Research report

Remnant natural forests management: an approach to resilience to effects of climate change. Case of Sanza natural forest, Ngororero District.

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Executive Summary

The resilience to effects of climate change is defined as the ability to anticipate, prepare for, and respond to hazardous events, trends and disturbances related to climate change. However, the contribution of forests, particularly remnant natural forests remain understudies in Rwanda. This research aimed at documenting the impacts of Sanza natural forest in strengthening the resilience to effects of climate change. Biomass estimation was calculated following the methodology suggested by FAO (2004). Further, the household survey was conducted to investigate impacts of restoration activities on socio-economic activities and to document the local community perceptions about restoration activities, forest and landscape management and the improvement of livelihoods. The carbon storage results indicated that the forest is estimated to store 885.5 t C ha^{-1} and through this it reduces greenhouse gases. The household survey indicated that local people used to extract different products such as firewood, fodder, and stakes for beans from the forest. During restoration activities, they benefited through casual labor and beekeeping cooperative projects supported by LDCFII project. However, some people have not yet managed to find alternatives to the forest products that they used to extract, this makes them to enter the forest illegally behind backs of forest guards and practice some illegal anthropogenic activities such as tree cutting, firewood and fodder collection. The majority of local people support the restoration of the forest due to its importance to maintain the health of the forest. Agroforestry, creation of buffer zone, and availability of alternative cooking energy were found to compensate the resources they used to collect from the forest before restoration. More research about landscape conservation, soil organic carbon, leaf litter and forest cover should be conducted.

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Chapter 1. Introduction

1.1. Background of the study

Most regions across the globe are vulnerable to climate change because it affects the environment and socio-economic sectors such as health, food security, agriculture, water resource, terrestrial and aquatic ecosystems and biodiversity (United Nations Framework Convention on Climate Change [UNFCCC], 2007). Africa is the most vulnerable continent to climate change and stresses (UNFCCC, 2007). This is characterized by natural disasters such as floods and droughts which can even occur at the same scale within the same month (UNFCCC, 2007). Hunger and disruption of socio-economic welfare affect consequently around a third of African population annually and not only human population but also threatened habitats, ecosystems and biodiversity (UNFCCC, 2007). This situation is being worsen by poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology and information, low levels of primary education and health care, poor access to resources, low management capabilities and armed conflicts (UNFCCC, 2007). In Asia and Latin America also there are many impacts of climate change such as hunger, diseases, loss of income (socio-economic sector including agriculture and fishery), water and air quality, extreme weather events, ecosystem and biodiversity (UNFCCC, 2007).

Resilience to effects of climate change is the ability to prepare for anticipate and respond to the severe effects of climate; communities, households and/or individuals need this capacity (Soto & Bahri, 2012). Among factors which build the resilience to effects of climate change is forest management because of its importance in economy, environment, social and cultural domains (Soto & Bahri, 2012). This is achieved through extent of forest resources, forest biological diversity, forest health and vitality, productive functions of forest resources, protective functions of forest resources, socio-economic functions of forests and legal, policy and institutional framework (Soto & Bahri, 2012).

Forests play an important role in human livelihoods and ecosystem management (Food and Agriculture Organization [FAO], 2010). They are crucial to climate change mitigation and adaptation, they provide different goods such as food, timber, medicines, fuels, fibers, and fodder, and contribute to soil erosion control (FAO, 2010). In addition, forests are home to different biodiversity, provide socio-cultural services, support human livelihoods and reduce and eradicate poverty (FAO, 2010). Forests as terrestrial ecosystems are also among reservoirs of carbon beside fossil fuels reserves, atmosphere, oceans and oceans sediments where 50% of total terrestrial carbon sink is in forest ecosystems (Convention on Biological Diversity [CBD], 2009a). Climate change can be regulated through carbon sequestration because this one regulates greenhouse gases (CBD, 2009a).

There are seven ecological principles that have been suggested to maintain and promote long term forest resilience especially under climate change: (i) maintaining genetic diversity in forests through practices that do not select only certain trees for harvesting based on site, growth rate, or form, or practices that depend only on certain genotypes for planting, (ii) maintaining the stand and landscape structural complexity using natural forests as models and benchmarks, (iii) maintaining connectivity across forest the landscapes by reducing fragmentation, recovering lost habitats, and expanding protected area networks, (iv) maintaining functional diversity and eliminate conversion of diverse natural forests to monotypic or reduced species plantations, (v) reducing non-natural competition by controlling invasive species and reduce reliance on non-native tree crop species for plantation, afforestation, or reforestation projects, (vi) reducing the possibility of negative outcomes by allocating some areas of assisted regeneration with trees from regional provenances and from climates of the same region that approximate expected conditions in the future and (vii) maintaining biodiversity at all scales (stand, landscape, bioregional) and of all elements (genetic, species, community) and by taking specific actions including protecting isolated populations of organisms, populations at margins of their distributions, source habitats and refugia networks because these populations are the most likely to represent pre-adapted gene pools for responding to climate change and could form core populations as conditions change (CBD, 2009a).

In Rwanda, climate change has been reported to result from increased temperatures, intensified rainfall and prolonged dry seasons and erosion, severe floods, droughts, desertification, reduction in water bodies level, and forest degradation arise as consequences (Ministry of Foreign affairs [MFA], 2018). Rwanda is also highly vulnerable to climate change in six life-supporting sectors: food, water, ecosystem services, health, human habitat and infrastructure and the fact that Rwandan economy is based on subsidiary agriculture which is rain-fed; employing 90% of the population, dependency on natural resources and high population density increase this vulnerability (MFA, 2018). Rwanda has put in place some adaptation and mitigation measures to address climate change impacts (MFA, 2018). Adaptation actions include sustainable intensive agriculture, agricultural diversity in local and export markets, sustainable forestry, agroforestry and biomass energy, integrated water resource management and planning, ecotourism, conservation and payment of ecosystem services in protected areas, disaster management and climate data and projections (MFA, 2018). Mitigation actions include low carbon energy mix, sustainable small energy installation, energy efficient and demand side management, efficient resilient transport system, green industry and private sector development, implementation of low carbon urban systems and sustainable forestry, agroforestry and biomass energy (MFA, 2018).

Forests play a big role in climate change mitigation and adaptation, their management ensures the survival of forest ecosystem and promotes their environmental, socio-cultural and economic functions and help local community depending on them to adapt to new conditions caused by climate change through their forest products, soil protection, water and environmental services, conservation of biodiversity, provision of socio-cultural services, livelihood support and poverty alleviation (FAO, 2010). In Rwanda forests play an ecological role such as biodiversity conservation, provide biomass energy and wood and contribute to national economy where they generate more than 45% of country export revenues; they protect watershed and downstream wetlands (Ministry of lands and forestry [MINILAF], 2018).

1.2. Statement of the problem

Human induced activities such as mining, farming, pastures and wood cutting have been reported to degrade Sanza natural forest which is a remnant forest playing many ecological and socio-economic functions (Bizuru et al., 2011). In order, to reduce the effects related to its degradation, including those related to climate change with extreme impacts on local people around the forest, the government of Rwanda introduced restoration and rehabilitation to strengthen the resilience of forest sites and landscapes and reduce effects related to climate change (Kollert, 2017). Reforestation and tree planting in Rwanda date from Belgian rule in 1930s to provide wood and timber and to protect soil erosion (Lens, 1949; Dubois, 1954; Languy,1954; Derenne,1989).

In addition to restoration and rehabilitation, the government of Rwanda has also put in place different strategies including law reinforcement to sustainably protect natural environments. However, less is known about how these initiatives have strengthened the resilience of the local people around Sanza natural forest to climate change effects in the area, in addition the amount of biomass sequestrated by the forest in climate regulations.

This research contributes to a better understanding of the impacts of natural ecosystem restoration and focuses on the assessment of socio-economic impacts and resilience to effects of climate change of Sanza natural forest to local community.

1.3. Significance of the study

Sanza natural forest provides various products and services to local community including provision of firewood, medicinal plants, honey and edible fruits, it also provides ecological services such as water catchment and protects Satinsyi river (Bizuru et al., 2011). This study will enrich the existing information upon the impacts of Sanza natural forest in strengthening the resilience of local community to effects of climate change to policy makers, researchers, experts, and local community and this will help in formulating alternative options for sustainable conservation and protection to enhance its ecosystem services.

1.4. Objectives

1.4.1. General objective

The general objective of this study was to examine the role of Sanza natural forest in strengthening resilience to effects of climate change to local community.

1.4.2. Specific objectives

- To investigate and analyze the impacts of restoration of Sanza natural forest on socio-economic activities of local communities.
- To quantify the aboveground biomass of Sanza natural forest.
- To examine perception and attitudes of local people on the use of Sanza natural forest towards its importance and its conservation measures.

1.5. Research questions

- What are the impacts of restoration of Sanza natural forest to socio-economic activities of local community?
- What is the amount of aboveground biomass sequestrated by Sanza natural forest?
- What are the perceptions and attitudes of local community on the use and conservation of Sanza natural forest?

Chapter 2. Literature review

2.1.Overview

A forest is a complex ecosystem composed of trees, shrubs and with a closed canopy. It is a natural vegetation of the area supporting biodiversity and provides products that are used by people day to day, plays many ecological services such as flood and climate regulation and contributes to economy too (Kirti, 2009; (International Union of Conservation of Nature [IUCN, 2017]). However, global ecosystems are being degraded due to either natural hazards or human induced activities such as deforestation and degradation associated to agricultural activities, wood extraction and infrastructure extension (Geist & Lambin, 2001). Deforestation and other forms of forest degradation are a serious threat to the environment which may result in the loss of biodiversity and causes climate variation and change (Masiero et al., 2019).

All these consequences in turn affect human well-being in different ways comprising natural hazards such as floods, landslides, droughts, forest fires, extreme heat and waves and diseases such as malaria and dengue (Hales et al., 2003). Forest and landscape restoration is an approach to address the issue of deforestation and forest degradation, it is a long process of taking back ecological functionality and enhancing human wellbeing across degraded area. Different issues such as food insecurity, disasters, climate change, economic systems, poverty, conflicts, rights and access affect resilience, so forest restoration enhances resilience to climate change by improving forest ecosystem goods and services (IUCN, 2017). Figure 1 shows more resilient socio-ecological system.

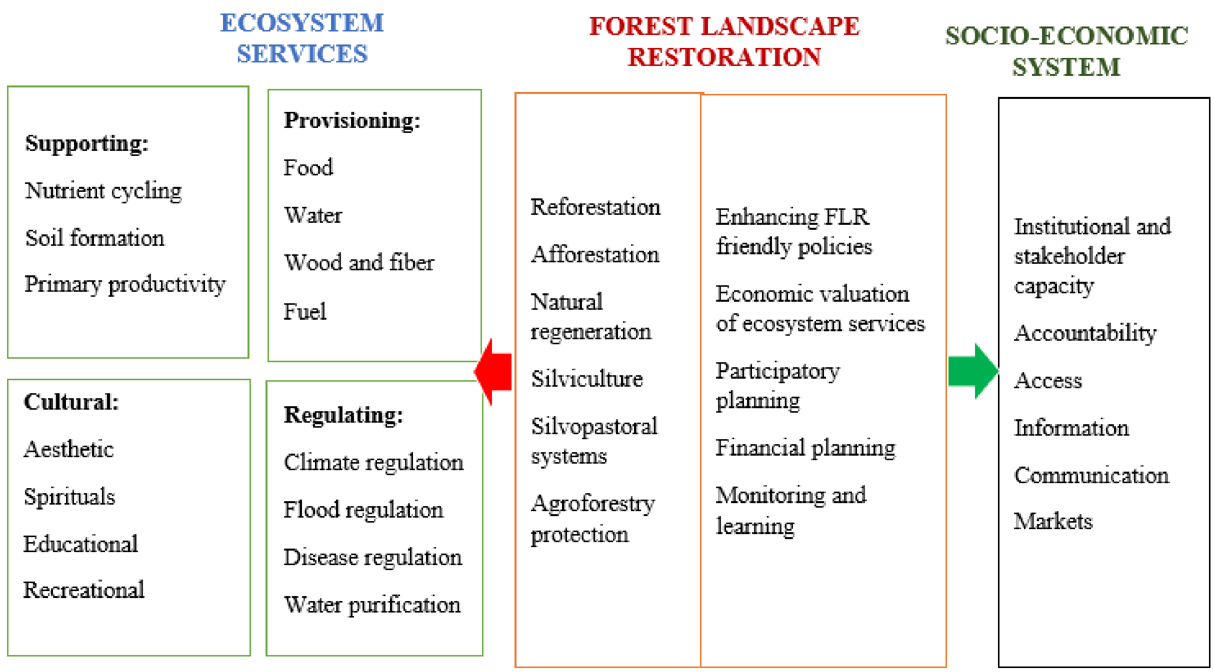

Figure 1. How forest landscape restoration can enhance resilience

2.2.Status of global forests

Forests around the world occupy around 30.8% of the total area with 4.06 ha however they are not equally distributed; more than a half of world forest are found only in 5 countries which are Russia, Brazil, Canada, United states of America and China and considering climatic domain and ecological zone; tropical forests occupy 45% of total global forest, followed by boreal domain with 27%, temperate 16% and subtropical 11% (FAO, 2020).

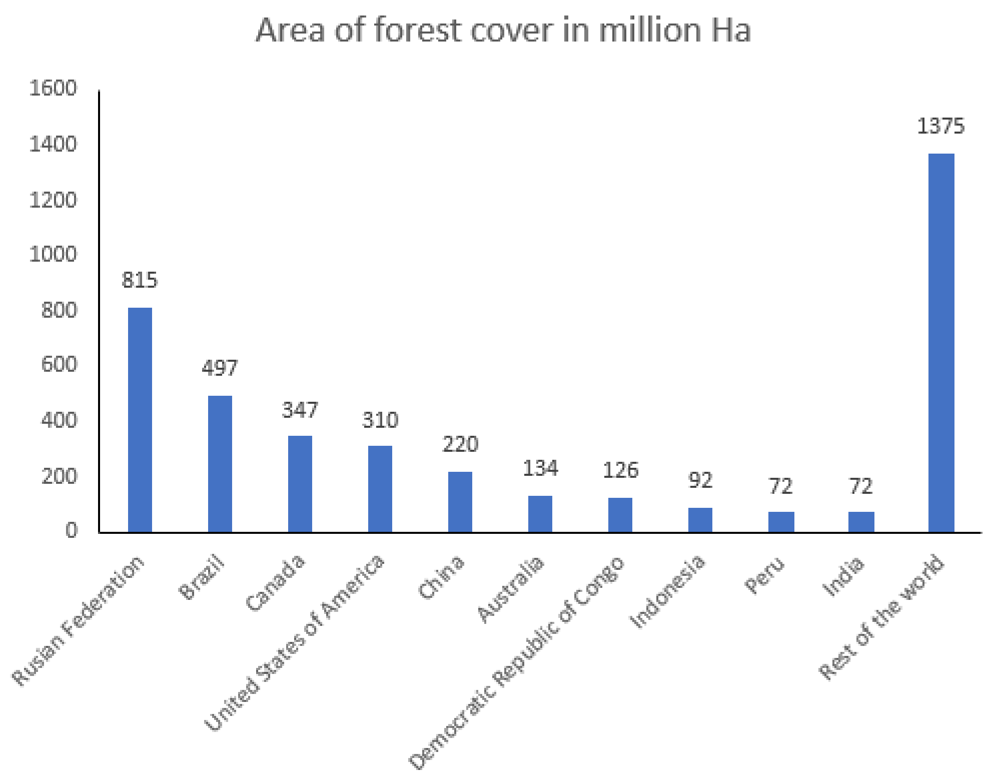

Figure 2. Global distribution of forests showing the 10 countries with the largest forest area

2.3.Ecosystem services and human societies

Natural ecosystems provide many benefits to humans in all domains of life including freshwater, recreational space, food, fuel, prevention of floods, recycling of nutrients and fish breeding sites (CBD, 2009b). Forest ecosystems are particularly the most biologically rich terrestrial ecosystems; their roles are not restricted to timber production, but also for other multi-functional services they provide including habitats for biodiversity, mitigation of natural hazards such as floods, droughts and carbon storage (CBD, 2009b).

Ecosystem services provided by the forests are classified into two main categories: ecosystem processes and ecosystem benefits. Ecosystem processes include core ecosystem services which are the basic ecosystem functions supporting the ecosystem services such as nutrient cycling, water cycling, weathering, decomposition, production, and ecological interactions (Balmford et al., 2008). However, the beneficial ecosystem processes are directly benefited by humans. They include processes such as biomass production, pollination, biological control, habitat for species, waste assimilation, soil formation, erosion control, air and water purification and climate regulation (Balmford et al., 2008).

Furthermore, the ecosystem services are grouped into four categories all of which contribute to a range of human wellbeing (Aznar-Sanchez et al., 2018). These are provisioning, supporting, regulating and cultural services. Provisioning services are the familiar, tangible, and direct products extracted from the forests and they are used or sold by humans to generate incomes. Examples of provisioning services include logs, wood, fiber, genetic resources, biochemical, freshwater, fuel and other products which may be planted or developed in the forest. Regulating services are related to the ability of the forests to store carbon, reduction of erosion, improvement of water quality, invasion resistance, herbivory, pollination, seed dispersal, pest regulation, disease regulation, climate regulation and protection of natural hazards such as floods and droughts. Cultural services are those non-material social and cultural benefits, they include recreational opportunities (walking, mountain biking, horse riding, hunting, running, water sport events, motorsport, and exercising dog), aesthetic enjoyment, spiritual enrichment, knowledge system, education, biodiversity conservation appreciation, furthermore, forests are often open to a range of other activities. Supporting services are the biological and physical processes in a forest that drive the other three services. Examples of these include primary production, provision of habitats, biodiversity maintenance and conservation, nutrient cycling, soil formation and retention, nutrient cycling, water regulation and oxygen production (Yao et al., 2017, Aznar-Sanchez et al., 2018; Michael & Brian, 2018)

2.4.Forest status in Rwanda

Planting trees is a tradition of Rwandan people, they used to plant native tree species such as *Ficus thoningii*, *Euphorbia tirucalli*, *Erythrina abyssinica*, *Vernonia amygdalena and Dracaena afromontana* and these tree species were planted mainly to make home fence while planting exotic tree species was introduced during colonial era from 1920 and 1948 with the main purpose of timber and fuel wood production (Nduwamungu, 2016).

Research conducted by Ministry of Environment [MoE], (2019b) showed that the forest cover in Rwanda occupies 30.4% of the total land.

Table 1. Summary statistics of forest cover types per category of forest density.

Forest cover type	**Very low (0-10%)**	**Low (10-40%)**	**Medium (40-70%)**	**High (>70)**	**Grand total (ha)**	**Percentage (%)**
Bamboo stand	15	39	149	410	613	0.1
Forest plantation	11034	46077	150752	179562	387425	53.5

Natural forest	466	2848	207	127329	130850	18.1
Shrub	3184	13791	24470	2518	43963	6.1
Wooden savannah	11336	83466	58425	8616	161843	22.3
Grand total	**26035**	**146222**	**234004**	**318434**	**724695**	**100.0**

Natural forests are with the purpose of ecological role such as conservation, (MINILAF, 2018). There are 4 major natural forests in Rwanda: Nyungwe National Park, Volcanoes National Park , Akagera National Park and Mukura-Gishwati Natural Park (Ndayambaje & Mohren, 2011). Other natural forests are Buhanda Natural Forest, Mashyuza Natural Forest, Ibanda-Makera Natural Forest, Karama Natural Forest, Dutake Natural Forest, Karehe-Gatuntu Natural Forest Complex, Nyagasenyi Natural Forest, Sanza Natural Forest, Mashoza Natural Forest, Muvumba Natural Forest, Ndoha Natural Forest, Kibirizi-Muyira Natural Forest, Busaga Natural Forest, (MINILAF, 2018). Artificial forests aim to satisfying population need such as fuel energy, timber, construction materials, soil erosion control and creation of buffer zones around natural forests and protected areas and the most planted tree species in Rwanda include *Eucalyptus*, *Pinus, Callitris, Cypress, Grevillea, Jacaranda, Alnus, Black wattle, Ac. melanoxylon* and *Maesopsis* (MINILAF, 2017a). Forests area coverage distribution in Rwanda is as follow:

Table 2. Summary statistics of forest cover and distribution per Province.

Province Name	**Province land (water bodies excluded) (ha)**	**Total forest cover (ha)**	**Forestland (%)**	**Non forestland (%)**
Kigali City	72829	12641	17.4	82.6
Eastern Province	910555	274630	30.2	69.8
Northern Province	319318	85688	26.8	73.2
Southern Province	596355	177537	29.8	70.2
Western Province	486773	174199	35.8	64.2
Grand total	**2385830**	**724695**	**30.4**	**69.6**

2.5.Climate change in Rwanda: impacts, mitigation, and adaptation

Rwanda has experienced an increase of 1.4 °C since 1970 and this increase goes beyond than that of global average and this temperature may go up to 2 °C in 2030 while the average annual rainfall models predict a change between 100 and 400 mm for the period of 2000-2050 (MFA, 2018). All of these changes in weather conditions cause droughts and floods in different areas of a country which consequently lead to famine, population displacement, conflicts, biodiversity loss, water stress, health problems, damage of infrastructure, economy, low electric production and ecosystem related problems such as water pollution, invasion of aquatic pollutant plants, increase of sediments on arable land, river, lake and reservoir sedimentation (Ministry of Lands, Environment, Forestry, Water and Mining [MINITERE], 2006; MFA, 2018).

The Government of Rwanda has taken the following policies to adapt and mitigate climate change effects: formulation of the national climate change and low carbon growth strategy, training and sensitization program on climate change and its effects to different stakeholders, preparation of the National Adaptation Plan of Action (NAPA) for climate change, development of a guidance manual for integrated climate change aspects into districts development plans, investing in sustainable land use management practices, implementation of carbon marketing and clean development mechanism projects and development of national capacity for climate change impacts modelling, sector based climate research and a climate observatory (Rwanda Environment Management Authority [REMA], 2011). These policies resulted into rehabilitation of critical ecosystems, coordination of climate change and international conventions programs, rehabilitation of degraded forests and encouraging private land owners, balancing conservation with food security and other land uses, restoration of aquatic ecosystems and protection of watersheds, sustainable mining and strengthening institutional capacity for policy coordination and monitoring (REMA, 2011).

2.6.Forest ecosystem services in Rwanda

The study conducted by MoE, (2019a) has shown that forests provide many products such as timber and charcoal and contribute to national economy where for example in the budgetary year of 2016-2017 forests contributed to US $ 365 billion equivalent to 5% of total gross domestic product (GDP). They are primary source of cooking energy, touristic sites, protection of watersheds and downstream wetlands, provide non timber products such as medicinal plants, handcraft materials and honey and they support agriculture, contribute to the national revenue (MINILAF, 2017b). Forests also provide shelter of 2150 known plant species, 151 mammal species and 670 bird species and additionally natural forests in Rwanda are refuge to endemic species, home of biodiversity which attracts tourists hence contributing to economic growth (REMA, 2009).

2.7.Forests degradation in Rwanda

Drivers of forest degradation in Rwanda are mainly based on a high population growth that relies heavily on forest products for construction materials, fuelwood, stakes for beans and lack of awareness on forest protection which leads to high pressure on the forest. These drivers are agriculture, infrastructure development, urbanization, illegal mining activities, forest product harvesting, and limited forestry extension services (MINILAF, 2017a). These drivers impact negatively on the forest and the main effects are the imbalance between wood demand and supply, loss of biodiversity, heavy soil erosion and increased greenhouse gases emission (MINILAF, 2017a; Rurangwa, 2017).

2.8.Forests restoration in Rwanda

To maintain the forest and biodiversity, the government of Rwanda has implemented various programs related to forests restoration and management such as incentives and forest and landscape restoration insights (national and international incentives), and shaping Forest Landscape Restoration (FLR) through conductive policy environment in Rwanda (MINIRENA, 2014). Restoration activities in Rwanda have many advantages including enhancing mitigation and adaptation to climate change and improving livelihoods for the population depending on the forest (Rurangwa, 2017). These restoration efforts reestablish the degraded lands using a combination of natural and protective forests, improving the management of existing woodlots in conjunction with restoring forests and using agroforestry on existing agricultural lands to improve crop productivity, reduce soil erosion, thereby increasing access to clean water, and reducing pressure on natural forests to supply fuel wood (Ministry of National Resources of Rwanda [MINIRENA], 2014).

From 1984 to 2015, key natural forests cover in Rwanda has reduced from 429728.47 ha to 235192.27 ha equivalent to 45,27% (FAO, 2020). Through restoration and forest management efforts, results from MoE, (2019) have shown that the area covered by natural forests in Rwanda is 337270 ha, this means that between 2015 and 2019 area of natural forests cover in Rwanda has increased by 43.94%.

2.9.Communities and forest management: responsibilities and benefits

Forests are being known to play a great role in addressing 21st century climate change challenges, conservation of biodiversity, proper land management and water resources (Agbogidi et al., 2005). To support sustainable forest management, the local community participation is very crucial (Agbogidi et al., 2005). This approach known as community forestry aims at sustainability of ecosystem and local community benefits with some degree of responsibilities in their management (Charnley & Poe, 2007).

Community forestry is an approach that exists under private property, leased land, land trusts, community forests, use of waste from woods, land covenants, cooperatives and tenured land under contract (Sim et al., 2004). To make community forestry more successful, the security for long-term rights, capacity building for local community and other stakeholders, researches, effective and regular funding, conflict management approaches, sustainable communication and encouragement of more communities and individuals to effectively manage the forests have to be taken into considerations (Agbogidi et al., 2005).

Engaging the community in forest management is mainly influenced by the benefits they gain from the forests and these benefits include the developmental projects such as schools, clinics, roads, and other infrastructures. However, the community must be educated about the role of forests, get involved in policy, decision making, protection and forest conservation initiatives, planning and increasing the level of income from forests (Jallah et al., 2017).

Community in Rwanda plays a role in forest management, they plant trees during community workdays or as paid job. However, these activities do not involve them fully in forest management. Putting them into cooperatives that are involved in forest management activities and increasing benefits from management of forests and tree resources to local community are expected to engage them fully in forests management (MINILAF, 2017a).

Practices that enhance forest management in Rwanda include (i) community-based ecotourism, (ii) afforestation, reforestation and improved forest management, (iii) agroforestry promotion, (iv) payment for ecosystem services and (v) Promotion of improved cook stoves and or other sources of cooking energy especially in Kigali city and secondary cities (MoE, 2019b; Dyszynski & Hogarth, 2011).

Chapter 3. Methodology

3.1.Description of study area

Sanza natural forest is a relict forest located in Sanza cell, Muhororo sector, Ngororero district in Western province of Rwanda (1°54'27.8"S and 29°35'16.4"E). Sanza forest is perched on the hill of Uwintobo between 1600 and 1950 m of altitude and is skirted downwards by the Satinsyi river (Figure 3). Sanza was much degraded due to some anthropogenic activities including wood cuts, farming, pastures and mining. (Bizuru et al., 2011). In 1984 Sanza forest covered an area of 49 ha, and it has been degraded to 51% till 2015 covering an area of 24 ha (MINILAF, 2017a). The area that is the most invaded by illicit mining activities mainly cassiterite and coltan is the central part of the forest (Bizuru et al., 2011).

The forest has been restored in 2017 by planting native tree species and reinforcing people restriction to enter and to extract the forest products that they used to extract illegally. Tree species diversity is mostly dominated by *Syzygium guineense*, *Xymalos monospora* and *Alnus japonica*. Other tree species found there are *Albizia gummifera, Allophylus chaunostachys, Bridelia micrantha, Erythrina abyssinica, Macaranga kilimandscharica, Maesa lanceolata, Markhamia lutea*, *Polyscias fulva* and *Rhus vulgaris*. Banana plantation occupies the first place of land use around this forest (38.9%) followed by cassava (19.4%). Other plantations are *Eucalyptus* woodlots (8.3%), *Colocasia* (5.6%), Maize (5.6%), Egg fruits (5.6%), Maracuja (2.8%) and Cupressus (2.8%).

The region is inhabited mostly by native people (77.6%). Based on socio-economy status; subsidiary agriculture is the most dominant socio-economic activity done by the local community (82.5%), casual labor (11.75%), masonry (4.05%) and shoe making (1.7%) and based on literacy most of them have done primary education (57.6%), ordinary level (9.4%), secondary education (2.4%) and the rest (30.6%) are illiterate.

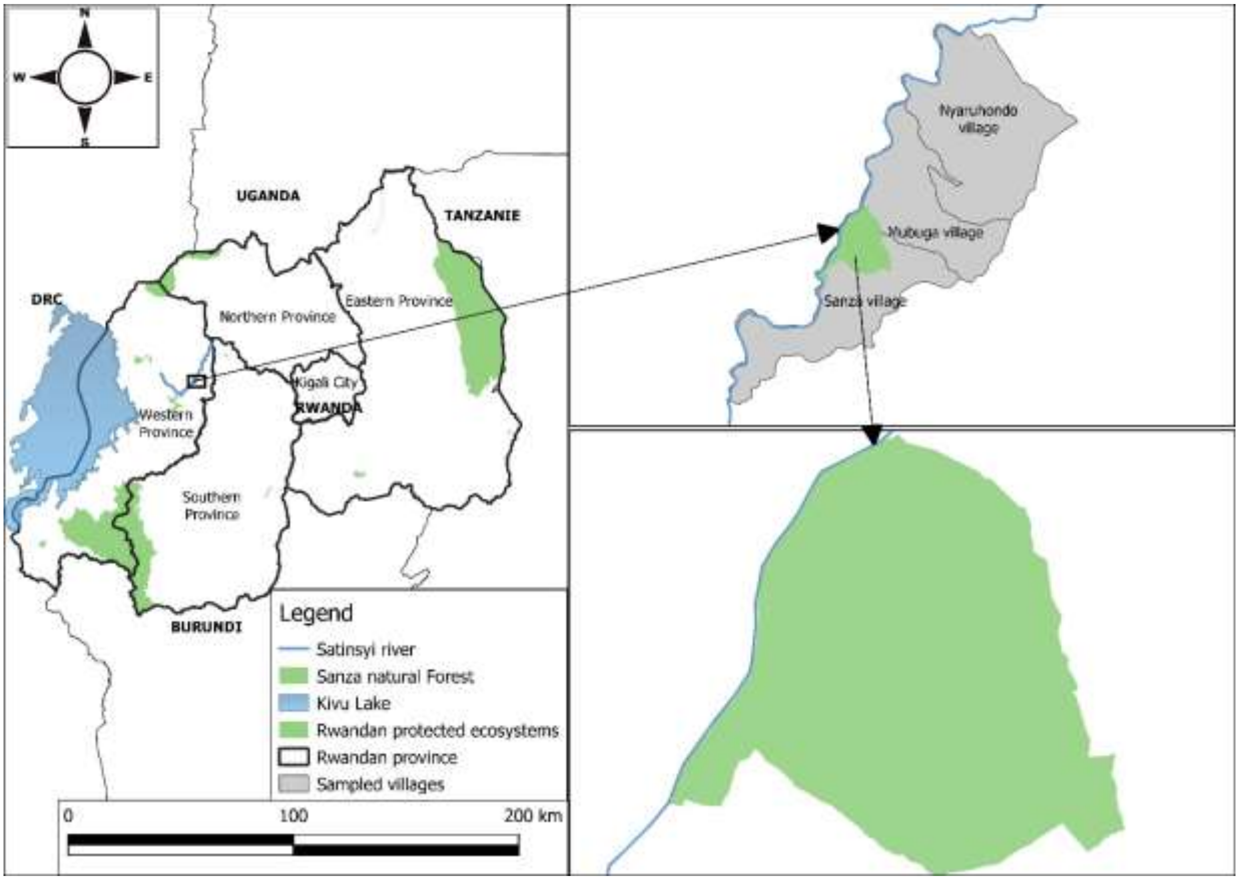

Figure 3. Map showing location of Sanza natural forest and study site.

3.2. Research design

3.2.1. Reconnaissance survey

Reconnaissance survey was conducted in the study area in November 2019 before the field work to obtain the present status of the forest and to identify ways of collecting data.

3.2.2. Stratification of the study area

Tree samples were taken in 12 plots for biomass and carbon stock analysis across the altitudinal gradients from the bottom up to the top of the forest. Each sub-plot was made up 10mx10m size and 100m distance were considered as the interval from one sub-plot to another following the horizontal side of the forest. Further, the interval of 50 m.a.s.l. has been vertically considered from one transect to another, and hence a total of 4 transects was set from the bottom up to the top of the forest. In addition, plots have been set from one side of the forest and three consecutive sub-plots were established towards the inside of the forest.

3.3.Data collection

3.3.1. Impacts of Sanza natural forest to socio-economy of local community

3.2.1.1. Household survey

Primary data were collected through interview guides (Figure 4) using structured questionnaires to 85 households surrounding Sanza natural forest. These households were selected using purposive sampling which is a technic of sampling with special situations where a researcher sets out to find people who can provide information by their knowledge or experience (Etikan et al., 2016). Due to the topography of the study area, it was difficult to find information from people far the forest. Before responding to the questionnaire, an introduction was given to respondents on nature of research and the contribution of the data they would provide to the sustainable management of the forest, then a consent to the interview was requested of the respondent.

The main aim of interview was to document the socio-economic impacts of Sanza natural forest to the local community and to investigate their perception on its use, management, and conservation. The questionnaires were first translated in Kinyarwanda which is the only local language used in Rwanda to help people understand questions during the survey and they were divided into three sections. Section one addressed the respondents' socio-economic profile including gender, age, marital status, profession, level of education and the time from when they are living around the forest. Section two dealt with forest products the local community used to collect from the forest before forest restoration toward the socio-economic activities. Section three focused on current socio-economic status after they are restricted to harvest forest products and how restoration activities/projects have contributed to their livelihood. The section was also concerned with perceptions of local people on the forest uses, participative management and conservation. Figure 4 shows how interview with household member was conducted.

Figure 4. Interview conducted with a household person in the study.

3.3.2. Policies and progression of Sanza forest restoration project

3.3.2.1. Key informant interview

Primary data on policy and institutions responsible for the management of the forest and well-being of the local community were collected in four institutions through telephone interview: District environment officer, LDCF II staff, sector agronomist officer and the cell executive secretary. The interview has been conducted via telephone because of COVID-19 prevention measures. It focused on the objectives and progression of the project, policies toward the forest conservation and improvement of livelihood of local communities.

3.3.3. Aboveground biomass estimation

All trees with greater or equal than 5 cm DBH were recorded, trees whose DBH is less than 5 cm were ignored because they have no significant contribution to aboveground biomass (Brown, 1997). Information recorded included measurement of DBH and height using ammeter tape and hga (Figure 3), species name and subplot. The purpose was to estimate the amount of carbon that can be sequestered from the atmosphere by the forest which is a mean of climate change mitigation.

Aboveground biomass was calculated in density tones (t)/hectare (ha)= VOB×WD×BEF.
Whereas

- VOB= Inventoried volume over bark of free bole, for example from stumps or buttress to crown point or first main branch,

- WD = Wood density as oven dry mass per unit of volume

The WD factor should be calculated either in tones (t) / cubic meters (m^3) or grams (gr) / cubic centimeters (cm^3) and,

- BEF = Biomass extension factor, which stands for the ratio of aboveground oven-dry biomass of trees to oven-dry total biomass of inventoried volume.

It is of vital importance to be aware of the WD factor effect on the determination of aboveground biomass. The WD factor is marred by a high level of uncertainty since it varies with different tree species. The BEF factor is a way to include the branches, roots etc. of the estimate of the tree's biomass. According to FAO (1997) BEF is fixed to 1.3.

To be able determine the total volume of biomass for the inventoried subplots, the base area of the stem Ab (m^2) at DBH for each tree has been measured using the following formula in FAO (2004); $Ab = \pi \times r^2$

whereas,

- π = pi and
- r = radius (m) which is the half of DBH (0.5 DBH).

The site dependent constant for cubing (Kc) was used to determine the volume for each tree according to the equation for volume in FAO (2004). The value of 0.5 for Kc was found to assume that the volume of the tree trunk is half the volume of a cylinder, which give Kc = 0.5.

To find the volume of each tree the formula in (FAO 2004) was used; $V = Ab \times H \times Kc$

Whereas,

- Ab = base area of the stem at DBH in square meters (m^2),
- H = height of the tree in meters (m) and
- Kc = site dependent constant for cubing (0.5).

Wood Density (WD) is calculated by the formula weight/volume. The volume was measured by using the water-displacement method (Chave, 2005). Here a plastic bottle has been used and was filled with water and then placed on a digital balance of precision at least 0.01 g. The electronic balance was then re-zeroed. The sample was then carefully sunk in the water, and completely underwater and did not contact the sides or bottom of the container and was forced underwater with a hook. The measured weight of displaced water was equal to the sample's volume (since water has a density of 1 – this is known as Pythagoras's theorem).

Biomass Expansion Factor (BEF) was fixed by the standards in FAO (1997). Aboveground Biomass was calculated by using the formula in FAO (1997), after Brown & Lugo (1992); Aboveground biomass in density tones (t) / hectare (ha) = VOB×WD×BEF,

Setting plots

Measuring DBH

Using haga meter

Recording data

Figure 5. Tree sampling, measuring of DBH and height

3.4.Data analysis

Quantitative data for assessing the impacts of Sanza forest restoration to local community to strengthen the resilience on effects of climate change and demographic data such as age, gender, education level, time spend there were analyzed using Excel software. Qualitative data about progression of the project, and policies toward forest conservation and improvement of community livelihood were analyzed using thematic methods (exploratory process about people's experiences**,** views, and opinions). Aboveground biomass was calculated in density tones (t) / hectare (ha).

Chapter 4. Results

4.1. Economic activities and forest products collected inside Sanza natural forest.

Farming was the dominant socio-economic activity recognized as indicated by many of the respondents before Sanza natural forest restoration (82.45%) and 57.1% of these farmers do only a subsistence farming. Other economic activities that are done in the area include mining (11.7%), cattle keeping (1.17%), masonry (1.17%), bee keeping (1.17%), casual labor (1.17%) and communication services. About 92.9% respondents reported that they used to harvest different forest products that were used in the different daily activities, and they did mines extraction and extract some forest products for money income generation. The prevailing products that were primarily harvested inside the forest include firewood (31.4%), stakes for beans (29.2%), fodder (22.6%), and minerals (8.03%). Other products include fruits (4.38%), medicinal plants (2.92%), handcraft materials (0.73%) and wood (0.73%).

4.2. Economic activities done by the local community after forest restoration.

After the restoration activities, people were no longer allowed to enter the forest and harvest some forest products. This made some of them searching for other jobs as alternative. In this regard, agriculture remains the main economic activity around the forest (82.5%). Other local people are doing casual labors (9.4%), forest guarding (2.35%), wholesale (1.7%), telecommunication services (1.7%), shoe making (1.7%), masonry (1.7%) and cattle keeping (1.7%).

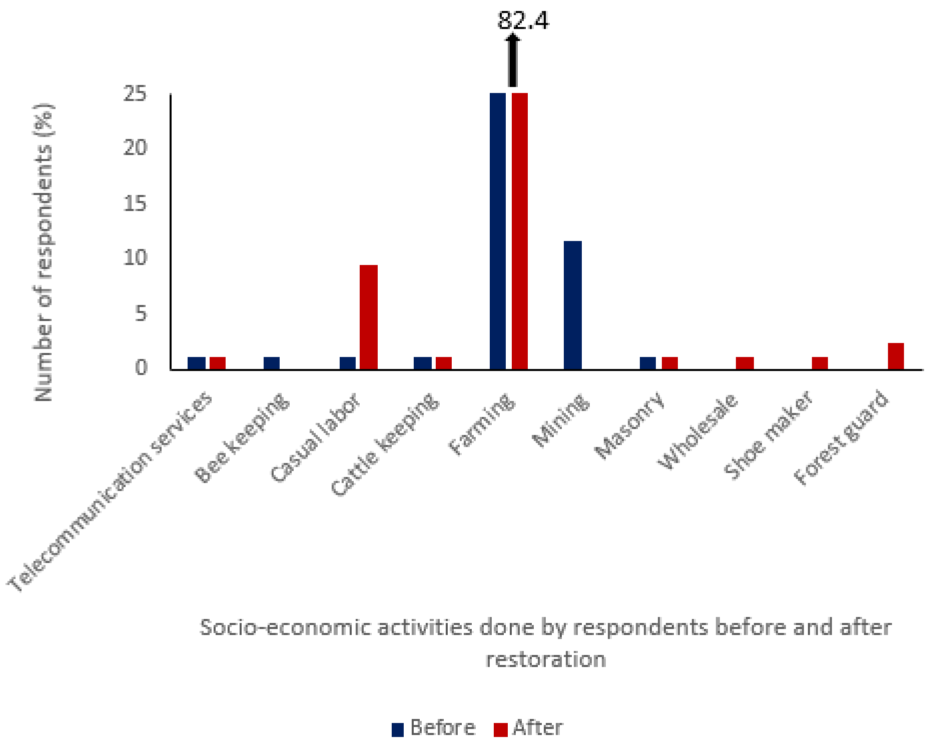

Figure 6. Comparative table of economic activities before and after restoration

Most of economic activities that were done by the local community before the restoration of the forest are still occurring. However, not all people are able to replace forest products they used to collect from the forest. A total of 45.9% of respondents reported that they did not encounter any special problem in finding alternatives of forest products used to harvest in the forest. Other 54.1% reported that it is hard for them to find the materials that were harvest inside the forest. These products include stakes for climbing beans, minerals, fodder, fruits, firewood, and medicinal plants.

To cope with changes, most of respondents managed to find other alternatives including planting their own farmland so that they can find fodder, firewood, and stakes for climbing beans. Some others use to buy forest products and use crop residues in place of firewood. Other alternative means include changing crop types, using other forests and people's farmlands, clinics instead of medicinal plants and rivers and streams for sand.

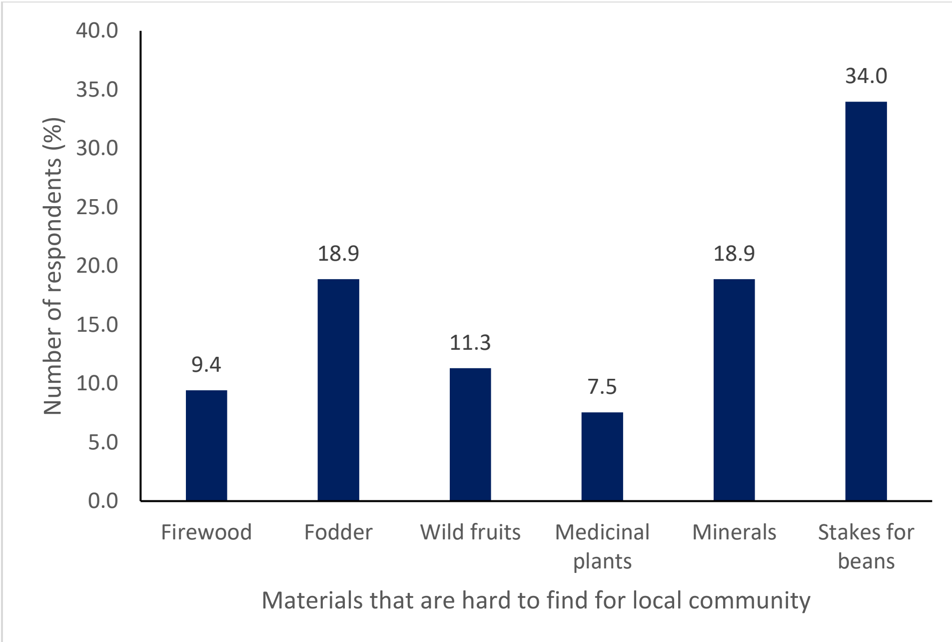

Figure 7. Forest products that are hard to find without depending on the forest.

4.3. Contribution of restoration activities to community livelihood

During restoration, some of local community have profited through casual labor and beekeeping projects. 28% of respondents stated that they have been employed during restoration. This made them generating income averaging 25000 RwF monthly and they expect to generate other income from beekeeping projects.

4.4. Forest management and conservation

Even though people are not allowed to access Sanza natural forest like before, findings from field observation showed that there are anthropogenic activities which are still carried out inside the forest (Figure 8). Those activities include firewood collection, tree cutting and fodder collection. Respondents have also mentioned that these activities are done during nighttime or daytime behind forest guards' backs. Beside these observed activities, respondents mentioned medicinal plants and stakes for beans collection, among others.

Beside anthropogenic activities, we have observed that the forest is threatened by the natural hazard mainly erosion (Figure 8). Some respondents have also mentioned tree species which have declined in the forest due to human-induced activities and natural reasons. These tree species are *Acacia sieberiana*, *Albizia gummifera*, *Baiearica regulorum*, *Bridelia micrantha*, *Chenopodium* *ugandae, Chlorocebus aethiopis, Clerondendrum myricoïdes, Cupressus sps, Dalbergia lacteal, Erythrina abyssinica, Ficus thonningi, Lantana camara, Macaranga kilimandscharica, Maesa lanceolata, Momordica foetida, Myrianthus holstii, Ocimum suave, Pinus sps, Polyscias fulva, Psidium guajava, Syzygium guineense, Trema orientalis, Vernonia pogosperma* and *Maytenus sps*, among others.

(a) Erosion

(b) Tree cutting

(c) Fodder collection

(c) Firewood collection

Figure 8. Natural and anthropogenic activities that are threats to the forest.

4.5. People's perceptions and practices on forest restoration, management, and conservation

Most respondents (76.47%) agree that the forest should be restored because they understand well the importance of the forest through the products like firewood, fodder, and stakes for climbing beans they may harvest and other ecological services such as microclimate regulation. They also added that the forest was going under extreme damage due to unregulated anthropogenic activities.

Few people (23.53%) including those who used to do mining strongly disagreed on the fact that the forest should be restored, and this is because they used to depend on it for money generation income unless they claimed it was illegal.

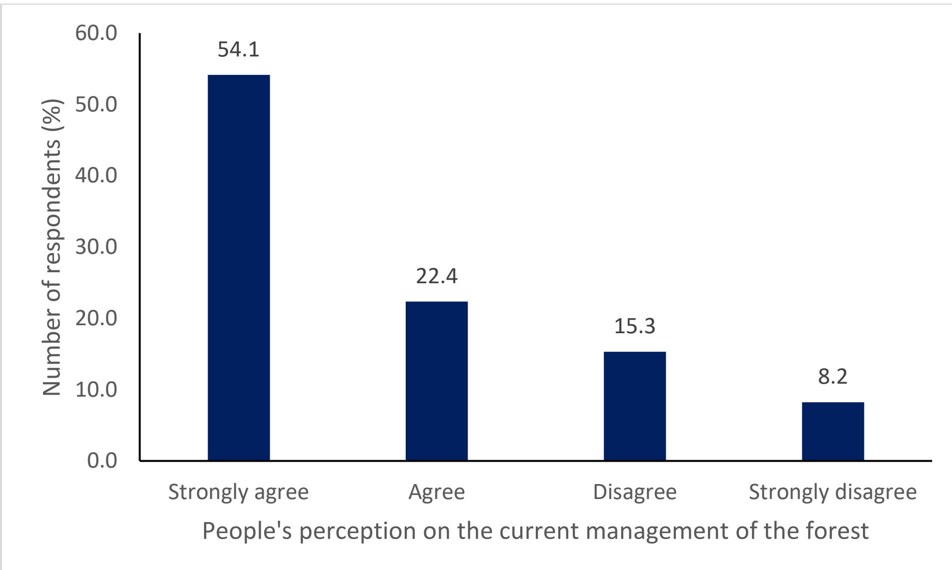

Figure 9. Graph showing people's perceptions on restoration of the forest.

Regarding tree species preferred by local people, the most preferable trees that could be used for restoration activities include *Eucalyptus sps.* (15.67%), *Grevillea robusta* (13.5%), *Fruit trees* (10.27%), *Pinus sps.* (7%), *Ficus thonningi* (6.48%), *Acacia sieberiana* (5.94%), *Erythrina abyssinica* (5,94%), *Macaranga kilimandscharica* (4.86%), *Myrianthus holstii* (4.86%), *Polyscias fulva* (4.32%), *Cupressus sps.* (3.78%), *Trema orientalis* (3.24%), *Albizia gummifera* (2.7%), *Syzygium guineense* (2.16%), *Maytenus sp.* (1.62%), *Yushania sps.* (1.62%), *Carapa grandiflora* (1.08%), *Phytolacca dodecandra* (1.08%), *Maesa lanceolate* (1.08%), *Chenopodium ugandae* (0.54%), *Lantana camara* (0.54%), *Acacia hockii* (0.54%), *Mormodica foetida* (0.54%), *Xymalos monospora* (0.54%) and *Vernonia fontinalis* (0.54%). They wish these trees especially for their provisioning ecosystem services such as charcoal, woods, firewood, and stakes for climbing beans.

Most respondents have reported that their role in protecting the forest includes providing information to the local leaders in case they see anyone trying to damage the forest in anyway especially those who may cut down trees. Some respondents mentioned avoiding illegal activities such as garbage deposit, firewood and fodder collection, tree cutting and educating they village mates how to conserve the forest, among others. However, they mentioned some projects could also be done to improve their livelihood vis-à-vis forest ecosystem conservation. These include creation of the buffer zone, agroforestry, provision of fruit seedlings, education, and capacity building to local community, hiring more security guards and provide a monthly allowance to them, improvement of infrastructures such as roads and electricity so that they may get other job opportunities, provision of other alternative forms of cooking and making it a national park, among others.

4.6. Purposes of restoration, progress of the project and policies towards sustainable conservation and local community livelihood

Key informants have stated that Sanza natural forest was restored because it is one among few natural forests which remain in Rwanda and it was highly degraded especially due to mining and other anthropogenic activities like tree cutting, firewood collection and fodder collection, among others. The restoration also aimed to conserve biodiversity within that natural forest including native tree species and animal diversity, especially birds.

They added that there is a progression of forest regrowing because mining which was the main threat to the forest is no longer there, and native tree species have been grown. Policies toward sustainable conservation and local community livelihood include increasing forest guards, implementation of bee keeping projects, promoting tourism, installation of radical terraces, agroforestry and providing fertilizers to local communities to increase their crop production.

4.7. Aboveground biomass

The biomass of the trees of Sanza forest varies across the altitudinal gradients. The lower elevation plot had 301.4 t ha^{-1}, lower intermediate elevation plot had 706.5 t ha^{-1}, upper intermediate elevation plot 3 had 2095.3 t ha^{-1} and the higher elevation plot had 438.9 t ha^{-1}. Estimated 2,797.734 tC per 23.90 Ha of biomass were estimated across all trees species individuals of Sanza natural forest.

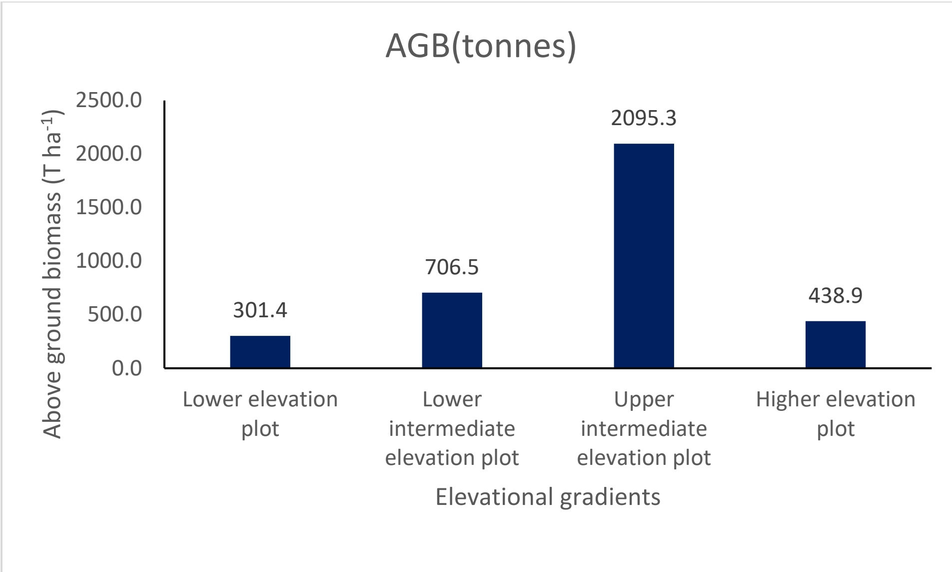

Figure 10. Biomass obtained in different elevation gradient per ha.

Table 3. Summary of above ground biomass obtained in different elevation gradients.

Elevational gradient	**Biomass (t)**	**Hectare (Ha)**
Low elevation plot	9.04	0.03
Intermediate elevation plot	21.20	0.03
Higher elevation plot	62.86	0.03
Upper elevation plot	13.17	0.03
Total biomass for all plots		106.26 t per 0.12 Ha
Estimated biomass per ha		885.2 tC ha^{-1}
Estimated biomass for whole forest		21155.8 tC per 23.90 Ha

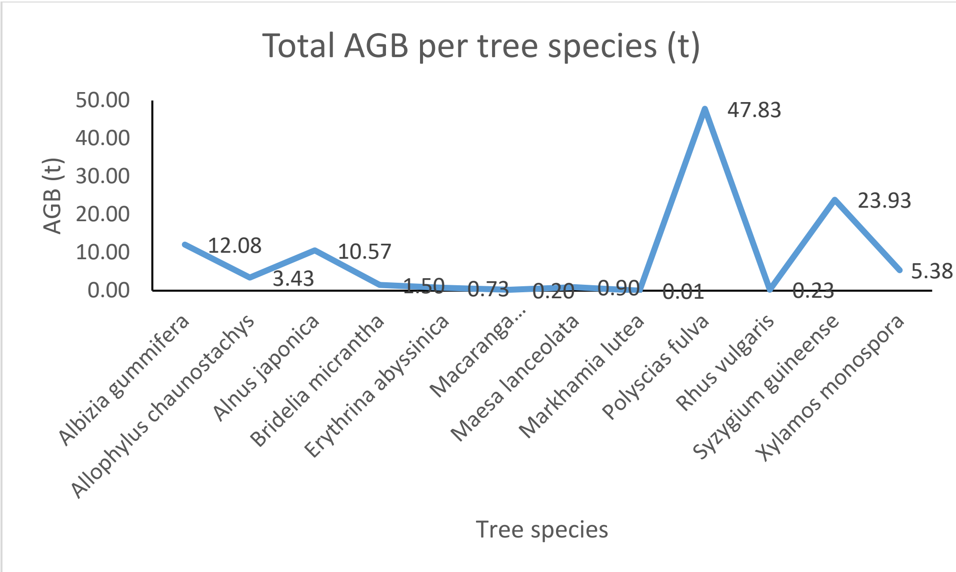

Figure 11. Total aboveground biomass (t) per tree species

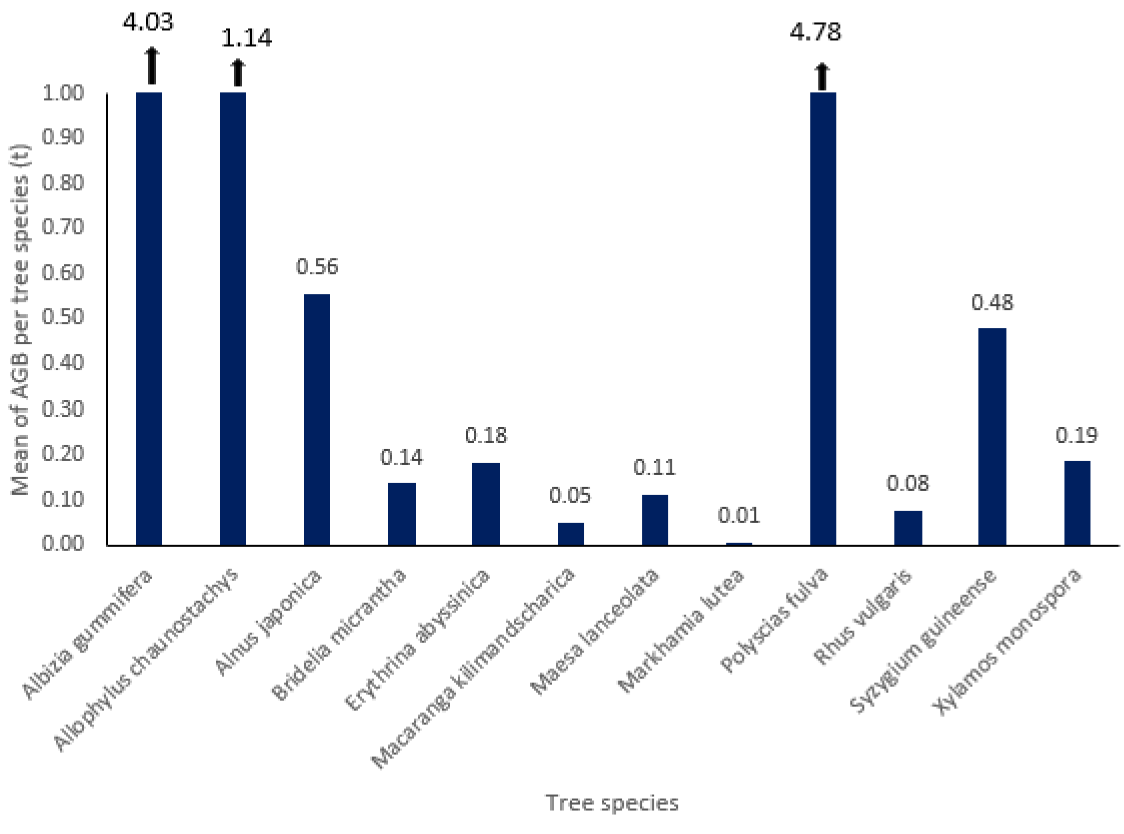

Figure 12. Mean of aboveground biomass in tones per tree species

Chapter 5. Discussion

This study showed that there have been changes in forest management and access. These changes caused local community to lose some products that they used to harvest in the forest because they were not provided alternative solutions before forest restoration hence to make forest restoration successful, study site about advantages and limitations has to be made (IRI, 2021) and local community has to be shown the interest of forest restoration so that they get strongly involved (Lamb & Gilmour, 2003).

The loss of forest products for local community when forests are restored has been observed also in other locations and when there is no alternatives provided, the best way local community can use to obtain forest products is to plant their owns (Lamb & Gilmour, 2003). In addition, other findings showed that local community must be provided with skill development trainings and financial support so that they become able to afford renewable or other energy to reduce forest resources dependance (Anup, 2017). However it is very necessary to restore degraded forests for its ecological and socio-economic reasons such as climate change mitigation, fulfilling the needs of people, environment and biodiversity conservation, and maintaining provision of forest ecosystem services (Lamb & Gilmour, 2003; IUCN, 2014).

This research highlighted that the forest is contributing to climate change mitigation through carbon storage, it is estimated to store 885.5 tC ha^{-1}. Nyungwe forest was found to store aboveground biomass equal to 427.7 tC ha^{-1} (Cohn, 2011) and in community forest of Syangja district in Nepal the forest was found to store aboveground biomass equal to 126.3 tC ha^{-1} (Anup, 2017). *Polyscias fulva* had the largest aboveground biomass, it was found to be 398.6 tC ha^{-1}. It is followed by *Syzygium guineense* which its aboveground biomass is estimated to be 199.4 tC ha^{-1}. DBH and age are the most important factors for the storage of aboveground biomass, and we think that is why there is a quit difference among aboveground biomass (Cohn, 2011)**.** In Nyungwe, study conducted by Cohn (2011) showed that *Syzygium guineense ssp* was the one to store largest amount of aboveground biomass, its aboveground biomass was found to be 201.71 tC ha-1.

We have also found the local community perception on types of trees they wished to be planted and other approaches related to forest and landscape conservation. *Grevellia robusta* and *Eucalyptus sps* are among the tree species preferred by local community due to their charcoal, timber, and stakes production. Findings also showed that different activities including putting radical terraces around Sanza landscape, promoting agroforestry, educating people about the practices and the role of forest conservation and native tree species, increasing number of forest guards, and paying them and effective monitoring of planted trees especially native species can be reinforced. This is because integration of people’s preferences and expectations in the decision-making process is a relevant aspect of sustainable natural resources management and it increases the social acceptance of the decisions and reduces conflict among users (Beierle, 1998).

Local community has a symbiotic relationship with the forests; local people may depend on the forest products for generation of incomes, medicinal products, wood, agroforestry, fruits, fuels, and fodder (Agbogidi et al., 2005). Through their traditional knowledge, implementation of different activities such as establishment of economic plantation, afforestation on naked hills, improved of low-yield forest, conservation of forest resources, prevention and control of pests and diseases, and allowing them to get right to manage and enjoy other benefits from the forest local people plays a great role in sustainable management of the forest (Agbogidi et al., 2005). Findings from this research showed that local community wish buffer zone, agroforestry, controlled fodder collection inside the forest, tourism activities and infrastructure promotion because they will help them to manage sustainably the forest thus also improving their livelihood.

Chapter 6. Conclusion and recommendations

6.1. Conclusion

This research aimed at assessing the impacts of Sanza natural forest in increasing resilience to climate change for local community. We found that people benefited from restoration activities from casual labor and beekeeping projects. Beside these socio-economic interests, the forest is regrowing, thus its ecological and ecosystem services will extend at large. However, they are some people who are struggling in finding alternatives to the forest products they harvested before forest restoration when there were not restricted to enter and harvest some forest products.

It has been observed that the forest is recovering due to the activities done by LDCF II project and it is maintaining many plant and animal species and in addition the forest is playing the role in mitigating climate change through carbon storage, we have found that the forest is estimated to store 885.5 t C ha^{-1}. *Polyscias fulva* and *Syzygium guineense* had the largest aboveground biomass.

6.2. Recommendations

Forest restoration activities have been appreciated from the findings in this research and need to be strengthened. However as mentioned by respondents both local community and leaders and from direct observation, they are other activities which may be done to promote Sanza forest ecosystem and local community livelihood. Long-term follow up of restoration activities are recommended to ensure the sustainability. Further studies regarding landscape conservation, land use and erosion modelling should also be carried out in the area.

REFERENCES

Agbogidi, O. M., Ofuoku, A., & Dickens, D. (2005). Role of community forestry in sustainable forest management and development. *Asset Series A*, *7*(October 2014), 44–54.

Anup, K. . (2017). Community Forestry Management and its Role in Biodiversity Conservation in Nepal. In *Intech: Vol. i* (Issue tourism, p. 13).

Aznar-Sanchez, J. A., Belmonte-ureña, L. J., Lopez-Serrano, M. J., & Velasco-Muñoz, J. F. (2018). Forest Ecosystem Services : An Analysis of Worldwide Research. *Forests*, *9*.

Balmford, A., Rodrigues, A. S. L., Watpole, M., Brink, P. ten, Kettunen, M., Braat, L., & Groot, R. de. (2008). *THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY : SCOPING THE SCIENCE*.

Beierle, T. C. (1998). *Public Participation in Environmental Decisions : An Evaluation Framework Using Social Goals Public Participation in Environmental Decisions*.

Bizuru, E., Nyandwi, E., Nshutiyayesu, S., & Kabuyenge, J. P. (2011). *INVENTORY AND MAPPING OF THREATENED REMNANT TERRESTRIAL ECOSYSTEMS OUTSIDE PROTECTED AREAS THROUGH RWANDA.*

Brown, S. (1997). Estimating Biomass and Biomass Change of Tropical Forests. *Fao Forestry Paper*, *134*.

CBD. (2009a). *Forest Resilience, Biodiversity, and Climate Change*.

CBD. (2009b). *Sustainable Forest Management, Biodiversity and Livelihoods*.

Charnley, S., & Poe, M. R. (2007). Community Forestry in Theory and Practice: Where Are We Now? *Annual Review of Anthropology*, *36*, 301–336.

Chave, J. (2005). *Measuring wood density for tropical forest trees* (pp. 1–7).

Cohn, J. (2011). *Variation in above ground biomass in Nyungwe Forest, Rwanda*. *March*, 26.

Dyszynski, J., & Hogarth, R. (2011). *Forests and Tree-based Systems Sector Working Paper* (Issue June).

Elias, B., Elias, N., Samuel, N., & Pierre, K. J. (2011). *National University of Rwanda CONSULTANCY BUREAU (NUR / CB) Université Nationale du Rwanda INVENTORY AND MAPPING OF THREATENED REMNANT TERRESTRIAL ECOSYSTEMS OUTSIDE PROTECTED AREAS THROUGH RWANDA.*

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and

Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*.

FAO. (2004). *Assessing carbon stocks and modelling win–win scenarios of carbon sequestration through land-use changes*. *January*. https://books.google.co.id/books?hl=id&lr=&id=c5gS5HfBZQ4C&oi=fnd&pg=PA1&dq=Raul+Ponce-Hernandez&ots=iZ7f9PpTDA&sig=prM_inihJhj32bO7bM286M01jeA&redir_esc=y#v=onepage&q=Raul Ponce-Hernandez&f=false

FAO. (2010). *Managing forests for climate change*.

FAO. (2020). The state of world's forests. In *Turning Point in Timber Construction*.

Geist, J. H., & Lambin, F. E. (2001). *What drives tropical deforestation?* (Issue 4).

Hales, S., Edwards, J. S., & Kovats, S. R. (2003). Impacts on health of climate extremes. In J. . McMichael, H. . Campbell-Lendrum, F. . Colvalan, K. . Ebi, D. . Githeko, & A. Woodward (Eds.), *Climate change and human health* (pp. 79–102).

IRI. (2021). *Forest Restoration*.

IUCN. (2014). Forest landscape restoration potential and impacts. *Arborvitae*, *45*.

IUCN. (2017). *Enhancing Resilience through Forest Landscape Restoration: Understanding Synergies and Identifying Opportunities*. *November*, 16.

Jallah, C. K., Nortey, D. D. N., Amoakoh, A. O., & Assumadu, R. (2017). COMMUNITY PARTICIPATION IN FOREST MANAGEMENT IN THE BLEIH COMMUNITY FOREST, NIMBA COUNTY, LIBERIA. *North Asian International Research Journal of Multidisciplinary*, *3*(January).

Kirti, A.-W. (2009). *Natural Resources - F o r e s t s*.

Kollert, W. (2017). *Forest Restoration and Rehabilitation*.

Lamb, D., & Gilmour, D. (2003). Rehabilitation and Restoration of Degraded Forests. In *Restoration Ecology* (Vol. 13, Issue 3).

Masiero, M., Pettenella, D., Boscolo, M., Barua, K. S., Animon, I., & Matta, R. (2019). Valuing forest ecosystem services A training manual for planners and project developers. Forestry Working Paper No. 11. Rome, FAO. 216 pp. Licence: CC BY-NC-SA 3.0 IGO. In *Fao*.

MFA. (2018). *Climate Change Profile*.

Michael, J., & Brian, S. (2018). Forest Ecosystem Services. In *Forest Ecosystem Services*.

MINILAF. (2017a). *Forest Investiment Program for Rwanda* (Issue November).

MINILAF. (2017b). *Forest Investment Program for Rwanda* (Issue November).

MINILAF. (2018). *Rwanda National Forestry Policy 2018*.

MINIRENA. (2014). *Forest Landscape Restoration Opportunity Assessment for Rwanda*.

MINITERE. (2006). *National Adaptation Programmes of Actionto Climate Change, NAPA-Rwanda* (Issue December 2006).

MoE. (2019a). Forestry Research Strategy and Guidelines for Rwanda (2018-2024). In *Ministry of lands and forestry*.

MoE. (2019b). *Rwanda Forest Cover Mapping* (Issue November).

Ndayambaje, D. J., & Mohren, G. M. J. (2011). Fuelwood demand and supply in Rwanda and the role of agroforestry. *Agroforestry Systems*, *83*(3).

Nduwamungu, J. (2016). Forest Plantations and Woodlots in Rwanda. In *African Forest Forum* (Vol. 1, Issue December 2011). https://doi.org/10.13140/RG.2.1.1360.4724

REMA. (2009). *REPUBLIC OF RWANDA FOURTH NATIONAL REPORT TO THE CONVENTION ON BIOLOGICAL DIVERSITY RWANDA ENVIRONMENT MANAGEMENT AUTHORITY MINISTRY OF NATURAL RESOURCES* (Issue May).

REMA. (2011). *Guidelines for Mainstreaming Climate Change Adaptation and Mitigation in the Environment and Natural Resources Sector*.

Rurangwa, F. (2017). *FOREST LANDSCAPE RESTORATION IN RWANDA Forest* (Issue December).

Sim, H. C., Appanah, S., & Youn, Y. . (2004). FORESTS FOR POVERTY REDUCTION : Opportunities with Clean Development Mechanism, Environmental Services and Biodiversity. In *Rap publication* (Issue August 2003).

Soto, D., & Bahri, T. (2012). *Building resilience for adaptation to climate change in Proceedings of a Joint FAO / OECD Workshop* (Issue January).

UNFCCC. (2007). CLIMATE CHANGE: IMPACTS, VULNERABILITIES AND ADAPTATION IN DEVELOPING COUNTRIES. In *Earth's Future*. https://doi.org/10.1002/2017EF000539

Yao, R. T., Harrison, D. R., & Harnett, M. (2017). The broader benefits provided by New Zealand ' s planted forests. *NZ Journal of Forestry*, *61*(4), 7–15.

APPENDICES

INTERVIEW QUESTIONNAIRE GUIDE FOR LOCAL PEOPLE

SECTION ONE: IDENTIFICATION OF RESPONDENT

1. **Sex:**
   Male: ☐ Female: . ☐
2. **Age:**
   18-30 ☐
   31-40 ☐
   41-50 ☐
   51-60 ☐
   61 above ☐
3. **Civil status:**
   Single ☐
   Married ☐
   Widow ☐
4. **Household position**
   Head of family ☐
   Spouse ☐
   Family member ☐
5. **Level of education:**
   None ☐
   Primary ☐
   Technical school ☐
   O' Level ☐
   A' level ☐
   University ☐
6. **How long have you been there?**
   < 5 years ☐
   6-10 years ☐
   11-15 years ☐
   16-20 years ☐
   20 years above ☐

SECTION TWO: SOCIO-ECONOMIC IMPACTS OF SANZA FOREST RESTORATION

1. **Which economic activities you used to conduct in Sanza Natural Forest before restoration activities and how much do you gain per month?**

   Farming ☐

   Cattle keeping ☐

   Beekeeping ☐

   Handcrafts ☐

   Masonry ☐

   Mining ☐

   Traditional healer ☐

   Others: (Specify)

   …………………………………………………………………………………………………

2. **Which is your current economic activity and how much do you gain monthly?**
   Farming ☐
   Cattle keeping ☐
   Beekeeping ☐
   Handcrafting ☐
   Masonry ☐
   Mining ☐
   Other (Specify) ☐
   ………………………….

3. **What forest products did you extract in the forest before?**
   Firewood ☐
   Water ☐
   Stakes of beans ☐
   Fodder ☐
   Wild fruits ☐
   Medicinal plants ☐
   Handcraft materials ☐
   None ☐

Other (Mention it)

……………………………………………………………………………………..

4. **What are the forest products that you used to harvest in Sanza before that you do not find easily?**

   Firewood ☐
   Water ☐
   Fodder ☐
   Wild fruits ☐
   Medicinal plants ☐
   Handcraft materials ☐
   None ☐
   Other (Mention it)
   ……………………………………………………………………………………..

5. **Are there any species which have been in the forest, but which are no longer there or under extinction? If yes, which ones?**

   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………

6. **Have you got a job during restoration of this forest?**

   No ………
   Yes ………
   If yes how much did you gain monthly ?.................Rwf

7. **Based on your own opinions, was it necessary to restore the forest? Support your argument**

   Strongly agree ☐
   Agree ☐
   Disagree ☐
   Strongly disagree ☐

8. **What are anthropogenic activities that are threats to this forest nowadays?**

…………………………………………………………………………………………………
…………………………………………………………………………………………………

……………………………………………………………………………………………
……………………………………………………………………………………………

9. **What are your suggestions toward forest management and your livelihood improvement?**

   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

Add any additional comment

GUIDE FOR KEY INFORMANT INTERVIEW

1. What are the reasons for forest restoration?
2. How far are outcomes of restoration activities in terms of expected results?
3. What are the possible means to manage sustainably Sanza natural forest so that both community and ecosystem gain?