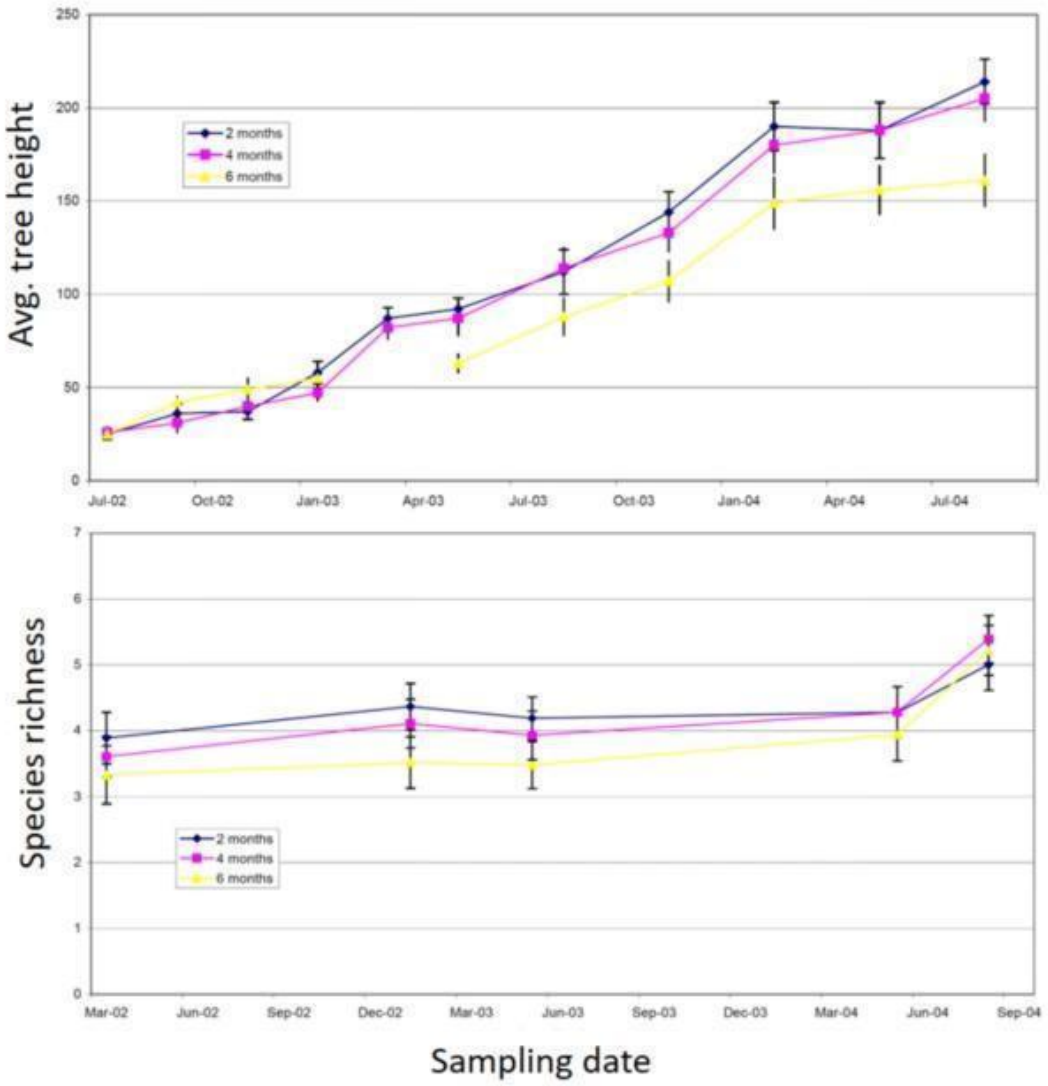


Figure 38. Results of fern clearing treatment in Nyungwe NP. The top panel demonstrates the effect of fern clearing on tree height, while the bottom panel shows the effect of fern clearing on species richness. Line colours represent different intervals between fern clearing treatments. Source: Masozera 2004.

Assisted natural regeneration involves repeated cutting of invasive bracken fern that inhibits natural recovery. Repeated cutting of the fern layer gives the opportunity for seedlings to grow taller than the fern layer and thus out-compete the ferns for light. It is not necessary to clear entire hillslopes, only carefully selected plots within the affected area, as native species will eventually grow tall enough to shade out uncleared fern areas. This is much more cost-effective

than active restoration (e.g. tree planting), as there are no costs associated with seedling production or tree planting, and an active restoration approach would require the removal of ferns regardless.

The Wildlife Conservation Society (WCS) has been conducting assisted natural regeneration on a small scale in Nyungwe NP since the mid-2000s. A specialized technique has been established to visually blend the treated area with the natural contours and conditions in the forest. Research has shown that plots appeared more natural when the plot size and shape is varied. Consequently, plots will be grouped into three size categories: a large plot of 750 $m^2$, a medium plot of 500 $m^2$, and a small plot of 250 $m^2$. Field teams will choose plot shape and orientation that blends with the natural landscape, as well as plots that will minimize potential erosion (plots running along slope contours and not downhill). Local community members will be hired to carry out the removal of bracken fern using machetes and other hand tools. Existing trees/saplings/seedlings will be protected throughout this process, and 2 - 5 cm of detritus will be left to protect the soil. Since bracken fern is uniquely proficient in mobilizing mineralized nutrients, such as inorganic phosphate, nitrogen, and potassium, the cut fronds will be left onsite to jumpstart the nutrient cycling process. Restoration sites will be revisited; and newly sprouted herbaceous vegetation removed every three months for a period of three years. This will be done to ensure establishment of new trees while keeping fern cover low.

### *6.4.2. Protective Forests and Riparian Land Interventions*

The aim is to restore 2,500 ha of protective forests on slopes >55% by promoting indigenous tree planting on farms and along altitudinal and riparian linkages to reduce landslides, soil erosion and downstream flooding. In addition, to increase the supply of fuelwood for cooking and to reduce the time woman allocate to collecting wood. In Rwanda, most protective forests comprise exotic species, including Eucalyptus and Pine. Thus, the project intervention is to facilitate the planting of indigenous species, where feasible. This shall be weighed against community needs for faster growing exotics and the higher cost of indigenous trees. Restoration will be conducted on public land, private land (community cooperatives) and public private partnerships (forest plantations) where food production is not taking place and agreements are signed.

#### *6.4.2.1. Restoration of Protective Forests on Steep Slopes (> 55%)*

The focus of the protective forest restoration programme on steep slopes in the Park Buffers, Stepping Stones and Landscape Linkages (Figure 39) should consider:

Steep land (over 55%) are the focus in priority sections of the landscape, namely Core PA Node Buffers, Stepping Stones and Landscape Linkages. A total of 17 637 ha is highlighted for potential protective afforestation (Table 19).

The focus is on agricultural land, cultivated pasture and plantations which are likely to be the most suitable land use classes for protective forest restoration on steep slopes. There are likely to be additional areas outside of these land use classes.

Further, should resources be available for additional slopes to be afforested to protect against erosion and landslides, this could include an additional 6 947 ha of eroded low angle slopes in the three landscape categories / priority sectors.

In addition, a very large area, measuring more than 16 550 ha of steep land exists within these three land cover classes in the Broader farming Mosaic.

Landscape Linkages areas includes the bulk of the slopes targeted for restoration at 9 620ha, whereas the Park Buffers and Stepping Stones amount to 4 896 ha and 3 119ha respectively (Table 20).

**Table 20. Steep land (over 55%) in priority sections of the three landscape categories and land use classes. The Core PA Node Buffers, Stepping Stones, and Landscape Linkages form the priorities for protective forests.**

| Sector | Agriculture (ha) | Cultivated Pasture (ha) | Plantations (ha) | Grand Total (ha) |
|---|---|---|---|---|
| **Core PA Nodes - Buffer Areas Only** | **1 151,7** | **101,9** | **3 643,1** | **4 896,8** |
| Gishwati NP Buffer | 271,7 | 36,5 | 248,6 | 556,8 |
| Mukura NP Buffer | 449,0 | 42,9 | 229,7 | 721,6 |
| Nyungwe NP Buffer | 392,2 | 13,6 | 3 127,2 | 3 533,0 |
| Volcanoes NP Buffer | 38,8 | 9,0 | 37,6 | 85,4 |
| **Stepping Stones** | **575,1** | **1 061,6** | **1 483,2** | **3 119,9** |
| Dutake Stepping Stone | 138,2 | 5,9 | 134,3 | 278,4 |
| Gishwati Pastures Stepping Stone | 420,4 | 1 055,4 | 1 294,5 | 2 770,3 |
| Karehe-Gatuntu Stepping Stone | 16,5 | 0,3 | 54,3 | 71,2 |
| **Landscape Linkages** | **3 901,2** | **370,6** | **5 348,9** | **9 620,8** |
| Gishwati NP to Volcanoes NP Linkage | 256,4 | 32,9 | 112,7 | 402,0 |
| Mukura NP to Gishwati NP Linkage | 1 067,1 | 267,4 | 1 107,8 | 2 442,4 |
| Nyungwe NP to Mukura NP Linkage | 2 577,7 | 70,3 | 4 128,5 | 6 776,4 |
| **Grand Total** | **5 628,0** | **1 534,2** | **10 475,2** | **17 637,4** |

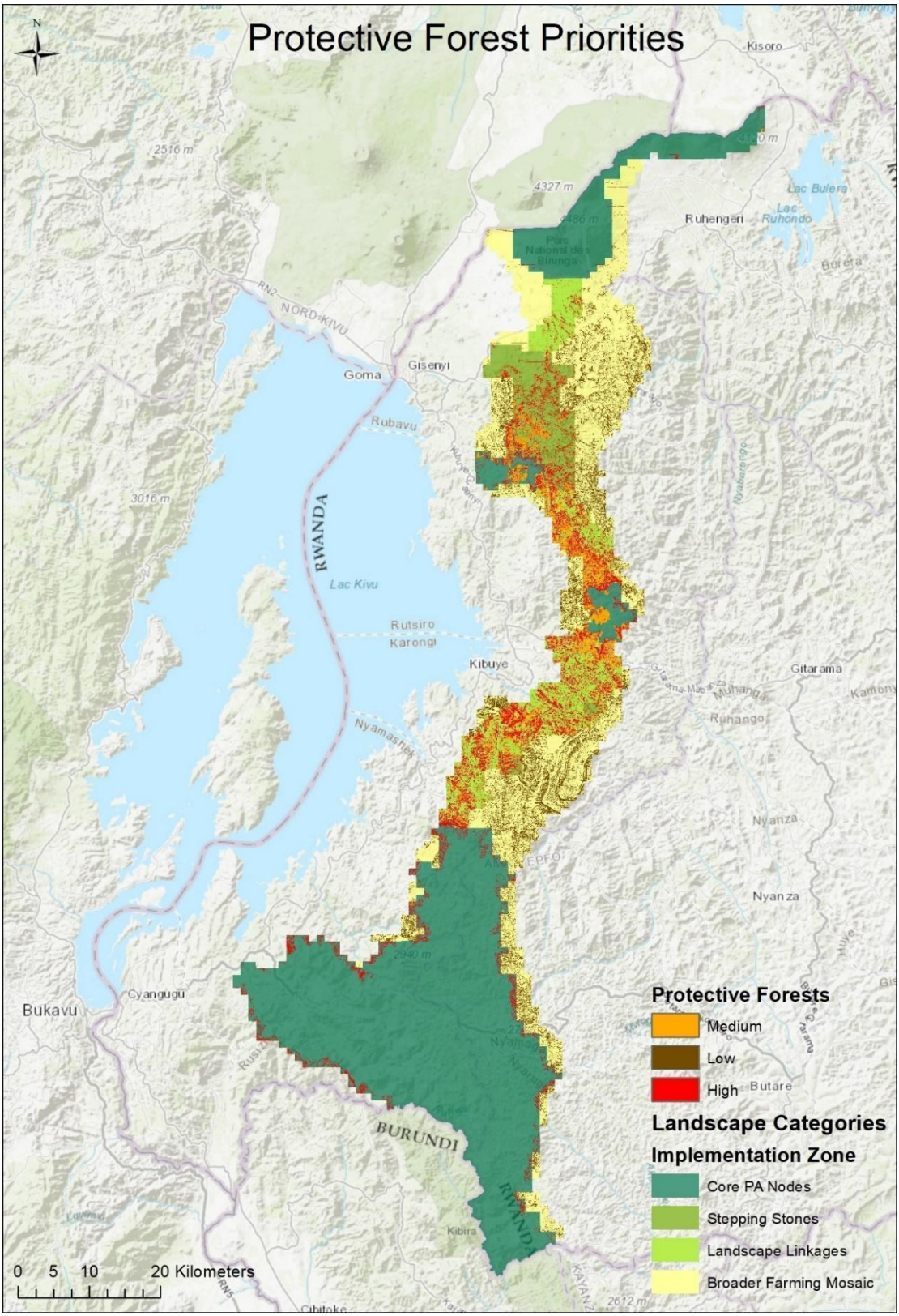


Figure 39. Map showing the extent of priority areas (High, Medium, Low) for protective forest restoration on steep slopes (>55%) in the Congo Nile Divide.

#### *6.4.2.2. Restoration of Protective Forests on Riparian Land*

The focus of the protective forest restoration programme along riparian lands in the Park Buffers, Stepping Stones and Landscape Linkages (Figure 40) should consider:
Riparian areas are both valuable in their own right and provide a key opportunity to link landscapes at a medium scale.
Two options are suggested:

- The first (Table 21) highlights the highest priority areas in the Core PA Nodes, Stepping Stones and Landscape Linkages. There are approximately 1 566 ha within this category.
- The second (Table 22) includes an additional 2 051 ha of riparian areas within the Broader Farming Mosaics, which would increase the potential footprint within which implementation could occur to 3 618 ha.

Given the extremely high value of riparian areas for supporting ecosystem services, ideally, wetlands throughout the area would be improved. However, the 1 566 ha wetlands in the Core PA Nodes, Stepping Stones and Landscape Linkages are of much higher overall priority as they contribute significantly more to overall landscape connectivity.

**Table 21: Riparian areas in Core PA Node Buffers, Stepping Stones and Landscape Linkages within impacted landscapes only (agriculture, grassland pastures, plantations etc).**

| Sector | River and Buffer (ha) | Wetland and Buffer (ha) | Grand Total (ha) |
|---|---|---|---|
| **Core PA Nodes - Buffer Areas Only** | **178,4** | **181,9** | **360,3** |
| Gishwati NP Buffer | 21,9 | 23,4 | 45,4 |
| Mukura NP Buffer | 18,4 | 59,0 | 77,5 |
| Nyungwe NP Buffer | 120,0 | 99,4 | 219,5 |
| Volcanoes NP Buffer | 18,0 | 0 | 18,0 |
| **Stepping Stones** | **133,6** | **135,5** | **269,1** |
| Dutake Stepping Stone | 18,9 | 22,9 | 41,9 |
| Gishwati Pastures Stepping Stone | 113,8 | 81,6 | 195,4 |
| Karehe-Gatuntu Stepping Stone | 0,9 | 31,0 | 31,8 |
| **Landscape Linkages** | **447,9** | **489,2** | **937,1** |
| Gishwati NP to Volcanoes NP Linkage | 16,5 | 63,8 | 80,3 |
| Mukura NP to Gishwati NP Linkage | 117,3 | 41,1 | 158,4 |
| Nyungwe NP to Mukura NP Linkage | 314,2 | 384,3 | 698,5 |
| **Grand Total** | **760,0** | **806,6** | **1 566,6** |

**Table 22. Riparian areas in Core PA Node Buffers, Stepping Stones, Landscape Linkages and Broader Farming Mosaics within impacted landscapes only (agriculture, grassland pastures, plantations etc).**

| Sector | River and Buffer (ha) | Wetland and Buffer (ha) | Grand Total (ha) |
|---|---|---|---|
| **Core PA Nodes (Buffer areas only)** | **178,4** | **181,9** | **360,3** |
| Gishwati NP Buffer | 21,9 | 23,4 | 45,4 |
| Mukura NP Buffer | 18,4 | 59,0 | 77,5 |
| Nyungwe NP Buffer | 120,0 | 99,4 | 219,5 |
| Volcanoes NP Buffer | 18,0 | 0 | 18,0 |
| **Stepping Stones** | **133,6** | **135,5** | **269,1** |
| Dutake Stepping Stone | 18,9 | 22,9 | 41,9 |
| Gishwati Pastures Stepping Stone | 113,8 | 81,6 | 195,4 |
| Karehe-Gatuntu Stepping Stone | 0,9 | 31,0 | 31,8 |
| **Landscape Linkages** | **447,9** | **489,2** | **937,1** |
| Gishwati NP to Volcanoes NP Linkage | 16,5 | 63,8 | 80,3 |
| Mukura NP to Gishwati NP Linkage | 117,3 | 41,1 | 158,4 |
| Nyungwe NP to Mukura NP Linkage | 314,2 | 384,3 | 698,5 |
| **Broader Farming Mosaic** | **1 038,3** | **1 013,4** | **2 051,7** |
| Gishwati Broader Farming Mosaic | 377,7 | 650,3 | 1 028,0 |
| Mukura Broader Farming Mosaic | 54,2 | 50,4 | 104,6 |
| Nyugwe to Mukura Broader Farming Mosaic | 403,9 | 155,5 | 559,3 |
| Nyungwe Broader Farming Mosaic | 175,9 | 144,7 | 320,6 |
| Volcanoes Broader Farming Mosaic | 26,6 | 12,5 | 39,1 |
| **Grand Total** | **1 798,3** | **1 820,0** | **3 618,2** |

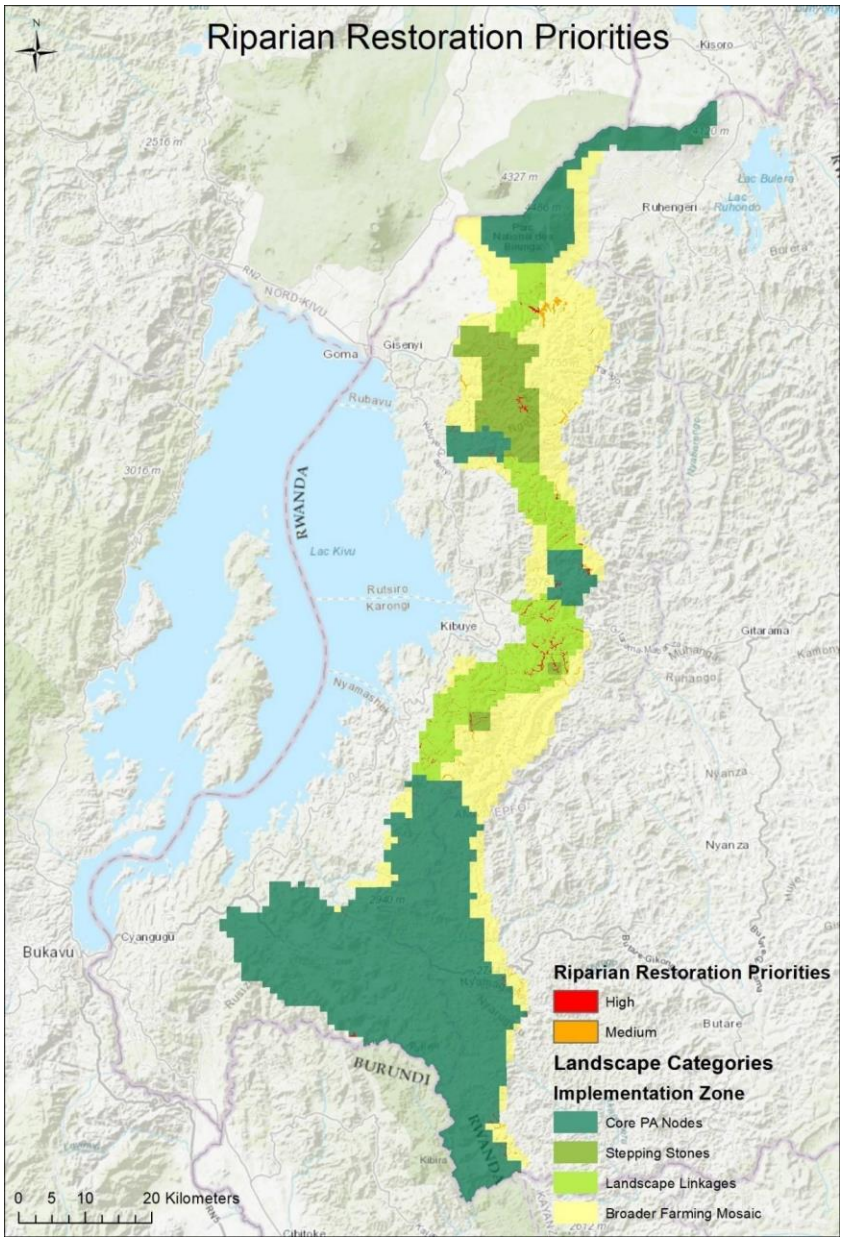


Figure 40. Map showing the extent of priority areas for protective forest restoration along riparian areas in the Congo Nile Divide.

#### *6.4.2.3. Protective Forests and Restoration Activities in the Congo Nile Divide*

Most of the plantation forests in Rwanda have protective and/or productive functions. Protective forests are used to prevent erosion on the many steeply sloped ridges and hillsides, and along riverbank and lake shores, while providing ecosystem services (e.g. woodfuel and non-timber forest products). Regulating ecosystem services are also provided (e.g. runoff control, climate regulation), as well as supporting ecosystem services (e.g. nutrient cycling). Using indigenous species can also provide substantial biodiversity benefits. Productive forests are a source of woody biomass for energy and construction materials, and many also have protective functions. However, demand for wood far outstrips supply, driving unsustainable and illegal exploitation of woodlots and natural forests, and reducing ecosystem service benefits.

Enhancing and restoring protective forest plantations is a key step toward restoring ecosystem function and services identified in the National Forest Policy, especially for (i) reducing the risk of flooding, landslides and soil erosion from extreme climate events, and (ii) increasing long-term supply of woodfuel resources (relied upon by 99% of Rwandans). In Rwanda, protective forests are generally defined as forest plantations managed predominantly for the provision of services (e.g. soil and water protection, rehabilitation of degraded lands), while productive forests are forest plantations predominantly intended for the provision of wood, fibre and non-timber forest products. However, protective forests are also often harvested for wood, and productive forests do play a role in providing ecosystem services, such as runoff reduction. As such, this assessment focuses on all plantation forests in the CND and does not attempt to categorize forests as productive/protective.

The vast majority of plantations in the CND are made up of *Eucalyptus spp.* and *Pinus patula,* with some other species (Figure 41). These two species are chosen primarily because they are fast growing and can provide several valuable products (e.g. fuelwood, timber, charcoal, and poles). However, a number of issues arise with these exotic monoculture plantations.

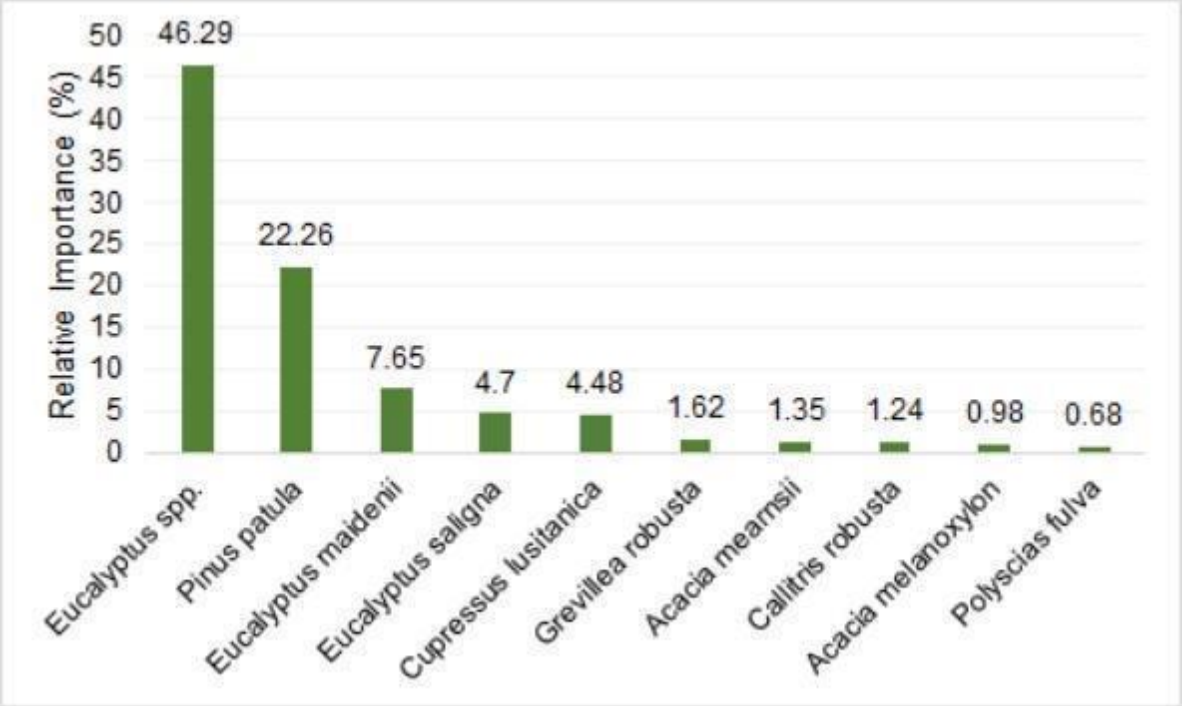


Figure 41. Top ten tree species in plantation forests of Rwanda (Source: National Forest Inventory 2015). All species are exotic apart from *Polyscias fulva*.

#### *6.4.2.3.1. Forest management practices in the CND*

Forest plantations in the CND can be divided into three categories by ownership, with different categories showing vastly different characteristics: state forests, district forests, and private forests. Regardless of ownership, many individual forest plantations in the CND are degraded and stocked at a much lower level than is possible. The 2019 national forest cover mapping report shows that 31 631 (43.3%) plantations in the CND have a density of medium or below (<70% canopy cover).

The reasons for this are varied, but the primary cause is poor forest management and a very high dependency on wood biomass, which results in a lack of adherence to silvicultural best practices throughout the harvest cycle of a plantation. Beginning with species selection, a key problem is that detailed site assessment information - concerning climatic, edaphic, and biophysical properties - is not widely available and therefore not used in matching species to site conditions. This, combined with the poor availability of high-quality seeds and seedlings, means that the species planted are seldom best suited to their planting sites.

Next, although some weeding and cultivation is undertaken in places, many seedlings are simply planted into the ground and effectively left to establish in competition with other vegetation. No fertilizer is added to the crop during planting. Late planting is also common, which leads to poor early growth and survival, reduces productivity, and increases establishment costs. Many young plantations have been densely established at very close spacing and not appropriately thinned later on, which leads to faster growing stems outcompeting and suppressing weaker trees. Suppressed trees become stressed and can attract pests and pest population build up. Trees are also often pruned too heavily to fill demand for fuelwood and stakes, leading to stress and poor tree growth (Figure 42).

Figure 42. An over-pruned *Pinus* plantation near Gitesi village in Karongi District.

Finally, harvesting is frequently undertaken extremely early, often at below three years of age, driven by a combination of the high demand for fuelwood and/or charcoal and to raise urgently needed finance for other needs (especially in privately owned woodlots). This reduces the overall wood volume harvested, as well as reducing forest productivity by accelerating coppice stool exhaustion. Harvesting is undertaken with axes or pangas, resulting in damaged trees, thus risking decay and infection. Silviculture practices are so poorly implemented in some forests that erosion features are visible even in the forested areas (Figure 55, Section 6.4.3.4.5). As a result, there is clear potential for improved management of CND forests to increase long-term supply of woodfuel resources, while also reducing the risk of flooding, landslides and soil erosion from extreme climate events.

#### *6.4.2.3.2. Climate rationale and alignment with National Policies*

Climate change is endangering the forest ecosystems and landscapes that are critical for building climate resilience for the 2.3 million people in the CND region. Most of the people in the CND are smallholder farmers living on steep slopes without access to irrigation. They are faced with severe erosion and land degradation, which reduces overall land productivity, and lack the financial means to invest in strategies to address this (e.g. afforestation, terracing). The increasing frequency of extreme rainfall events due to climate change – combined with forest loss and degradation - is increasing the loss of lives and property from landslides. The CND also loses an average of 1.5 million tons of fertile soil per year from heavy rainfall due to climate change, landslides and erosion. Loss of soil fertility through drought and erosion on steep

slopes, combined with a severe woodfuel supply deficit, forces farmers to convert more forests to farmland to maintain crop yields, therefore degrading existing plantation forests through over-exploitation for wood. This further reduces the buffering effect that forests have against soil loss; and reduces available wood supply in the future because plantations enter an extremely degraded and unproductive state. Afforestation and restoration of degraded protective forests therefore has great potential to increase the climate resilience of vulnerable communities in the CND, by reducing the impact of extreme rainfall events on soil erosion and landslides, and by increasing overall wood supply, which will also reduce pressure on existing forests.

A key strategy of the Rwandan government is to increase protective forest cover on steep slopes, to help control erosion and to increase woodfuel supply. Rwanda's National Land Use and Development Master Plan calls for all slopes >55% to be forested, using both natural forests and exotic species. Rwanda's Nationally Determined Contribution under the UNFCCC also promotes afforestation and reforestation as a key part of the country's climate mitigation and adaptation programme. Similarly, Rwanda's Green Growth and Climate Resilience Strategy and Rwanda's National Forest Policy both outline targets for afforestation and establishment of new forest plantations. Many other government strategies which support the establishment of protective forests are outlined in Section 3 of this document. The establishment of protective forests is thus clearly aligned with government policies and is an essential tool to increase the resilience of rural communities in the CND.

#### *6.4.2.3.3. Field assessment of protective forest opportunity*

Field visits to seven sites across the CND were conducted in August 2021 (applying the Vital Signs methodology outlined in Appendix 1) to better understand the suitability of the protective forest priority areas. As expected, the state of forested areas varied considerably across the CND, and silvicultural practices were generally quite poor. The number of tree plots varied substantially, and the widespread use of poor tree management practices (such as over-pruning and not thinning seedlings to reduce over-competition and poor growth of mature trees) was confirmed (Figure 43).

Figure 43. Very densely planted *Eucalyptus forest* in Ruhango.

Soil erosion was present in all plots visited. One of the key determinants of soil erosion in forests is the percentage cover of leaf litter on the ground. Poor leaf litter coverage was observed in many plots, which may explain the widespread erosion (Figure 44). Overall, these results help confirm the results of many previous studies and indicate that degradation of plantation forests in the CND is widespread. There is a clear need for interventions to restore the health of protective forests across the CND, such that erosion control and woodfuel benefits can be fully realized.

Figure 44. Poor leaf litter coverage in plantation forest in Sovu.

#### *6.4.2.3.4. Species selection for protective forests*

While the vast majority of woodlots in the CND are made up of *Pinus* and *Eucalyptus* species, this project will emphasize diversification and quality improvement of the plantation tree species, especially indigenous species which are better adapted to local conditions. The project will also prioritize mixed forests where possible, as evidence shows they are more resistant to natural disturbances. Additionally, diversity in terms of hydraulic strategies increases ecosystem resilience during droughts, which are predicted to worsen under climate change in Rwanda. A more detailed assessment of the pros/cons of exotic and indigenous tree plantations is provided in Section 5 (Options Analysis).

On publicly owned land, the primary focus will be to conduct restoration using a mix of native species to restore natural forest. On private land, landowner preferences must be considered, and many landowners want to plan fast-growing exotics, such as *Eucalyptus* or *Pinus*. To help promote the use of indigenous species, the project will implement an outreach and education program on the benefits of indigenous species, to ensure farmers understand the utility of indigenous species. When farmers wish to plant exotic species that have the potential to negatively impact natural forest, then the potential impacts of those species on natural forest will be assessed. Additionally, appropriate mitigation measures will be applied (e.g. heavy pruning to reduce risk of seed transmission). If mitigation of the risk is not possible (e.g. they are very close to natural forest areas), those sites will not be targeted by the project.

A preliminary list of suitable species for protective forests is shown in Table 23. The list focusses

on indigenous species, as that is the primary focus of the project. During project implementation, evaluation of landowner preference, site suitability, forest benefits, value for forest resilience and species availability will be considered to determine the most appropriate species mix for each context. The project will focus on promoting indigenous species; but may plant some exotic species, such as *Eucalyptus* or Pine (dependent on landowner preference and risk of negative impacts from exotic species).

**Table 23. Preliminary list of indigenous tree species that can be used for establishment of protective forests.**

| Names | Family | Origin | Growth Rates | Altitude Range (m) |
|---|---|---|---|---|
| *Acacia polyacantha* | Fabaceae | Native | Fast | 200-1800 |
| *Carapa glandiflora* | Meliaceae | Native | Fast | 1700 - 2700 |
| *Croton megalocarpus* | Euphorbiaceae | Native | Fast | 1200 -2450 |
| *Dombeya torrida* | Sterculiaceae | Native | Fast | 1600 - 3400 |
| *Entandrophragma excelsum* | Meliaceae | Native | Slow | 1280 – 2150 |
| *Entandrophragma excelsum* | Meliaceae | Native | - | 925 - 2220 |
| *Ficalhoa laurifolia* | Theaceae | Native | Fast | - |
| *Ficus ingens* | Moraceae | Native | Fast | - |
| *Ficus sp.* | Moraceae | Native | Fast | - |
| *Hagenia abyssinica* | Rosaceae | Native | Fast | 2000-2430 |
| *Harungana montana* | Hypericaceae | Native | Fast | 2000-3000 |
| *Macaranga kilimandscharica* | Euphorbiaceae | Native | Fast | 1300 - 3000 |
| *Maesa lanceolata* | Myrsinaceae | Native | Fast | 600-2500 |
| *Maesopsis emnii* | Rhamnaceae | Native | - | 600-1800 |
| *Markhamia lutea* | Bignoniaceae | Native | Fast | 700-2000 |
| *Myrianthus holstii* | Moraceae | Native | Fast | 351-2263 |
| *Neoboutonia macrocalyx* | Euphorbiaceae | Native | Fast | 600 - 2500 |
| *Podocarpus falcatus* | Podocarpaceae | Native | Fast | 1500-3000 |
| *Polyscias fulva* | Araliaceae | Native | Fast | 1180-2500 |

| Names | Family | Origin | Growth Rates | Altitude Range (m) |
|---|---|---|---|---|
| *Prunus africana* | Rosaceae | Native | Medium | 900 - 2500 |
| *Rapanea melanophloeos* | Myrsinaceae | Native | Fast | - |
| *Symphonia globulifera* | Clusiaceae | Native | Slow | 0 -2600 |
| *Syzygium guineense* | Myrtaceae | Native | Medium | 0-2500+ |
| *Xymalos monospora* | Monimiaceae | Native | Fast | 900 - 2700 |

#### *6.4.2.3.5. Approaches and methods for sustainable forest management*

Under the Support Programme to the Development of the Forestry Sector (PAREF Be2) project, Rwanda Natural Resources Authority (RNRA) developed detailed guidelines around sustainable forest management techniques in two documents:

- Tree plantation establishment and management manual for Rwanda (Unique Ltd. & RNRA, 2015)
- Tree harvesting techniques manual for Rwanda (Unique Ltd. & RNRA, 2015).

These guideline documents will provide general guidance on physical forest management activities, such as nursery management, planting, pruning etc. All plantations established under this project will follow the best practice guidelines outlined in the manuals.

While the guidelines outline the physical aspects of good forest management, it is also important to use appropriate regulatory structures and management approaches to ensure the sustainability of forest plantations. The recent establishment of a hierarchy of District Forest Management Plans (DFMPs), comprised of smaller 50-300 ha Forest Management Units (FMUs), aggregates several forest stands into one coherent management entity. This is done according to land ownership, key purpose of the forest, species and regime etc. Each FMU has a Simplified Forest Management Plan (SFMP). The detailed methodology and the technical modalities for the design and implementation of the plans have already been developed and will be followed in this project. To implement the SFMPs, officer level positions, such as Rwanda Forestry Authority Officers, District Forest Officers, and Forest Sector Extensionists, are created and personnel are recruited. While this approach can be effective, monitoring of implemented plans is often challenging due to the lack of adequate training and skills and a lack of clarity on the ownership and boundaries of woodlots. This project will build on the recent development of a Forest Monitoring and Evaluation Software (FMES) by the ENABEL Forest Management and Biomass Energy project. Training of forest officers in the use of this software will be a key focus of this project.

### *6.4.3. Agroforestry Interventions*

The aim is to establish biodiversity-friendly agroforestry practices in existing agricultural lands located within Park Buffers, Stepping Stones and Landscape Linkages. This will be achieved through several mechanisms and/ or project activities, including the promotion of silvo-pastoral systems to increase biodiversity on pasture lands in Gishwati areas, agroforestry interventions on 2 500 ha of farmland, and the introduction of indigenous shade trees in tea and coffee plantations.

#### *6.4.3.1. Agroforestry in Key Highland Linkages*

The focus of the agroforestry programme in key highland linkages in the Park Buffers, Stepping Stones and Landscape Linkages (Figure 42) should consider:

- Agroforestry interventions focus on existing agricultural land within the priority landscape sectors (i.e. in the buffers around the Core PA Nodes, the areas around the Protected Forests in the Stepping Stones and in the key Landscape Linkages) (Table 24). A total of 24 216 ha has been identified.
- The Gishwati Pastures Stepping Stone is dealt with separately as it is the focus of a different implementation activity, i.e. agroforestry on pastoral land (silvo-pastoral practices).
- The areas of agricultural land which would significantly benefit from agroforestry interventions substantially exceed potential project interventions. Therefore, the focus should be on:
    - Priorities around the Core PA Nodes and the Protected Forests in the Stepping Stones, and then in the Landscape Linkages.
    - Areas where landscape degradation has occurred (i.e. 2 198 ha of steep, eroded areas and 5 013 ha of eroded areas that are not steep, which together total 7 211 ha) or is a high risk (i.e. steep but not eroded, which include an addition 3 009 ha).

**Table 24. Existing agricultural land in key highland linkages are the focus areas for agroforestry interventions.**

| Sector | Eroded and Steep (ha) | Eroded but Not Steep (ha) | Steep but Not Eroded (ha) | Not Eroded or Steep (ha) | Total (ha) |
|---|---|---|---|---|---|
| **Core PA Nodes - Buffer Areas Only** | **546,7** | **1 351,5** | **605,0** | **3 509,3** | **6 012,5** |
| Gishwati NP Buffer | 176,5 | 518,0 | 95,2 | 469,4 | 1 259,1 |
| Mukura NP Buffer | 344,2 | 785,5 | 104,8 | 322,8 | 1 557,3 |
| Nyungwe NP Buffer | 25,9 | 43,7 | 366,3 | 1 082,2 | 1 518,1 |
| Volcanoes NP Buffer | 0,1 | 4,3 | 38,7 | 1 634,9 | 1 678,0 |
| **Stepping Stones** | **38,8** | **79,3** | **115,9** | **440,8** | **674,7** |

| Sector | Eroded and Steep (ha) | Eroded but Not Steep (ha) | Steep but Not Eroded (ha) | Not Eroded or Steep (ha) | Total (ha) |
|---|---|---|---|---|---|
| Dutake Stepping Stone | 38,3 | 78,5 | 99,8 | 262,6 | 479,3 |
| Karehe-Gatuntu Stepping Stone | 0,5 | 0,7 | 16,0 | 178,2 | 195,5 |
| **Landscape Linkages** | **1 612,5** | **3 582,2** | **2 288,6** | **10 045,6** | **17 529,0** |
| Gishwati NP to Volcanoes NP Linkage | 0,1 | 4,9 | 256,2 | 2 036,0 | 2 297,2 |
| Mukura NP to Gishwati NP Linkage | 553,5 | 1 173,4 | 513,7 | 1 534,7 | 3 775,3 |
| Nyungwe NP to Mukura NP Linkage | 1 058,9 | 2 403,9 | 1 518,7 | 6 474,8 | 11 456,4 |
| **Grand Total** | **2 198,1** | **5 013,0** | **3 009,5** | **13 995,7** | **24 216,2** |

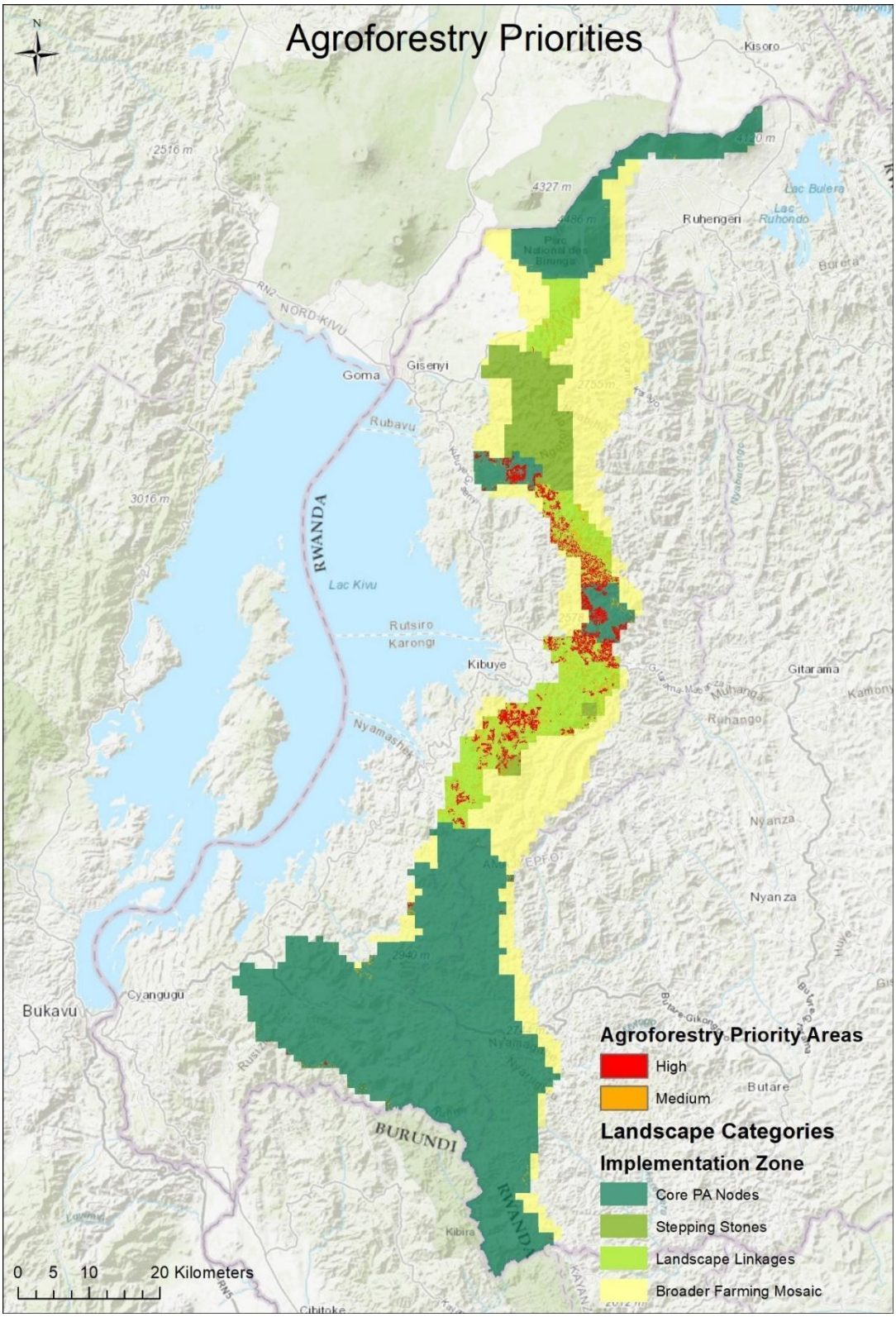


Figure 45. Map showing the extent of agroforestry priority areas (high and medium) in key highland linkages of the Congo Nile Divide.

#### *6.4.3.2. Gishwati Pastures Stepping Stone – Agroforestry on Pastoral Land (Silvo-Pastoral Practices)*

The Gishwati Pastures Stepping Stone is an identified key focus area for pasture focused agroforestry interventions (Figure 43). Interventions should be prioritised in the following areas:

- The potential implementation area is classified as “Cultivated Pasture” for cattle farming, “Possibly Natural” and interspersed “Plantation” areas. These areas total 11 932 ha.
- There should be a particular focus on the 1 224 ha which known to be in an eroded or degraded state (Table 25).

**Table 25. Areas identified for the Gishwati agroforestry on pastoral land intervention.**

| Sector | Possibly Natural (ha) | Cultivated Pasture (ha) | Plantations (ha) | Grand Total (ha) |
|---|---|---|---|---|
| **Gishwati Pastures Stepping Stone** | **2 475,4** | **6 228,7** | **3 228,5** | **11 932,6** |
| Eroded | 173,7 | 1 007,0 | 44,0 | 1 224,7 |
| Not Eroded | 2 301,7 | 5 221,7 | 3 184,6 | 10 707,9 |
| **Grand Total** | **2 475,4** | **6 228,7** | **3 228,5** | **11 932,6** |

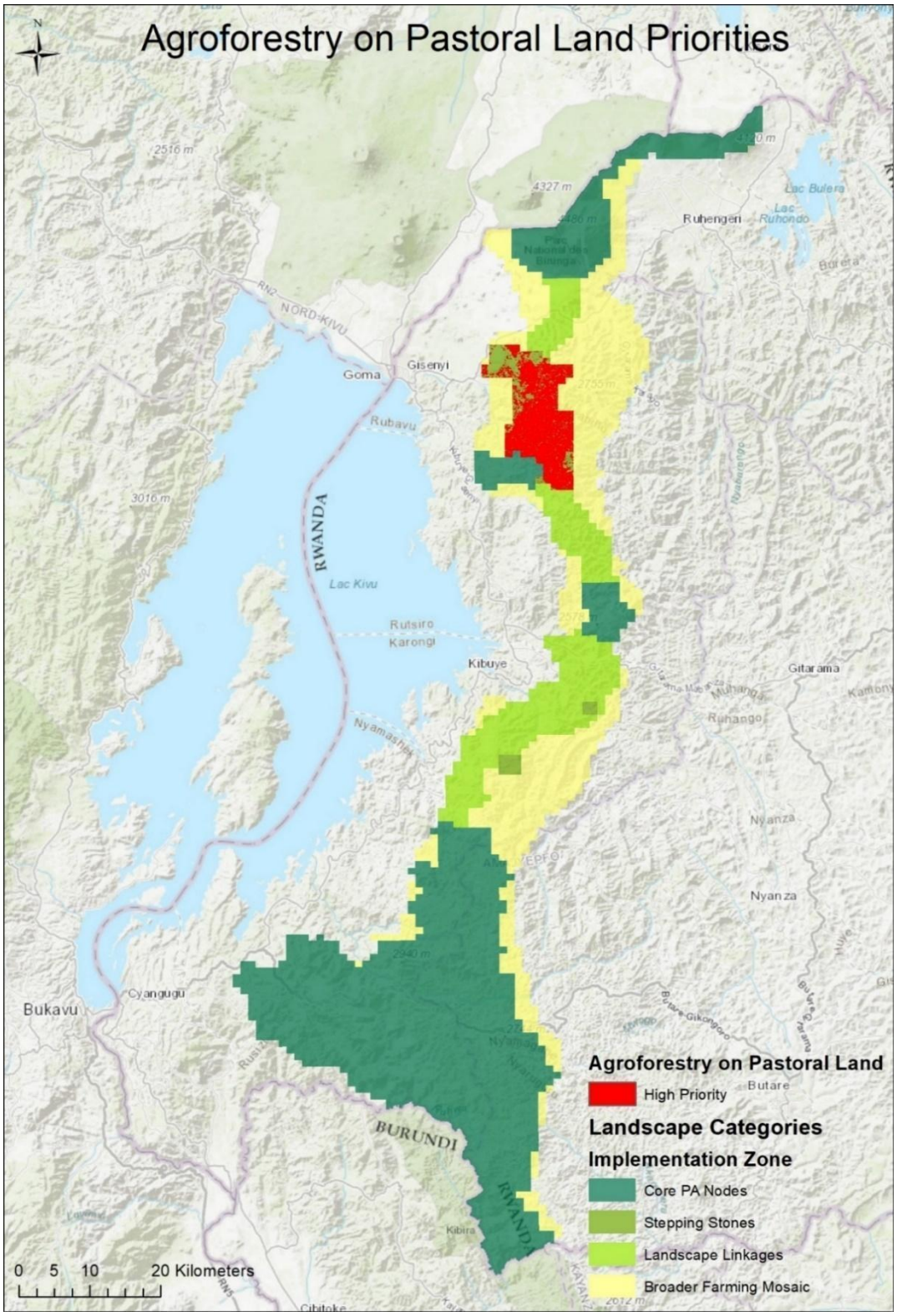


Figure 46. High priority agroforestry intervention areas on pastoral land in the Congo Nile Divide.

#### *6.4.3.3. Indigenous Shade Trees for Coffee and Tea*

The focus of agroforestry interventions in the coffee and tea plantations (Figure 44) should focus on:

- Tea and coffee plantations in the buffers of the Core PA Nodes (1 362 ha), in the buffers around the Protected Forests and elsewhere in the Stepping Stones (122 ha) and within the Landscape Linkages (883 ha) are a sensible focus for improving landscape biodiversity value through the introduction of indigenous shade trees (Table 26).
- The intervention could be extended to the Broader Farming Mosaic (5 818 ha) if project budgets allow.

This would bring the total intervention area to 8 186 ha.

**Table 26. Areas of identified tea and coffee plantations for potential promotion of the use of indigenous shade tree species to improve overall biodiversity value.**

| Sector | Tea (ha) | Coffee (ha) | Grand Total (ha) |
|---|---|---|---|
| **Core PA Nodes - Buffer Areas Only** | **1 362,8** | **0** | **1 362,8** |
| Gishwati NP Buffer | 33,4 | 0 | 33,4 |
| Mukura NP Buffer | 20,3 | 0 | 20,3 |
| Nyungwe NP Buffer | 1 309,1 | 0 | 1 309,1 |
| **Stepping Stones** | **122,4** | **0** | **122,4** |
| Dutake Stepping Stone | 105,1 | 0 | 105,1 |
| Gishwati Pastures Stepping Stone | 4,2 | 0 | 4,2 |
| Karehe-Gatuntu Stepping Stone | 13,1 | 0 | 13,1 |
| **Landscape Linkages** | **881,6** | **1,7** | **883,3** |
| Gishwati NP to Volcanoes NP Linkage | 51,6 | 0 | 51,6 |
| Mukura NP to Gishwati NP Linkage | 123,2 | 0 | 123,2 |
| Nyungwe NP to Mukura NP Linkage | 706,8 | 1,7 | 708,5 |
| **Broader Farming Mosaic** | **5 818,2** | **0** | **5 818,2** |
| Gishwati Broader Farming Mosaic | 2 066,8 | 0 | 2 066,8 |
| Mukura Broader Farming Mosaic | 53,4 | 0 | 53,4 |
| Nyugwe to Mukura Broader Farming Mosaic | 1 341,1 | 0 | 1 341,1 |

| Sector | Tea (ha) | Coffee (ha) | Grand Total (ha) |
|---|---|---|---|
| Nyungwe Broader Farming Mosaic | 2 348,5 | 0 | 2 348,5 |
| Volcanoes Broader Farming Mosaic | 8,5 | 0 | 8,5 |
| **Grand Total** | **8 185,0** | **1,7** | **8 186,6** |

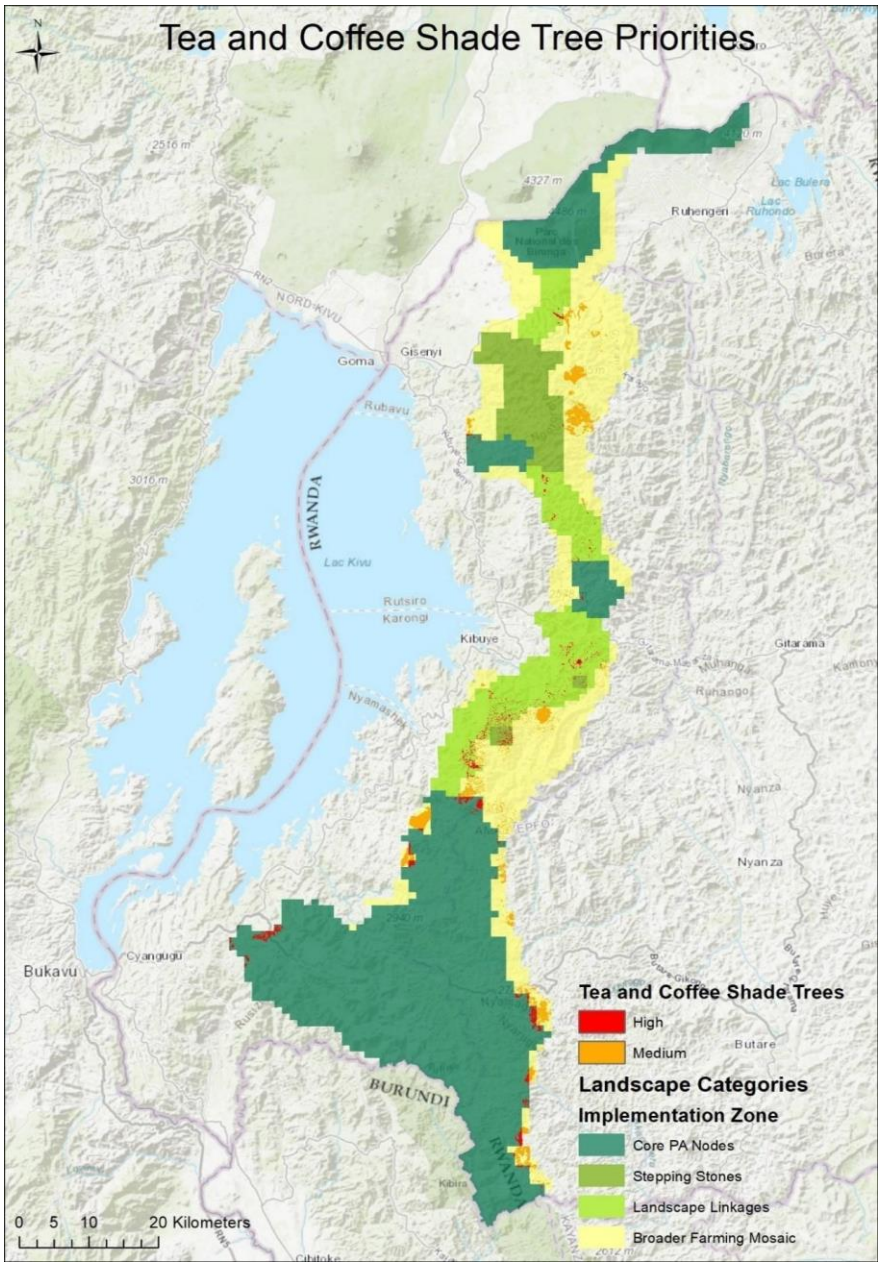


Figure 47. Map showing the extent of agroforestry priority areas (high and medium) for tea and coffee plantations in the Congo Nile Divide.

#### *6.4.3.4. Agroforestry Practices and Project Activities in the Congo Nile Divide*

The Congo Nile Divide, like elsewhere in Rwanda, is dominated by subsistence and rainfed agriculture. The main crops cultivated include maize, potatoes, climbing beans, cassava, banana and sweet potatoes. Cultivation occurs on small plots with an average plot size of 0.5 ha. There are also perennial crops like coffee, tea and pyrethrum. Rangelands around Gishwati-Mukura are dominated by cattle in a free grazing system for milk and meat production. In general, land management in the CND is very poor, leading to low crop productivity and land degradation, particularly on steep slopes where severe soil erosion is common. To combat this degradation, many farmers have adopted agroforestry - the practice of incorporating trees on cropland. Across the CND, agroforestry is currently practiced on over 60 000 ha of land, with district development plans targeting a doubling of this number by 2024 (Table 27).

**Table 27. The current area covered by agroforestry in CND in 2018. (Source: District Development Strategies 2018-2024)**

| District | 2018 Agroforestry Area (ha) | 2024 Target Area (ha) |
|---|---|---|
| Karongi | 4,067 | 36,047 |
| Musanze | 10,729 | 4,529 |
| Ngororero | 12,515 | 5,908 |
| Nyabihu | 11,000 | 18,471 |
| Nyamagabe | 6,000 | 29,088 |
| Nyamasheke | 2,100 | 580 |
| Nyaruguru | 3,207 | 14,765 |
| Rubavu | 500 | 6,600 |
| Rusizi | 12,000 | 900 |
| Rutsiro | 1,754 | - |
| **Total (ha)** | **63,872** | **116,888** |

The highest average density of agroforestry trees is in Rwanda's Western Province at 32.3/ha, which is higher than the national average at 25.1 trees/ha. These agroforestry trees produce an average of 9.3 $m^3$/ha of wood in the Western Province, making them a substantial source of woodfuel in the region. However, Rwanda's Biomass Energy Strategy shows that national woodfuel demand is around five times higher than supply. Further, that increasing the adoption of agroforestry practices is essential to reduce this supply-demand imbalance.

The vast majority of agroforestry in the CND consists of small woodlots, scattered trees, and hedgerows. This adoption is generally driven by economic and agro-ecological factors, with farm woodlots and scattered trees often being the only viable option for farmers with steep and highly degraded land. Given that the CND is mainly characterized by such land, most of on-farm trees are present in woodlots. It is claimed that practically all charcoal in Rwanda is derived from trees planted on private woodlots. On steep land, where terraces have been established, or on more gently sloping land, planting trees on hedgerows enables farmers to control soil erosion and stabilize land. This practice also brings other benefits to the farmer including fuelwood and stakes for climbing beans. In some parts of the CND, agroforestry trees are also found scattered on farms and on farm boundaries; and keeping fruit species, such as avocado trees, in and around the home is a common practice. Fruit species are extremely popular and are identified among the top priority species for farmers who perceive positive market opportunities.

**In summary, according to Mukuralinda et al. (2016) and Ndayambaje et al. (2014)[137], observed agroforestry systems and species across the CND include:**

**Farm woodlots** (Figure 48), involving small stands of trees being grown together for multipurpose wood production and services (including fuel, timber, and stakes), to support high value crops and to control soil erosion by retaining sediment. *Eucalyptus globulus var. maidenii* is the most common species. Only on-farm woodlots <0.25 ha are considered agroforestry interventions according to the national agroforestry strategy, with woodlots >0.25 ha considered to be full-scale forestry.

Figure 48. Typical small on-farm woodlot of Eucalyptus in the CND.

**Hedgerows** (Figure 49), involving trees planted along contour lines for soil erosion control; and on cropped bench terraces, leading to benefits of woodfuel and stakes, as well as stabilization

[137] Ndayambaje, J. D., T. Mugiraneza, and G. M. J. Mohren. "Woody Biomass on Farms and in the Landscapes of Rwanda." *Agroforestry Systems* 88, no. 1 (February 1, 2014): 101–24. https://doi.org/10.1007/s10457-013-9659-0.

through increasing soil, organic carbon, green manure and fodder. *Alnus acuminata* and *Grevillea robusta* are the dominant tree species, associated mainly with maize, wheat, Irish potato and climbing beans.

Figure 49. **Hedgerows on radical terraces in Kanyirandori, Nyamagabe District.**

**Boundary planting** (Figure 50), involving planting of trees to delineate boundaries between two farms. The trees act as live fencing, a buffer between roads and farms, and provide woodfuel, poles, fruits, and services like wind breaks. *Alnus acuminata, Grevillea robusta, Calliandra calothyrsus, Acacia angustissima* and *Vernonia amygdalina* are the most common trees and are generally associated with bean and potato agriculture.

Figure 50. **Trees planted on a farm boundary.**

**Scattered trees** (Figure 51), involving planting trees on farms without any arrangement, where crops are grown between trees coppiced regularly to reduce competition for light. This provides woodfuel, fodder and stakes, as well as green manure for soil fertility improvement. *Alnus acuminata* and indigenous trees, like *Ficus thonninghii, Erythrina abyssinica* and *Vernonia amygdalina*, are mostly found in these systems associated with beans and Irish potatoes.

Figure 51. Scattered trees on farms in Nyaruguru district.

**Home gardens** (Figure 52), involving a mix of upper and under story trees - including both indigenous and exotic fruit, timber, and fodder species - planted in the vicinity of the homestead to fill multiple functions, such as shelter, windbreaks, shade, and cultural function. Fruit trees like avocado (*Persea americana*), as well as indigenous and medicinal trees, such as *Ficus thonninghii*, *Erythrina abyssinica*, *Vernonia amygdalina* and *Tetradenia riparia*, are commonly found on homesteads.

Figure 52. Home gardens and trees around homesteads in the Gishwati area.

#### *6.4.3.4.1. Challenges related to adoption of agroforestry in CND*

**Socio-economic limitations to agroforestry adoption**

The majority of the CND's population is very poor, meaning they cannot afford to make the initial investments required to establish agroforestry systems because they prioritize their basic needs (food, education, housing etc). This is especially true for farmers in steeply sloped areas. In many cases terracing will be the most effective erosion control measure, but it is prohibitively expensive for almost all farmers. Supporting poor farmers to construct terraces; and obtain the seedlings of timber and fodder-fertilizer-fuelwood trees can contribute to poverty reduction and facilitate further adoption of agroforestry practices. However, even when farmers have the financial capacity to purchase seedlings, their limited land size remains a significant challenge. An average ordinary farming household owns less than 0.5 ha to produce their subsistence crops. Based on focus group discussions, farmers have competing priorities and adding trees is sometimes perceived as compromising farm productivity. This issue is compounded by the lack of diversity in available seedlings, meaning farmers may not be able to access species which are more suitable for smaller farms (e.g. boundary species, species with small crowns).

**Access to diverse quality planting trees**

A prerequisite for agroforestry adoption is the availability of tree planting material. The lack of tree planting materials, both in quantity and quality, has often been reported as one of the main barriers to tree planting in different agro-ecological regions of Rwanda, including the CND. Across the CND, there is no reliable supply of diverse tree reproductive materials necessary for forestry, agroforestry and restoration activities. Nurseries are limited to a few districts like Karongi (One-Acre Fund), Nyabihu (ICRAF) and Rutsiro (Arcos), along with other nurseries scattered and run by individuals and NGOs. The quality of seedlings these nurseries produce is generally poor, apart from the ICRAF and One Acre Fund nurseries. Despite significant work on awareness raising around the benefits of agroforestry by many different projects, and the willingness of farmers to plant trees on their farms, most farmers cannot access good quality tree seedlings in their proximity.

One significant impact caused by a lack of seedling availability is that seeds and scions from poor quality, locally available trees are frequently used. This results in agroforestry trees being of poorer quality, which are more prone to pests and diseases, and are generally less productive (reducing the apparent benefit of agroforestry to farmers). Further compounding this problem is a lack of knowledge and genetic material for propagation of most indigenous trees. Many indigenous trees require wildings and cuttings for propagation, but there are no reliable tree stands to source from, and thus agroforestry systems are focused on the few exotic species for which planting material is available. This lack of diversity decreases the overall resilience of community livelihoods and landscapes.

For example, *Alnus acuminata* is promoted by almost all existing agroforestry projects in Rutsiro, Nyabihu and Musanze. *Alnus* is often desired by farmers due to its multipurpose uses, including the provision of stakes for climbing beans, soil erosion control, soil fertility improvement,

provision of timber, firewood, poles and fodder. Studies also indicate that *Alnus* competes less with crops and could increase crop yields through litter fall in favourable seasons. However, the species is not native to Rwanda, and invasive populations have been reported in Gishwati-Mukura NP. Given the very small amount of natural forest remaining in the CND, any impacts of agroforestry species on natural forest must be carefully managed. With a more diverse range of indigenous agroforestry species available in nurseries, as well as promotion of the benefits/uses of such species, the reliance on a narrow range of exotic species with potential negative impacts could be reduced.

**Inadequate extension system for agroforestry**

In the CND, most farmers do not have access to reliable information on potential economic, social and environmental benefits of agroforestry practices. This is partly due to the lack of dedicated extension services to agroforestry. The existing extension system employs officers at the sector level, meaning these employees cannot regularly follow up on agroforestry initiatives. Other agricultural extension systems, like Farmer Field Schools and Twigire Muhinzi, while useful for sharing knowledge on agricultural practices, do not accommodate agroforestry technologies. This means local farmer facilitators have very limited knowledge on agroforestry. An average farmer will therefore have no 'go-to' person to enquire about tree planting and management on their farms. The capacity of current extension services in agroforestry is still low and requires strengthening. On the other hand, experiences in smallholder contexts indicate top-down approaches often result in mismatches between technologies introduced and the needs of farmers.

**Knowledge and capacity of farmers on agroforestry**

As a result of inadequate extension systems, most farmers in the CND have limited capacity to establish and maintain agroforestry systems on their land. In general, there is a lack of knowledge and skills on seedling production, silvicultural practices, tree management, and management of pests and diseases. Image 6-9 is an example of poor tree management in the CND. Based on Focus Group Discussions (FGDs) conducted during the feasibility assessment, most farmers also have limited understanding on tree-crop competition management, which leads to misconceptions about agroforestry species reducing crop yields, and subsequent low adoption of agroforestry. Very few farmers have the skills to identify and manage tree diseases in their home garden or fruit orchards. Lack of information becomes an even greater challenge in the northern part of the CND, where farmers have very limited knowledge regarding indigenous tree species. Focus group discussions in the Gishwati region discovered that there is an indigenous species nursery in the area, but demand for the seedlings is very low. This area is populated by refugees who have lived in the area for less than 30 years, and thus have limited knowledge on tree species that used to occur in their landscapes. In this area (and to some extent across the entire CND), this lack of knowledge on the uses and benefits of different indigenous species is a contributing factor in low overall desire to plant indigenous species. However, many farmers simply prefer to use fast-growing exotic species to yield rapid returns, despite the issues of poor-quality seedlings, pests and disease etc. Any attempts to increase use of indigenous species for agroforestry will require a comprehensive awareness raising program on the characteristics of various indigenous species and their benefits.

Figure 53. Poor tree management practices in an agroforestry system in Sovu area, Huye District.

#### *6.4.3.4.2. Tree and shrub species - community preferences and species selection for agroforestry*

Farmers adopt agroforestry trees according to tree attributes that are most relevant to their contexts. The top ranked agroforestry products according to farmers' needs and preferences in the CND are: woodfuel, timber, poles and fruits. Adoption of agroforestry should follow the following criteria: quality materials/inputs are available; trees introduced are compatible with existing local crop systems and do not impact natural ecosystems; planted species are resilient to climate risks/ resistant to pests-diseases; management is not complicated with low input requirement for maximum outputs thus ensuring positive returns; and there is guaranteed access to markets with growing demand for final products.

Focus group discussions have revealed that many farmers have a limited understanding of the products provided by different tree species, especially indigenous trees. Experience from previous projects shows that farmers' preferences are often guided by the information they have on certain species. For example, farmers with a good understanding of the benefits of *Alnus acuminata* (green manure, stakes) intensively manage the species as contour hedgerows. However, it can become invasive and negatively impact natural forest (e.g. in Gishwati) and in some areas it is reported as negatively affecting soil fertility or moisture in cropland. It is therefore crucial that agroforestry projects assess the benefits and drawbacks of various agroforestry species. This information must be used to present a selection of suitable species to farmers, to allow them to make an informed decision on which species are likely to suit their circumstances.

Gender is likely to substantially impact farmer preferences for agroforestry species. Even though the Government of Rwanda promotes gender balance throughout government structures, many inequalities persist, particularly in rural areas. Women constitute a large portion of smallholder farmers and are often responsible for many of the agricultural activities (weeding, sowing etc.), along with children's education. They play a critical role in agriculture and agroforestry-based value chains, yet they suffer from a vast range of discriminatory practices. Traditionally, women

farmers have been mostly excluded from accumulating material wealth and participating in economic and political decision making (See Annex 8: Gender Analysis for more details). According to the Focus Group Discussions, their decisions are mostly limited to subsistence crops and small livestock, while decisions on large household properties, such as forests or cattle, are not made. Along with the structural barriers faced by women farmers, they are also impacted by major day-to-day challenges, such as collecting food, firewood and water, which often require traveling very long distances. Women farmers are thus likely to prefer agroforestry species that can provide access to fuelwood near to the household or farm. This project will involve women farmers in agroforestry project design and implementation according to a comprehensive gender analysis (Annex 8), to ensure that women farmers receive the many benefits of agroforestry. Land restoration interventions that recognize gender-sensitive entry points are likely to be more effective than gender-blind approaches. For example, fuelwood, fodder, green manure, and coppicing shrub production substantially increases benefits to women farmers that cannot be captured by men. By improving food security, access to fuelwood, fruits and other tree products; increasing participation in agroforestry related value-chains; and increasing the overall climate resilience of communities, the project is likely to make a significant contribution to improving the livelihoods and wellbeing of women farmers.

Along with women farmers, species preferences within historically marginalized farmers are likely to differ from the wider community. These communities often face limited access to resources, lack of land, and malnutrition. For historically marginalized farmers, promoting agroforestry systems with fruits and other trees will help to increase overall income and food security. These communities will be comprehensively engaged in site selection, species selection, and overall project design. Similarly, the preferences of youth will also be considered and incorporated into the project as the Focus Group Discussions have revealed that youth require particular attention in project implementation. These communities can also be involved in the project through planting trees and establishing nurseries. Providing job opportunities are especially vital to those without land.

The objective is to promote, as far as possible, indigenous species. Indigenous species are well suited to the climatic conditions of the CND, and pose no danger to natural forests, unlike exotic species. However, farmer preferences must be considered, and demand for exotic species is high. The project will implement an outreach and education program to promote the benefits of indigenous species, to ensure farmers understand the utility of indigenous species. When farmers are only interested in planting exotic species, the potential impacts of those species on natural forest will be assessed, and appropriate mitigation measures will be applied (e.g. heavy pruning to reduce risk of seed transmission). If mitigation of the risk is not possible (e.g. farms are very close to natural forest areas), those sites will not be targeted by the project. For example, field visits and focus group discussions have demonstrated that Alnus acuminata has become established as an invasive species in Gishwati NP. As a result, the project will not promote Alnus around protected natural forests.

Table 28 shows a preliminary list of the fuelwood, fodder, timber and fruit tree species that have been identified as suitable for agroforestry systems. Suitability is based on their resilience capacity against climate-driven temperature and precipitation changes, as well as community preferences, particularly the needs of women farmers, historically marginalized households, and

youth. The species also align well with recommended species for the North and Western Province, as described in the Agroforestry Technical Guide.

**Table 28. List of considered tree species for agroforestry (non-exhaustive). Invasive exotic species such as *Alnus* and *Eucalpytus* will only be considered in situations where potential negative impacts on natural forest and other biodiversity are deemed to be very low.**

| Species | Wood Density ($g/cm^3$) | Wood Calorific Value (KCal/g) | Charcoal Calorific Value (KCal/g) | Exotic/ Indigenous | Soil Erosion Control Potential |
|---|---|---|---|---|---|
| *Acacia angustissima* | - | - | - | Exotic | Yes |
| *Acacia nilotica* | 0.624 | 4.9 | 7.3 | Indigenous | Yes |
| *Acacia polyacantha* | 0.467 | 4 | 6.4 | Indigenous | Yes |
| *Acacia seyal* | 0.49 | | 7.2 | Indigenous | Yes |
| *Acacia tortilis* | 0.504 | 4.4 | | Indigenous | Yes |
| *Acacia xanthophloea* | 0.532 | | 7.6 | Indigenous | Yes |
| *Alnus acuminata* | 0.5 - 0.6 | - | - | Exotic | Yes |
| *Carica papaya* | - | - | - | Exotic | Unknown |
| *Casuarina equisetiflolia* | 0.82 | 5 | 7.7 | Exotic | Yes |
| *Cedrela serrata* | 0.5 | - | - | Exotic | Yes |
| *Commiphora africana* | 0.331 | 4.8 | 6.9 | Indigenous | Yes |
| *Commiphora baluensis* | 0.541 | 4.4 | 6.6 | Indigenous | Yes |
| *Commiphora campestris* | 0.388 | 4.2 | 6.9 | Indigenous | Unknown |
| *Croton megalocarpus* | 0.395 | | 7.5 | Indigenous | Yes |
| *Cyphomandra betacea* | - | - | - | Exotic | Unknown |
| *Eucalyptus camaldulensis* | 0.6 | 4.8 | - | Exotic | Yes |
| *Eucalyptus grandis* | 0.79 | 4.5 | 7.5 | Exotic | Yes |

| Species | Wood Density ($g/cm^3$) | Wood Calorific Value (KCal/g) | Charcoal Calorific Value (KCal/g) | Exotic/ Indigenous | Soil Erosion Control Potential |
|---|---|---|---|---|---|
| *Eucalyptus maculata* | 0.603 | - | 7.4 | Exotic | Yes |
| *Ficus Thoningii* | 0.51 | Unknown | Unknown | Indigenous | Yes |
| *Grevillea robusta* | 0.53 | - | 7.2 | Exotic | Yes |
| *Maesa lanceolata* | | Unknown | Unknown | Indigenous | |
| *Maesopsis eminii* | 0.4-0.5 | Unknown | Unknown | Indigenous | Yes |
| *Markhamia lutea* | 0.356 | | 8.1 | Indigenous | Yes |
| *Mitragyna stipulosa* | 0.51-0.64 | Unknown | Unknown | Indigenous | Yes |
| *Persea americana* | 0.39 - 0.54 | - | - | Exotic | Unknown |
| *Podocarpus falcatus* | 0.43-0.62 | Unknown | Unknown | Indigenous | Yes |
| *Polyscias fulva* | 0.3-0.45 | - | - | Indigenous | Yes |
| *Senna spectabilis* | 0.337 | | 8 | Exotic | Yes |
| *Terminalia brownii* | 0.445 | 4.6 | 7.3 | Indigenous | Yes |
| *Terminalia orbicularis* | 0.685 | 5.1 | 5.9 | Indigenous | Unknown |
| *Vernonia amygdalina* | 0.6 | Unknown | Unknown | Indigenous | Yes |

#### *6.4.3.4.3. Nursery practices in the CND*

Currently, lack of good quality tree reproductive materials is a major limitation to tree growing in the CND. A key challenge is limited supply of high-quality seeds for supplying seedlings, with all tree seeds currently sourced from the National Tree Seed Centre in Huye District. A recent evaluation of tree seed sources (e.g. forests from which quality seeds can be collected) in Rwanda found that only 12.2% of tree seed stands were categorized as good sources (Figure 54). In the CND alone, there is only one tree seed stand categorized as a good source. Similarly, focus group discussions and district workshops held as part of this feasibility study, revealed there is only one official permanent nursery in Nyabihu at Karago Rural Resource Centre, along with other nurseries scattered and run by individuals and NGOs. In addition, One Acre Fund has established a nursery at Karongi and another nursery managed by Arcos, is located near Mukura.

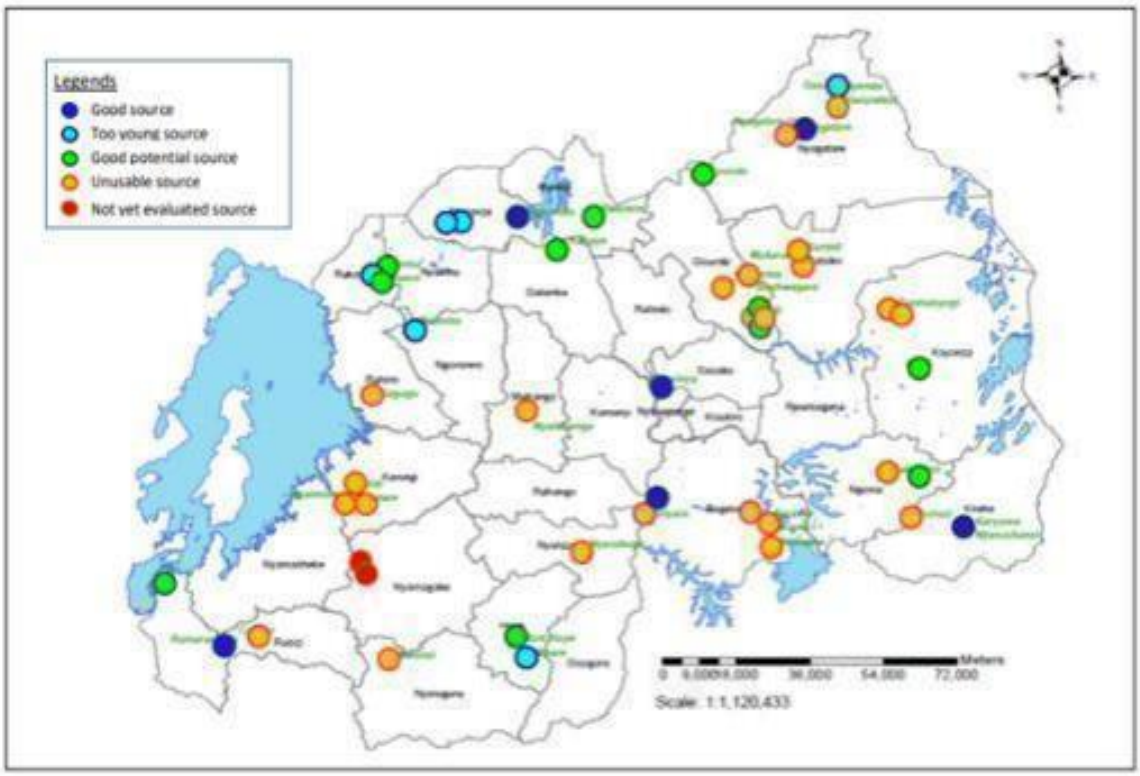


Figure 54. The state and distribution of tree seed stands in Rwanda (MINILAF 2018).

Despite measurements taken by the National Tree Seed Centre to supply quality tree seeds, an informal tree seed sector that does not consider the quality of tree seeds has rapidly developed to fill the growing demand for seedlings. Many seeds used in tree planting, forestry and agroforestry activities are taken from unknown sources. This increases the risks of unwanted phenotypes, and inbreeding or species hybrids, which could lead to quality reduction in forests (e.g. increased sensitivity to pests and diseases) and therefore a potential reduction in productivity of forests or agroforestry systems.

Poor nursery practices, which are widespread throughout the CND, compound the use of poor-quality seeds to further inhibit agroforestry and forestry activities. Most existing tree planting programmes rely on small tree nurseries with very limited resources for mass production of

planting materials. More recently, the government has resorted to seedling production through small scale contractors. However, due to lack of sufficient resources and technical know-how, many seedlings are of poor quality. Table 29 summarizes current nursery practices in comparison to best practices.

**Table 29. Business as usual nursery practices in the CND compared to best practices.**

| Current Nursery Practices | Best practices |
|---|---|
| Pot beds too wide to facilitate ease of working and shade placed too low to provide comfortable working height. | Pots beds designed to be appropriate width and height. |
| Sites far from water supply and without water storage facilities. | Sites are placed close to water supplies or have adequate water storage facilities. |
| Seed beds used for germination; and then small seedlings pricked out into pots; seed beds often too densely stocked leading to root damage during pricking out. | Seed beds appropriately stocked to avoid root damage during pricking out. |
| Pot sizes too small, and often placed directly on soil, causing seedlings to root through the pot and then be damaged when lifted. | Appropriate pot sizes used to avoid seedlings rooting through into soil below. For shrubs and trees with small seeds, pots should have a diameter of 10-15 cm. For shrubs and trees with large seeds, the diameter should be 12 cm and height 15 cm. For fruits, pots should be 20 cm diameter and 20 cm height. |
| Seedlings of very variable quality and beds contain numerous small, degraded plants which should not be used. | Use of quality genetic seeds for sowing, and removal of small, degraded seedlings as needed. |
| Seedlings grown too long in nursery, leading to unsuitable heights and root-shoot ratios. | Healthy, appropriately sized seedlings used for planting. |
| Poor potting mixture with improper ratios used, which inhibits seedling growth and survival. | Appropriate mixing ratios of potting mixture used:<br>● For heavy soils: 5 baskets of topsoil, 3 of manure and 2 of sandy soil.<br>● For mixed soils: 6 baskets of topsoil, 3 of manure, 1 of sand.<br>● For light soils: 7 baskets of topsoil, 3 of manure, and 0 of sand. |

Along with seedling quality concerns, seedling availability is also a challenge for farmers. For instance, District Development Strategies indicate that agroforestry practices will be established on 9 310 ha in 10 districts. This requires about 24 820 460 shrub seedlings and 1 768 900 tree seedlings according to the Agroforestry Technical Guide. In August 2021, the Rwanda Forestry Authority reported that only 4 920 080 seedlings were available, identifying a shortfall of ~20 million seedlings (Table 30).

**Table 30. Available seedlings for planting in fiscal year 2021/2022 in comparison with required seedlings.**

| District | Seedlings in Public Nurseries | Seedlings in NGO Nurseries | Seedlings in Private Nurseries | Total Available Seedlings | Planned (ha) | Required Shrubs | Required Trees |
|---|---|---|---|---|---|---|---|
| Karongi | 13,500 | 1,548,000 | 222,100 | 1,783,600 | 650 | 1,732,900 | 123,500 |
| Musanze | - | | 04,300 | 104,300 | 400 | 1,066,400 | 76,000 |
| Ngororero | - | 857,750 | 11,700 | 869,450 | 2,101 | 5,601,266 | 399,190 |
| Nyabihu | 23,287 | 17,000 | 105,300 | 145,587 | 1,900 | 5,065,400 | 361,000 |
| Nyamagabe | | 145,240 | 127,500 | 272,740 | 1,000 | 2,666,000 | 190,000 |
| Nyamasheke | | 242,000 | 70,550 | 312,550 | 350 | 933,100 | 66,500 |
| Nyaruguru | - | 891,162 | 23,542 | 914,704 | 570 | 1,519,620 | 108,300 |
| Rubavu | - | 1,471,000 | 270,000 | 1,741,000 | - | - | - |
| Rusizi | - | 533,000 | - | 533,000 | 2,000 | 5,332,000 | 380,000 |
| Rutsiro | - | 457,450 | 59,700 | 517,150 | 339 | 903,774 | 64,410 |
| **Total** | **36,787** | **6,162,602** | **994,692** | **7,194,081** | **9,310** | **24,820,460** | **1,768,900** |

### *6.4.3.4.4. Climate rationale and alignment with National Policies*

Most of the people in the CND are smallholder farmers living on steep slopes without access to irrigation. They are faced with severe erosion and land degradation, which reduces overall land productivity, and lack the financial means to invest in strategies to address this (e.g. afforestation, terracing). Climate change is negatively impacting farmers in the CND by increasing frequency of extreme rainfall events due to climate change, which further degrades land via soil erosion and increases the loss of lives and property from landslides. The CND loses an average of 1.5 million tons of fertile soil per year from heavy rainfall due to climate change,

landslides and erosion. This loss of soil fertility forces farmers to convert more forests to farmland in order to maintain crop yields, and to degrade existing plantation forests through over-exploitation, further reducing the buffering effect that forests have against soil loss and landslides. As such, agroforestry activities combined with erosion reduction measures (e.g. terracing) have great potential to increase the climate resilience of vulnerable communities in the CND, by directly reducing the impact of extreme rainfall events on soil erosion and landslides, and by reducing pressure on forests so they can continue to buffer communities against the impacts of climate change.

Recognising the value of agroforestry activities for climate adaptation in rural communities, the government of Rwanda has outlined numerous targets and strategies to increase agroforestry adoption throughout the country. Rwanda's National Land Use and Development Master Plan calls for climate-resilient agricultural options to be implemented throughout the country, including improved radical terraces and agroforestry. Additionally, one of the key priorities under Rwanda's Nationally Determined Contribution under the UNFCCC is the development of Agroforestry and sustainable agriculture (to control soil erosion and improve soil fertility). Rwanda's Green Growth and Climate Resilience Strategy also outlines targets for implementation of agroforestry techniques and tree species in order to increase overall forest cover and enhance agriculture land productivity. Many other government strategies which support establishment of agroforestry are outlined in section 4 of this document, meaning agroforestry is clearly aligned with government policies and is an essential tool to increase resilience of rural communities in the CND.

#### *6.4.3.4.5. Field assessment of Agroforestry opportunity in the CND*

To better understand the suitability of the Agroforestry priority areas, field visits to eight sites across the CND were conducted in August 2021. The assessments followed the Vital Signs methodology outlined in Appendix 1. Overall, the state of agricultural areas and the current adoption rates of agroforestry practices varied considerably across the CND. Agroforestry systems observed included scattered trees on farms, boundary planting, hedgerows, and small woodlots. Despite trees being quite widespread on farms, poor tree management and tree health was evident in many areas (e.g. severe over-pruning; see Image 6-1). Soil erosion was present in all plots visited, even those with high levels of on-farm tree planting, which is likely because most trees were small and often in poor condition due to poor management. This indicates the clear need for interventions to increase the overall extent of on-farm tree cover, as well as to improve on-farm tree management such that the erosion control and woodfuel benefits of agroforestry trees can be fully realized.

Figure 55. Landslide in Sovu.

### *6.4.4. Beekeeping Interventions*

The aim is to promote modern beekeeping among 4 000 farmers surrounding the Core PA Nodes to reduce the risk of fires that threaten forest habitat, especially due to illegal honey harvesting in forests.

A community participation approach will be adopted, with a focus on woman, youth and gender equality. Promoting fire management by park managers will also be an intervention through capacity building.

#### *6.4.4.1. Beekeeping in Park Buffers and Stepping Stone Buffers*

The focus of activities to support beekeeping in Park Buffers and Stepping Stone Buffers (Figure 36) should consider:

- Focusing on natural forest and possibly natural areas in the buffer areas around the Core PA Nodes, and the buffer areas around the Protected Forests in the Dutake and Karehe-Gatuntu Stepping Stones. These areas total 5 555 ha, with the largest and highest priority areas being around Nyungwe NP (3 955 ha) (Table 31).
- Plantation areas in these buffers could also form part of the priority areas[138].
- Together these present a potential working footprint of 15 375 ha.
- Gishwati Pastures Stepping Stone was not included as it is the focus for a separate intervention.

[138] *It is assumed plantation areas are also suitable, as fires would also have impacts on forest habitat.*

**Table 31. Beekeeping priority areas in the Buffers of the Core PA Nodes and Stepping Stones.**

| Sector | Known Natural (Ha) | Possibly Natural (Ha) | Plantations (ha) | Grand Total (ha) |
|---|---|---|---|---|
| **Core PA Nodes - Buffer Areas Only** | **3 730,2** | **1 729,4** | **9 521,2** | **14 980,8** |
| Gishwati NP Buffer | 172,4 | 235,6 | 617,2 | 1 025,2 |
| Mukura NP Buffer | 308,1 | 77,2 | 387,7 | 772,9 |
| Nyungwe NP Buffer | 2 864,9 | 1 090,5 | 8 035,7 | 11 991,0 |
| Volcanoes NP Buffer | 384,9 | 326,2 | 480,6 | 1 191,7 |
| **Stepping Stones - Buffer Areas Only** | | **95,2** | **299,1** | **394,2** |
| Dutake Stepping Stone | | 47,9 | 198,4 | 246,2 |
| Karehe-Gatuntu Stepping Stone | | 47,3 | 100,7 | 148,0 |
| **Grand Total** | **3 730,2** | **1 824,6** | **9 820,2** | **15 375,1** |

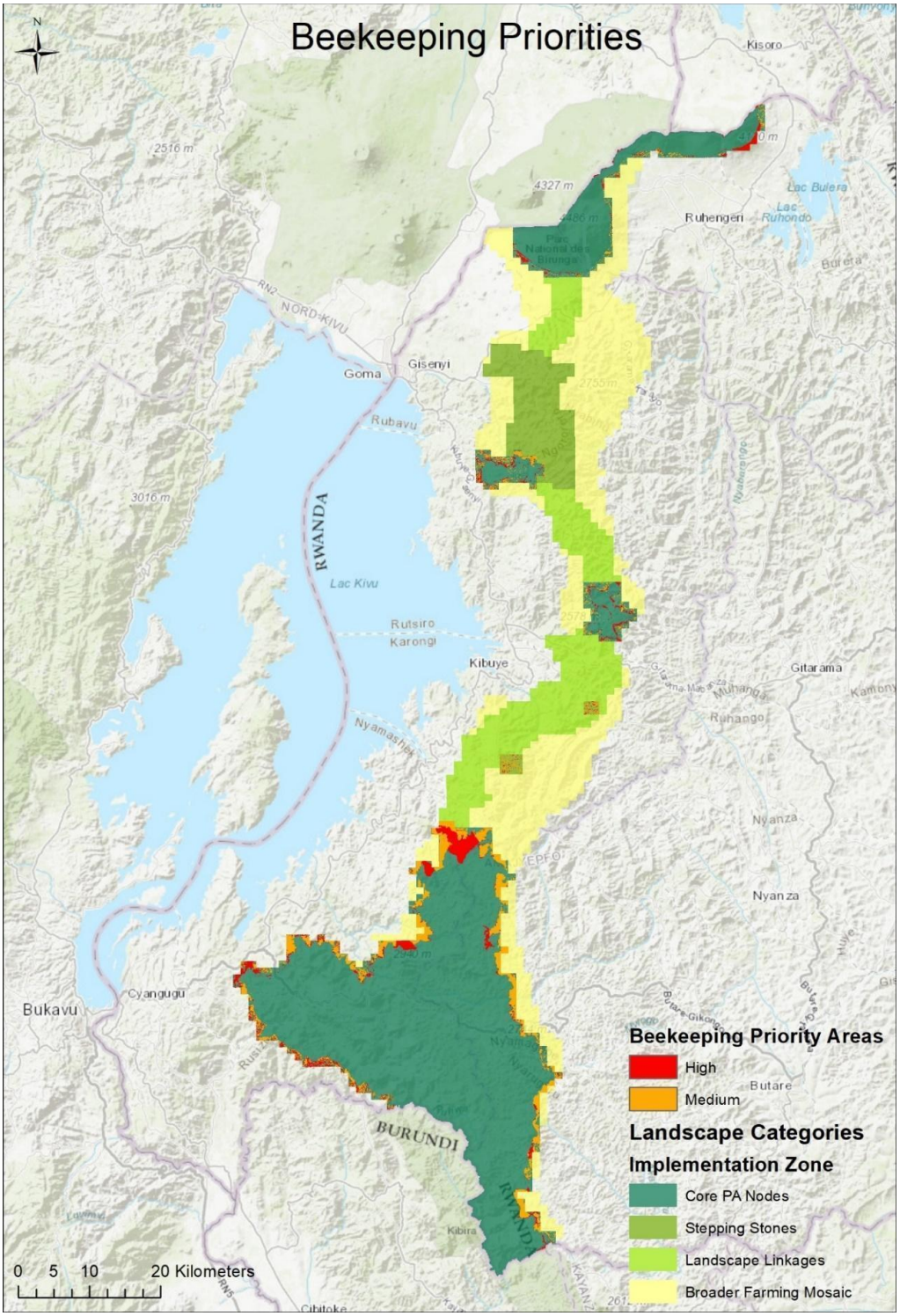


Figure 56. Map showing the extent of beekeeping priority areas (high and medium) for interventions in buffer areas around the National Parks and Protected Forests in the Congo Nile Divide.

### *6.5. Analysis and identification of preferred alternatives for Energy Efficient Stoves to reduce wood fuel demand.*

#### *6.5.1. Context of household cooking in Rwanda*

Rwanda is highly dependent on the traditional use of biomass to satisfy the demand for cooking energy. It has been estimated that households of Rwanda consume 81% of the country's final energy balance[139] and the bulk of this is in the form of solid woodfuel. Within rural areas such as CND, firewood remains the primary cooking fuel for an estimated 95.7% of households in the region[140,141]. The demand for both firewood and household energy efficient cooking solutions is also set to increase in the foreseeable future given that the country's total population is expected to increase from approximately 11 million in 2016 to approximately 17 million in 2032[142]).

Nationwide, the estimated annual supply potential for woody biomass available for energy use stands at 1.7Mt, while total consumption by residential, commercial and public sectors is estimated at 2.9 Mt. Therefore, the balance between supply and demand of woodfuel in Rwanda is negative. This implies that without adopting biomass energy-efficient cooking solutions - especially within rural households such as those within the CND - Rwanda runs a huge risk of woodfuel resource scarcity and continued depletion of its forests. Beyond driving forest loss, this lack of fuel also drives other types of environmental degradation. For example, in certain areas of the country where there is scarcity of fuelwood, farmers use agricultural residues as cooking fuel, which leads to soil degradation because agriculture residues are no longer used as manure for soil fertility.

Because wood fuel is so scarce in Rwanda, families spend up to 6 hours per day collecting firewood and up to a third of their income for their energy needs, exacerbating the cycle of poverty. Nationwide, 76.5% of households spend over 7 hours a week to acquire (through collection or purchase) and prepare cooking fuel. Acquiring and preparing fuel are time-consuming tasks for most households. About 84% of households use firewood as their primary cooking fuel, and most of them likely collect it for free, hence spending over 1 hour a day acquiring and preparing fuel collection and preparation[143]. In addition, households that use a three-stone stove spend 25% more time acquiring and preparing fuel than households that use an improved biomass stove[144,145]. This additional time spent on cooking limits the ability of poor and vulnerable households to cater for other livelihood activities that could generate income.

The Energy access diagnostic report by the World Bank[146] highlighted that: 1) in rural areas

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139 EUEI, Biomass Energy Strategy (Best) - Rwanda - Volume 2 - Background & Analysis.

140 Jagger, Pamela, and Ipsita Das. "Implementation and Scale-up of a Biomass Pellet and Improved Cookstove Enterprise in Rwanda." *Energy for Sustainable Development* 46 (2018): 32–41. https://doi.org/10.1016/j.esd.2018.06.005.

141 UNDESA. "World Population Prospects - Population Division - United Nations." UNDESA Online Database, 2019. https://population.un.org/wpp/DataQuery/.

142 Jagger & Das

143 World Bank, MTF – Energy Access Diagnostic Report for Rwanda, 2018

144 MININFRA. Sustainable Energy for All. Agenda Action. 2015.

145 World Bank, MTF

146 World Bank, MTF

women spend an average of 80 minutes a day acquiring fuel, compared with 40 minutes for men, and 28 minutes a day preparing fuel, compared with 19 minutes for men, 2) 82.6% of female-headed households are willing to pay upfront or with a 6- to 12-month payment plan for an improved cookstove if the price is reduced to 1,000 Rwandan francs, and 3) women alone make the decision for 49.7% of cookstove purchases, including 85.6% of clean fuel stove purchases.

Despite previous policy targets that were set to reduce the share of woody biomass in Rwanda's overall household energy consumption mix, little progress has been made and biomass continues to be by far the primary source of cooking fuel. The use of firewood as the main source of energy for cooking reduced from 83.3% in 2014 to 79.9% in 2017[147], but the rate of reduction must be increased.The low penetration of alternatives to biomass for cooking, such as LPG, biogas or electricity, has contributed significantly to this lack of progress. Identifying energy efficient cooking alternatives energy is key to ensuring Rwanda meets climate change targets as outlined in countries' Nationally Determined Contributions (NDC).

### *6.5.2. Government policies, strategies and institutional framework*

The strategic framework for Rwanda's energy sector is established in the Energy Sector Strategic Plan (ESSP) and the Rwanda Energy Policy (REP). These documents recognize the essential role of clean cooking in accelerating economic development, as well as improving health outcomes and standards of living for people in Rwanda. Energy policies and strategies interact closely with wider, national policies: with high-level national objectives set by Vision 2050 and NST-1 (2018).

The Energy Sector Strategic Plan (ESSP) for 2018/19-2023/24 presents the current status and future plans for Rwanda's energy sector, covering its three subsectors: electricity, biomass and petroleum. It is mutually reinforcing with the Rwanda Energy Policy (2015), which outlines a long-term vision, provides high-level goals, and recommends approaches for achieving that vision. The objective for clean cooking under this strategic plan is to "*halve the number of households using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies*".

The policy and overall regulation of Rwanda's household energy efficient cooking agenda falls under its Ministry of Infrastructure (MININFRA). MININFRA recently approved an ambitious new Biomass Energy Strategy (2019-2030) and an amendment to its NDC, with targets of reducing the percentage of households that use firewood for cooking from the baseline value of 79.9% in 2017 to 42% by 2024, as well as phasing-out the use of charcoal in urban areas[148]. This target will be met through a combination of improving efficiency of the existing biomass technologies and boosting the adoption of cleaner fuels.

The Government action to modernize the biomass subsector is driven by two parallel efforts,

147 Rwanda Poverty Profile Report 2016-2017 (EICV 5, NISR)

148 DBR*, Rwanda Energy Access and Quality Improvement Project - Component 3b Increasing Access to Clean Cooking*; Hakizimana et al., "Environmental Impacts of Biomass Energy Sources in Rwanda."

focused on reducing the demand of firewood for cooking, along with increasing the supply of wood resources.

The Biomass Energy Strategy (BEST) is broken out into five discrete programmes to ensure a comprehensive approach is taken to address a complex subsector:

1. Increasing supply of woody biomass through improved sustainable management of wood biomass resources,
2. Reducing the demand of wood biomass by *institutional consumers* by shifting to alternative fuels, primarily LPG,
3. Reducing the consumption of wood by *urban households* through:
    - switching to alternative fuels, primarily LPG
    - replacing traditional charcoal with improved charcoal technologies
4. Improving efficiency of biomass usage by *rural households* by:
    - strengthening woody pellets gasifier and briquettes value chains (for households with problems in accessing wood)
    - increasing penetration of high efficiency Improved Cookstoves (ICS) for firewood (for households with easy access to wood)
5. Strengthening coordination and capacity building, monitoring and evaluation, to effectively manage the biomass energy sector.

Furthermore, BEST (2019) has specific complementary proposed solutions to ***increase supply of biomass*** to 4-5 million tons per year in 2030, which is in line with subcomponent 2.2 of this project.

- Large investment in afforestation of non-forested land;
- Conversion of poorly managed forests into high productivity forests under sustainable management; Increase tree density in crops land through agroforestry promotion;
- Increase forest productivity through seed genetic improvement privileging energy-intensive species.

The key indicators to achieve the targets of this strategy are summarised in Table 32.

**Table 32. Key indicators for the Biomass Energy Strategy**

| Indicators | | Baseline values and second-level targets |
|---|---|---|
| Percentage of biomass consumers shifting from traditional biomass to clean alternative fuels | | Baseline value 2017: 1.1%<br>Target value 2024: 42%<br>Target value 2030: 75% |
| Percentage of rural population shifting from traditional woody biomass to modern improved cooking solutions (primarily woody pellets and firewood Improved Cookstoves) | | Baseline value 2017: 0 %<br>Target value 2024: 30 %<br>Target value 2030: 65 % |
| Percentage of public biomass high consuming institutions (e.g. schools, prisons, tea factories) shifting from traditional woody biomass to clean cooking solutions | | Baseline value 2017: 0 %<br>Target value 2024: 50 %<br>Target value 2030: 90 % |
| Increase of exploited tree plantations under Sustainable Forest Management (SFM) | Private forests | Baseline value 2017: 3%<br>Target value 2024: 60%<br>Target value 2030: 65% |
| | Public forests | Baseline value 2017: 21%<br>Target value 2024: 80%<br>Target value 2030: 90% |
| Forest productivity under improved management | | Baseline value 2017: 10 $m^3$/ha/yr<br>Target Value 2024: 11 $m^3$/ha/yr<br>Target Value 2030: 12 $m^3$/ha/yr |
| Average annual income per ha by producer of wood energy under improved management | | Baseline value 2017: 8,000 RwF<br>Target Value 2024: 12,000 RwF<br>Target Value 2030: 15,000 RwF |

The implementation mandate of the Biomass Energy Strategy (BEST) is led by the Renewable Energy Group (REG) and its subsidiary the Energy Development Corporation Limited (EDCL). On the other hand, the Rwanda Standards Board (RSB) is tasked with certifications and setting standards for cooking products and a testing lab is currently under development[149]. At the local level, the central government agencies outlined above are supported by a series of local government structures which range from district, sector and village levels.

[149] BRD, *Rwanda Energy Access and Quality Improvement Project - Component 3b Increasing Access to Clean Cooking*.

The specific roles some key institutions in Rwanda's energy sector are briefly summarized below[150];

i) MININFRA – mandated with the development of national policies and strategies related to energy generation in the country
ii) Rwanda Utilities Regulatory Authority (RURA) – regulates the energy sector in Rwanda.
iii) Rwanda Energy Group (REG) – this is a private company established in 2014, wholly owned by the government. It carries out operations by two subsidiaries, the Energy Development Corporation Limited (EDCL) and the Energy Utility Corporation Limited (EUCL).
    a. EDCL - is responsible for developing both generation and transmission projects, exploiting new energy resources, and executing a least-cost power development plan and with Independent Power Producers (IPPs)
    b. EUCL - is in charge of day-to-day operations of power generation, transmission, distribution and sales to final customers. The utility also plays a key role in the execution of power purchase/sales agreements with IPPS and other regional utilities for import and export.

Other key central agencies include those under Ministry of Environment and Ministry of Agriculture which focuses on regulating the silvicultural aspects and productivity of plantations and agroforestry.

### *6.5.3 Baseline household cooking sector in CND*

The various cooking solutions available in Rwanda have been assigned standardised performance levels (Tiers) from the perspective of their comparative efficiency, CO2 emissions, fire safety and emission of particulates. Table 33 below summarizes the various tiers of fuelwood cooking in the CND and Rwanda at large.

**Table 33. GACC tier-based Voluntary Performance Targets (source: BEST 2019)**

| Voluntary Performance Targets – Default Values | | | | | |
|---|---|---|---|---|---|
| Tier | Thermal Efficiency (%) | Carbon Monoxide Emissions (gram/megajoule delivered) | Fine Particulate Matter Emissions (milligram/megajoule delivered) | Safety (score) | Durability (score) |
| 5 | ≥50 | ≤3.0 | ≤5 | ≥95 | <10 |

[150] Hakizimana et al."Environmental Impacts of Biomass Energy Sources in Rwanda."

| Voluntary Performance Targets – Default Values | | | | | |
|---|---|---|---|---|---|
| 4 | ≥40 | ≤4.4 | ≤62 | ≥86 | <15 |
| 3 | ≥30 | ≤7.2 | ≤218 | ≥77 | <20 |
| 2 | ≥20 | ≤11.5 | ≤481 | ≥68 | <25 |
| 1 | ≥10 | ≤18.3 | ≤1031 | ≥60 | <35 |
| 0 | <10 | >18.3 | >1031 | <60 | >35 |

The Congo Nile Divide (CND) population is predominantly (93%) rural. Households within this region are typically characterized with serious woodfuel deficits, high incidences of poverty and are extremely vulnerable to climate change impacts[151]. The typical household cooking technology used in the CND region are the three stone cookstoves and traditional stoves (Tier 0) which are used by 97.8% of households[152]. Almost 90% of households in the CND depend primarily on firewood to meet their cooking needs, which is about 10% higher than the national average of approximately 80%[153].

**Table 34. Households' primary fuel source for cooking (Source: EICV 5 report 2016/17)**

| | Primary fuel used for cooking | | | | Total | Total no. of HHs( 000) |
|---|---|---|---|---|---|---|
| | Firewood | Charcoal | Crop waste | Others | | |
| All Rwanda | 79.9 | 17.4 | 0.6 | 0.9 | 100 | 2,708 |
| Nyaruguru | 95.6 | 3.6 | 0.0 | 0.6 | 100 | 64 |
| Nyamagabe | 96.1 | 3.2 | 0.0 | 0.4 | 100 | 77 |

151 FAO, WISDOM Rwanda - Spatial Analysis of Woodfuel Production and Consumption in Rwanda Applying the WISDOM Methodology.

152 Rwanda NISR report 2018

153 Rwanda NISR report 2018

| | Primary fuel used for cooking | | | | Total | Total no. of HHs( 000) |
|---|---|---|---|---|---|---|
| | Firewood | Charcoal | Crop waste | Others | | |
| Karongi | 92.0 | 7.4 | 0.0 | 0.4 | 100 | 78 |
| Rutsiro | 97.1 | 2.8 | 0.0 | 0.1 | 100 | 73 |
| Rubavu | 58.9 | 40.1 | 0.0 | 0.5 | 100 | 96 |
| Nyabihu | 88.1 | 11.9 | 0.0 | 0.0 | 100 | 67 |
| Ngororero | 96.7 | 3.0 | 0.0 | 0.3 | 100 | 82 |
| Rusizi | 86.2 | 12.4 | 0.0 | 0.7 | 100 | 95 |
| Nyamasheke | 98.0 | 1.8 | 0.0 | 0.2 | 100 | 83 |
| Musanze | 80.7 | 18.7 | 0.0 | 0.2 | 100 | 91 |
| Average for CND | 88.9 | 10.5 | 0.0 | 0.3 | 100 | 80.6 |

Source: NISR (2018)

Regarding improved cookstoves, almost 98% of rural households in Rwanda use Tier 0-1 cookstoves. Tier 2 cookstoves are used by approximately 1.8% of the population while Tier 3 and above are used by 0.5% of the population[154], as illustrated in Figure 47 below.

[154] Koo et al., Rwanda – Beyond Connections - Energy Access Diagnostic Report Based on the Multi-Tier Framework.

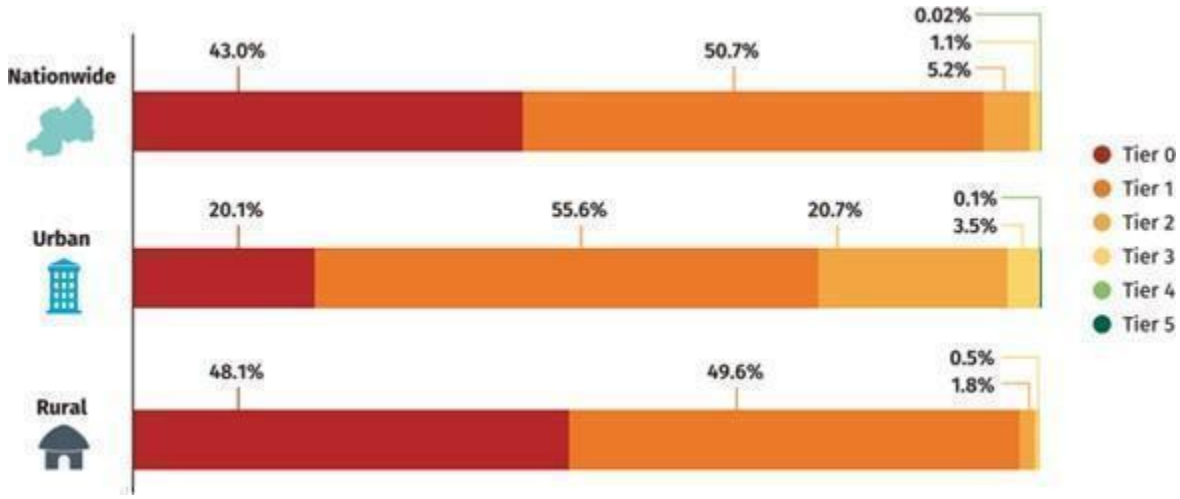


Figure 57. - Less than 1% of households in Rwanda use Tier 4-5 cooking solutions such as LPG, biogas or electricity (Source -Koo et al., 2018).

Secondary data obtained from the districts, discussions with district officials, NGOs and cookstove producers, focus group discussions (FGDs) conducted during this feasibility study revealed that households in the CND region use predominantly Tier 0 and Tier 1 (Table 35). Since 2016, the Government of Rwanda and its partners have distributed more than 35,000 Tier 1 ICS in the CND landscape. During the FGDs community members reported having received different types of stoves including Delagua, Canarumwe, Rondereza, Gabanyibicanwa and Songa. Overall, 50% of community members consulted during the FGDs preferred Canarumwe compared to other types of ICS. However, it should also be noted that very often community members identify all kinds of stoves as Canarumwe despite the fact they are a different brand.

**Table 35. Indicative distribution of cookstoves in the CND from 2016-2021**

| Organizations/ Implementers | Funders | Area of intervention (Districts) | No. of stoves distributed | Target no. to distribute | Types/ model of stove |
|---|---|---|---|---|---|
| Wildlife Conservation Society | LIKANO and USAID | Nyungwe National Park region (Rusizi, Nyamasheke, Nyaruguru and Nyamagabe Districts) | 24,000 | 25,000 | CANARUMWE (Tier 1) |

| Organizations/ Implementers | Funders | Area of intervention (Districts) | No. of stoves distributed | Target no. to distribute | Types/ model of stove |
|---|---|---|---|---|---|
| ARECO – Rwanda Nziza | LIKANO | Gishwati-Mukura National Park region (Rutsiro and Ngororero Districts) | 6,000 | 78,541 | CANARUMWE (Tier 1) |
| EWMR Sebeya Project (SNV, RWB, IUCN, RWARII, IMBARAGA, Rutsiro District) | Kingdom of the Netherlands | Gishwati-Mukura National Park region (Rutsiro District) | 1,000 | 3,225 | Stoves made by loan soil (Tier 1) |
| Rwanda of Peace and Progress | LIKANO | Rubavu and Nyabihu Districts | 4,258 | - | GABANYIBICANWA (Tier 1) |
| Rwanda of Peace and Progress | LIKANO | Musanze District | 5,493 | - | GABANYIBICANWA (Tier 1) |
| **TOTAL** | | | **40,751** | **106,766** | |

Other available cooking solutions in the CND include biogas that was introduced in the region around 2011. Records from the districts of the CND and discussions with various stakeholders have revealed that since 2011, the Government of Rwanda has supported the construction of biogas for individual households, institutional biogas for schools and prisons as well as for new settlements. Table 36 below illustrates the distribution of biogas in the districts of CND and their current status.

**Table 36. Distribution and current status of biogas in the CND**

| Districts | Number of private biogas (individual household) constructed | % of biogas still functioning | Number of collective biogas (school, hospital, prisons) installed | % of biogas functioning | Challenges |
|---|---|---|---|---|---|
| **Nyamasheke** | 241 (2011)* | 13.28% | 0 | 0% | Limited manure excrement, lack of maintenance skills, limited availability of water to mix with manure excrement |
| **Nyamagabe** | 545 (2011) | 36.9% | 9 (2018-2019) | 11.1% | 8 installed in the model village do not function. 1 biogas installed at the prison functions well. Major challenge are the same as above in Nyamasheke district |
| **Nyaruguru** | 250 (2011) | 24% | 20 (2018-2019) | 20% | All collective biogas installed in model villages. Same challenge as above. |
| **Rutsiro** | 370 (2011) | 18.4% | 4 (2018-2019) | 100% | All collective biogas installed in model villages |
| **Rusizi** | 183 (2011) | 42.1% | 23 (2018-2019) | 100% | |

* figures in parentheses are years of construction of biogas. Sources: Districts data.

Table 36 above illustrates that the majority of individual biogas do not operate to their optimal capacities as they require maintenance skills, along with sufficient supply of manure and water, and many individual households are not able to provide these A recent critical review of biogas systems in Rwanda by estimated that at a daily excretion rate of 5 kg/animal/day, about 7 cows

would be required to feed a 4m$^3$ biodigester[155]. Based on the daily cooking energy requirement of 31 MJ, (equivalent to 4.5 m$^3$ of biogas) the estimates suggest that only a 10 m$^3$ plant can produce enough biogas to completely satisfy the daily cooking energy demand of a household. Therefore, to produce enough biogas to supply 100 percent of a households cooking energy demand, a 10 m3 biodigester would need manure from at least 4 cows, if daily manure excretion rate per animal is 20 kg or 17 cows if the daily manure excretion rate per animal is 5 kg.

While the government has provided subsidies for the households, the impact evaluation study confirms that in the long term the biodigesters might provide several benefits, however, the high upfront cost of the biodigester remains a challenge for poor households. According to a report issued by Rwanda's National Institute of Statistics, in 2012[156] (ISS, 2013) the average person living in a rural area in Rwanda spent 247 240 RWF annually. The cost of a 4 m$^3$ digester, which is the most economical option, is estimated to be 350 000 RWF – 1.4 times the amount of the total annual personal expenditure of the average rural inhabitant per capita. Clearly, biogas is not a cooking solution for 34,000 vulnerable communities being targeted by this project in the CND.

### *6.5.4 Status of ICS market (supply and demand) in CND*

The Improved Cookstoves (ICS) market in the CND is largely nascent. The total estimated population using ICS Tier 1 is around 40,000 households (Table 35). Other ICS Tier 2 -Tier 5 have not penetrated the market in the CND, mainly because there are no local producers who can manufacture them, and as a result they are not affordable to poor households in the region.

Tier 2-4 cookstoves available are typically manufactured in Kigali where there is enough industrial capacity to produce them and then distributed in the CND. Some of the Tier 3-4 cookstoves are imported, and this usually attracts a tax of between 30-40% which is passed on by the private sector to the end-users. This makes Tier 3-4 cookstoves relatively expensive, with estimated costs between $30-50 each, which is too expensive for poor rural households to afford without a subsidy, rendering the provision of such stoves unsustainable.

The stakeholders involved in ICS manufacturing value chains in the CND are briefly described below;

#### *6.5.4.1 Actors in ICS production in the CND*

The key actors in the ICS production in CND are community cooperatives and the private stove manufacturing businesses. Cooperatives are supported by the GOR, international or local NGOs using funding from bilateral or multilateral organizations, while businesses are typically operated by local companies and cooperatives with financial support from a number of government and development partner actors. There are currently 9 cooperatives and 1 private company producing Tier 1 cookstoves in the CND. Table 37 below provides the list of producers and their locations.

[155] FAO. 2021. Biogas systems in Rwanda – A critical review. Rome. https://doi.org/10.4060/cb3409en

[156] ISS. 2013. Impact evaluation of Netherlands supported programmes in the area of Energy and Development Cooperation in Rwanda. Impact Evaluation of Rwanda's National Domestic Biogas Programme.

**Table 37. Producers of ICS in the CND region**

| No | Cooperative Name | Model of cookstoves produced (Tier 1,2,3,… | Membership | | Legal status | District | sector |
|---|---|---|---|---|---|---|---|
| | | | Men | Women | | | |
| 1 | Cooperative de Poterie des Mareriaux Ornomentaux de Nyamasheke (COPMONYA) | CANARUMWE / Tier 1 | 6 | 5 | Legally registered | Nyamasheke | Kagano |
| 2 | Cooperative Twite Ku Bidukikije Jomba (KOTUKUBIJO) | CANARUMWE / Tier 1 | 6 | 14 | Legally registered | Nyabihu | Jomba |
| 3 | ADO Green Conserve Company Ltd(ADO G.C.Company Ltd) | CANARUMWE / Tier 1 | 3 | 17 | Legally registered | Rubavu | Rugerero |
| 4 | TERIMBERE RUBYIRUKO NYANGE | CANARUMWE / Tier 1 | 22 | 16 | NO | Ngororero | Nyange |
| 5 | HUGUKA MUBUMBYI | CANARUMWE / Tier 1 | 9 | 16 | Legally registered | Ngororero | Kageyo |
| 6 | Cooperative Turengere Ibidukikije | CANARUMWE / Tier 1 | 10 | 5 | Legally registered | Rutsiro | Kivumu |
| 7 | Cooperative de Frabrication des Briques(COFABRI) | CANARUMWE / Tier 1 | 10 | 8 | Legally registered | Rusizi | Gitambi |
| 8 | AMAHUMBEZI YA CYAMUDONGO | CANARUMWE / Tier 1 | 3 | 19 | Legally registered | Rusizi | Nyakabuye |
| 9 | TWITEZIMBERE KARONGI | CANARUMWE / Tier 1 | 8 | 12 | Legally registered | Karongi | Rubengera |

| No | Cooperative Name | Model of cookstoves produced (Tier 1,2,3,… | Membership | | Legal status | District | sector |
|---|---|---|---|---|---|---|---|
| | | | Men | Women | | | |
| 10 | DUFATANYE GASAKA | Modern CANARUMWE Tier 2/CANARUMWE Tier 1 | 14 | 26 | Legally registered | Nyamagabe | Gasaka |

Once the stoves are produced; they are typically analyzed by the Rwanda Bureau of Standards before being assigned a tier and thereby qualify for the available subsidy programs. The process of standardization is both costly and very stringent. Therefore, several stove manufacturers choose not to get certified. This has in turn created a situation in which a number of would be improved cookstoves are marketed and sold in the Rwanda market but without standardization. This leads to varying cookstove outcomes amongst the end-users and further erodes their trust in the ICS market.

#### *6.5.4.2 Actors in ICS distribution*

Along with manufacturing, distribution of cookstoves is also usually subsidized in Rwanda. Various projects funded by the Africa Development Bank (AfDB), World Bank, GIZ, USAID and implemented by international and local organizations have facilitated the distribution of ICS. Currently, more than 40,000 ICS of various types/models have been distributed in districts of CND landscape (Table 35).

Once the stoves arrive within the CND, they are distributed through existing formal and informal institutions including through womens cooperative associations. However, during the feasibility analysis 46% of stakeholders consulted during FGDs noted that they don't undertake any follow-up monitoring to assess whether or not the stoves are used consistently and appropriately. There is therefore a need for continuous monitoring as well as enhancement of local capacity to undertake routine maintenance and repair to extend the lifetime of the ICSs.

### *6.5.5 Assessment of key barriers to household ICS adoption and use in CND*

There are three major barriers to the adoption and use of ICS in the CND. These include the limited affordability of end-users, gender barriers, and market related barriers. Each of these barriers is briefly discussed below.

i) Affordability:

As discussed above, Tier 3-4 cookstoves are the most expensive of all ICS used in the CND region. The average cost of Tier 3 and 4 cookstoves is between $30 to $50 respectively. Given the average monthly income of approximately $66 (NISR, 2019), this would represent 45-76% of average monthly income which many households are unable to afford.

ii) Gender-based barriers:

According to a World Bank report[157] on energy access in Rwanda, the gender gap in access to ICSs and clean fuel stoves is small: 28.8% of female-headed households use an ICS or clean-fuel stove, compared with 30.4% of male-headed households. This suggests that female-headed households prioritize investment in modern energy cooking solutions. However, the same report shows that the ability to pay for an ICS is a bigger constraint for female-headed households, who are less willing to pay full price for a stove and more often require a longer repayment plan (up to 24 months). Programs that promote the use of ICS and clean fuel stoves should therefore pay particular attention to constraints on female-headed households' ability to pay.

iii) Market barriers:

There are various market related barriers affecting the ICS in the CND. First and foremost is the issue of physical access. Given the mountainous nature of the landscape, it is difficult to reach ICS customers spread out in hilly dispersed settlements. Secondly, ICS programs have historically been characterised by poorly designed subsidy/incentive programs which in some instances have provided 100% subsidies to end-users. Other ICS subsidy programs didn't effectively engage end-users in the design and implementation of the program, leading to unnecessary long-term dependence and poorly managed exits, which consequently created long-lasting ICS market distortions. In some cases this has eroded consumer trust, which in turn has made it difficult to build properly functioning ICS markets.

The barriers highlighted above are not exhaustive, but rather indicative of the nascent and early development context of the ICS context in the CND region and in Rwanda in general. The barriers also tend to have forward and backward linkages whereby affordability further reinforces market barriers and vice versa.

### *6.5.6 Analysis of alternative solutions for improved adoption and use of household ICS to reduce fuel demand in CND*

The options for improved adoption and use of ICS in CND are broadly categorized into three groups; Demand-side support, Supply support and MRV (Monitoring, Reporting and Verification). These are briefly described below:

*Supply-side support program:*

The ultimate objective of this project is to provide 8,500 vulnerable households with access to cooking solutions that are clean, efficient, convenient, affordable, safe, and available. However some of the potential solutions (ICS Tiers 3 and 5) are expensive and vulnerable communities in the CND cannot afford them. In the interim, an immediate solution could be to help households switch from Tier 0 stoves to Tiers 1 – 2. This will allow vulnerable households to switch from a three-stone or traditional stove to an ICS (from Tier 0 to Tier 1 or higher) at low cost and with minimal disruption in cooking practices. This would involve a series of targeted interventions aiming to increase the supply of affordable ICS within the CND region, while also addressing the

[157] RWANDA | Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework

supply side of biomass by promoting on-farm afforestation with trees of high calorific value. Farms targeted for ICS adoption will be the same farms that are targeted for agroforestry interventions described earlier in this report. Taken together, these efforts will drive scale-up and improve access to ICS technologies (stoves and fuels).

Part of the supply-side support program for ICS would involve creation of a specialized small business development fund, to help local women and youth groups build innovative business models for accelerated distribution of ICS. These groups would be provided with ongoing technical support to support the purchase, distribution, repair and maintenance of Tier 2 ICS in the CND. This intervention would also involve establishing partnerships with the Integrated Polytechnic Regional Colleges (IPRCs) of Karongi and Musanze to help design prototype Tier 2 ICS that address local constraints/needs (such as cold and altitude region), affordability and community preferences. The project will ensure that these energy-efficient cookstoves are of superior quality and make business sense for participating SMEs to guarantee their uptake, scalability, and business sustainability. This project will encourage these colleges to work with students and come up with models of Tier 2 ICS as well as to provide training to cooperatives willing to manufacture ICS in the region. It will include development of demonstration equipment and information materials on access to clean energy; training of technical staff to support field promotions and promotional activities in the field to increase the uptake of Tier 2 ICS. It will also support the construction of modern kilns, drying halls, and storage facilities to facilitate the production of good quality Tier 2 ICS. As part of the cooperative agreement with vocational training schools, IPRCs will also be used to train local producers of ICS.

Local manufacturing cooperatives will be supported to accelerate the production, marketing, and distribution of Tier 2 stoves. In addition, this project will build the capacity of new cooperatives of youth which will play key roles in the distribution of ICS to the targeted households. The work will involve support of legal registration of new cooperatives as well as providing training in cooperatives management and business skills.

*Demand-side interventions:*

Two specific strategies are proposed for demand-side interventions;

i) **Raising public awareness:** Enhancing public awareness on the benefits of ICS would involve creation and dissemination of mass media outreach and specific marketing materials (mini-billboards, flyers, stickers, truck banners etc.) to help raise public awareness on the benefits of ICS as well as the public health and environmental risks of traditional cooking technologies. This is also expected to stimulate demand for ICS in the CND. Other public outreach mechanisms will including using existing forums such as the weekly clean up meetings (Umuganda), other social gatherings (schools, churches, women and youth group meetings etc) as well as mass media. Public radio campaigns emphasizing the unique benefits of improved stoves to consumers will further drive demand and overall sector growth in the CND. As mentioned above, IPRCs will also be involved in this outreach and promotional work.

ii) **End-user subsidy:** Project beneficiaries' vulnerable groups, including the historically marginalized groups (social categories UBUDEHE c,d,e and people with disabilities), will access cookstoves at 100% subsides while categories UBUDEHE a and b will use financing from micro-finance institutions (MFIs) like Savings and Credit Cooperatives (SACCOs where

farmers pay back the whole price in scheduled installments. This intervention is designed to help overcome one of the key barriers to adoption of tier 2 ICS, which is the cost being out of reach for poor rural households in the CND. The end-user subsidy would be implemented in close cooperation with other key actors already operating in this space such as the REG (Rwanda Energy Group) and GIZ who are providing Tier 1-2 end-user subsidies. The aim will be to coordinate our efforts to ensure that those households already introduced to Tier 1 cookstoves are enabled to upgrade to Tier 2. Farmer Savings Group (FSG) approach will be adopted and will reduce loan default rate through group guarantee mechanisms by which a group of borrowers undertake to be liable jointly or severally to a loan of any one of the members. This will increase MFIs' appetite to finance cookstoves as their risks will be mitigated. Specifically, the end-user subsidy program will include development of an operations manual, recruitment and training of suitable MFIs/SACCOs and as well technical assistance to develop tailored loan products for FSGs and operationalize end-user ICS financing programs within their areas of jurisdiction. Regular savings by FSGs members and access to loans from participating financial institutions (PFIs) will help farmers to raise sufficient funds for cookstove replacement. By taking a market perspective on this, the Project will strengthen the cookstove supply chain in CND, creating strong linkages and business relations among the key three actors: cookstove producers/youth SMEs, farmers/savings groups and MFIs to ensure sustainable access and finance of cookstoves. Cookstove producing, youth-led SMEs will be capacitated to improve business practices to ensure sustainable cookstove production beyond project period.

Monitoring Reporting and Verification (MRV):

A key barrier highlighted above is the absence of ongoing follow-up and support for ICS programs within the CND region. Consequently, lessons learned are not secured and the long-term benefits of the adoption and use of ICS are not well documented. This prevents the generation of insights into continuous improvement and targeted interventions to support consistent and proper use of the ICS solutions among end-users. The MRV program under this project will include the development of a suitable MRV tool-kit which will be administered to monitor progress of supply-side and demand side interventions described above and to facilitate periodic opportunities for reviews and improvements of ICS program effectiveness from the demand and supply side respectively.

### *6.5.7 Estimated GHG reductions from adoption of Household ICS in CND*

The aim of the proposed ICS program above is to enable the adoption and use of 8500 improved cookstoves by households within the CND region. This overall ICS program is therefore expected to yield cumulative total reduction of 166,763 $tCO_2eq$ for the 20 year monitoring period of the program.

The objective of this project is to reduce deforestation and empowering women through adoption of fuel efficient cookstoves. This project targets adoption of improved Canarumwe stoves by 8500 smallholder households in the CND (the same households targeted for on farm tree planting) to reduce the national wood fuel deficit. The table below summarises options that could be used to achieve this objective.

**Table 38. Options for energy efficient cooking stoves**

| Tier | Description | Efficiency[158] | Energy saving relative to Tier 0[159] | Pros | Cons | Average cost per stove |
|---|---|---|---|---|---|---|
| Tier 0 | 3-stone fire | 14% | 0% | Can heat the house in cold regions and light the house<br>Domestic lighting<br>Protect the house against insects<br>Flexibility to use a wide variety of fuels in different seasons<br>A place for family and friends gathering at night<br>No additional tools or skills needed to construct it | Indoor air quality Respiratory and vision problems in mostly women and children<br>Takes longer to cook meals<br>Consume more fuelwood | 0 |
| Tier 1 | ICS - Conventional ICS | 19% | 23% | Locally made<br>The cost is affordable by the poorest<br>Don't need specialized skills to make and install<br>Inexpensive to build<br>Flexibility to use a wide variety of fuels in different seasons | Safety: can't be left unattended<br>Low durability<br>High smoke | $2.5 -3.5 |

158 From WB / ACCES report Table 1.1 referenced to Global Alliance for Clean Cookstoves.

159 SE4ALL Rwanda

| Tier | Description | Efficiency[158] | Energy saving relative to Tier 0[159] | Pros | Cons | Average cost per stove |
|---|---|---|---|---|---|---|
| Tier 2 | Rocket stove - ICS with chimney, rocket stove with conventional material for insulation | 30% | >40% | Locally made<br>Relatively affordable<br>Improved technology can be adapted to local cooperatives<br>Availability of energy source locally<br>Easy to use<br>Durable<br>Building materials can be sourced locally<br>Convenient to the size of houses in rural areas | No flexibility to use a wide variety of fuels in different seasons<br>Produces some smoke<br>Doesn't heat the house in cold regions | $7-15 |
| Tier 3 | Forced draft - Rocket stove with high insulation, rocket stove with chimney (not well sealed) | 40% | >57% | Locally made<br>Produces very little smoke<br>Durable<br>Substantial reduction of fuels and smoke<br>. | Unaffordable by most of rural community<br>Some materials have to be imported (metal sheets) from abroad<br>Fuels must be dry<br>Imported from abroad<br>Requires biomass collection and processing points with sufficient electricity supply at each to power the chipping and pelletizing operations, with transport arranged to get the biomass from remote | $30-$40 (ex Songa, EMS)<br><br>$ 80 -$100 (Mimi-Moto, Ngufu)<br>Minimum 2kg pellets/day /family |

| Tier | Description | Efficiency[158] | Energy saving relative to Tier 0[159] | Pros | Cons | Average cost per stove |
|---|---|---|---|---|---|---|
| | | | | | rural areas to these collection points.<br>High technical skills required for maintenance<br>Not appropriate for villages without electricity or solar energy to run the fan | 1kg pellets=$ 0.2 |
| Tier 4 | LPG | 50% | >67% | Very clean<br>Satisfies strict health and environmental criteria<br>Flexibility to cook more than one meal at the same time | Need spacious kitchen<br>Unfordable by the poorest<br>Not accessible in remote areas<br>High technical skills required for use and maintenance<br>Accidents can be very devastating<br>No opportunity for social gathering | A two-burner LPG stove and cylinder (12 kg) full of gaz costs $65 additional cylinder used is $13-15 |
| | Biogas | | | Clean | Upfront investment cost is high<br>An equal amount of water is required per amount of manure used in the biogas system. Therefore, access to reliable source of water is critical | $859[160]/ biodigester |

160 FAO. 2021. Biogas systems in Rwanda – A critical review. Rome. https://doi.org/10.4060/cb3409en

| Tier | Description | Efficiency[158] | Energy saving relative to Tier 0[159] | Pros | Cons | Average cost per stove |
|---|---|---|---|---|---|---|
| | | | | | On average households need the equivalent of 4.5 m3 of biogas per day which requires a 10m3 plant.<br>2 cows would be needed to provide manure for a 4 m3 biodigester and around 5 cows will be needed for a 10 m3 plant | |

### *6.6. Value chain scanning and access to finance in CND*

See Annex 2.3

## 7. *PROGRAM DESCRIPTION*

The CND represents a complex landscape – a geospatial mosaic of forest and farming patches, each dependent on the other. These coupled, biological and socio-economic systems are under great strain due to intense land pressure, which has resulted in a negative cycle of natural resource degradation that undermines the well-being of both natural and socio-economic systems. The advent of climate change is a forceful driver that intensifies this cycle of degradation, with the resultant loss of key ecosystem services that importantly link forests and people. This cycle must be disrupted in order to chart a path toward climate resilience for natural and human systems. The approach to be taken by this Project is therefore based on principles of ecosystem-based adaptation: that healthy and resilient ecosystems form an essential foundation for adaptation to climate challenges[161]. Climate-aware management of both natural and human-dominated ecosystems – interacting and integrated at a landscape level – can break the cycle of degradation and instead lead to a positive sequence of mutually reinforcing, climate-smart, sustainable, and resilient benefits.

To address the present and intensifying threats from climate change requires that this region also be managed as an integrated and ecologically connected system. This need is recognized in several key policies and plans enacted in recent years by the Rwandan government. However, implementation and integration of these have lagged, their decentralized application on the ground is largely unrealized, and climate-related technical capacity remains limited in key institutions at all levels. This Project is designed to increase the climate resilience of the CND. Its intended outcomes are:

- The development and implementation of effective landscape planning, policies, and management, coordinated across sectors and scales, to address climate risks and adaptation benefits;
- Improved protection, restoration, and connection of existing natural forests, with enhanced resilience to climate impacts and risks; and
- The transformation of vulnerable rural livelihoods to be more climate-resilient, diverse, economically sustainable, and nature positive.

The Project has three main components directly targeting vulnerabilities within climate impact chains. This section provides a detailed technical description of project interventions by component. Activities that are part of the Gender and Youth Action Plan area marked with a G, and Social Safeguards activities are marked with an SS.

[161] Scarano, F.R. et al, 2017. *Ecosystem-based adaptation to climate change: concept, sustainability and a role for conservation science,* Perspectives in Ecology & Conservation 15(2), 65-73.

1. ***Component 1: Mainstreaming Climate Adaptation into Integrated Land Use Planning***

This component is designed to address planning at landscape level through coordinated multi-sector processes to integrate the ways in which different government sectors apply their mandates with respect to forests and natural resources and more importantly to mainstreaming climate adaptation. Key to this integrated, multi-sector approach is the use of up-to-date knowledge to identify high conservation value and carbon sites, resources, habitats and landscapes with respect to safeguarding species diversity, carbon stocks, ecosystem services, community interests and cultural values, and reducing communities vulnerability to climate change.

There is an urgent need for more effective collaboration among Rwandan government agencies, civil society, private sector, and diverse partners to balance difficult-yet-inevitable land use trade-offs that will have profound impacts on the climate resilience of both natural systems and people. The GoR recognizes that a piecemeal approach to decision making has exacerbated competition over scarce land resources and reduced the adaptive capacity of both ecosystems and rural populations[162]. Rwanda's Baseline Climate Change Vulnerability Index (2015) recommends establishing a multi-ministry technical climate resilience coordinating committee, including NGOs[163]. In 2017 the MoE developed the Strategic Programme for Climate Resilience (SPCR), to focus on three cross-cutting priorities to achieve climate change resilience: (a) technical capacity building and strengthening institutional coordination; (b) integrated land use and spatial planning; and (c) climate services and disaster risk management [164]. The SPCR is a key step towards ensuring inter-ministerial and multi-sectoral collaboration and integration of climate resilience considerations into development plans and actions. However, there remains a need to comprehensively implement the strategy and mainstream climate change adaptation at the sub-national level, engaging a diverse set of actors and sectors and empowering women to provide input into decision making at district and community levels.

The outputs and activities under this component will address themes (a) and (b) of the SPCR, by comprehensively mapping relevant stakeholders, educating them on the value of forests for increasing climate resilience, and strengthening an existing cross-sectoral taskforce to strengthen institutional coordination. It will also engage local land-use experts and community members (especially women) in updating Rwanda's National Land Use and Development Master Plan, and facilitate development of an Integrated Land-use Plan for Resilient Livelihoods and Ecosystems in the CND.

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[162] National Land Use Management Plan.

[163] United Nations, 2015. Economic Commission for Africa; Rwanda Environment Management Authority. Baseline climate change vulnerability index for Rwanda. Kigali. Rwanda Environment Management Authority.

[164] Rwanda's Green Fund (FONERWA), 2017. Strategic Programme for Climate Resilience (SPCR) Rwanda - December 2017. Link.

| Key Aspects | Description |
|---|---|
| Overview | The objective is to ensure climate adaptation and climate resilience are explicitly incorporated into land-use planning processes in the CND, such that trade-offs between different sectors can be resolved while balancing the climate resilience of nature and people. This will be achieved by building knowledge among land-use planning actors on the value of forests for climate resilience, and institutionalizing cross-sectoral meetings to encourage synergies and avoid overlapping mandates and redundancy in different climate resilience interventions. Local land-use planning experts and community members will be engaged to review and interpret the National Land Use and Development Master Plan, to ensure the plan accounts for current and future climate risks, and that these risks are also considered in district level planning schemes. In collaboration with all stakeholders, the knowledge and insights gained from these activities will be synthesized and used to inform the design of an Integrated Land-use Plan for Resilient Livelihoods and Ecosystems, which will reconciles the cross-sectoral (e.g., tourism, environment, forestry, food production, cash crops for export) trade-offs necessary to sustain forest ecosystem functions, deliver critical ecosystem services and improve community livelihoods. An innovative scientifically credible system for monitoring trends in natural forest cover and forest types will also be established, and a comprehensive capacity building programme will improve use of remote sensing, ecosystem service modelling and spatial planning tools to inform decision making. |
| Adaptation Benefits | 1. Facilitation of adaptation actions, monitoring and reporting across different government levels and sectors<br>2. Access and understanding of climate information enhances adaptive capacity of local communities to adopt climate-resilient land-use practices<br>3. Create an enabling environment for scaling up of climate resilient landscape solutions<br>4. Effect of activities will be a reduction of farmer production losses because of climate adaptation in land-use planning<br>5. Reduced pressure on forest ecosystems and drivers of forest degradation as a result of improved land-use planning leading to less crop failures |
| Barriers Addressed | 1. Insufficient mechanisms for integrated landscape planning and coordination among agencies<br>2. Inadequate mechanism for inclusive participatory in land use planning<br>3. Insufficient mainstreaming of climate change into land use planning<br>4. Limited understanding of the value of forest extent and intactness for ecosystem services and ecosystem based adaptation<br>5. Low recognition of, and capacity to address climate change in government and in society |

***Output 1.1: Landscape-wide land-use plan developed for climate-resilient livelihoods and forest ecosystems, integrating district strategies.***

The transformation of land into agriculture, urban, suburban and industrial uses presents one of the fastest alterations of the Rwanda landscape today. This rapid change produces cumulative ecological stresses that are exacerbated by climate change. The combination of multiple climate change stressors and extremely high pressure on land use creates an urgent need for more effective collaboration between government agencies, civil society and the private sector to balance difficult yet inevitable trade-offs that will have profound impacts on nature and people.

The GoR completed a National Land Use and Development Master Plan (NLUMP 2020) to guide land use planning and regulate permitting processes. The NLUDMP 2020 highly recommended the establishment of district land use plan clusters. These clusters should comply with green principles and climate resilient strategies to become a District green land use plan. However, effective and strategic land use has yet to be applied at a local and district level, and the conversion of plantation and riparian forests to agriculture continues and development projects are approved without sufficient knowledge of climate change risks or the value of existing forests for ecosystem-based adaptation (EbA)[165]. The Project will add climate-change resilience and adaptation content to central government efforts such as NLUMP and the SPCR process by acquiring, synthesizing, and disseminating key information on climate trends, the importance of remaining natural forests, and the value of ecosystem services. This information will also be shared at district and community levels through various outreach networks and workshops, with particular attention to reaching disadvantaged women and youth.

Building on the information base outlined above, the Project will work with the Rwanda National Land Authority to establish a working group, with participation from relevant ministries, agencies, and districts to develop a climate-resilient land-use plan for the CND landscape. At the national level, each relevant ministry and government agency will select and appoint a working group member while at the district level, participants will be selected from the Joint Action Development Forum (JADF). JADF is a multi-stakeholder platform meant to facilitate and promote the full participation of citizens in the decentralized and participatory governance and improve service provision processes with representatives from the public sector, private sector and civil society. The following stakeholders will form the basis of the collaboration: a) the Ministry of Environment represented by three of its agencies: the Rwanda Environment Management Authority (REMA); the National Land Authority (NLA), Rwanda Water Board (RBA) and the Rwanda Forest Authority (RFA); b) the Ministry of Agriculture, including the Rwanda Agriculture Board (RAB); c) the National Agriculture Export Board (NAEB) d) Ministry of Local Government; e) Rwanda Development Board (RDB); f) Gender Monitoring Office (GMO) g)Districts Decentralized Structures – the District Administrative Units, which supervise several technical and administrative activities; h) civil society, international organisations, academia and community based organizations. This list will be discussed during the inception period and expanded as necessary.

[165] Scarano, F.R. et al, 2017*. Ecosystem-based adaptation to climate change: concept, sustainability and a role for conservation science,* Perspectives in Ecology & Conservation 15(2), 65-73.

From this, a spatial framework for district level land use planning will be developed that accounts for current and future climate risks, reconciles cross-sectoral land-use conflicts, and guides development decisions.

Output 1.1 comprises of the following activities and sub-activities. All the activities and sub activities will be executed by the Rwanda Forest Authority in collaboration with National Land Authority, and districts.

| | Activities |
|---|---|
| **Output 1.1 - Landscape-wide land-use plan developed for climate-resilient livelihoods and forest ecosystems, integrating district strategies.** | **Activity 1.1.1. - Synthesize and disseminate information on value of natural forests and ecosystem services** |
| | **Activity 1.1.2 - Develop climate-resilient landscape land-use plan** |

*Activity 1.1.1. Synthesize and disseminate information on value of natural forests and ecosystem services*

This activity will involve conducting a stakeholder mapping & consultation exercise in order to better understand the use of climate adaptation data in existing sectoral planning processes, and identify cross-sectoral linkages or conflicts. These results, along with a comprehensive literature review, will inform the design of high-level information packages that will synthesize information on climate risks for various sectors (e.g. agriculture, forestry) and highlight the value of forests for increasing resilience of local communities. An information dissemination program (e.g. presentations, workshops, and newsletters) will be implemented to share this knowledge among key ministries as well as government, non-government and community organizations. This project will use JADF as a platform to disseminate information to key stakeholders. Particular attention will be paid to ensure women, vulnerable and youth groups are represented. Cross-sectoral tradeoffs and climate adaptation solutions with cross-sectoral implications will also be highlighted, in order to begin promoting the benefits of integrated land-use planning. To complement the high-level information dissemination program, a suite of technical training materials will also be developed for delivery to district technical staff. These materials will provide training on climate risks & the need to incorporate climate adaptation into land-use planning, with a focus on the technical skills required for climate-sensitive planning (e.g. sourcing climate data, mapping ecosystem services). In addition, the program will use mass media in the form of a radio program and complementary community action campaigns to improve community, women, youth, other vulnerable groups knowledge on climate information, climate risks and climate adaptation options. This will stimulate discussion on issues pertaining to climate risks and other social issues locally and support engagement of each in responding effectively to climate adaptation and resilience options.

Sub-activities will include:

1.1.1.1 Map the sectors involved in land-use planning in the CND and review how forest ecosystem services and climate resilience are incorporated into each sector's planning process

1.1.1.2 Conduct comprehensive literature review & stakeholder consultation to collect & synthesize information on climate risks for various sectors (e.g. agriculture, forestry), the value of forests for increasing resilience of local communities, and highlight adaptation solutions with cross-sectoral implications

1.1.1.3 Host workshops & presentations with key ministries, government organisations, NGOs and community organizations to disseminate high-level knowledge on value of forests for increasing resilience of local communities

1.1.1.4 Develop guidelines for integrating climate risk into land use planning and cross sectoral planning

1.1.1.5 Develop outreach materials on climate and related risks in the CND and the value of forest ecosystems for increasing resilience

1.1.1.6 Implement outreach program tailored to different stakeholders (local government, civil society, communities) to enhance capacities for land-use planning, funding mobilization, and delivery of climate adaptation actions

1.1.1.7 Conduct climate literacy seminars for local government and civil society organizations, aimed at increasing women and youth participation

1.1.1.8 Provide financial and logistical support to trained organizations in grassroots mobilization to increase women and youth participation in climate adaptation planning

1.1.1.9 Introduce social safeguards at a high level at each meeting, including the GRM, FPIC, and Access Restrictions Mitigations as safeguards to be in place for work with local communities

Activity 1.1.2. Develop climate-resilient landscape land-use plan

This activity aims to ensure that climate change adaptation requirements are fully integrated into planning processes at local, district and national scales. This will involve i) participatory scenario analysis to understand the problems local communities and district officials face in terms of natural disasters (flooding, soil erosion, forest loss/degradation) and climate change, as well as the future land use plans of the districts, including an assessment of the national consequences of these problems in terms of ecosystem service delivery and climate change resilience and adaptation capacity; ii) risk assessment to estimate the impacts of the planned land use changes, as well as climate change, on flood risk, soil erosion, forest loss/degradation and the well-being of local people; iii) climate change adaptation and mitigation measures development to decide possible climate actions for both adaptation and mitigation and prioritize these actions according to their feasibility and urgency in consultation with local communities, district leaders, and other stakeholders; and iv) land use plan development based on the recommendations from the previous 3 steps. A comprehensive consultation and feedback process will be undertaken to incorporate views of stakeholders at all levels (e.g. civil society; men, women, youth, and

historically marginalized people in local communities; district & national government), upon which the plan will be finalized and approved by the Government of Rwanda.

Sub activities will include:

1.1.2.1 Engage district officials, Joint Action Development Forums (JADF), and community members in the CND (especially women) in reviewing and interpreting the National Land Use and Development Management Plan (NLUMP), to ensure the plan accounts for current and future climate and related risks, while building local support for climate sensitive planning

1.1.2.2 Conduct participatory land-use planning process in communities from village to district level to support integrated climate resilient land use planning

1.1.2.3 Develop Integrated Land-use Plan that supports Resilient Livelihoods and Ecosystems in the CND, ensuring alignment with National Land Use and Development Master Plan and ensuring the CND plan guides the district plan

1.1.2.4 Develop and roll out a series of trainings (virtual sessions and online modules) on gender sensitivity and mainstreaming women and youth into planning

1.1.2.5 Assess specific climate impacts on historically marginalized and Category c,d,e populations through a participatory NR process to ensure the Project components address their needs for adaptation.

***Output 1.2 Local and national institutional capacities strengthened to integrate biodiversity and climate risks into land use planning and management***

Forest data in Rwanda has historically been generated in an ad-hoc fashion[166] through the support of external agencies. This precludes comprehensive consideration of forest and biodiversity data in land-use planning processes. As Rwanda moves to achieve the goals outlined in the Green Growth and Climate Resilience Strategy and the National Land-Use Development Master Plan, building governmental capacity in generating and utilizing spatial data to inform decision making is essential. The activities under this output will involve recruiting experts in mapping, remote sensing and ecosystem service modeling, in order to establish a formal spatial planning unit within government. These experts will also lead a formal information dissemination and capacity building program, in order to i) promote the importance of considering forest & climate resilience into land-use planning, and ii) deliver detailed training to technical staff on forest mapping, climate and ecosystem service modeling. The Project will also increase the understanding of the importance of forest landscape restoration in securing ecosystem services for local economic development and resilient livelihoods. It will ensure that the public, decision-makers, private sector and other stakeholders in the CND landscape have a high level of awareness of the risks to the economy and livelihoods associated with deforestation under current and possible evolution of these risks

[166] Arakwiye, B., et al, 2021. *Thirty years of forest-cover change in Western Rwanda during periods of wars and environmental policy shifts.* Regional Environmental Change 21(2).

with the changing climate, and the benefits of reforestation in an integrated landscape approach. Key activities under this output will be executed by WCS and are described below.

| | Activities |
|---|---|
| **Output 1.2. Local and national institutional capacities strengthened to integrate biodiversity and climate risks into land use planning and management** | **Activity 1.2.1.- Create interagency taskforce institutionalizing integrated landscape planning and policy** |
| | **Activity 1.2.2 - Build capacity for spatial planning in national agencies re climate change** |
| | **Activity 1.2.3 - Develop an effective forest monitoring system to underpin forest management decisions** |

Activity 1.2.1 Create interagency taskforce institutionalizing integrated landscape planning and policy

Insufficient mechanisms for integrated land use planning constitute one of the key barriers for sustainable natural management in Rwanda. Planning processes within government agencies are carried out in silos without paying attention to the impacts a certain land use activity or project will have on other sectors of the economy. For instance, the targeted areas for tea expansion in the CND overlap with priority areas for landscape restoration and high biodiversity value, it is obvious that without cross-sector linkages and better land use planning these priorities may be in conflict and dramatically reduce the effectiveness of any one alone. It is key to identify large-scale, cross-sectoral opportunities (agriculture, forestry, tourism, and climate change) to safeguard remaining natural ecosystems for their ecological, social and economic benefits.

This Project aims to facilitate improved collaboration among government agencies by strengthening the government's existing cross-sectoral planning task force. The existing task force was set up to support cross-sectoral implementation of the National Strategy for Economic Transformation, but it suffers a number of weaknesses, including: i) a lack of official mandate for the task force to carry out activities; ii) irregular attendance of members; and iii) lack of clear and regular funding to facilitate meetings. This activity will review the mandate and structure of the cross-sectoral task force and promote solutions for strengthening its operation to RFA (the task force coordinator). It will also facilitate quarterly meetings of the task-force, in particular between institutions in charge of agriculture and agroforestry, to encourage synergies and avoid overlapping mandates and redundancy in different climate resilience interventions. The involved staff at both national and local levels shall be empowered to readily share information and activity plans, and will be offered technical support to generate materials that can inform decision-making (e.g. policy briefs, map, presentations). The Project will support collaborative integrated landscape planning, which secures climate resilience undertaken with appropriate social safeguards.

Sub activities will include:

1.2.1.1 Review & strengthen operationalization of the current cross-sectoral task force

1.2.1.2 Hold quarterly sectoral planning meetings with both national, district administrations in CND and the private sector involved in mining, agriculture and livestock production in the landscape

1.2.1.3 Facilitate discussions and provide technical support (e.g. policy briefs) in decision-making for cross-sectoral actions around climate adaptation and forest resilience in the CND

1.2.1.4 Continue to introduce social safeguards at each meeting including the GRM, FPIC, and Access Restrictions Mitigations as safeguards to be in place for work with local communities. For those at the district or community level, provide options for feedback on the process and best ways of communication with local partners.

Activity 1.2.2 Build capacity for spatial planning in national agencies re climate change
Spatial planning is emerging as a valuable tool for the development of evidence-based land use and climate resilience strategies[167]. This subcomponent will develop capacity within the Rwanda's university network and the MoE to use remote sensing, ecosystem service modeling and spatial planning tools (e.g., Marxan, InVEST, RIOS, SWAT) to incorporate climate risks and climate resilience strategies into development plans and to readily identify and reconcile land use conflicts. A prime example of the latter is the potential for climate-driven shifts in optimal elevation zones for coffee and tea cultivation conflicting with current subsistence agriculture in the case of coffee, and key remaining natural forest fragments with regard to any upward migration of tea.

The Project will assist the GoR in developing a dedicated spatial planning unit (SPU) within an appropriate ministry or cross-cutting agency. This will include support for training high level Rwandan specialists to provide the technical expertise needed to process and integrate spatial planning into decision-making within and across sectors. A specific contribution of this SPU in coordination with appropriate governmental and non-governmental partners is the development and operationalization of an innovative, scientifically credible, scalable system for monitoring trends in natural forest cover and forest types at multiple scales.

Capacity building is essential for execution of the Project, even more so for the sustainability of project elements in the long run. To improve Rwanda's collective ability to integrate land use planning in support of climate change resilience and delivery of ecosystem services, these sub-activities are planned:

1.2.2.1 Recruit spatial planning expert/s to support spatial planning unit

1.2.2.2 Assess and identify the institutional home and operationalize the spatial planning unit

1.2.2.3 Conduct a capacity needs assessment and identify the appropriate tools for spatial planning to fit the Rwandan context and conduct familiarization

[167] Mathias S., et al, 2019. The Spatial Development Framework to facilitate urban management in countries with weak planning systems, International Planning Studies, 24:3-4, 235-254, DOI: 10.1080/13563475.2019.1658571

1.2.2.4 Led by the spatial planning unit, develop capacity within the University of Rwanda and the MoE to use remote sensing, ecosystem service modeling and spatial planning tools (e.g., Marxan, InVEST, RIOS, SWAT) to incorporate climate risks into land use planning processes.

1.2.2.5 Deliver training workshops on utilization of earth system models for land use planning purposes, utilization of remote sensing resources (lightning, satellite radiances) for hazards detection and climate monitoring and on regional climate monitoring and applications.

Activity 1.2.3 Develop an effective forest monitoring system to underpin forest management decisions

Within Rwanda, forest-related data is limited in scope and generally outdated[168] [7]. Consequently, the current state and trends of Rwanda's forests are not well understood. Efforts to improve the situation through individual studies have been valuable but have not led to systematic increases in spatial information on trends in different forest cover types and resilience at the scales at which land use decisions are being made. For example, the FMES software focuses on forestry and plantation forests, but does not address natural forests. This activity will update and monitor forest cover data in different ecological zones and forest types using high resolution satellite imagery, field work, and remote sensing techniques. This Project will hire a Rwandan postdoc who will be trained by WCS experts in applying spatial planning and forest monitoring tools in Year 1 and year 2 and later transition to a government agency from year 3 to 5 to support and strengthen the SPU.

An adaptive forest, climate change and land use monitoring system will be established to support climate resilient forest management decisions through the following:

1.2.3.1 Recruit forest ecologist or remote sensing postdoc to support the design and implementation of indigenous forest monitoring system

1.2.3.2 Review existing forest mapping data and monitoring software, and assess utility for generating quantitative assessments of indigenous forest cover from local to national scales

1.2.3.3 In collaboration with REMA, MINAGRI, RAB, RDB, RISA, MoE and affiliated agencies and University of Rwanda, design structure and operation of forest monitoring system, including required inputs (data, computing, personnel), desired outputs, and operational structure (e.g. location, reporting structure, funding)

1.2.3.4 Purchase and install 2 new weather automatic stations in the CND

1.2.3.5 Establish & operationalize forest monitoring system

168 Food and Agriculture Organization of the United Nations, 2017. *Analysis of forests and climate change in Eastern Africa.* Forests and Climate Change Working Paper 16.

1.2.3.6 Generate updated maps & statistics for indigenous forest cover, forest type etc. using forest monitoring system

1.2.3.7 Develop capacity within the hosting institution for continued operation of the forest monitoring system.

## 2. *Component 2: Forest and landscape management and restoration*

The GoR has prioritized forest management and restoration – including natural forests in protected areas – as a key component of climate change adaptation strategies for the CND landscape.[169] [8] Natural forests within the national park system have been generally well protected and managed in recent years, earning high marks for biodiversity conservation while also developing a high quality – and quite lucrative – set of ecotourism attractions. Current Park management plans, however, include little attention to the potential effects of projected climate change. Outside of parks, few areas with natural forest cover remain and forest management and restoration approaches are not being implemented at the scale required to significantly improve forest climate resilience. Where forests are restored, most use exotic species and mono-specific plantations that are generally incompatible with mixed agricultural uses; they are also vulnerable to diseases and pests with climate warming.

In this component, targeted interventions will integrate climate change awareness and adaptation into national forest park planning, policies and management, as well as restore degraded areas within those parks. These efforts will help sustain the forests' rich biodiversity, the lucrative tourism revenues that flow into local and national economies, and the ecosystem services needed for climate resilience of vulnerable communities. This suite of activities will also identify priority areas outside of parks – in remnant natural stands, around wetlands, and along streams – for protection and restoration as "stepping stones" and linkages for long-term climate change connectivity (See figure 621.)

| Key Aspects | Description |
|---|---|
| **Overview** | **The objective of this component is to enhance forest resilience across the CND, through a combination of increased forest cover, improved forest condition, and improved management to reduce degradation and pressure on forests. This component will increase the extent and condition of natural forest within the CND's national parks, by facilitating regeneration of large areas previously degraded by fires, securing key remaining natural areas outside PAs and and developing a financial sustainability plan for the CND. A simultaneous capacity building program for National Park managers and local communities in fire management will decrease the risk of future degradation and increase overall forest resilience. Outside national parks, activities will focus on establishing biodiversity connections between fragmented natural forests. Management plans for the CND's national parks will also be updated to explicitly consider climate adaptation.** |

169 IUCN, 2014. *Forest landscape restoration opportunity assessment for Rwanda*. Link.

| Key Aspects | Description |
|---|---|
| Adaptation Benefits | 6. Enhanced climate resilience of natural forests<br>7. Enhanced delivery of ecosystem services that will reduce topsoil erosion, improve water quality; protect source water, and regulate climate<br>8. Enhanced livelihoods of climate vulnerable communities and their families in the CND<br>9. Increased resilience of protective forests & woodlots to climate impacts through sustainable forest management practices<br>10. Reduced stormwater runoff resulting in flood risk mitigation<br>11. Sustainable forest management to ensure wood products are sourced from a sustainable supply<br>12. Reduced forest degradation and deforestation as a result of community knowledge around climate-sensitive forest management practices<br>13. Enhanced adaptive capacity of local communities to sustainably operate nature-based enterprises (e.g. beekeeping)<br>14. Reduced risk of crop failure due to soil erosion and landslides<br>15. Enhanced climate resiliency of vulnerable communities through diversification of livelihoods<br>16. |
| Barriers Addressed | 1. Limited understanding or recognition of natural forests value, nor means to restore<br>2. Insufficient mechanisms for integrated landscape planning and coordination among agencies<br>3. Increasing demand for fuelwood drives deforestation and degradation<br>4. Protected areas largely funded by tourism revenues (greatly reduced by COVID 19) |

### *Output 2.1 Protected Area management effectiveness improved re climate risks and adaptation*

The remnant natural forests of the CND harbor globally significant biodiversity across multiple taxa, from primates to birds and orchids. More than 10% of these species are regionally endemic[170] [9] – 47 flowering plants are endemic to Nyungwe Forest alone[171] [10]. Though each has suffered from significant past habitat loss, the Nyungwe and Volcanoes National Parks have been generally well-managed under the Rwanda Development Board (RDB), with assistance from NGOs, PPPs, and the private sector. Rwanda's reputation for ecotourism and nature tourism attractions is world class. It has also earned conservation recognition for the dramatic recovery of its endangered mountain gorillas, sustained protection of its remaining biodiversity, and creation of a significant revenue-sharing program with parks-adjacent communities. The recent addition of Gishwati-Mukura National Park to this mountain forest network underscores the government's

170 CBD. 2020. Rwanda 6th National Report to the Convention on Biodiversity

171 Fischer, E. and Killmann, D., 2008. *Illustrated field guide to the plants of Nyungwe National Park Rwanda*. University of Koblenz-Landau.

commitment to conservation, though both forest blocks require significant restoration for the purposes of biodiversity conservation, connectivity, and ecosystem services enhancement.
In contrast to Rwanda's areas of conservation success, relatively little attention – and less action – has been focused on climate change and its potential impacts on habitats and biodiversity, especially in the climate-adapted mountain forests of the CND. The investment required to build and sustain the institutional and human capacity to achieve Rwanda's recent conservation success now needs to be joined with a parallel investment to ensure that PA management plans, policies, and actions address the realities of climate change both within and outside of their boundaries.

| | **Activities** |
|---|---|
| **Output 2.1. Protected Area management effectiveness improved re climate risks and adaptation** | **Activity 2.1.1 Facilitate revision of PA management plans to address climate risks** |
| | **Activity 2.1.2 - Establish long-term plans for CND financial sustainability post-GCF** |
| | **Activity 2.1.3 - New fire management curriculum developed and operationalized Given the expected increase in drought, and the natural forest vulnerability already demonstrated in the past, the capacity for effective fire prevention and management in core PAs and adjacent landscapes will be increased.** |

Activity 2.1.1 Facilitate revision of PA management plans to address climate risks
Climate change is increasingly recognized as not only a major future threat to protected areas, but one that will also exacerbate existing threats and vulnerabilities[172] [11]. This is particularly true for the three national parks of the Congo Nile Divide landscape that are surrounded by a large number of smallholder farmers who are dependent on natural resources for their livelihoods. The park planning processes need to be expanded to best meet challenges posed by climate change as well as ensure full incorporation of buffer zone and landscape linkage requirements, and the ability to engage with the larger CND and district landscape management planning processes. The revised management plans will aim to:

- Develop specific goals and objectives for improving climate resilience
- Identify areas and species of particular importance to climate adaptation, mitigation and resilience
- Identify and prioritize threats that exacerbate climate impacts
- Identify and prioritize critical actions for strengthening resilience
- Identify areas important for climate change adaptation and mitigation into protected area zones and regulations
- Develop indicators of climate resilience

To this end, the Project will undertake these sub-activities:

172 World Bank, 2019. *Rwanda Systematic Country Diagnostic.*

2.1.1.1 Review and update existing national park management plans to ensure climate and related landscape changes, risks, impacts and required management responses are integrated

2.1.1.2 Provide technical and financial support to planning, research and monitoring as well as community-based conservation units within RDB in managing the parks as part of larger CND landscapes

2.1.1.3 Train PA staff to integrate gender and social inclusion into programming

2.1.1.4 Train PA staff on integrating needs of women, youth, historically marginalized and Ubudehe Categories c,d,e populations into climate adaptation risks and responses

2.1.1.5 Train PA staff on SEAH, GRM, FPIC, and Access Restriction Mitigation Processes to ensure NP climate change responses are undertaken in a way which supports social inclusion and equity

Activity 2.1.2 Establish long-term plans for CND financial sustainability post-GCF

Rwanda has recently developed a Biodiversity Finance Plan[173] [12] through support from BIOFIN. This plan has identified a number of financing solutions that will not only contribute towards improved biodiversity protection in Rwanda, but also aligns with Rwanda's sustainable development and green growth objectives. These solutions include:

- Introduce a Biodiversity Conservation Fund into Rwanda's National Fund for the Environment (FONERWA) to help streamline and attract domestic and international sources of finance to support conservation investments and thereby reduce transaction costs to increase conservation benefits.
- Improve efficiency and effectiveness of environmental fees and fines to strengthen the effectiveness of the regulatory environment that will ultimately improve ecosystem and biodiversity conservation goals.
- Water User Fees for Catchment Management to secure the financial resources necessary for effective water catchment management.
- Pilot Business Plans for Selected Wetlands to enable the sustainable development of wetlands for ecotourism and biodiversity-friendly enterprises such as handicrafts, fisheries, and sustainable agriculture.
- Promote biodiversity-friendly enterprises in the transition to a green economy and accelerate the transition to a green economy by incentivizing and supporting businesses to adopt sustainable practices and attracting investments in new conservation enterprises.
- Strengthen the tourism revenue sharing scheme to improve biodiversity outcomes and effectively address conservation-development objectives
- Develop a Protected Area Finance Strategy to support the goal of increasing the financial and ecological sustainability of Rwanda's Protected Area System (PAS)
- Rwanda is also developing a REDD + strategy to help streamline carbon development projects.

173 BIOFIN Rwanda – Biodiversity Finance Plan, REMA, 2019.

There are also new emerging solutions such as the Wildlife Conservation Bond (WCB) which is an outcome-based, financial instrument that channels investments to achieve conservation outcomes – measured in this case by an increase in umbrella species populations. In the case of Rwanda, Gorillas and Chimpanzees are considered umbrella species that play a crucial role in shaping entire ecosystems on which countless other species depend. Through the WCB, investors could support the financing of activities to protect and grow a critically endangered species with clear conservation targets, contributing directly to biodiversity and bringing jobs to local communities through the creation of conservation-related employment in rural areas of the CND. The South African Rhino Bond has already attracted foreign investment, and it is a good model Rwanda could emulate[174] [13].

A technical advisor will be recruited by this project to provide technical support to RDB, REMA, and MoE and explore these various solutions to identify financial instruments that could be employed for revenue generation post-GCF for sustainable management of the CND landscape.

Activity 2.1.3 New fire management curriculum developed and operationalized given the expected increase in drought, and the natural forest vulnerability already demonstrated in the past, the capacity for effective fire prevention and management in core PAs and adjacent landscapes will be increased.

While current climate projections call for increased rainfall in the CND, they also project higher temperatures and a rise in elevation of the natural forests' cloud cover zone (Annex 2.1). The combination of the latter two trends raises the potential for increased fire risk. In order to sustainably address the threat of fire to the natural forests and regenerated areas in particular, this project will increase the capacity of RDB in the area of fire prevention, with emphasis on education and outreach, monitoring of fire danger conditions across the parks, response plans, and fire suppression. A collaborative effort in fire management planning and implementation in CND districts will be carried out, facilitated by a fire management expert. Based on training needs, the project will also carry out RFA district and sector foresters' training in Integrated Forest Fire Management approaches and activities and firefighting; they will then build the capacity of community fire brigades.

Sub-activities include:

2.1.3.1 Develop a curriculum tailored to needs and capacities of different stakeholders

2.1.3.2 Build the capacity of RDB to manage fire in National Parks

2.1.3.3 Build the capacity of RFA, local authorities and communities to collaboratively manage fire in forests outside PAs

2.1.3.4 Implement a "fire wise" outreach and awareness program for communities and local government (district, sector, cell), as well as Rwanda Forest Authority, surrounding natural forests to reduce the incidence of human-caused fires

174 World Bank, 2022. *Wildlife Conservation Bond Boosts South Africa's Efforts to Protect Black Rhinos and Support Local Communities.* Press Release NO: 2022/059/AFE.

### *Output 2.2: Natural forest cover restored, biodiversity connections established*

The natural forests of the CND exist as an archipelago of isolated islands within a surrounding matrix of intensive human land use. Although some have raised the possibility of reconnecting these islands, it is important to understand that their isolation is not a recent phenomenon (with evidence of the initial isolation of the main forest blocks from the pre-colonial era). Furthermore, large-scale proposals for landscape linkages have thus far failed to provide alternatives for the tens of thousands of rural smallholders who would be displaced by such schemes. However, important actions can be taken to restore degraded natural forest lands and protect or reestablish natural "stepping stones" and ensure a functional level of ecological linkage between the existing parks.

In some areas where natural forests have been cleared, the Project will work to restore forest cover. This will be done primarily around the Gishwati and Mukura reserves, using native species and building on nursery and planting techniques already tested in Rwanda. New techniques may need to be developed to expand reforestation to degraded lands on steep slopes and along waterways and wetlands.

All work outside of protected areas will require careful attention to private land ownership claims and related social and gender equity issues.

| | Activities |
|---|---|
| **Output 2.2 - Natural forest cover restored, biodiversity connections established** | **Activity 2.2.1 - Secure key remaining natural areas outside PAs** |
| | **Activity 2.2.2 - Restore natural forest cover in and outside Protected Areas including riparian linkages** |
| | **Activity 2.2.3 - Promote silvopastoralism with indigenous trees around Gishwati** |

Activity 2.2.1 Secure key remaining natural areas outside PAs

Outside of current protected areas, the Project will identify remaining natural areas and seek to secure their continued protection within district management plans or through other means. These are mostly small stands of natural vegetation on rocky outcroppings or strips of forests along the CND's myriad of waterways. Although these will not permit large mammals (e.g. elephants or mountain gorillas) to migrate between the forested parks, these small remaining natural areas provide critical intermediate stepping stones for the broader biodiversity elements of the CND forest ecosystems. For the CND's rich assemblage of bird species, these vegetated patches and gallery groves could prove to be essential stepping stones for connectivity under changing conditions. Small mammals and insects are likely to also directly benefit. And most importantly, the movement of birds and small mammals will support the transfer of seeds between forest patches, greatly improving the ability of forest ecosystems to adapt to changing climates, and continue supplying key ecosystem services to the people of the CND. The Project will support the Ministry of Environment, Districts and RDB in establishing mechanisms to manage these forests.

They will organize surveillance and monitoring to reduce illegal logging, uncontrolled clearing, and encroachment for agriculture and mining. The project will then facilitate the development of a set of management and business plans for the remnant forests, developed with the active participation of key stakeholders to be implemented using a range of governance mechanisms, including co-management and other community-based systems. To the extent possible, these co-management agreements will take gender issues and the Environmental and Social Management Plan on board.

Sub-activities include:

2.2.1.1 Raise awareness on remaining protected natural forests in CNDL to secure their protection

2.2.1.2 In collaboration with RFA, REMA, districts identify and implement actions that support conservation and management of remnant protected natural forests in CNDL

Activity 2.2.2 Restore natural forest cover in and outside Protected Areas including riparian linkages

While the boundary integrity of the Nyungwe and Volcanoes NPs has been maintained for several decades now, internal degradation has occurred. Prior to 2004, approximately 12% of Nyungwe National Park had been affected by wildfire, including a catastrophic fire during a period of prolonged drought in 1997.[175] [14] The natural vegetation was quickly replaced by a carpet of invasive ferns. In recent years, teams of local community workers led by WCS have demonstrated that careful removal of the fern cover reveals still viable native tree seeds and seedlings that respond to this exposure by rapid growth and the formation of new forest stands. The project will expand this labor-intensive process of assisted regeneration to the remaining 4,500 ha of burned lands within the NNP, restoring forest values and generating significant employment for local rural communities.

For the Gishwati-Mukura National Park, its history over the past decades has been one of dramatic deforestation for conversion to settlements, agricultural lands and pasture, mining and as well as for timber and energy usage. Around 500 ha of the remnant GMNP, much of which was previously subject to extensive human use, is highly degraded and in need of restoration. Also, as a result of previous restoration efforts with exotic species, there are patches of eucalyptus and other non-native invasive tree species that need to be removed and replaced to allow for natural forests to regenerate. This intervention will restore areas (through tree planting indigenous species or natural regeneration) that have been degraded by mining using indigenous tree species and remove exotic species inside GMNP that are becoming invasive. Planted trees will be maintained for at least three years. Restoration sites will be visited every 3 to 4 months to ensure trees are well established, dead ones are replaced, and newly sprouted exotic trees uprooted. A special element within the CND landscape is its dense network of waterways. Historically forested riparian habitats along these streams and rivers, however, have been largely cleared of their forest cover. Riparian reforestation efforts on 1,500 ha will restore an important

[175] Masozera, A.B., Mulindahabi, F., 2007. *Post-Fire Regeneration in Nyungwe National Park, Rwanda.* Wildlife Conservation Society.

erosion control factor as well as recreate important biodiversity connectivity along linear corridors. A mix of indigenous and other agroforestry species will be used.

There is a lack of available high quality seed and plant material for indigenous species in Rwanda. This project will set up an efficient supply system for native tree seeds and seedlings to facilitate use of native species in forest restoration and agroforestry activities. This and other restoration efforts will benefit from tree nursery techniques and planting trials already initiated by RFA, RDB, and NGO partners around Nyungwe, Volcanoes, and Gishwati itself. The project will work with the National Tree Seed Centre to provide training on tree propagation and supply of quality seeds/seedlings/propagation materials, especially of indigenous species and plantation species not being sourced locally.

With support from district, sector leaders and community representatives around PAs, community members will be hired for restoration activities.It is estimated that there will be 3,000 people hired from Nyungwe neighboring communities during the five years of this project (1,500 in the first year, 2,250 in the second year, 3,000 in the third year, 1,500 in fourth year and 750 in the last year) for clearing fern stands. The majority of the 3,000 labour forces in Nyungwe restoration will be youth (young men) due to the physical nature of many aspects of ecological restoration and extended remote work far from families for several weeks.

The restoration of GMNP will employ and support approximately 400 vulnerable community members such as women (at least 50%), youth and historically marginalized groups for exotic tree removal and to establish and manage indigenous tree nurseries that will provide seedlings for restoration efforts.

Restoration of riparian lands will involve 820 community members including the most vulnerable, women (at least 50%), youth and other marginalized people.

Depending on the site, restoration techniques that will be used require a set of skills. Community participants will be trained in methods to control exotic trees to stimulate natural regeneration of native species (for example by debarking invasive trees), planting and maintenance of native seedlings and techniques for assisted natural regeneration through fern cutting to avoid improper cutting that could lead to the loss of desired tree saplings and seedlings.

In anticipation of potential risks associated with core PAs and buffer zones restoration such as fire, poaching, disposal of wastes at camping sites, snake bites and injuries, training sessions on safety, park rules and regulations, and use of first aid kits will be organized for all communities recruited. Code of conduct, park rules and regulations as well as safety and evacuation plans will be developed and communicated to community members involved in this project during the training sessions. Community workers will be provided with tools and equipment needed for restoration activities and for safety. This will include camping equipment, first aid kits, machetes, and protective and rain gears.

In addition to job creation in afforestation of the degraded forest with indigenous trees and clearing invasive species from the natural forests and buffer zones, other direct benefits for the

communities will be harvesting of non-timber forest products (NTFPs) from the natural forests, under sustainable use plans. The project will provide training on improved harvesting techniques, processing, packaging and marketing, to those engaged in NTFP value chain (financed under outcome 3).

Key sub-activities include:

2.2.2.1 Review mapping of degraded natural forest areas in core NPs, stepping stones and unprotected riparian lands using updated imagery and ground truthing

2.2.2.2 Identify parcels for restoration in core PAs, stepping stones and riparian lands using desktop and field-based assessment

2.2.2.3 Establish indigenous tree seed nurseries in the CND to serve core PAs, stepping stones, riparian land restoration and promotion of indigenous trees on farms and in protective forests

2.2.2.4 Recruit, train (in forest restoration methods), and equip community workers to be involved in core PAs restoration and riparian linkages

2.2.2.5 Assisted rehabilitation of 4,500 ha of indigenous forest in NNP

2.2.2.6 Active restoration of natural forest on 500 ha Gishwati Mukura National Park

2.2.2.7 Restore 1,500 ha of riparian lands

2.2.2.8 Using permanent plots sampling, collect field monitoring data on tree species recruitment and growth for estimation of biomass, species richness, etc. in restored parcels in Nyungwe and Gishwati-Mukura National Parks as well as on riparian lands to assess success of initiatives, then replicate or adapt as needed

2.2.2.9 Perform Environmental and Social Screening on all positions being created by the project

2.2.2.10 Establish a grievance process for laborers

2.2.2.11 Update emergency and preparedness plan including risk mitigation guidance to local conditions at restoration sites

2.2.2.12 Train all workers on their rights and how to access the GRM

2.2.2.13 Provide code of conduct and emergency preparedness and safety training for all laborers

2.2.2.14 Hire and train labor and safety leads at each site to provide guidance to staff, be available for grievance issues, and monitor health and safety conditions for workers

2.2.2.15 Develop and implement strategy (including social marketing) to ensure that women and youth participate and benefit from forest restoration projects

Activity 2.2.3 Promote silvopastoralism with indigenous trees around Gishwati

Roughly 80% of Rwandans own livestock of some sort. While it is government policy to expand this percentage, conflicts over competing land uses are inevitable, especially for the country's most vulnerable rural populations. In the area around the protected forest of Gishwati, the presence of many slopes greater than 55% opens the possibility for reforestation of larger blocks with tree species compatible with an undergrowth of grass or other forage. In addition, some existing pasturelands could be enriched with tree species. These areas could then provide critical off-farm fodder for goats, sheep, and perhaps even cows, while also serving vital ecosystem services. The project targets at least 1000 ha of Gishwati pastures to be restored and will involve 546 community members mostly pasture land and livestock owners. Needed manpower will be recruited in the neighboring villages in collaboration with landowners, local communities and authorities. The project will make efforts to recruit the most vulnerable, women, landless, youth and other marginalized people.

Key sub-activities include:

2.2.3.1 Assess the status of pasture lands in the Gishwati area and identify key areas for restoration and the potential to introduce indigenous species

2.2.3.2 In collaboration with landowners, identify suitable indigenous species for fodder trees, shrubs, grasses, and herbaceous legumes that have potential to improve rangelands and increase their climate adaptive capacity

2.2.3.3 Produce and disseminate fodder trees, shrubs, grasses, and herbaceous legumes to project beneficiaries

2.2.3.4 Train beneficiaries on improved livestock and pasture management

***3. Component 3: Enhancing climate adaptation through resilient livelihoods***

Increasing the extent of protective forests, enhancing and restoring forest plantations, and increasing agroforestry tree cover are key steps to restoring ecosystem function and services identified in the National Forest Policy Report (NFPR 2017), especially i) reducing the risk of flooding, landslides and soil erosion from extreme climate events and ii) increasing long-term supply of wood fuel resources (the primary energy source for 77% of Rwandans[176]). Together with fuel efficient cookstoves, these trees will provide a sustainable source of fuelwood and reduce the amount of time women spend collecting fuelwood, enabling them to participate in other economic activities and programmatic opportunities. These outputs (cookstoves, plantation restoration, and agroforestry) will deliver carbon sequestration co-benefits totaling 1,720, 744 $tCO_2eq$ over 20 years.

In working to develop a comprehensive land use plan that incorporates climate adaptation, and while ensuring Rwanda's forest ecosystems are strengthened through forest management and restoration, attention must be paid to people who live next to the forests and those who are the most prone to causing degradation of these forest systems. In particular, this includes people who

[176] Government of Rwanda, 2021. *Rwanda Household Survey 2019/2020*. National Institute of Statistics of Rwanda.

either do not have access to land or whose land holdings are insufficient to meet their daily needs. These people are most likely to enter into and unsustainably use protected and protective forests to help meet their daily needs. Thus, this Project component targets these vulnerable households – youth, people from historically marginalized groups, and farmers with insufficient holdings – to build their capacity in financial literacy and enterprise, in order to strengthen their resilience to economic and climate shocks.

Also, to maximize the opportunities from improved silvicultural practices, it is necessary to improve business practices and market linkages for farming communities. More specifically, organizing and linking farmers to local and national wholesale traders will enable them to sell their produce more efficiently, maximizing profit and reducing wastage. To facilitate these linkages, this component will also build the business capacity and market linkages necessary to support the transition of farmers and their communities away from unsustainable practices that magnify their vulnerability to climate change and towards more secure livelihoods and expanded income opportunities. This includes strengthening capacities, developing inclusive business models, and developing market value chains for livelihoods that do not depend on traditional smallholder farming.

| Key Aspects | Description |
|---|---|
| **Overview** | **The objective of this component is to strengthen the livelihoods of the most vulnerable households, who are often most at risk of unsustainable use of protected areas and resources within protective forests. This includes women, landless and other vulnerable households, and youth, most of whom have no land. This component will increase the extent and condition of natural forest within the CND by reducing a key threat to their existence.**<br><br>**Outside national parks, activities will focus on improving the condition of extremely degraded plantations and woodlots, restoring the ecosystem functions and services identified in the National Forest Policy Report (NFPR 2017), especially (i) reducing the risk of flooding, landslides, and soil erosion from extreme climate events, (ii) increasing long-term supply of woodfuel resources. Erosion control measures (terracing) and on-farm tree cover will also be increased across the CND, helping reduce the risk of crop failure from extreme events like landslides, reduce land and water degradation caused by soil erosion, and increase provision of valuable products like woodfuel. To decrease pressure on forests for resource extraction, existing successful programs distributing improved cookstoves will be dramatically scaled up.** |
| **Adaptation Benefits** | **17. Enhanced climate resilience of natural forests**<br>**18. Enhanced delivery of ecosystem services that will reduce topsoil erosion, improve water quality; protect source water, and regulate climate**<br>**19. Enhanced livelihoods of climate vulnerable communities and their families in the CND**<br>**20. Increased resilience of protective forests & woodlots to climate impacts through sustainable forest management practices**<br>**21. Reduced stormwater runoff resulting in flood risk mitigation** |

| Key Aspects | Description |
|---|---|
| | 22. Sustainable forest management to ensure wood products are sourced from a sustainable supply<br>23. Reduced forest degradation and deforestation as a result of community knowledge around climate-sensitive forest management practices<br>24. Enhanced adaptive capacity of local communities to sustainably operate nature-based enterprises (e.g. beekeeping)<br>25. Reduced risk of crop failure due to soil erosion and landslides<br>26. Enhanced climate resiliency of vulnerable communities through diversification of livelihoods<br>27. Reduced time spent collecting firewood, allowing women to participate more fully in decision making processes<br>28. Reduction in risks for Indoor Air Pollution (IAP) resulting in enhanced health and livelihoods of climate vulnerable communities and their families in the CND.<br>29. Increased resiliency of households to expected extreme weather events such as droughts and floods through reduction of their demand on woodfuel.<br>30. Improved income and time savings of participating households (particularly women and girls) from the avoided costs from traditional cooking technologies. This will enable better resiliency of such households to climate shocks which would otherwise lower their household income.<br>31. Enhanced climate resiliency of vulnerable communities and households through diversification of livelihoods |
| **Barriers Addressed** | 5. Rural farmers have limited access to alternative livelihoods, capital, markets for farm and non land based incomes<br>6. Fuelwood demand drives deforestation<br>7. Perception of conflicts between immediate development needs and sustainability |

### *Output 3.1 Farming methods enhance productivity, reduce erosion and flooding risks, contribute to ecosystem services, and support connectivity*

Soil degradation and loss, largely from the cultivation of steep slopes in the western highlands of the CND, has caused declines in agricultural productivity and serious downstream problems of siltation and flooding. While the former means that smallholder farmers in the hills increasingly struggle to feed their families, the latter poses a threat to the long-term viability of water provision services in municipal areas and hydro-power generation[177], which is a key pillar for Rwanda's low carbon growth strategy.

This Project will support smallholder farmers in high erosion risk areas to implement Sustainable Land Management (SLM) practices techniques and the active *restoration* of degraded forest lands. By targeting high risk areas the Project can have a significant impact to reduce soil erosion,

[177] Rwanda Environment Management Authority (REMA), 2009. *Rwanda State of Environment and Outlook Report, Chapter 8: Energy Resources.*

improving the resilience of agricultural livelihoods in the highlands, while having a positive impact on water flow and water quality in the lowlands.

In each selected priority site, the Project will support the implementation of the full range soil erosion control best practices including agroforestry. While the erosion control practices may vary (e.g. radical vs progressive terracing), agroforestry practices will be established across the entire 2,500 ha. Interventions will be made in collaboration with district officials, according to agreed priorities and objectives, and involving local farmers and contractors.

| | Activities |
|---|---|
| **Output 3.1.: Farming methods enhance productivity, reduce erosion and flooding risks, contribute to ecosystem services, and support connectivity** | **Activity 3.1.1: -Restore high slope areas (>55%) as protective forests** |
| | **Activity 3.1.2: Develop on-farm agroforestry for high-caloric and indigenous tree species** |

Activity 3.1.1 Restore high slope areas (>55%) as protective forests

In Western Province, a major part of the CND landscape, 80% of the increase in tree-planting in recent years has come from private landowners seeking to earn revenue or increase their access to wood-based fuel[178]. Beyond this utilitarian interest, however, the NFPR 2017 calls for increasing the extent of protective forests and enhancing and restoring forest plantations as key steps to restoring ecosystem function and services, especially i) reducing the risk of flooding, landslides and soil erosion from extreme climate events and ii) increasing long-term supply of woodfuel resources (the energy source for 77% of Rwandans[179]), providing biodiversity habitat, and sequestering 942,233 t $CO_2$-eq over 20 years.

The current land use master plan discourages cultivation on slopes greater than 55% and encourages protection of existing vegetation and afforestation with indigenous species. This Project will promote indigenous species in rehabilitating existing forests and establishing new ones on bare lands. This activity will result in highly productive, climate-resilient woodlots and forestland with fully restored ecosystem services and significantly increased long-term carbon sequestration. It will afforest/restore 2,500 ha of degraded private smallholder land and district/state land by restoring existing degraded tree stock, afforesting bare areas, promoting good silvicultural practices, and facilitating the adoption of Simplified Forest Management Plans (SFMPs), as recommended by 2013 forest law. In the priority regions selected for afforestation/restoration, awareness and capacity building activities will be undertaken to build support and understanding of the PFMU approach. For privately owned land, only small-scale individual private landowners will be included, and this activity will not involve restoration of private

178 Arakwiye, B., et al, 2021. *Thirty years of forest-cover change in Western Rwanda during periods of wars and environmental policy shifts.* Regional Environmental Change 21(2).

179 Government of Rwanda, 2021. Rwanda Household Survey 2019/2020. National Institute of Statistics of Rwanda.

institutional plantations. Following this, private woodlot owners will be organized into local groups (around 40-50 ha of woodlot per group), and they will be assisted with developing MoUs for engaging in private FMUs management.

With the support from Belgium, RFA is piloting innovating Private Forest Management in Rwamagana, Rulindo, Gakenke and Gicumbi Districts to support small-holder private forest landowners in managing their plantations under organized Private Forest Management Units (PFMU). The support of the smallholder private forest owners consists in:

- Identifying, mapping and gathering their individual woodlots into consolidated PFMUs of around 25-50 ha
- Converting their unproductive old forests into newly established productive plantations
- Ensuring sustainable management and good silvicultural practices through establishment and correct implementation of a Simplified Forest Management Plans (SFMP, 1 per PFMU) approved by districts
- Establishing and properly managing cooperatives constituted by gathered woodlot owners (1 per PFMU)

The main lessons learnt from this pilot experience:

- Strong awareness and sensitization/training session are required to convince and involve forest owners in the process.
- Successful sensitization requires the identification and strong mobilization support of local leaders and officials (from cell/sector/district).
- Forest owners quickly understood the advantage of respecting rotation according to SFMP to increase forest productivity.
- The main concern was about the first 5-year period from the new planting (2018) until the first harvesting, during which forest owners could not harvest trees. However, they understand that, after this 5-year period, annual harvesting will provide regular and even significantly higher income over subsequent years.
- This system allows farmers with insufficient investment (money, man-power) capacity to shift from poor management of their old forest to productive plantations.
- Working in cooperatives provides additional opportunities for initiating other income generating opportunities, such as honey production.
- Within cooperatives, these farmers have access to financial loans by consolidating collateral.
- Within cooperatives, marketing of wood products will become easier: already some private companies (like the former pellet-making company Inyenyeri) had started contacting these cooperatives to sign a supply contract of wood products from tree-pruning within the next 2 years. Similarly, the East Africa SawMill has been contacted and is interested in signing a supply contract with these cooperatives.
- Grouping smallholder forest owners in cooperatives also facilitates other development initiatives (such as health insurance, saving schemes, etc.)
- However, the cooperatives' success requires support (coaching, training, M&E) to increase and sustain their management capacity.

On public land, forests will be organized into state/district FMUs to be managed by professional private companies through long-term concession agreements in line with the government strategy. While a concession agreement will be signed between the private forest companies and the MoE, the Project will only support the design of the forest management plans and development of contracting documents. Registration of restored forest parcels will be guided by well-trained district forest officers and forestry sector extensionists, assisted by the new FMES software and related GPS/tablets, which will provide automatic statistics, maps and register owners. For each FMU, a SFMP will be participatory reviewed or developed, outlining the basic information of the site (e.g. owner, species etc.), as well as a harvesting plan and schedule for silvicultural operations (thinning, pruning etc.). However, some areas of the state plantations that are vulnerable and exposed to high risk of degradation (high slopes) will require setting up special protective measures. Restoration on identified vulnerable areas will be done by establishing appropriate tree plantations that will offer a better protection and conservation of biodiversity while providing other ecosystem services. The project will employ 1,370 community members including woodlot owners and as much as possible, the most vulnerable communities, women, youth and landless.

Sub-activities include:

3.1.1.1 Introduce and raise awareness of indigenous species to target stakeholders in CND

3.1.1.2 In consultation with RFA, National Land Authority, districts and communities, determine fragile areas (steep slopes > 55%) to be allocated for protective forests and their ownership

3.1.1.3 Assess the current status of the indigenous tree species in selected areas for protective forests and select indigenous tree species appropriate to CNDL

3.1.1.4 Develop restoration plan for protective forests

3.1.1.5 Build capacity of local stakeholders (men and women) on PFMU approach and methods

3.1.1.6 Design and approve SFMPs of private FMUs

3.1.1.7 Ensure consent of smallholders prior to planting trees

3.1.1.8 In collaboration with smallholders reforest/restore 2,500 ha of public or private land with slopes >55% and ensure sustainable management under private FMUs according to approved SFMPs

3.1.1.9 Support monitoring and evaluation of restored private FMUs

3.1.1.10 Assess impacts of exotics on neighboring lands and mitigate their negative impacts

3.1.1.11 Develop and implement strategy (including social marketing) to ensure that women and youth participate and benefit from forest restoration projects

3.1.1.12 Assess the benefits and costs of each proposed tree and plant species and how those benefits affect different population segments.

Activity 3.1.2 Develop on-farm agroforestry for high-caloric and indigenous tree species

The extreme land scarcity of the CND precludes smallholder farmers – many of them among the most vulnerable and land-poor of the region – from dedicating any significant proportion of their holdings to tree production. However, the use of certain agroforestry species that both enrich the soil and control erosion when interplanted with ground crops can greatly reduce this conflict.

Under this activity, the Project will facilitate the production of on-farm afforestation plans with action plans for implementation. Formulation of the forest landscape restoration plans will follow the methodology introduced by the World Resources Institute (WRI) and IUCN and already tested in the country by the former Ministry of Natural Resources, as recently modified and applied for the Gatsibo Forest Landscape Restoration baseline conditions assessment. The methodology will involve three simple steps: a) Geospatial analysis to map degraded land that presents an opportunity for forest and landscape restoration (FLR), which will highlight areas with best potential for restoration; b) economic analysis to model the costs and benefits of degraded and restored land); and c) designing a restoration/afforestation action plan, based on an in-depth assessment of the conditions required to implement the FLR in the selected sectors. Agroforestry practices will be established across 3,346 ha and will involve around 16,456 community members including landowners, women(at least 50%), youth and other vulnerable groups as manpower. Interventions will be made in collaboration with District officials, according to agreed priorities and objectives, and involving local farmers and contractors.

For selected areas where Project activities may lead to reduced access to resources, the Project will undertake an in-depth Environmental and Social Impact Assessment (ESIA) in the first year of implementation and design an Environmental and Social Management Plan (ESMP) to guide implementation. This ESMP will include an access restriction mitigation plan, if deemed necessary. The matter of Free, Prior and Informed Consent (FPIC) will be explored during the ESIA and the approach applied if deemed appropriate. These documents will be based on materials contained in Annex 6.

Drawing on experience with high-elevation species identified both in Rwanda and across East Africa, the Project will support the following sub-activities:

3.1.2.1 Identify sub-areas of intervention for agroforestry dissemination in the CND

3.1.2.2 Introduce and raise awareness of agroforestry in target communities

3.1.2.3 Develop the capacity of extension agents at district/sector level and NGOs to support adoption of agroforestry technologies

3.1.2.4 Establish agroforestry/fruit tree nurseries to facilitate access to quality planting material

3.1.2.5 Promote sustainable land management practices by stabilizing existing terraces, and plant high calorific agroforestry species to provide a sustainable source of fuelwood for energy-efficient cookstoves to protect sloping land against severe soil erosion

3.1.2.6 Train RFA, extension agents, Project participants and community members on specific techniques for identification of and management of invasive pests and pathogens

***Output 3.2 Rural livelihoods generate alternative incomes & reduce pressure on forests***

The Project aims to respond to the growing pressure on natural resources and increase the local community's resilience to climate change in the CND landscape by evaluating and promoting forestry, agroforestry, and alternative short-term crop value chains. The Project will also support groups of historically marginalized people and other vulnerable groups of youth and women in the CND to develop alternative revenue streams by providing them with business coaching, value chain development, and access to finance. The selection of vulnerable groups will be based on the results of an assessment of level of poverty conducted by the Government of Rwanda.

Additionally, smallholder farmers will be supported to develop bankable income-generating activities, strengthen their cooperatives, and adopt fuel-efficient cook-stoves to limit the excessive use of firewood that leads to forest degradation. The Project will be implemented through multi-stakeholder collaboration with business service providers, financial institutions, community-based enterprises, value chain actors, and farmers' union.

Interventions of this output are primarily focusing on enhancing on-farm production capacities in promising value chains such as avocado, macadamia, forestry, agroforestry, short-term crops, honey, and ecotourism. The ultimate goal of the Project is to develop a financial model that create better livelihoods and supports access to energy-efficient cook-stoves to reduce pressure on forests and stimulate finance in forestry and agroforestry sectors.

| | Activities |
|---|---|
| **Output 3.2 Rural livelihoods generate alternative incomes & reduce pressure on forests** | **Activity 3.2.1 Develop forestry and agroforestry-related value chains for market access** |
| | **Activity 3.2.2 Facilitate and scale up climate-resilient value chain products** |
| | **Activity 3.2.3 Facilitate access to input & output markets for vulnerable farmers** |
| | **Activity 3.2.4 Scale up use and sales of fuel-efficient cook-stoves** |

Activity 3.2.1 Develop forestry and agroforestry-related value chains for market access

Most traditional tree farming in Rwanda is linked to fuel production in terms of firewood, charcoal, and timber for construction. However, to strengthen community resilience to climate change, there is a need to introduce fruit trees in the agroforestry system to generate income for smallholder farmers, especially women-headed households. Short-term crops will be promoted to support smallholder farmers with limited land resources (less than 0.4 ha) to create additional quicker income and incentivize adopting agroforestry practices. Regular income will help vulnerable communities to cope with climate variabilities and shocks.

Among promising agroforestry-related value chains, this Project has compiled a list of fruit trees and nuts with the potential for intercropping with short-term horticultural vegetables and fruits while providing further impacts on carbon sequestration, nutrition value, and market access in the CND. Selected fruit trees are expected to meet the dual purpose of soil protection and climate impact while generating long-term economic benefits to the most vulnerable community members of the CND region.

For each crop value chain identified, specific bottlenecks will be addressed while focusing on specific product-place combinations within the CND. Especially, attention will be on enhancing the quality and quantity of production in sync with particular demands from market niches, development of various models to improve access to finance together with financial institutions, and exploration of market opportunities that can generate off-farm jobs to absorb a good number of landless and other vulnerable groups of youth and women.

- Macadamia: A low-volume, high-value export crop that can create jobs for women and youth through in-country processing. The global demand for macadamia is greater than the available supply, creating a business opportunity for macadamia farmers in Rwanda. The project will work with the government to promote macadamia farming in CND areas and include macadamia in its tree planting drive in the CND.
- Avocado: The increasing demand for export and cash yield/ha are higher than maize or Irish potato. Through linkage to local avocado private value chain actors, there is an expectation that the increase of local women and youth-led SMEs to create jobs in the production collection, processing, and retail of both fresh and other emerging products like avocado oil. Packaged avocados will be exported to the European Union, providing an estimated 32% margin.
- French beans and chili: These vegetable crops can double the income per hectare of maize and potatoes and employ a good percentage of the 16% reported unemployed women and youth. French beans can potentially deliver a gross margin of 22,040Rwf per acre and a return on labor of 2,755Rwf per day, while chili can offer a gross margin of 46,384Rwf per acre and a return on labor of 7,731Rwf per day.
- Ecotourism and honey: The Project will enhance ecotourism and honey value chains. Particularly close to national parks, the potential business development of ecotourism can go hand in hand with honey and wax product development. The project will focus on a specific linkage between ecotourism destinations and agro-tourism to enhance the potential for an improved business case and help beekeeping cooperatives to enhance their processing, quality management, and marketing processes.

Rwanda has a well-established record of generating off-farm benefits from its protected area ecotourism programs. The Project will build on this by supporting sustainable tourism activities around and between the Gishwati and Mukura Forests, as outlined in the GMNP Tourism Master Plan.[180] New trails and base camps outside of the parks will generate employment and income opportunities for rural women and youth, as well as attract tourism revenue to help support forest protection and management.

The project will work with district authorities in CND to select cooperatives based on value chains, number of women and youth, number of members with vulnerability, and membership size. Selected cooperatives, PFIs, and value chain actors/SMEs will receive capacity building to improve their business skills, improve access to finance, and strengthen the chain.

Key sub activities are:

3.2.1.1 Identify and map of vulnerable groups of youth and women within the CND

3.2.1.2 Capacity building for farmers' cooperatives/unions on good agricultural practices (GAP) for market standards in the selected agroforestry-related tree fruits and horticulture.

3.2.1.3 Development of Global GAP standards modules and market access linkage for the selected value chains

3.2.1.4 Strengthen CND honey value chain, macadamia, avocado and vegetable by improving the capacity for production, marketing, and access to finance

3.2.1.5 Development of Tourism value chain

Activity 3.2.2 Facilitate and scale up climate-resilient value chain products

In the agriculture sector, this Project aims to build the capacity of smallholder farmers in producing, processing and marketing quality products that meet national and international standards to be competitive on the market. The Project will organize farmer-to-farmer knowledge-sharing workshops to facilitate sharing of best practices among the CND community members. Also, cooperative members will receive training in adopting contract farming principles. Furthermore, this activity will strengthen farmer cooperatives in understanding market needs, negotiations, pricing, production aggregation, and value addition for local and export markets. Linking small producers to established strong value chain actors in the private sector is critical for the sustainability of the chains and to guarantee markets for local farmers.

This activity includes in-depth target area assessments to tailor business cases for the selected value chains, particularly focusing on identification and engagement of existing farmer organizations and cooperatives, youth and women-owned businesses and local small and medium enterprises (SMEs, value chain actors) with capacity for production aggregation, value addition, and market potential to absorb production from smallholder farmers' cooperatives. This

[180] Rwanda Development Board (RDB), Rwanda Environmental Management Authority (REMA), 2018. *Tourism Development Master Plan for Gishwati - Mukura National Park.* Link.

localized stakeholder and value chain exploration will serve as a basis for organization of market linkages to help value chain actors better understand the market, challenges and opportunities.

Key sub-activities are:

3.2.2.1 Analyze identified value chains and promote them among the CND stakeholder networks

3.2.2.2 Strengthen the capacity of producer organizations to improve managerial capacities, farming practices, and gender inclusion in their organizations

3.2.2.3: Establish and strengthen relevant value chain platforms in the CND area and promote business development services to strengthen the chain and enhance value chain coordination.

3.2.2.4: Build and strengthen the capacity of off-takers (MSMEs, SMEs, and off-takers aggregators) to increase their competitiveness and comply with various standards

3.2.2.5: Facilitate and strengthen access to quality inputs for farmers and producer organizations in the CND regions

3.2.2.6: “CND brand” establishment for landscape labeled honey and wax products

Activity 3.2.3 Facilitate access to input & output markets for vulnerable farmers

The project aims to enhance productivity, quality, and sustainability at the farm level, as well as explore market linkages between farmers, suppliers, and buyers. By building small producers' understanding of the market ecosystem and linking them to input markets (fertilizers, seeds and seedlings) and contract farming principles, the project aims to address rural poverty and food insecurity through off-farm agricultural activities. The selected forestry, agroforestry, and horticulture value chains will be demonstrated to members of the CND community through access to quality seeds and seedlings of horticultural fruit trees. The project will also focus on building strong business relations and linkages between input suppliers, markets, and farming cooperatives, training vulnerable groups and farming cooperatives on the business-oriented farming concept, and developing an inclusive market access business model for vulnerable groups and cooperatives to increase their aggregation, marketing capacities, bargaining power, and participation in the formal value chain.

Key sub-activities:

3.2.3.1 Develop an inclusive business model to Integrate vulnerable farmers into formal market

3.2.3.2 Organize Microenterprise training and develop and implement green grants programs targeting landless youth and poor, as well as women who are unable to access direct benefits from land-based project activities.

3.2.3.3 Facilitate market access for women, youth, and historically marginalized communities through market linkage sessions

3.2.3.4 provide technical support on market standards, contract farming, and financial connectivity.

3.2.3.5 Develop various market access channels including digital market access for rural farmers especially women and marginalized groups

Activity 3.2.4 Scale up use and sales of fuel-efficient cook-stoves

The proposed project aims to introduce energy-efficient cook-stoves as a solution to reducing pressure on natural resources and addressing issues related to fuel scarcity and pollution from traditional cooking methods. A feasibility study will be conducted to assess the potential for adoption of energy-efficient cook-stoves in the target community. The project will partner with Technical and Vocational Education and Training (TVET) institutions and youth-led Small and Medium Enterprises (SMEs) to develop a prototype of energy-efficient cook-stoves. These cook-stoves will then be produced and distributed by the youth-led SMEs.

The project will ensure that the cook-stoves produced are of superior quality and economically viable for the SMEs involved, to guarantee their uptake, scalability, and business sustainability. Vulnerable groups, including those identified as UBUDEHE c,d,e and people with disabilities, will have access to the cook-stoves at a 100% subsidy, while UBUDEHE a and b will have access through financing provided by Microfinance Institutions (MFIs). MFIs will receive technical assistance to develop tailored loan products for the cook-stoves.

The project will target 8500 farmers for access to energy-efficient cook-stoves, with 4000 vulnerable farmers receiving them at full subsidy at an approximate cost of $65 per cook-stove. The remaining 4500 farmers in categories 3 & 4 will access the cook-stoves through MFI financing, with the loan to be paid back in scheduled installments. The use of Farmer Savings Groups (FSGs) is expected to reduce loan default rates and increase the appetite of MFIs and participating financial institutions (PFIs) to finance the cook-stoves.

The project will take a market systems approach to strengthening the cook-stove supply chain in the target community, creating strong linkages and business relations among key actors including cook-stove producers/youth-led SMEs, farmers/FSGs, and MFIs to ensure sustainable access and finance of the cook-stoves. The cook-stove producing youth-led SMEs will be capacitated to improve their business practices to ensure sustainable cook-stove production beyond the project period. The stoves will be sourced based on a market analysis of available options and the needs of the beneficiaries, considering factors such as affordability, carbon sequestration potential, and current cooking methods. The success of the project will be dependent on the outreach and capacity building planned for the FSGs as outlined in Output 3.3, Activity 3.3.2.

Key sub-activities are:

3.2.4.1. Identification and production of energy efficient cook-stoves

3.2.4.2. Distribute energy efficient cookstoves to CND community members based on wealth categories

***Output 3.3 Financial services & private sector investment increased***

With a particular focus on landless people, historically marginalized communities, and vulnerable groups of youth and women in the CND, the Project will deploy a FSG model to capacitate the

communities' productivity and financial resilience. Besides this, to address the significant challenges facing MFIs and Participating Financial Institutions (PFI) such as limited understanding of forestry and agriculture sectors, access to finance, and risks associated with climate change, this Project will guide financial service providers to enhance their knowledge on good agricultural practices and assess impact of climate change on their clientele and loan portfolio. Furthermore, the Project will facilitate Local and International impact investors and PFIs to engage in investment and credit provision for farmer cooperatives and SMEs in the selected value chains.

Addressing above challenges will help MFIs and PFIs design and develop financial products that respond to both local communities needs and the financial sector's expectations. The financial products will be consistent with climate resilience and capacity-building for macadamia, avocado, vegetable, honey and ecotourism value chain actors under Outputs 3.2.3 and 3.2.4. Techniques will be developed to analyze and score forestry and agroforestry value chains that are climate-resilient.

| | **Activities** |
|---|---|
| **Output 3.3 Financial services & private sector investment increased** | **Activity 3.3.1 Facilitate access to finance & private sector investments** |
| | **Activity 3.3.2 Set up and support savings & loan groups, enhance asset-building** |
| | **Activity 3.3.3 Build the capacity of financial institutions to serve targeted value chains and communities** |
| | **Activity 3.3.4 Facilitate learning & knowledge sharing** |

Activity 3.3.1 Facilitate access to finance & private sector investments

To de-risk the selected forestry and agroforestry-related value chains, the Project will organize sensitization sessions for value chain actors and private financial institutions. This will help build a common understanding with regard to the selected value chains and introduce monitoring and measurement systems to support the risk and climate impact assessment on the value chains to be undertaken by the financial service providers.

Furthermore, the Project will capitalize on the fast outreach of informal saving groups. These groups are made up of a limited number of people who have freely chosen to work together, save together, and take loans together. The poorer segments of the community and those with the same socio-economic background often do not have a regular source of income. Women are usually highly participating in these groups. In this context, the group comes from the same cooperative, they save to purchase agricultural inputs, such as seeds, fertilizer or equipment. The

group may also provide mutual assistance, such as medical insurance or providing loans to members in need. The group set up a clear set of rules and regulations that are known and respected by all.

The project will strengthen the capacity of saving groups and link them to more formalized financial institutions. We will further enhance financial education and client protection principles while furthering digitalization into a national payment system as a tool to reach out to the majority of people living in remote regions of the CND.

Sub-activities include:

3.3.1.1 Develop tailored credit assessment tool for selected value chains, while integrating climate impact data

3.3.1.2 Facilitate access to finance for selected value chains of avocado, macadamia, vegetable and ecotourism that are relevant to build climate resilience

3.3.1.3 Develop tailored financial products to meet the needs of women and youth

Activity 3.3.2 Set up and support savings & loan groups, enhance asset-building

To improve the financial literacy and access to finance for local smallholder farmers, the Project will focus on supporting and assisting farmers' cooperatives in setting up saving groups. Saving groups are a proven and effective approach for financial inclusion, particularly for the most vulnerable communities. This approach is recognized for its ability to generate high levels of social capital through its savings approach. Additionally, saving groups provide a platform for linkage with financial institutions and other business development services. Importantly, saving groups have a history of high levels of female inclusion.

In these groups, farmers co-guarantee each other for accessing loans, and strong groups form low lending risks for MFIs as members mutually reinforce each other's repayment. The saving groups will be created within cooperatives, with farmers deciding which group to join. The groups will set up governing rules and conditions, such as the saving amount and frequency of meetings, as well as criteria for new members to join.

The Project will pay particular attention to social inclusion, focusing on vulnerable communities and landless people. Youth and women-owned businesses will be selected in activity 3.2.2 to be matched with target beneficiaries in FSGs for input supplying such as modern beehives, seedling supply systems, and youth SMEs implementing energy efficient cooking-stoves use and distribution.

Key sub-activity:

3.3.2.1 Establish/form saving groups for access to finance

3.3.2.2 Provide organizational/technical/financial capacity building to women, youth, and CSOs (such as cooperatives or VSLA) with focus on financial literacy and provide long-term coaching to beneficiaries

3.3.2.3 Support women, youth, other marginalized groups strengthen savings and loan groups and register for MFI accounts

Activity 3.3.3 Build the capacity of financial institutions to serve targeted value chains and communities

To address the significant challenges facing MFIs and Participating Financial Institutions (PFIs) in understanding the forestry and agriculture sectors, and the risks associated with climate change, the Project will focus on providing guidance and support to these institutions. This will include the deployment of a digitalized forestry and agri-loan assessment tool to assist in the assessment of potential loan applications, as well as training and education on good agricultural practices and the impacts of climate change on their clientele and loan portfolio.

Furthermore, the Project will facilitate engagement with local and international impact investors and PFIs to increase investment and credit provision for farmer cooperatives and SMEs in the selected value chains. These efforts will help MFIs and PFIs to design and develop financial products that are responsive to the needs of local communities, while also meeting the expectations of the financial sector.

The Project will also focus on building the capacity of smallholder farmers in financial literacy and access to finance, by assisting and supporting farmers' cooperatives in setting up saving groups. This approach is recognized as an effective way to promote financial inclusion among vulnerable and marginalized communities, and is particularly effective in increasing the participation of women.

Overall, the Project aims to improve the ability of MFIs and PFIs to provide cost-effective and affordable services to smallholder farmers and vulnerable groups, by improving their understanding of the forestry and agriculture sectors, and the impacts of climate change on these sectors. This will help to increase access to finance for these communities and promote sustainable and resilient agricultural practices.

Key sub-activity:

3.3.3.1 Capacity-building of PFIs

Activity 3.3.4 Facilitate learning & knowledge sharing

To document the outcomes of the project's activities and promote a state of knowledge and learning sharing, this activity will focus on collecting data on existing indigenous and traditional skills, promoting technology adoption, and enhancing access to finance perspectives. This will be done through dialogues with community members in the CND and by developing a digital and shareable documentation of all activities.

One important learning topic for this program is to combine effective landscape management and restoration practices with improved livelihoods for communities through a market system and financial inclusion approach. The goal is to develop a set of approaches, practices, and results that can be used and embedded in the practices of present and future generations.

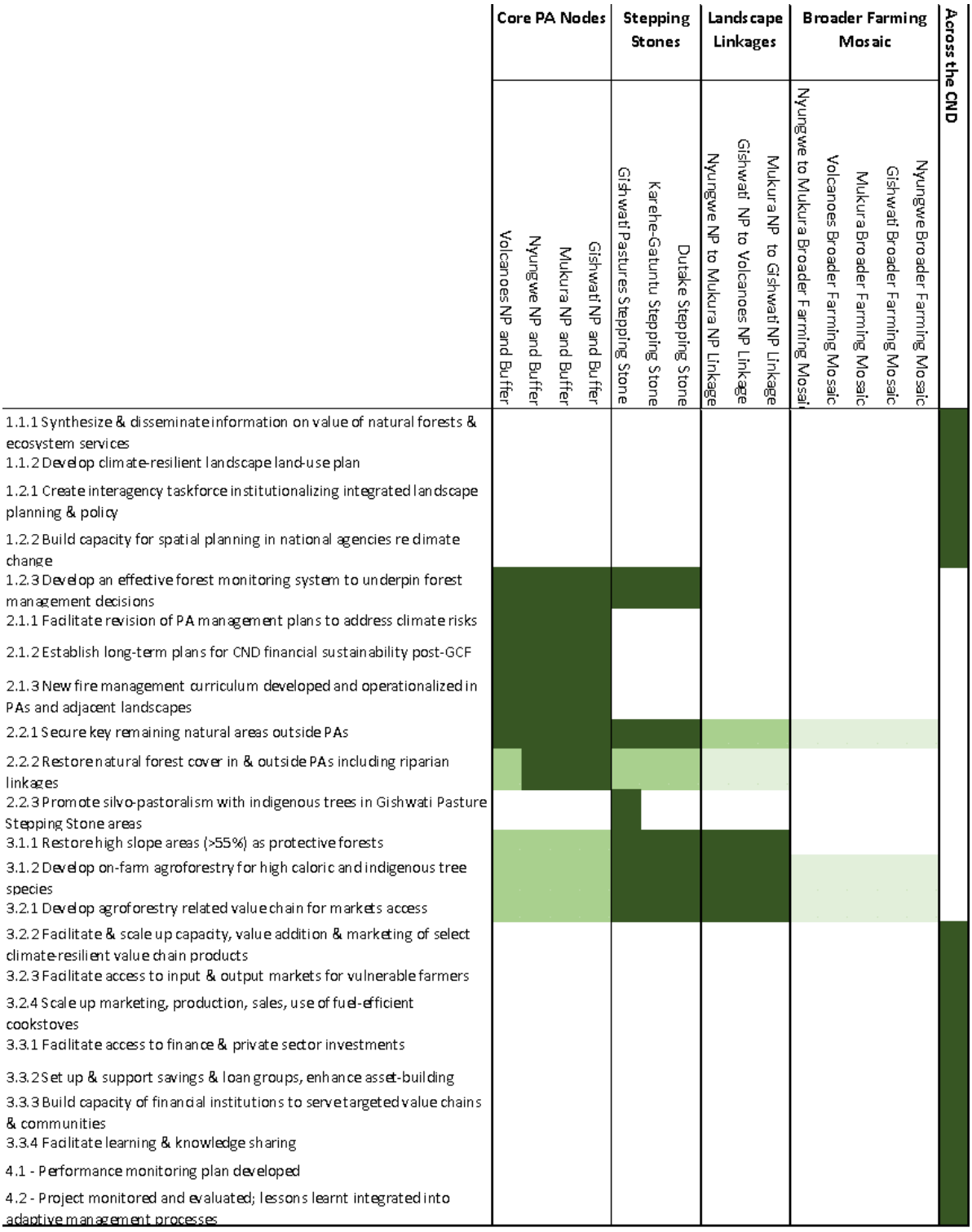
To achieve this, the activity will involve developing various forms of communications such as fact sheets, blogs, documentaries, and videos, as well as creating case studies. The project will also organize quarterly Plan, Do, Check & Act (PDCA) sessions with partners, participate in knowledge exchange events and webinars, and attend conferences with value chain actors. Additionally, the project will conduct monitoring activities such as field visits, quality data audits, and quick assessments, and maintain a management information system (MIS) to ensure regular output monitoring.

### *4. Summary of Project Activities across the Congo Nile Divide Landscape*

The Table 39 below presents a geographical summary of the project activities that will be implemented in the Congo Nile Divide landscape. The project activities are either a primary, secondary or tertiary focus based on the relative importance of these activities in each area as set out in the previous sections.

Many project activities are not place-based and would occur across the entire CND domain. These include land use planning, developing a forest monitoring system, developing and operationalizing a new fire management curriculum, facilitating access to finance and private sector investments, and facilitating learning and knowledge sharing.

**Table 39. Summary of project activities (place based and non-place based) to be implemented across the Congo Nile Divide.**



## APPENDIX 1 - FEASIBILITY REPORT ON FOREST MONITORING DATA SOURCES AND ANALYTICAL METHODS IN THE CONGO NILE DIVIDE

### 1. Introduction

Rwanda is ranked among the first of all African countries in terms of natural resource dependency and is thus highly vulnerable to climate change (Nabalamba et al., 2011). The country is already experiencing the impacts of climate change, including increased occurrence and severity of droughts along with more frequent floods and landslides. In the Congo Nile Divide of Western Rwanda, forest ecosystems are an essential tool for ecosystem-based adaptation to climate change, as identified in the government's Green Growth & Climate Resilience Strategy.

Achieving the ambitious goals that Rwanda has set around forest restoration, afforestation & agroforestry requires accurate measures of forest extent & condition. However, there is currently insufficient availability of accurate data on changes in forest cover and forest type at the spatial and temporal scales needed to inform integrated land use planning and management. Similarly, data on the ecosystem services provided by forests is generally lacking in Rwanda. As such, a clear priority of this project is to build capacity within the Government of Rwanda and University of Rwanda to use remote sensing, ecosystem service modelling and other spatial planning tools to regularly generate forest related data that is essential for integrated land-use planning.

To identify the most appropriate data sources and methods to focus capacity-building activities during the project, this feasibility study reviews available GIS data for forest monitoring in Rwanda, summarising the pros and cons of each dataset and methodology. It also assesses methods for mapping ecosystem services associated with forests and compiles guidance on best practices for field based forest monitoring.

### 2. Forests in the CND

The Congo-Nile Divide (CND) is an area of 4,446 $km^2$ separating the drainage basins of the Congo and Nile rivers. The Rwanda portion of the CND runs from the Virunga Mountains and Volcanoes National Park (VNP) on the border with Uganda in the North, down through Gishwati-Mukura National Park (GMNP), to the south end of Lake Kivu and Nyungwe National Park (NNP) on the southern border with Burundi.

According to Rwanda's 2019 Forest Cover Mapping Report[181], there is a total of 226,891 ha of forest in the CND, which makes up 32.6% of Rwanda's total forest area (Figure 1). Of this area, over 120,981 ha (53%) is natural forest, almost all of which is located within the CND's three national parks (Figure 1). A small amount is made up of bamboo plantations (90ha, 0.03%) and shrubland (123ha, 0.05%). All other forests in the CND are plantation forests established on the sloping hillsides and ridgetops of the CND. Forest categories in the CND are summarised in Table 1 below.

[181] Rwanda Ministry of Environment. "Rwanda Forest Cover Mapping." Kigali: Government of Rwanda, 2019.

**Table 1. Forest categories in the Congo Nile Divide and their size (ha) per district (Source: Forest Cover Mapping Report 2019)**

| *Forest category* | *Bamboo (ha)* | *Forest Plantation (ha)* | *Natural (ha)* | *Shrub (ha)* | *Total (ha)* |
|---|---|---|---|---|---|
| KARONGI | | 13,532 | 1,063 | 1 | 14,596 |
| MUSANZE | 26 | 4,719 | 9,929 | 3 | 14,678 |
| NGORORERO | 12 | 9,642 | 206 | 2 | 9,863 |
| NYABIHU | 49 | 9,769 | 4,473 | 6 | 14,297 |
| NYAMAGABE | | 22,156 | 21,046 | 0 | 43,202 |
| NYAMASHEKE | | 11,750 | 23,595 | 108 | 35,454 |
| NYARUGURU | | 16,371 | 21,799 | | 38,170 |
| RUBAVU | 2 | 3,796 | 801 | 1 | 4,600 |
| RUSIZI | | 2,073 | 34,546 | | 36,619 |
| RUTSIRO | | 11,894 | 3,520 | | 15,414 |
| **Grand Total** | **90** | **105,701** | **120,981** | **123** | **226,891** |

Forest plantations are widespread in the CND, with 72,076 individual plantations covering around 105,000 ha and making up 46.5% of total forest area[182] (Figure 1). Despite covering a large total area, more than half of these plantations are smaller than 0.25ha, and over 70% are smaller than 0.5ha (Table 2). This CND is an extremely mountainous landscape that is densely populated (primarily by farmers), meaning there is very little space for large contiguous blocks of forest. Not only does this reduce the overall resilience of forests and the ecosystem services they provide, it also makes accurately mapping forest extent and condition extremely challenging.

[182] Rwanda Ministry of Environment. "Rwanda Forest Cover Mapping." Kigali: Government of Rwanda, 2019.

**Table 2. Number and size of plantation forests in Rwanda (Source: Forest Cover Mapping Report 2019)**

| *Area Class* | *# of Plantations* | *Average plantation area (ha)* |
|---|---|---|
| **<0.25 ha** | 37471 | 0.105 |
| **0.25 - 0.5 ha** | 12377 | 0.357 |
| **0.5 - 1 ha** | 9345 | 0.705 |
| **1 - 2 ha** | 6070 | 1.4 |
| **>2 ha** | 7713 | 11.935 |
| **Total** | 72976 | 1.58 |

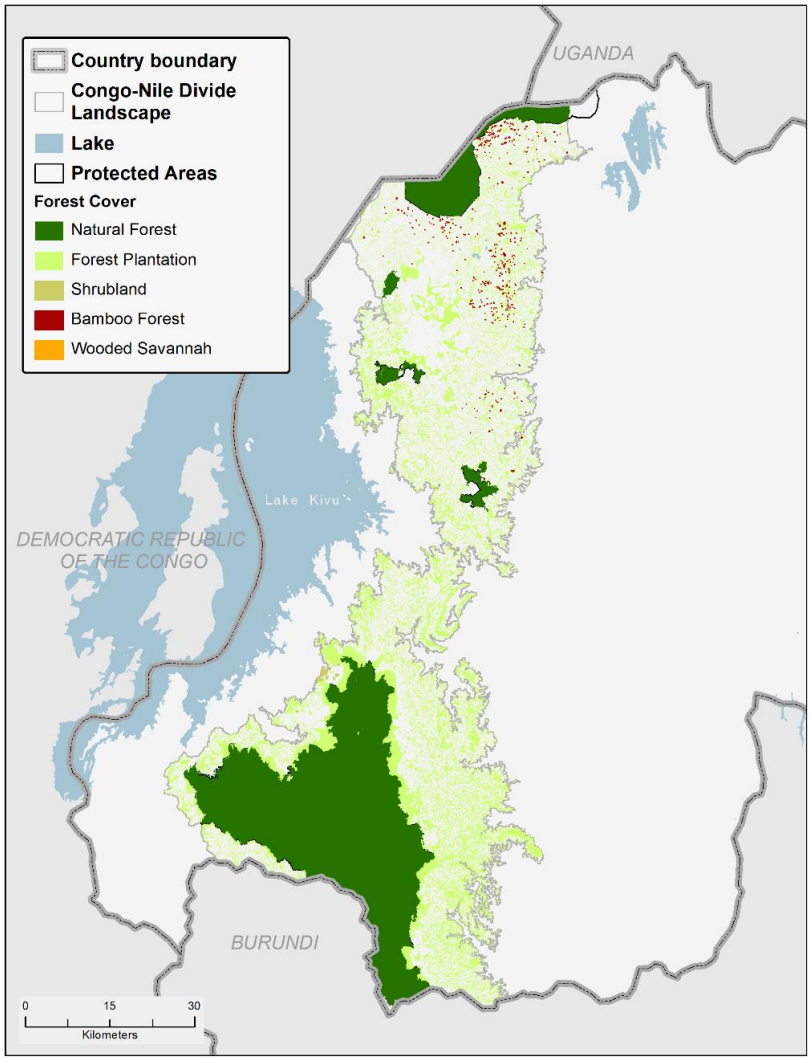



**Figure 1 - Forest categories in the CND. (Source: Forest Cover Mapping Report 2019)**

### *2.1. Existing Forest Cover Maps*

There are a number of existing products available to map forest extent in Rwanda[183], ranging from coarse global datasets to very detailed national-scale maps. Global-scale forest cover maps have not been included in this assessment, as they are all too coarse to be of use in the CND where there are a large number of very small forest parcels. In general, forest cover maps in Rwanda can be split into two groups according to their methodology: i) maps based on manual delineation of forests from very high-resolution orthophotos or satellite images, or ii) supervised classifications of forest types based on training data from known points. Table 3 summarizes existing maps of forest cover in Rwanda.

183 https://www.nature.com/articles/s41558-022-01544-w#citeas

**Table 3. Forest Mapping Datasets in the CND**

| Project | Mapping date | Underlying dataset | Spatial Resolution | Notes |
|---|---|---|---|---|
| **Arakwiye et al. (2021) -** Thirty years of forest-cover change in Western Rwanda during periods of wars and environmental policy shifts[184] | 1986-2019 | LANDSAT | 30m | • Supervised classification using training data<br>• Maps forest change from 1986-2019<br>• 30m resolution likely to miss many small plantations<br>• No information on forest density |
| **Basnet & Vodacek (2015) -** Tracking Land Use/Land Cover Dynamics in Cloud Prone Areas Using Moderate Resolution Satellite Data: A Case Study in Central Africa[185] | 1988-2011 | LANDSAT | 30m | • Supervised classification using training data<br>• Maps forest change from 1988-2011<br>• Maps open/degraded forest as well as natural forest<br>• 30m resolution likely to miss many small plantations |

184 Arakwiye, Bernadette, John Rogan, and J. Ronald Eastman. "Thirty Years of Forest-Cover Change in Western Rwanda during Periods of Wars and Environmental Policy Shifts." Regional Environmental Change 21, no. 2 (March 8, 2021): 27. https://doi.org/10.1007/s10113-020-01744-0.

185 Basnet, Bikash, and Anthony Vodacek. "Tracking Land Use/Land Cover Dynamics in Cloud Prone Areas Using Moderate Resolution Satellite Data: A Case Study in Central Africa." *Remote Sensing* 7, no. 6 (June 2015): 6683–6709. https://doi.org/10.3390/rs70606683.

| Project | Mapping date | Underlying dataset | Spatial Resolution | Notes |
|---|---|---|---|---|
| **Oduor et al. (2016) -** Land Cover Mapping for Green House Gas Inventories in Eastern and Southern Africa Using Landsat and High-Resolution Imagery: Approach and Lessons Learnt[186] | 1990-2010 | LANDSAT | 10m | • Supervised classification using training data<br>• Confuses croplands (mainly banana plantations) across Western Rwanda with forests, leading to the large overestimation of forest area<br>• 30m resolution likely to miss many small plantations<br>• No information on forest density |
| Rwanda Ministry of Environment (2019) - Rwanda Forest Cover Mapping 2019[187] | 2019 | Worldview Satellite Images | 0.25m | • Manually mapped through visual examination of high-resolution imagery<br>• Very high-resolution imagery allows mapping of small plantations |
| Rwanda Ministry of Environment (2018) – Rwanda Land Use and Land Cover Mapping 2018 | 2018 | | 20m | • Supervised classification using training data<br>• Maps open/degraded forest<br>• 20m resolution likely to miss small plantations |

186 Oduor, Phoebe, Jaffer Ababu, Robinson Mugo, Hussein Farah, Africa Flores, Ashutosh Limaye, Dan Irwin, and Gwen Artis. "Land Cover Mapping for Green House Gas Inventories in Eastern and Southern Africa Using Landsat and High Resolution Imagery: Approach and Lessons Learnt." In *Earth Science Satellite Applications: Current and Future Prospects*, edited by Faisal Hossain, 85–116. Springer Remote Sensing/Photogrammetry. Cham: Springer International Publishing, 2016. https://doi.org/10.1007/978-3-319-33438-7_4.

187 Rwanda Ministry of Environment. "Rwanda Forest Cover Mapping." Kigali: Government of Rwanda, 2019.

Rwanda's 2019 forest cover map[188] is the most accurate and up-to-date available for the country. This map relied on a team of 10 trained GIS technicians who digitised forest parcels on-screen by visual examination of high-resolution worldview satellite imagery (30-50cm), combined with other auxiliary datasets (e.g., elevation, slope). Forest parcels are delineated by type (e.g., plantation, natural forest, bamboo), and also assessed for density. The data maps forest parcels at an extremely high resolution (down to <0.25ha), and provides a good basis for identification of degraded plantations using the density field (Figure 2). Generating a better or more up-to-date forest map will be very difficult using any commonly available remote sensing classification techniques, and would likely require a similar on-screen digitisation approach.

Beyond the 2019 Forest cover map, there are some relatively recent datasets which map forests, but which are hampered by either being a coarse spatial resolution or by missing information about forest type. Arakwiye et al. (2021)[189] provides a time series of forest cover in Rwanda over a thirty-year period, but these maps are based on LANDSAT Data, which at 30m resolution is too coarse to accurately map small woodlots and plantations in Rwanda. Similarly, Rwanda's 2018 Land Cover Map is at 20m resolution which again is too coarse for accurate mapping of small forest patches. Figure 2 provides a comparison between the 2019 Forest Cover Map and the 2018 Land Cover Map.

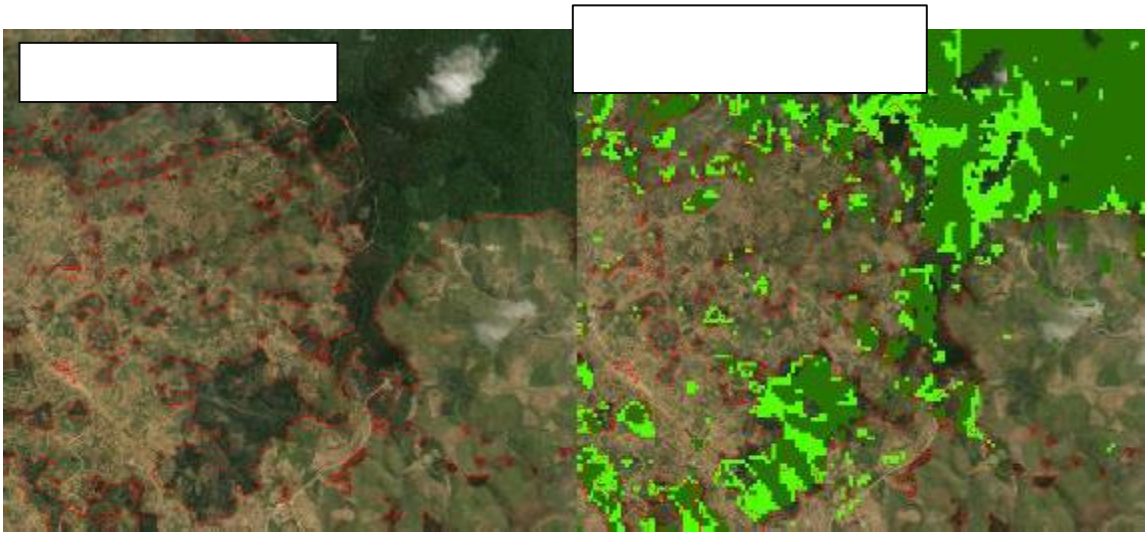


**Figure 2. A) Forests around Mukura mapped at high resolution by the 2019 Forest Cover Map, and B) Forest (dark green) and sparse forest (light green) as mapped by the 2018 land cover map.**

188 Rwanda Ministry of Environment. "Rwanda Forest Cover Mapping." Kigali: Government of Rwanda, 2019.

189 Arakwiye, Bernadette, John Rogan, and J. Ronald Eastman. "Thirty Years of Forest-Cover Change in Western Rwanda during Periods of Wars and Environmental Policy Shifts." Regional Environmental Change 21, no. 2 (March 8, 2021): 27. https://doi.org/10.1007/s10113-020-01744-0.

### *2.2. Datasets to update forest cover maps*

Rwanda's 2019 forest cover map provides a good basis for understanding forest extent in Rwanda, and any updates to this map should be well justified and consider the workload required. However, as this project aims to build capacity around forest mapping and monitoring, potential datasets which could be used are summarized here.

Tables 4 and 5 summarize the most relevant data sources for GIS mapping of forest extent in Rwanda. In general, there are two main categories of GIS data available: medium resolution multi-spectral data (e.g. Sentinel) which can be used for supervised classification of forest cover/land cover (based on a set of known training points) or high-resolution satellite imagery (e.g., Worldview) which can be manually digitized to create forest cover maps.

**Table 4. Multi-spectral Forest Monitoring Data Sources**

| Dataset | Temporal Resolution | Spatial Resolution | Cost | Notes |
|---|---|---|---|---|
| ESA Sentinel 2 data[190] | 5 days | 10m | Free | • Raw data, requires training points to develop forest/non-forest maps<br>• High temporal resolution, good potential for frequently updated monitoring<br>• Contains bands needed for supervised classification |
| Trees Outside Forests map[191] | 5 days (relies on could-free sentinel imagery) | 10m | Free | • Very promising for remote-monitoring of small woodlots and trees with crown diameter >3m<br>• Computationally intensive and methodologically complex |

[190] Drusch, M., Del Bello, U., Carlier, S., Colin, O., Fernandez, V., Gascon, F., Hoersch, B., Isola, C., Laberinti, P., Martimort, P., Meygret, A., Spoto, F., Sy, O., Marchese, F., Bargellini, P., 2012. Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services. Remote Sensing of Environment, The Sentinel Missions - New Opportunities for Science 120, 25–36. https://doi.org/10.1016/j.rse.2011.11.026

[191] Brandt, J., Stolle, F., 2021. A global method to identify trees outside of closed-canopy forests with medium-resolution satellite imagery. International Journal of Remote Sensing 42, 1713–1737. https://doi.org/10.1080/01431161.2020.1841324

| Dataset | Temporal Resolution | Spatial Resolution | Cost | Notes |
|---|---|---|---|---|
| Aster[192] | NA | 15m | Free | • Raw data, requires training points to develop forest/non-forest maps<br>• Contains bands needed for supervised classification<br>• Coarser resolution than Sentinel |

**Table 5. High-resolution satellite imagery data sources[193]**

| Dataset | Temporal Resolution | Spatial Resolution | Cost | Notes |
|---|---|---|---|---|
| Worldview satellite imagery[194] | 4.5 days | 30cm | $22.50 per $km^2$ (free with Rwanda's Memorandum with DigitalGlobe) | • Very high resolution<br>• Requires labour-intensive manual digitizing |
| Planet - SkySat [195] | NA – scheduled on demand | 50cm | Minimum $5000-15000 | • Very high resolution<br>• Can be manually tasked to visit specific area<br>• Requires labour-intensive manual digitizing |

The most appropriate dataset to use for forest mapping/monitoring in Rwanda depends on a number of key considerations (Table 6). Multi-spectral data such as Sentinel can be used in a semi-automated classification analysis where users input a series of known training points and use a statistical model to predict forest cover across the entire country[196]. This is a relatively

192 Baldridge, A.M., Hook, S.J., Grove, C.I., Rivera, G., 2009. The ASTER spectral library version 2.0. Remote Sensing of Environment 113, 711–715. https://doi.org/10.1016/j.rse.2008.11.007

193 There are a number of other high-resolution satellite imagery producers but all offer similar levels of resolution and cost

194 https://apollomapping.com/worldview-4-satellite-imagery

195 https://www.planet.com/products/hi-res-monitoring/

196 Murray, Nicholas J., David A. Keith, Daniel Simpson, John H. Wilshire, and Richard M. Lucas. "Remap: An

quick and less labour-intensive process and can be useful to create regularly updated maps of forest cover across large scales (e.g., districts/provinces/national scale). However, these data have historically been unable to capture small woodlots or plantations, as these forest parcels are smaller than the spatial resolution of a single pixel (10-30m). New approaches such as the Trees Outside Forests map[197] hold great potential to allow for mapping of individual trees and small woodlots using Sentinel data, but these approaches are methodologically complex and require very strong GIS capacity to reproduce.

Compared to supervised classifications using multi-spectral imagery, on-screen digitising of forest using high-resolution satellite imagery can allow for much more detailed and accurate mapping of forest cover. However, these approaches take a long time and are very labour intensive (Table 6). Despite the time and effort required, given that most of Rwanda's forest outside protected areas consists of very small patches and trees on farms, on-screen digitising is the most suitable and accurate approach for forest mapping (Table 6). Supervised classifications rely on data ~10m in resolution, and while quicker and simpler to undertake than manual digitisation of forests, they are unlikely to accurately map most of Rwanda's small woodlots.

Online Remote Sensing Application for Land Cover Classification and Monitoring." *Methods in Ecology and Evolution* 9, no. 9 (2018): 2019–27. https://doi.org/10.1111/2041-210X.13043.

[197] Brandt, J., Stolle, F., 2021. A global method to identify trees outside of closed-canopy forests with medium-resolution satellite imagery. International Journal of Remote Sensing 42, 1713–1737. https://doi.org/10.1080/01431161.2020.1841324

**Table 6. Pros and Cons of GIS based forest mapping approaches**

| Forest mapping method | Pros | Cons |
|---|---|---|
| Supervised classification/statistical model | • Relatively quick, and can be semi- automated<br>• Can be easily updated with new imagery<br>• Uses freely available imagery | • Reliant on medium-resolution multi-spectral imagery, likely to miss small forests<br>• Requires set of training points showing known land cover/forest cover<br>• Generally less accurate than a manual approach |
| Manual delineation/digitising | • Very accurate<br>• Captures small woodlots/forests more effectively due to high-resolution imagery | • Very labour intensive and take a long time<br>• Use expensive, high-resolution commercial high-resolution imagery<br>• Cannot be quickly updated |

### *2.3. Recommendations for future forest mapping*

Rwanda's 2019 Forest Cover Mapping Report states that overlap between an attempted supervised classification and on-screen digitization was only around 40 to 60%, indicating that it was not sufficiently accurate to map forests in the Rwandan context. As such, updates of Rwanda's 2019 Forest Cover Map should focus on manual delineation of forest parcels using more recent high-resolution satellite imagery (e.g.,Worldview), or utilising a combination of on-screen digitising and classifications using newly available imagery at very high resolutions (e.g. <50cm). However, doing so comprehensively will be a very large undertaking, requiring more up-to-date satellite images and a substantial investment of time. Given the workload involved in completely updating the map for the entire CND, future forest cover updates should focus on building from the 2019 map rather than starting afresh.

The simplest approach for building on Rwanda's 2019 forest cover map will be to build on the newly developed Forest Monitoring and Evaluation System developed under the PAREF.be2 project[198]. This system is to be adopted by the forestry sector across the country in the near future and will consist of a centralised national database using a modern GIS system for managing spatial and attribute data of plantation forest. The system will be used to automatically generate maps and summary statistics around forest extent, deforestation rate, forest density

[198] Rwanda Forest Authority, Enabel, 2021. Technical guidelines on the use of the Forest Monitoring & Evaluation System - FMES. Kigali.

etc., to facilitate simple monitoring of Rwanda's forest in the future. Once populated with data, the FMES system should provide accurate information on the location of plantation forests throughout Rwanda, removing one of the large challenges in accurate forest mapping - which is to separate plantation forests from natural forests. By utilising data on plantation forest location from the FMES software, combined with an approach that uses on-screen digitisation and supervised classification using very high resolution imagery, a system that can accurately monitor changes in natural forest cover should be possible.

### 3. Forest Ecosystem Service Modelling

Forests in the CND provide a vast range of ecosystem services – the benefits that ecosystems provide to people. Forests regulate Rwanda's climate by capturing and creating rainfall[25], which is crucial for Rwanda's rainfed agriculture. These also recharge aquifers; regulate water flow; control flooding; retain soil; provide wood fuel energy and timber (Figure 3); underpin the country's tourism, which provides the largest contribution to Rwanda's foreign exchange earnings[27]; and provide wider benefits of atmospheric pollution control that sustain the country's economy and the wellbeing of its people[199].


Figure 3. Four categories of ecosystem services that contribute to human well-being (Source: adapted from Millenium Ecosystem Assessment)

In order to comprehensively incorporate the value of forests in land-use planning decision

199 Andrew, G., and M. Masozera. "Payment for Ecosystem Services and Poverty Reduction in Rwanda." *Journal of Sustainable Development in Africa* 12, no. 3 (2010): 122–39.

making processes, it is essential to understand the spatial distribution of forest ecosystem services and how these may be affected by climate change. The activities under Output 1.2 of this project will map ecosystem services values and forest extent across the CND, and build capacity within the Government of Rwanda and Rwanda's civil society to model and map ecosystem services. This is necessary, as although there have been sporadic assessments of ecosystem services in Rwanda[200,201], the production of such data is not regular or systematic.

There are a vast number of tools and methodologies for modelling ecosystem services, as outlined in Table 4 (adapted from Christin et al., 2016[202]). The most appropriate tool for a given situation depends on many factors, including the ecosystem services to be modelled, the spatial scale, data availability, cost and uncertainty[203].

### *3.1. Ecosystem Modelling Tools*

The ecosystem services mapped under this project will include regulating services (e.g., runoff/erosion reduction, landslide risk reduction), provisioning services (e.g.,food, fibre, wood biomass, freshwater), and supporting services (e.g., nutrient cycling, soil formation). Given the number of ecosystem services needing to be modelled in order to inform land-use planning in the CND and the wide variety of ecosystem service modelling approaches available, a systematic approach should be taken to determine the most appropriate tools to be used.

To help deal with the challenge of selecting appropriate ecosystem modelling tools, Christin et al. (2016)[204] have developed a Restoration Ecosystem Service Tool Selector (RESTS) framework that describes key characteristics of 13 ecosystem services assessment tools. The framework allows analysts to enter information about their decision context, services to be analyzed, and desired outputs. Ecosystem service modelling tools are then filtered and presented based on five evaluative criteria: scalability, cost, time requirements, handling of uncertainty, and applicability to benefit-cost analysis.

This framework provides a transparent and repeatable way to decide on appropriate ecosystem modelling tools for use in this project and should be applied as part of Output 1.2. Figure 4 gives a general overview of the decision framework, inputs required, and outputs generated. It is likely that a combination of ecosystem modelling tools will be required to comprehensively map the range of ecosystem services provided by forests in the CND.

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200 Bagstad, K.J., Semmens, D.J., Waage, S., Winthrop, R., 2013. A comparative assessment of decision-support tools for ecosystem services quantification and valuation. Ecosystem Services 5, 27–39. https://doi.org/10.1016/j.ecoser.2013.07.004

201 Nyesheja, E.M., Chen, X., El-Tantawi, A.M., Karamage, F., Mupenzi, C., Nsengiyumva, J.B., 2019. Soil erosion assessment using RUSLE model in the Congo Nile Ridge region of Rwanda. Physical Geography 40, 339–360. https://doi.org/10.1080/02723646.2018.1541706

202 Christin, Z.L., Bagstad, K.J., Verdone, M.A., 2016. A decision framework for identifying models to estimate forest ecosystem services gains from restoration. Forest Ecosystems 3, 3. https://doi.org/10.1186/s40663-016-0062-y

203 Bagstad, K.J., Semmens, D.J., Waage, S., Winthrop, R., 2013. A comparative assessment of decision-support tools for ecosystem services quantification and valuation. Ecosystem Services 5, 27–39. https://doi.org/10.1016/j.ecoser.2013.07.004

204 Christin, Z.L., Bagstad, K.J., Verdone, M.A., 2016. A decision framework for identifying models to estimate forest ecosystem services gains from restoration. Forest Ecosystems 3, 3. https://doi.org/10.1186/s40663-016-0062-y

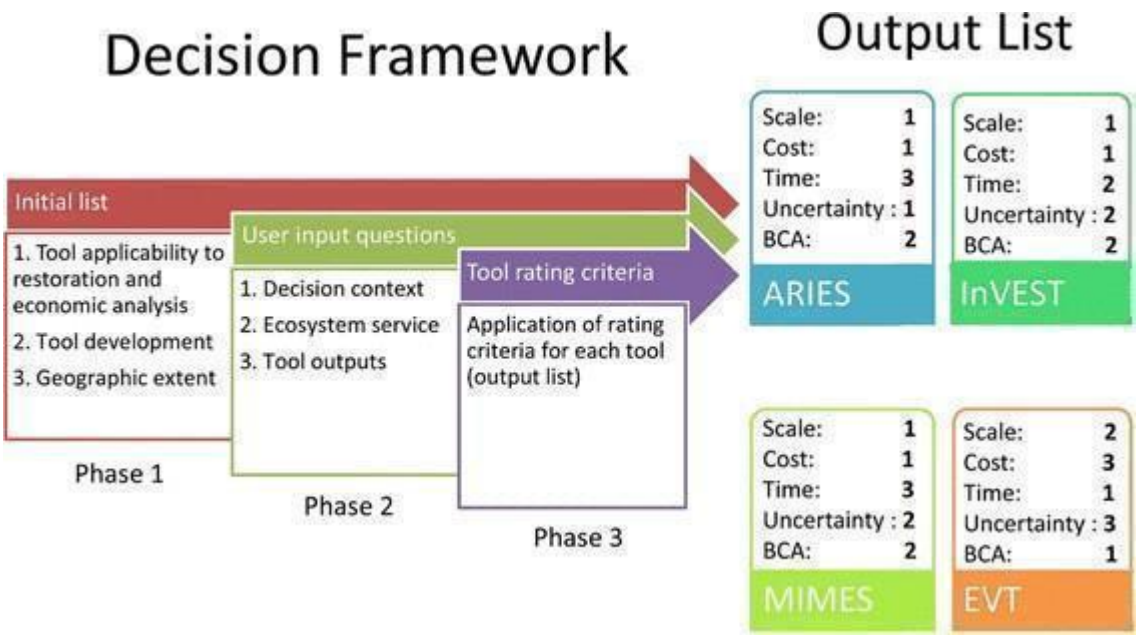



**Figure 4. RESTS Decision making framework, of use in deciding on appropriate ecosystem modelling tools. Source: Christin et al. (2016)**

**Table 7. Summary of ecosystem service modelling tools**

| Abbreviation | Tool name | Developer | Tool description & reference |
|---|---|---|---|
| ARIES | Artificial Intelligence for Ecosystem Services | Basque Centre for Climate Change (BC3) | Framework to integrate multiple modeling paradigms in spatial modeling and mapping of ecosystem services. Supports artificial intelligence-based data and model selection through semantic modeling to quantify ecosystem service flows from ecosystems to beneficiaries (Villa et al. 2014, http://aries.integratedmodelling.org/). |
| Co$ting Nature | Co$ting Nature | King's College London and AmbioTEK | Mapping and modeling tool for multiple ecosystem services using global datasets. Quantifies ecosystem services as opportunity costs (i.e., avoided cost of producing those services from a non-natural capital substitute) (Mulligan 2015, http://www.policysupport.org/costingnature). |
| EcoMetrix | EcoMetrix | EcoMetrix Solutions Group and Parametrix | Field-based tool designed for use at relatively fine spatial scales. Primary use is to illustrate the effects of human activities (i.e., development or restoration scenarios) on ecosystem services (Ecometrix Solutions Group 2013, http://www.ecometrixsolutions.com/ecometrix.html). |
| EnSym | Environmental Systems Modelling Platform | State of Victoria, Australia | Environmental systems modeling platform for researchers to apply process-based models. Designed to provide information on how and where to invest to maximize environmental outcomes (Ha et al. 2010, https://ensym.dse.vic.gov.au/cms/). |
| Envision | Envision | Oregon State University | GIS-based tool for scenario-based planning and environmental assessment. Enables "multi-agent modeling" to represent human decisions on landscape simulations (Guzy et al. 2008, http://envision.bioe.orst.edu/). |

| Abbreviation | Tool name | Developer | Tool description & reference |
|---|---|---|---|
| ESR for IA | Ecosystem Services Review for Impact Assessment | World Resources Institute | Method to address project impacts and dependencies on ecosystem services within the environmental and social impact assessment process. It identifies measures to mitigate project impacts on benefits provided by ecosystems and to manage operational dependency on ecosystems (Landsberg et al. 2011, http://www.wri.org/publication/ecosystem-services-review-impact-assessment). |
| EVT | Ecosystem Valuation Toolkit | Earth Economics | Provides monetary values for natural assets under multiple modules. Includes a Researcher's Library, searchable database of ecosystem service values, and SERVES, a web-based tool for calculating ecosystem service values (Earth Economics2015, http://esvaluation.org/). |
| InVEST | Integrated Valuation of Ecosystem Services and Tradeoffs | Natural Capital Project | Spatial mapping and modeling of multiple ecosystem services. Includes a diverse set of provisioning, regulating, and cultural services from marine and terrestrial environments. The models primarily provide results in biophysical terms to which valuation can be applied (Sharp et al. 2014, http://www.naturalcapitalproject.org/). |
| LUCI | Land Utilisation and Capability Indicator | Victoria University of Wellington | Explores the capability of a landscape to provide a variety of ecosystem services. It compares the services provided by the current use of the landscape and its potential capability. The model uses this information to identify areas where change or maintenance of current conditions may be most beneficial (Jackson et al. 2013, http://www.lucitools.org/). |
| MIMES | Multiscale Integrated Models of Ecosystem Services | Affordable Futures | Modeling platform designed to quantify causal linkages between ecosystems and the economy. MIMES allows an individual to map decisions/policies, and the output illustrates how those choices affect the economy and ecosystems (Boumans et al. 2015, http://www.afordablefutures.com/orientation-to-what-we-do/services/mimes). |

| Abbreviation | Tool name | Developer | Tool description & reference |
|---|---|---|---|
| NAIS | Natural Assets Information System | Spatial Informatics Group | Integrated valuation database and reporting engine. The database is integrated with proprietary spatial modeling tools to characterize ecosystems and flow of services on the landscape (Troy and Wilson 2006, http://www.sig-gis.com/services/ecosystem- services/). |
| SolVES | Social Values for Ecosystem Services | U.S. Geological Survey (USGS) | Spatial mapping and modeling tool primarily for quantifying cultural ecosystem services using public participatory GIS (Sherrouse et al. 2011, http://solves.cr.usgs.gov/). |
| TESSA | Toolkit for Ecosystem Service Site- based Assessment | BirdLife International | A process using flow charts to describe how ecosystem services benefit society under current conditions and alternative scenarios (Peh et al. 2013, http://tessa.tools/). |

## 4. Field-Based Forest Monitoring

To help verify the accuracy of forest and ecosystem service maps developed under this project, as well as to monitor the success of project activities such as forest restoration or agroforestry, field-based monitoring is essential. Field-based monitoring can provide detailed and accurate information on forest extent and condition, carbon stocks, climate resilience, water availability and quality, soil health, biodiversity, household income and nutrition. If planned in a systematic way, field-based monitoring data can also be extrapolated to estimate results in areas that were not measured.

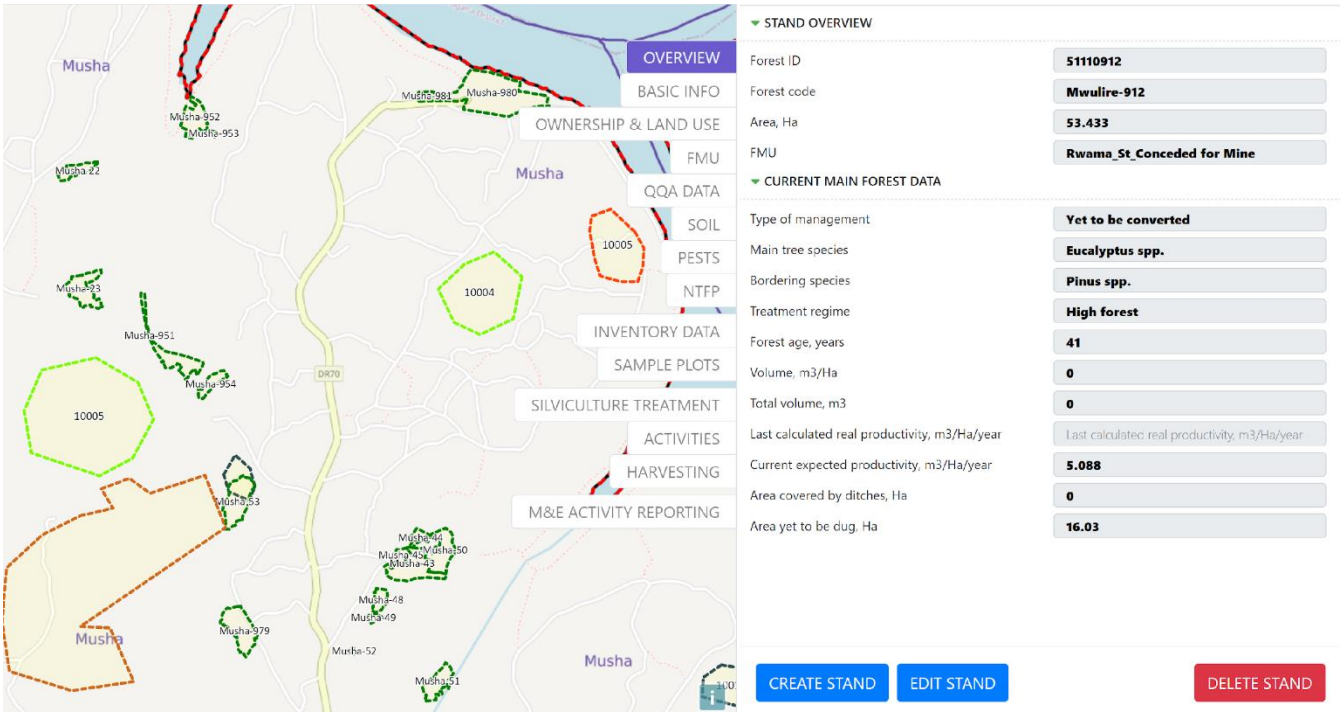
While field data is the most accurate way to monitor forest extent, condition, and ecosystem service provision, it is labour intensive and takes a long time. As such, this is likely only to be feasible for monitoring areas where project activities take place and will not be used for generating overall statistics on forest cover, etc. As such, it is complementary to the GIS-based forest mapping and ecosystem service modelling approaches described in earlier sections of this report. The next sections outline some of the different scenarios where field-based monitoring will likely be used in this project, and present existing procedures or guidelines that will be followed where possible.

### *4.1. Registering project parcels*

The most basic level of field-based monitoring of project activities requires registration and mapping of intervention boundaries (e.g.,the area of forest planted) and collection of basic site information including landowner, area, main species, forest age, etc. In Rwanda's forestry sector, this was traditionally done in an ad-hoc fashion. However, the recent development of a Forest Monitoring and Evaluation System (FMES) will facilitate systematic collection of forest monitoring data into a centralised database for managing spatial and attribute data of forest parcels.

The FMES system facilitates the demarcation and registration of land parcels using GPS tablets in the field, or using desktop GIS software. Figure 5 shows a screenshot from the FMES, highlighting forest parcel boundaries on a map and showing basic information such as ID, species, etc. FMES also provides guidelines on naming conventions and proper labelling of forest parcels, which will be useful for this project to keep track of multiple small intervention sites. Given the recent adoption of this software by the Government of Rwanda, and its utility for tracking and monitoring forest parcels, all project intervention sites should be registered in the FMES software. The FMES software will also be used to track project inputs and activities as restoration, afforestation & agroforestry work is carried out. For example, the software can record # of seedlings planted, silviculture treatments applied (e.g.,pruning) etc.

Figure 5. Screenshot showing Forest Monitoring and Evaluation System software




### *4.2. Monitoring project results*

This project will implement a comprehensive monitoring and evaluation program for tracking project inputs, activities, outputs and impacts across all components. A large part of this monitoring program will involve collecting field data on the success of forest restoration, afforestation or agroforestry activities. By visiting a representative sample of project intervention sites over the life of the project, repeated measurements will allow for estimation of project impacts in terms of variables such as forest coverage and density, wood and fruit production, runoff and erosion control, water quality improvements, carbon sequestration, and soil nutrients.

Because it is not possible to conduct repeat field visits to all intervention sites, this project will design a stratified sampling system which divides the CND into a series of strata based on variables which are likely to influence the success/outcomes of project activities. Stratified sampling is the preferred approach for monitoring and evaluation where it is possible to classify the area or population to be sampled into a number of strata, where the variation of some attributes within the class is less than the variation within the region as a whole[205]. Plot samples within a landscape are placed on a stratified random basis, such that a minimum number of

205 Papa, Daniel de Almeida, Danilo Roberti Alves de Almeida, Carlos Alberto Silva, Evandro Orfanó Figueiredo, Scott C. Stark, Ruben Valbuena, Luiz Carlos Estraviz Rodriguez, and Marcus Vinício Neves d' Oliveira. "Evaluating Tropical Forest Classification and Field Sampling Stratification from Lidar to Reduce Effort and Enable Landscape Monitoring." *Forest Ecology and Management* 457 (February 1, 2020): 117634. https://doi.org/10.1016/j.foreco.2019.117634.

samples is located within each strata, and the number of samples roughly corresponds to the area of a given strata (larger strata = more sample sites). Table 8 outlines datasets that will likely inform stratification in the CND.

**Table 8. Datasets to inform stratification of the CND for field sampling**

| Stratification Dataset | Rationale |
|---|---|
| Type of project activity | The project is undertaking different activities (e.g., agroforestry, restoration) and monitoring needs to take place across each |
| Species planted | Project results may vary depending on species used for different activities |
| Parcel size | Project results may vary based on the size of land parcels where activities take place |
| District | Project results should be monitored across all districts |
| Elevation | Elevation affects species suitability and growth rates, and thus may affect project results |
| Distance from natural forest | Project results may vary depending on availability of resources taken from natural forests |

The kinds of monitoring protocols that take place during the project will vary depending on the specific project activities being undertaken. The below sections outline best practice monitoring strategies for natural forest restoration, protective forest restoration, and agroforestry interventions.[206]

[206] This study focuses on forest monitoring methods, and does not attempt to describe monitoring techniques that will be used for other project interventions such as distribution of improved cookstoves. A monitoring and evaluation plan for the full project will be provided as an annex to the project proposal document.

### *4.2.1 Natural Forest Restoration*

This project will conduct fern clearing operations within degraded areas of Nyungwe National Park, where fires have led to invasion by bracken fern. Random sampling has been used previously to monitor success of natural forest restoration in Rwanda, so this represents a suitable approach for monitoring of project interventions[207]. This method involves randomly allocating 0.25ha plots throughout areas of restoration, while stratifying for elevation and district to ensure a representative set of areas are sampled. Relatively small sample plots of 0.25ha are suitable for natural forest restoration areas, as these are often irregularly shaped and larger plots may cover areas where project activities did not take place. For each plot, all trees greater than 10cm diameter at breast height (DBH) should be measured, and information recorded on species identification (family, genera), number of individuals and DBH of each tree.

### *4.2.2 Protective Forests*

To ensure consistency with ongoing monitoring of woodlots and plantation forests under District Forest Management Plans (DFMP), monitoring of protective forests planted/restored during the project will follow standard practices outlined by the new Forest Monitoring and Evaluation System (FMES). The FMES guidelines use a standard circular plot of ~10m diameter (0.03ha in area), with the overall number of plots per forest parcel being stratified by the size class of the parcel (see Table 9). This project will likely add some additional stratifying variables such as district and elevation.

**Table 9. Sampling plot requirements for protective forest parcels (adapted from Rwanda Forest Authority and Enabel, 2021)[208]**

| Forest parcel size | # of plots per ha of forest parcel |
|---|---|
| Very Small (<1 ha) | 3 |
| Small (1-3 ha) | 2 |
| Medium (3-10 ha) | 2 |
| Large (10-30 ha) | 2 |
| Very Large (>30 ha) | 1.5 |

FMES guidelines also specify a standard set of variables for collection in each plot, and the project

[207] Arakwiye, Bernadette, S. Andelman, Rinku Roy Chowdhury, John Rogan, J. Ronald Eastman, and Anselme Abaliho. “Early Ecological Outcomes of Passive and Active Forest Restoration Approaches in Western Rwanda.” *PLOS ONE*, 2021.

[208] Rwanda Forest Authority and Enabel. “Technical Guidelines on the Use of the Forest Monitoring & Evaluation System - FMES.” Kigali, 2021.

will follow these to ensure consistency with other government monitoring efforts (Table 10).

**Table 10. Variables for collection in protective forest monitoring plots**

| Plot Level Data | Species Level Data (within each plot) |
|---|---|
| • Land ownership: State, District, Private Individual, Private Institutional, Unclear<br>• Field enumerator name<br>• Field enumerator phone contact<br>• Date of measurement in the field<br>• Slope (degree)<br>• Soil type: Rock, Gravel, Sand, Clay, Loam, Humic, Schistous, Laterite<br>• Soil quality: Low, Medium, High<br>• Dominant silviculture regime if applicable: *High Forest, Coppice, Coppice with Standard*<br>• Year of forest establishment<br>• Year of last cut<br>• For the dominant tree species 1 of regeneration (stem<5cm dbh): the trees species name, the number of stem from coppice and the number of stem from seeds<br>• For the dominant tree species 2 of regeneration (stem<5cm dbh): the trees species name, the number of stem from coppice and the number of stem from seeds;<br>• For the dominant tree species 3 of regeneration (stem<5cm dbh): the trees species name, the number of stem from coppice and the number of stem from seeds;<br>• Dominant coppiced stump tree species name and their number of coppiced living stump; | • Tree species<br>• Tree stem origin: *coppice, seed*<br>• DBH (cm)<br>• Stem form: Straight, Leaning, Curved, Twisted, Forked, Multi-stemmed<br>• Stem sanitary condition: Good condition, Damaged crown, Decay, Injuries, More than one effect<br>• Bole form: Straight, Leaning, Curved, Twisted, Forked, multi-stemmed (only for tree with dbh>20cm)<br>• Bole quality: *Very good, Good, Medium, Low, Very bad* (only for tree with dbh>20cm)<br>• Horizontal Distance from tree (L) in m<br>• Angle (%) for top of the stem (AT)<br>• Angle (%) for the base of the stem (AB)<br>• Angle (%) for the top of the bole (only for tree with dbh>20cm) (ATB) |

### *4.2.3 Agroforestry*

Rwanda's FMES system has a process for registering agroforestry blocks (groups of nearby farms practicing agroforestry), but does not prescribe guidelines for monitoring the success of agroforestry beyond simply counting the number of trees per agroforestry block. Because this project aims to conduct a more comprehensive monitoring and evaluation of project activities, the

protocol from Rwanda's Vital Signs initiative will be followed[209]. Vital Signs is a program which collects and integrates data on agricultural management and productivity, ecosystems and human well-being, making its protocols very suited for agroforestry monitoring.

Agroforestry sampling sites will use a stratified sampling design, similar to the methods described for protective forests, where sites are selected to represent different classes of elevation, districts, distance from natural forest, or species planted. The exact number of sampling sites will be determined based on the number of land parcels in which agroforestry activities are undertaken, and the location of these parcels in the CND. As per Vital Signs guidelines, each plot will be a 1ha square that contains 36 circular subplots of ~10m in diameter. Depending on the sub-plot, different variables will be measured including diameter of trees at breast height, erosion severity, and herbaceous cover. Appendix 2 outlines plot measurement methodology and variable collection.

209 http://rwanda.vitalsigns.org/

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## APPENDIX 2 – AGROFORESTRY FIELD MONITORING METHODOLOGY

The following methodology was adapted from the Vital Signs project (http://rwanda.vitalsigns.org/).

### Methodology

We will use E-plot (approximately a square of 1 hectare in size with dimensions of 100 x 100 m) used by Vital Signs project for biomass measurement. This data collection guide was adapted from "Vital Signs Protocol: E-Plot Biomass Measurements. Version 2.0, March 2014".

Each E-plot has 36 circular sub-plots (Figure 1). The sub-plots are numbered according to the pathway taken to complete the E-plot: starting at sub-plot 1 and ending at sub-plot 36. Herbaceous Species Ranking and Woody Plant Measurements are made in every sub-plot, with additional measurements (geo-location using the GPS, canopy cover, and Landscape Functional Analysis: land use, site condition, erosion control measures) made at sub-plots 1, 6, 11, 16 and 23 (the four corners and near the centre of the E plot) as it is illustrated in Figure 1 below.

**Personnel** - An E-plot is sampled by a team of two to three people.

List of Equipment

i. GPS unit: GPSMAP 60Cx
ii. Spare batteries for GPS unit (2 AA batteries)
iii. Suunto compass
iv. 30 m measuring tape
v. 4 co corner pegs with red flags
vi. Field guides for identifying plants
vii. Convex densiometer for measuring tree cover
viii. Two 2-meter stem circumference measuring tapes marked in cm
ix. 2.5 meter ranging rod
x. 0.5 x 0.5 steel quadrat
xi. 30 meter nylon rope

xii. Roll of insulation tape
xiii. Clipboards, notebooks and pens
xiv. Letters of introduction
xv. Packs for carrying equipment
xvi. Camera

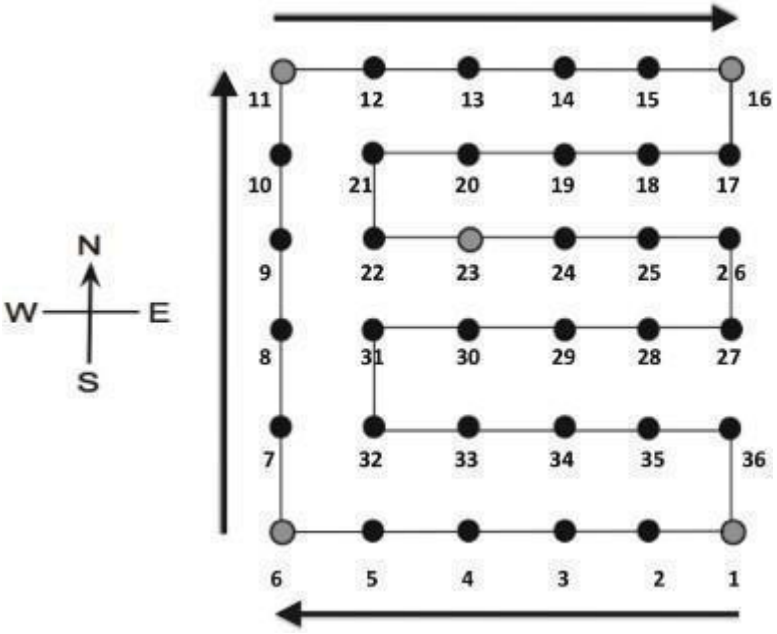


Figure 1. Plot sampling for ground thruthing biomass. Source Vital Signs E-plot protocol[210]

Plot sampling and vegetation measurements

1. Measuring E-plot - Navigate to the S.E. corner of the E-plot (point 1) and follow the steps up to 36 sub-plots. The 36 sub-plots within the plot are circular in shape and will have 10m radius maximum. The objective is to measure approximately all individual woody plants and other indicators of land use and land conditions in the 1-hectare E-plot.
2. Obtain the exact latitude and longitude of 4 corners and sub-plot 23 using the GPS unit, allowing it to average for about 5 minutes.
3. Once you have determined the E-plot, the circular subplots will be sampled starting at the origin (S.E. corner of the plot, sub-plot 1) and proceed around the E in a clockwise direction.
4. Measurement of slope – a slope is measured in subplot 1, 6, 11, 16, and 23 using clinometer.
5. Measure canopy cover for the sub-plot - Estimates of canopy cover are made using a densitometer in sub-plot 1, 6, 11, 16, and 23. Record canopy cover using the following codes:
   0 = square reflects no overhead tree cover (empty)
   1 = some cover located just inside the square
   2 = square half covered by reflected canopy
   3 = square more than half but not completely full of reflected canopy, and
   4 = the square has full, complete cover

210 http://rwanda.vitalsigns.org/protocol-manuals

6. Evidence of soil erosion - Evidence including soil pedestals, gullies, exposed roots, rills, sediment deposits, soil splash will be measured in sub-plot 1, 6, 11, 16, and 23. Rate the ground in the quadrat (0.5 x 0.5 m) for soil erosion:

   0=none,

   1= present but uncommon (<10%),

   2=common (11-50%),

   3= ubiquitous (> half of quadrat).

7. Measure ground herbaceous cover in sub-plot 1, 6, 11, 16, and 23 - estimate what fraction of the ground has standing live or dead herbaceous cover above it (excluding litter, which is dead plant material on the soil surface) in 0.5 x 0.5 m quadrat. Score the herbaceous cover between 1 and 10 (i.e., the percentage cover divided by 10)
8. Assess the Herbaceous Layer and enter species ranking for the sub-plot - species ranking in all 36 sub plots. Record three most abundant species in the 0.5 x 0.5m in ascending order. The most prevalent species by aboveground species gets listed first, the second next and the third, last. Enter only the top three species that fall inside the quadrat. If a single species constitutes over two-thirds of the biomass within the quadrat, it should be ranked both 1st and 2nd. If all the biomass within the quadrat is constituted by a single species, it gets first, second and third.
9. Measuring trees/shrub density and composition – A woody plant is a tree or shrub with one or many stems. It must be taller than your knee (0.5 m) and greater than 5cm DBH (approximately 15 cm circumference). Trees and shrubs will be measured in a circular plot of 10 m radius maximum.
   - Consider the Vital Signs standard for stem diameter measurement: at 0.5 m (knee height) for trees that branch below 1.5 m,
   - And the more conventional 1.3 m (breast height) for tall, straight trees that only branch above this level.
   - For each tree/shrub, measure circumference, height and crown maximum width.
   - In the case of trees branching below 0.5 m, each stem above the branch should be measured and recorded separately. In the case of highly multi-stemmed bushes (> 5 stems, each small, but together adding up to the equivalent of a 50 mm diameter stem), measure an average stem circumference, record it along with a count of the number of stems. For unusual stems, refer to the figure below for DBH/circumference measurement.

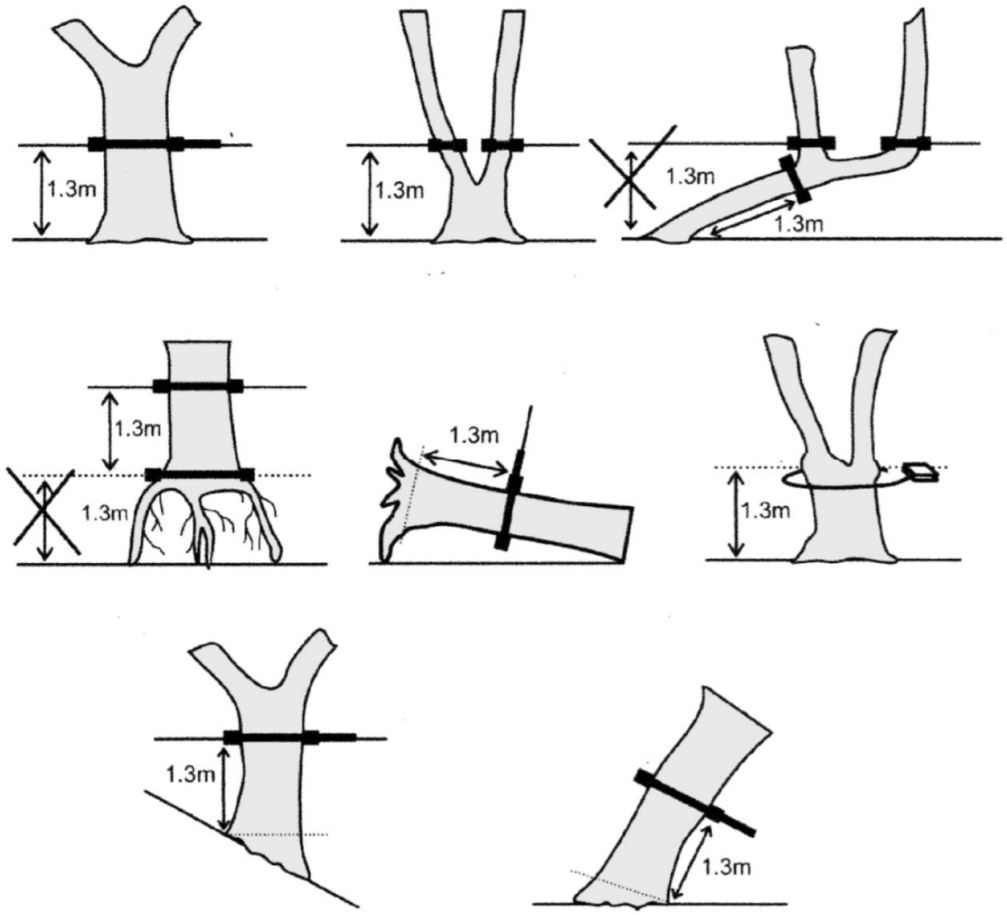


Figure 2. Variation in the type and position of plant stems. When faced with such variation, protocol is to measure the basal area of the stem above the basal swelling, where the diameter of the stem is fairly constant and before the stem begins to taper or branch. Source: Vital Signs e-plot sampling protocol[211]

10. Measuring the Height of Woody Plants - Plant height is measured from ground level at the base of the stem to the highest point in the plant's canopy. Record the height of plants to an accuracy of 10 cm or 0.1 m. When measuring tall trees with an extensive canopy, take the upper measurement from the centre of the top of the canopy, not from the edge of the canopy. The height of trees and shrubs shorter than 2.5 m can be directly measured using a ranging rod. Measure bushes and trees that are taller than 5 m with a clinometer.

211 http://rwanda.vitalsigns.org/protocol-manuals

Datasheets

| Plot Metadata | | | | |
|---|---|---|---|---|
| District: | Sector: | Day (DD) | Month (MM) | Year (YYYY) |
| Manager | | | | |
| Scribe | | Plot #: | | |
| Measurer1 | | Land use: | | |
| Measurer 2 | | Ownership: | | |

| | Easting | Northing | Accuracy |
|---|---|---|---|
| 1 SE Corner sub-plot | | | |
| | | | |
| 6 SW Corner sub-plot | | | |
| | | | |
| 11 NW Corner sub-plot | | | |
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|---|---|---|---|
| 16NE Corner sub-plot | | | |
| | | | |
| 23 Center sub-plot | | | |
| | | | |

| Landscape Function Analysis (Site condition): Measured in .50 x 0.50 m quadrat | | | | | |
|---|---|---|---|---|---|
| District: | Sector | Day | Month | Year | |
| Manager: | | | | | |
| Scribe: | | Plot #: | | | |
| Measurer1: | | Measurer 2: | | | |

| | 1 SE Corner | 6 SW Conner | 11 NW Conner | 16NE Conner | 23 Center |
|---|---|---|---|---|---|
| Herbaceous cover (1-10) | | | | | |
| Soil erosion (0-3) | | | | | |
| Surface condition (0-10) | | | | | |
| Downed trees | | | | | |
| Stone or Gravel | | | | | |
| Cultivated | | | | | |
| Erosion control measure | | | | | |
| Slop | | | | | |

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| Photo Panorama | N | E | S | W | |
| (Plot 23) | | | | | |

| Woody Plant Measurements | | | | |
|---|---|---|---|---|
| District: | Sector: | Day: | Month: | Year: |
| | | | | |
| Manager | | Plot#: | | |
| Scribe | Measurer1 | Measurer 2 | | |

| Sub-plot # | # stems | Basal Circumference (cm) | Height (m) | Canopy width (m) | Species | Photo # |
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| Herbaceous Cover | | | | |
|---|---|---|---|---|
| District: | Sector: | Day: | Month: | Year: |
| Manager | | Plot #: | | |
| Scribe: | Measurer 1: | Measurer 2: | | |

| Sub plot# | Cover (%) | Species Rank 1 | | | Species Rank 2 | | | Species Rank 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Species | Common | Kinyarwanda | Species | Common | Ver. name | Species | Common | Ver. name |
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