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Remote sensing and Community perception evidences on the Impacts of land use/cover change on natural resources in Rungwe Volcanic Province in Tanzania

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Research Article

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Posted Date: September 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10403104/v1

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Additional Declarations: No competing interests reported.

Remote sensing and Community perception evidences on the Impacts of land use/cover change on natural resources in Rungwe Volcanic Province in Tanzania

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Abstract

The study analyzed trends of crop type and land cover/use change in the Rungwe Volcanic Province (Rungwe, Busokelo, Kyela districts) with its impact on natural resources. Survey was conducted in each agro-ecological zones in villages proximal to forests and water bodies. Interviews and LandSat 7^{TM} were used to gather community's information and land-use images. Information were analyzed based on categories and magnitudes of change, findings showed that, population was growing due to high birth rate and immigration. Immigrants were attracted by coal mining and cultivation of avocado, Irish potatoes and pyrethrum in the highland and midland agro-ecological zones while horticulture, cashew, ginger, cocoa, palm oil, rice and fishing in L. Nyasa with associated petty businesses in lowland agro-ecological zones. Forests were previously used for traditional services and firewood collection, but currently are used for cultivation, charcoal making, timber harvesting and settlements. 75% respondents in the highlands and midland revealed that river water levels were decreasing, while downstream L. Nyasa water level was increasing owing to increased sediment load (51%) resulting from upstream agricultural expansion on forests and wetland areas. Crop yield was decreasing (76.9% respondents) in the lowland agro-ecological zones owing to declined soil fertility, prolonged drought and unreliable rainfall. Community perceptions and satellite images revealed that, land-use/cover change was a result of agricultural and settlement expansion. However, trends differed with administrative area, Kyela and Rungwe experienced higher land-use change, necessitating community awareness raising on ecosystem management, land use plans and assessment of river hydro-morphology responses to land use/cover change.

Key words: Land-use change, Crop yield, River water level, L. Nyasa water level, Population growth

INTRODUCTION

Background Information

Increasing population growth and the rate of development often impact land conversion [1]. The global population depends on mineral and agricultural products sourced from tropical forests, driving land use changes with widespread impacts to biodiversity, food-security, and forest integrity. Land use change is thus the result of decisions taken by farmers, collectives, and institutions with different cultural backgrounds who are influenced by social and market relations at local and global scales [2]. Land conversion results from population pressure on land, indicating

that there is a role for the community, both on a specific scale and in general, that affects the sustainability of land availability and natural resources [3]. This eventually increases the frequency and magnitude of flooding in the rainy season and water shortages in the dry season, affecting agricultural production activities and river and lakes water levels. Flood disaster actually stems from the soil being eroded by water and then landslides mixed with water, flowing to erode weak riverbeds and cliffs [4]. Thus, widening river banks and increases sediment loads with eventual decreasing lake's water depth and spread of lake's water into terrestrial land in the lowland areas.

In Africa, hundreds of millions of poor and marginal farmers rely on degraded land and water resources and struggle to cope with a diverse array of agro-climatic, production and market risks. The world is rapidly converting forest, wetlands and other critical habitats into agricultural land to meet growing demands and diverting major rivers to produce food [5]. How to produce more and better food and maintain or improve critical ecosystem services without further undermining our environment is a major challenge. Under such a scenario, the challenge is to manage land and water sustainably to achieve higher productivity levels, husband resources for future generations, and derive livelihoods in the most equitable manner possible. These are laudable goals; yet, specific management options must focus at the level of what is practical. Thus, comprehensive and holistic analysis of souring landscapes in the various agro-ecological areas became imperative in most tropics.

Highland agroecosystems do provide major biodiversity, water and food resources in more than 35 tropical countries, however the biophysical response of tropical highlands to climate variability and to economic and demographic trends remains sparsely documented and understood [6]. Tropical montane ecosystems are threatened by land use pressures, which compromises their capacity to provide ecosystem services and the local patterns and interactions among anthropogenic and biophysical factors shape the socio-ecological system while the analysis of landscape changes and their driving forces is often qualitative and sector oriented.

[7]. This is the case in eastern and central Africa, where a complex mosaic of highland landscapes and agroecosystems is nested along contrasted geological, climate and socioeconomic gradients. Rungwe Volcanic Province (RVP) is one of the eastern Africa highlands in the southern highlands of Tanzania facing the impact of interacting climate, ecosystem and social divers over highland resources which is linked to the lowland resources' availability and flooding dynamics in Kyela district and Lake Nyasa/Malawi downstream.

The rainfall and hydrology of the region is firstly controlled by the 3000 m elevated SE-NW rift escarpments, and by the topographic 'lock' posed by three main volcanic centers (Rungwe, Mporoto and Kiejo) at the triple junction between the Malawi, Rukwa and Usangu rift basins [8]. South of the RVP, is the large open water body of Lake Nyasa/Malawi (478 m.a.s.l.) which acts both as a reservoir and source of moisture for highlands through land/lake breeze effects and orographic lifting [6]. The soil hydrological properties and the soil fertility also follow the geological and orographic frame. The upper zone of Precambrian escarpment rocks and volcanoes, near the wetter and forested areas, strongly contributes to the recharge of the regional underground aquifer. It is generally covered by young volcanic soils providing a highly fertile and favorable environment for agriculture [8]. The transitional zone consists of older, poorly permeable and cation-depleted weathered materials prone to desiccation during dry season and flooding during rainy season [1]. The lower alluvial plains of Lake Nyasa/Malawi (southern RVP) directly depend on water and sediment inputs from the upper and transitional zones and are intensively cultivated and irrigated [9].

The seasonal distribution of temperature and rainfall with altitude confirm a shorter duration of the rain season and lower annual rainfall amount in the warmer flood plain and the systematic and regular decline of the Lake Masoko level (around 10 cm yr^{-1}) has been reported [6], associated with a delay of the rainfall onset, pointing to a continuous decrease in local water availability. The L. Masoko drop corresponds to a trend toward drier conditions, illustrated in altitude (Tukuyu) by an almost 30% decrease in total rainfall over the last 35 years, along with a longer dry season [6].

Agriculture is the main socio-economic activity of the RVP area; cropping is developed from the upper wet to the lower alluvial soil end for subsistence and commercial purposes. Decreasing tree cover and increased density of farms have been reported along the entire climate sequence of RVP [10]. It occurs along with the disappearance of initially 4 - 5 years' fallows and the consecutive loss of soil nutrients and food production with the development of livestock keeping and cultivation expansion around lakes, river shores and springs, which increases soil erosion, biodiversity loss and the risk of schistosomiasis infection [6][11].

Conversion of forest into cropland is associated with a devastating loss in carbon stock [12], reduced rainwater infiltration into soil and increased runoff, soil erosion and rates of land/mud slides in highlands. Tapping of river water in the mid altitude zones of the climate sequence (above

1200 m) is increasingly undertaken to supply the growing demand of water for irrigation during dry season. Taken together, land use practices and land pressure over the main end-members most likely contribute to the depletion of water resources across the climate sequence, amplifying a trend toward drier conditions. The combined impacts of warming (currently 0.4 °C per decade in the Mbeya region [13], as well as the increased socioeconomic and demographic trends have resulted in a general fragmentation of agroecosystems, associated with a shift toward higher altitudes of the main crops.

These environmental, land use and socioeconomic dynamics calls for a comprehensive understanding among researchers, leaders, stakeholders and communities in the area on the current situation of the resource and land use management and collaboratively agree for the future researches, management of natural resources and watersheds in Rungwe Volcanic Province, i.e Rungwe, Busokelo and Kyela districts.

METHOD AND MATERIALS

Description of the Study Area

Rungwe Volcanic Province comprises three administrative districts of Rungwe, Kyela and Busokelo located in Mbeya Region's southern end. Mbeya region is located in southwestern Tanzania. Busokelo district is located at the latitude of 8^0 30'E 9^0 30'S of equator and longitudo 33' and 34' east boarded by Kyela district in the south, Rungwe district in the west, the Makete district in the east and Mbeya Rural district in the north. Kyela district lies between 35º 41º and 30º longitudes East of Greenwich meridian and 9º 25º and 9º 40º latitudes south of Equator. Kyela borders with Makete district and Ludewa district of Njombe region in the east, Ileje district in the west and Rungwe district in the North. On the south of the district, Kyela borders with Lake Nyasa and the republic of Malawi (Figure 1).

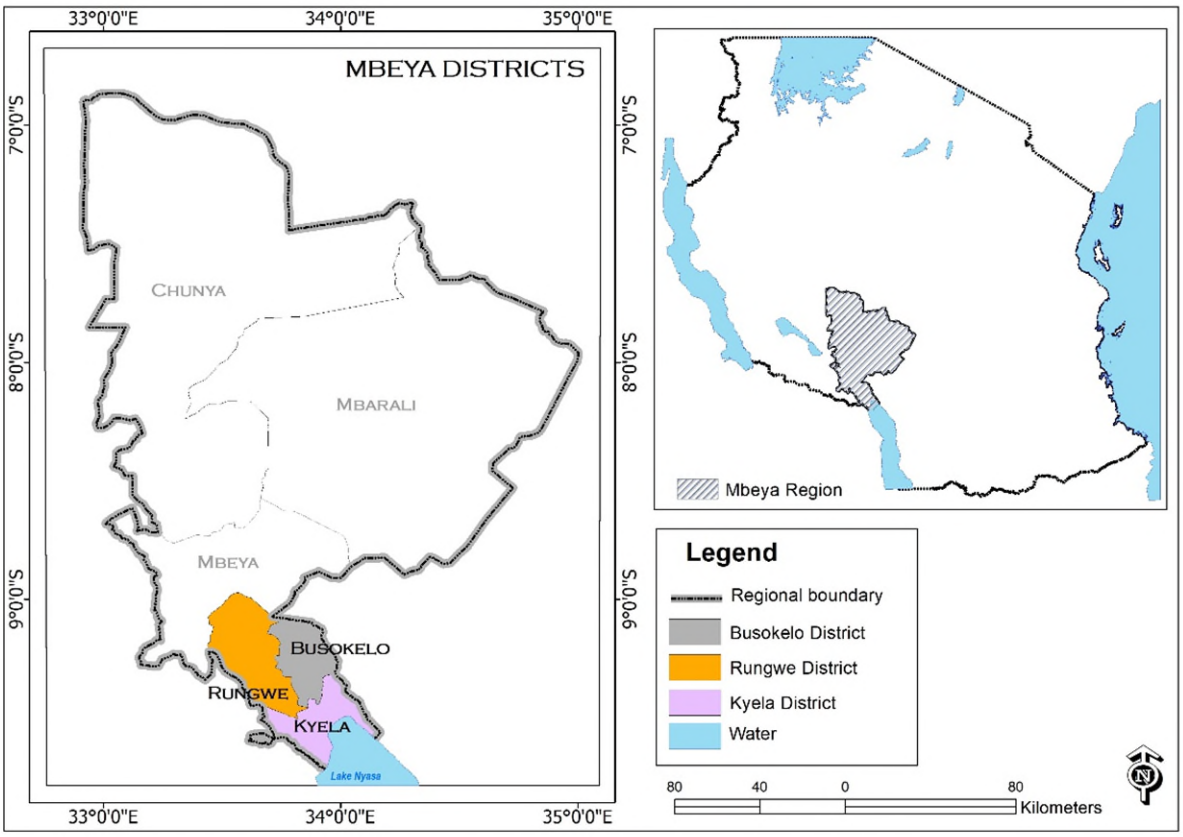


Figure 1: Map of Mbeya region showing Rungwe, Busokelo and Kyela districts

Data Collection procedures

Mixed approach and an action-research approach were used, cluster sampling using agro-ecological zones were used to select the areas to be involved in the study ensuring the coverage of different agro-ecological zones in the study area with different environmental conditions, vegetation cover and crop types. Each district was divided into three agro-ecological zones comprising highland, midland and lowland agro-ecological zone as established with the respective district administration, in which wards and villages were selected based on; (i) closeness to the natural forest (i.e. village forest reserve or national forest reserve) (ii) proximity to the water body (i.e. river, swamp or lake) (iii) experience of environment catastrophe like flooding, landslide and (vi) wards with uniquely different economic activities to the rest of other wards such as fishing activity in Kyela district. Therefore, the selected wards in Rungwe district were Swaya, Suma and Kisiba while in Busokelo district were Luteba, Lufilyo and Kisegese and in Kyela district were Ngana, Ndobo and Matema. Proportional technique was used to identify sample size from which

a participant in each village was selected for an interview. Key informant interview were purposefully sampled based on their expertise on the matter at hand, community representatives, ward and village leaders and religion leaders. Satellite images of 30 years with an interval of 10 years were established by using Landsat TM satellite images.

Data Analysis

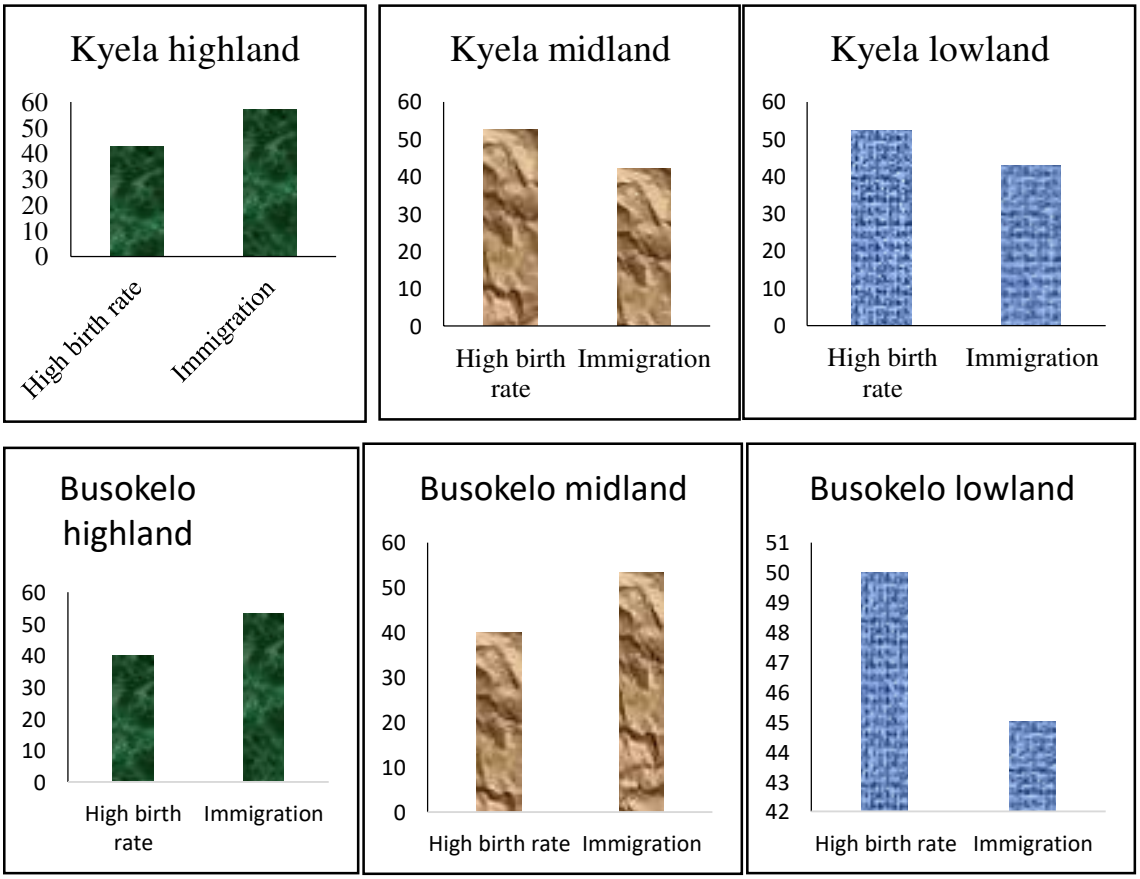
The gathered data were coded and entered into SPSS Version 25 software for analysis. Due to the nature of questions and different answers provided. Priority of matrix were used to give weight and significance of the proposed challenges and solutions in Key Informant Interviews. Internal consistency check was performed and assessed using both Kuder-Richardson Formula 20 (KR-20) and Cronbach's alpha to measure internal consistency reliability of questions and responses. Data were analyzed through pattern analysis as the first and an important step to test the results framework. Landsat TM satellite images using Thematic Mapper ™ sensor were used to analyse the land use/ cover change over 30 years with an interval of ten (10) years comprising 2000, 2010 and 2020 years and the magnitude of change was calculated in kilometer squares.

Results and Discussion

Demographic information of the study area

The main ethnic groups existing in the study areas of Kyela district were Nyakyusa (90.9%) which is the native tribe in the area, Ndali (5.6%), Fipa (1.1%) and Kisi (2.4%) while in Rungwe and Busokelo district majority were Nyakyusa (99%), the native tribe with 1% other tribes who were governmental employees. All respondents in the three districts agreed that the population in the study area was increasing over time responding to the higher birth rate (48%) and immigration (45%) from nearby regions of Njombe, Iringa, Ruvuma and Songwe and neighboring countries of Malawi and Zambia. Majority of immigrants (70%) in Kyela district followed agricultural production of rice, cocoa and palm oil (35%), fishing activities (10%) in Lake Nyasa and the associated agri-business (50%) activities while in the lowland agro-ecological zone of Rungwe district, 30% of immigrants followed agricultural activities of avocado, pyrethrum and horticulture farming. Likewise,51% of respondents said, immigrants in lowland agro-ecological zone of Busokelo district followed agricultural production of cocoa, rice/paddy irrigation, horticulture farming and 25% petty businesses of agricultural products.

Higher ethnic diversity was observed in Kyela district where majority (80%) in the lowland agro-ecological zone and 57% in the highland agro-ecological zone were engaged in rice and cocoa production as well as 20% in the lowland agro-ecological zone and 10% in the highland agro-ecological zone were engaged in petty business as a result of higher rice and cocoa production and market price which in turn attracted various business activities. In the Lake Nyasa shore, majority (46%) migrated to the area for fishing activities and potting business that eventually contributes to the higher population growth in the area. Higher immigration has been observed in Kyela and the lowland of Busokelo districts, however according to the respondent's perception, higher birth rate still contributes a lot to population growth in the study area especially in the midland and lowland of Kyela and Rungwe districts and the lowland of Busokelo district (Figure 2).



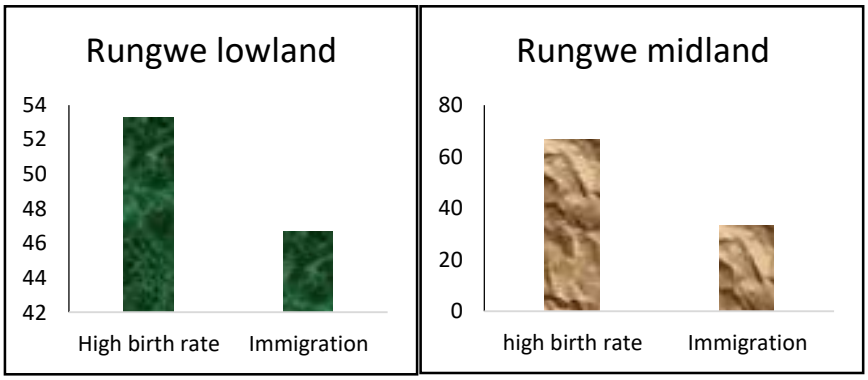


Figure 2: Causes of population growth in Kyela, Busokelo and Rungwe districts (%)

The observed population increase in the three districts corresponds with the overall Mbeya region population growth rate which is increasing over time such as between 2002 and 2012 census the growth rate was 2.1 and between 2012 to 2022 the growth rate increased to 3.2 [14] and corresponds with [15]. However some ethnic groups mentioned in socio-economic and investment profiles were missing whom might be concentrated in urban areas.

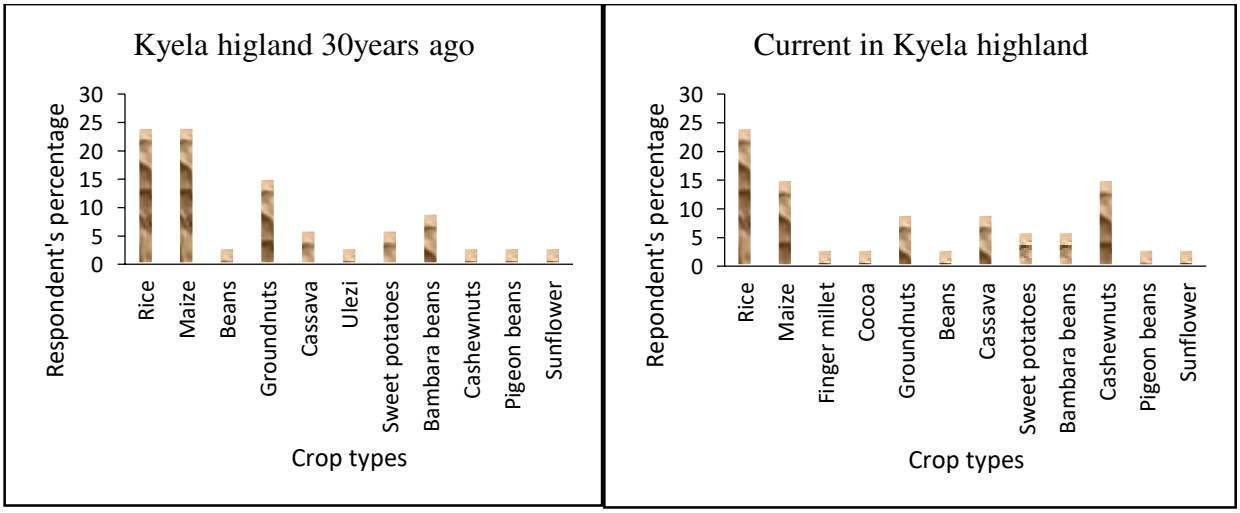
Higher population in the area increases more demand to natural resources such as land, water, energy and food acquired through land clearance for settlements, crop cultivation, irrigation and intensive harvesting of natural resources like fish and forestry products. Similar situation was revealed in Busokelo, Rungwe and Kyela districts where clearing of forest land, marshes, riverine vegetation and grassland for crop cultivation is a growing concern, exposes more land to agents of soil erosion, taking more fertile surface soils into valleys and rivers which in turn results into river and lake siltation reducing lake and river water depth, rainwater infiltration, groundwater recharge and increases the intensity of land/mud slides in the highlands, flooding and spread of lake water into terrestrial and residential land in the downstream areas. Demographic pressure transforms natural habitats and rural landscapes, often leading to deforestation, fragmentation of productive farmland, and rapid, uncoordinated urban sprawl [16], which increase demand for land for cultivation impacting negatively on forest land and grassland. Farming activities on the steep slopes using poor agricultural practices increases risks to landslides and soil erosion [17]. Population growth and local immigration drive significant land use change by escalating the demand for settlements, infrastructure, and agriculture.

Crop Production and Management

Crop production and Management in Kyela district

Communities in the study areas of Kyela district used to cultivate various crop types for the past 30 years, the choice of crops was based on the quality of the crop, the use of the crop and farmer's preferences. Most respondents (73%) said, major crops used to be grown in the highland agro-ecological zone were rice (25%), maize (24%), groundnuts (15%) and ground beans (9%). Currently, 25% of respondents reported that rice cultivation is still practiced, followed by 45% maize, 15% groundnuts and 15% cashew nuts. Cashew nuts cultivation is gaining popularity as a cash crop in the highland agro-ecological zone due to its increasing market demand and favorable warmth environmental conditions which can be associated by increased temperature due to climate change.

In the midland agro-ecological zone, 28% of the respondents said used to grow rice, 17% maize, 23% banana,15 palm trees and 17% cocoa while the current crops grown were 21% of respondents said rice, 19 % maize, 10% banana, 17 palm trees and 33% cocoa (Figure 3) while in the lowland agro-ecological zone especially in Matema ward in Ikombe village, majority (61%) used to grow cassava followed by millet (28%). However, millet cultivation has been currently abandoned, majority (75%) are cultivating cassava for food, followed by rice (17%) in the valleys of lower slopes of Livingstone Mountain.



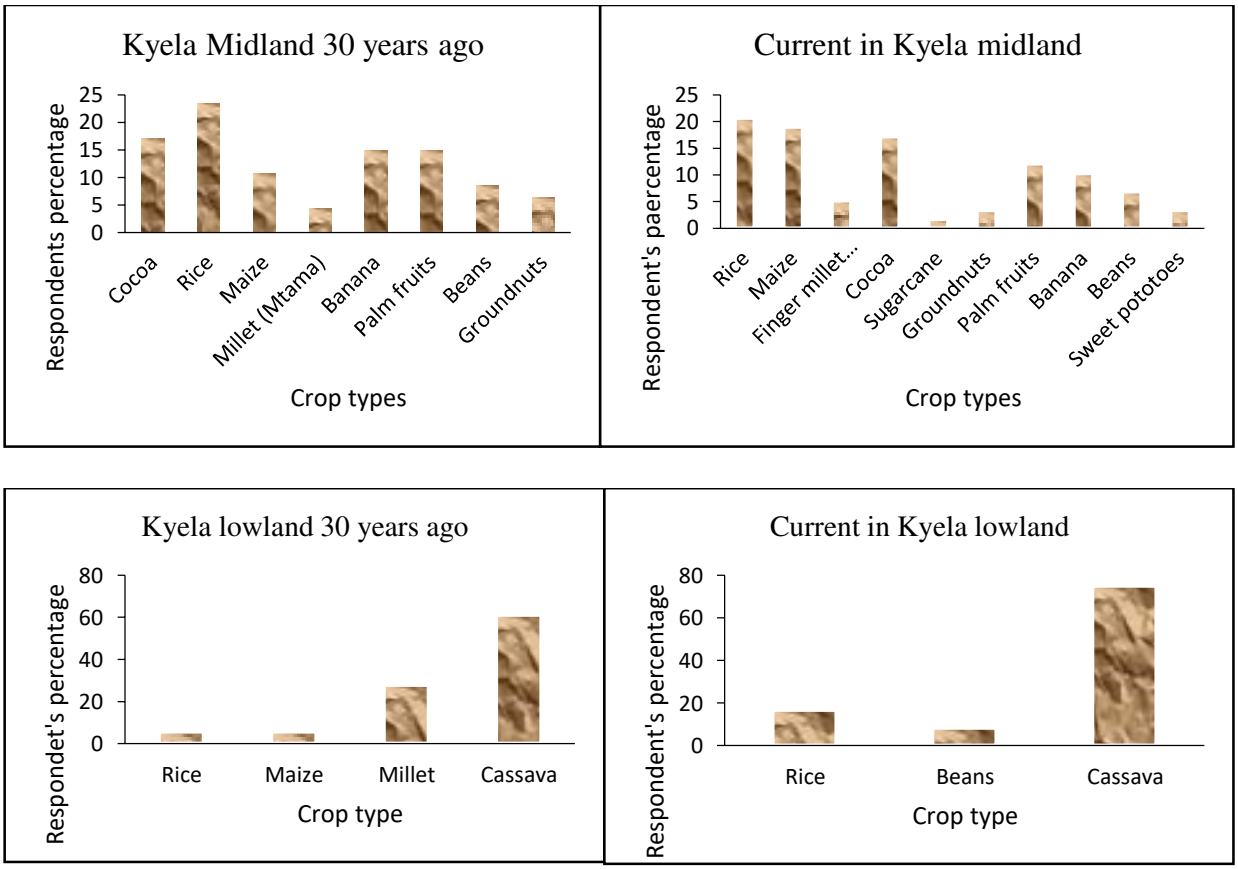


Figure 3: Dynamics of major crops over a period of 30 years in Kyela district

The observed reduction of banana cultivation and preferences among communities was mainly due to the increased market demand of cocoa as a cash crop which its current higher prices has stimulated majority of the smallholder farmers to plant cocoa in most of their lands which was used for intertwine banana and cocoa growth. Likewise, the abandonment of millet in the lowland (Ikombe ward), was due to its low market price and people's preference as food crop as compared to cassava.

The current growing trend of rice, cocoa and maize production demands more land from wetlands and forest lands. Clearing and burning of vegetation for establishment of new farms in forests and wetlands, removes most of the vegetation cover which were previously slowing down surface water flow during flooding and enhancing infiltration and groundwater recharge. Thus, clearing of the vegetation has exposed soil to runoff and erosion which ultimately removes the fertile surface soil and arguments the speed of surface water runoff, reducing infiltration rate and groundwater recharge in highlands and increasing sediment transport in rivers and lakes downstream which in

turn reduces river and lake's water depth and increase flood intensity in the lowland areas. As a result, most of the rivers upstream changes into seasonal rivers due to low groundwater recharge rates and augments the flooding intensity and Lake's water spread in the lowland areas during rainy seasons.

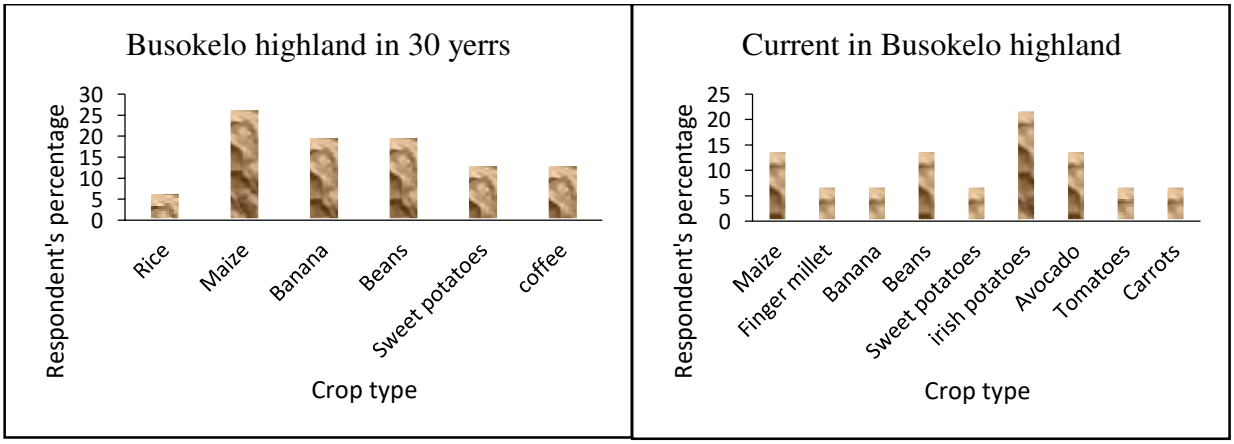
On the other hand, the use of pesticides in rice farms which ultimately ends up into rivers and the lake, threatens human health and the survival of aquatic organisms that may lead into prevalence of non-communicable diseases to human and aquatic biodiversity loss. Communities in the study area of Kyela district perceived that crop production per hector is decreasing over time, majority (76.9%) said, the decrease of crop production in the midland and lowland agro-ecological zone were mainly caused by unreliable rainfall, (45.5%) decline in soil fertility, (18.2%) increased use of pesticides which kills the soil organisms used for decomposition of organic matter, 9.1% prolonged drought and 9.1 % intensive flooding. Similarly, in the highland agroecological zone, most of respondents (62.5%) reported that crop production is decreasing, caused by decline in soil fertility (57.1%), prolonged drought (28.6%) and unreliable rainfall (14.3%). Contrary to the highland and midland, the lowland areas where fishing is the main livelihood activity, crop production is not really perceived as decreasing (40%) or increasing (40%). These findings reveal that, according to community's experience in crop production, the main reasons to the reduced crop production in Kyela district is the unreliable rainfall and reduced soil fertility.

Crop production and Management in Busokelo District

Respondents in the highland agroecological zone of Busokelo district responded that, maize (27%), banana (20%), beans (20%), sweet potatoes (13%) and coffee (13%) were the main crops grown in the past 30 years ago, however currently, there has been introduction of new crops including Irish potatoes (22%), hybrid species of avocado (14%), carrots (7%) and tomatoes (7%) which are the main cash and food crops (Figure 4). Based on these findings, coffee crop has gradually been abandoned due to its low and unreliable market price as compared to newly introduced Irish potatoes and avocado fruits. Tomato farming in the valleys of highlands of Busokelo district where it used to be very cold is an indication of increased temperature that currently favors the growth of medium temperature crops, signifying the positive impact of climate change and increasing community's resilience to the impacts of climate change. Likewise,

introduction of Irish potatoes, hybrid avocados and carrots increases individual resilience to the impacts of climate change on agricultural production.

Respondents from midland agroecological zone of Busokelo district said major crops in previous years were maize (29%), beans (23%), cassava (10%), rice (8%), banana (8%), and finger millet (7%), but the current main crops are maize, cocoa, rice, beans and palm fruits (Figure 4). The increased temperature in the area and the higher market demand of cocoa and palm oil favoured the current growth of cocoa and palm trees in areas where previously were not grown due to cold climatic conditions, thus, increasing crop diversification to communities and resilience to the impacts of climate change. In the lowland agro-ecological zone, there was no shift in crop types but an introduction of sunflower as a new crop and increase in cocoa, rice and palm trees cultivation while decreasing in maize and banana production and abandonment of finger millet production. The main reasons for the increased cocoa and palm production were its highest market demand and introduction of hybrid species of rice and maize supported by the establishment of irrigation system in Kisegese ward.



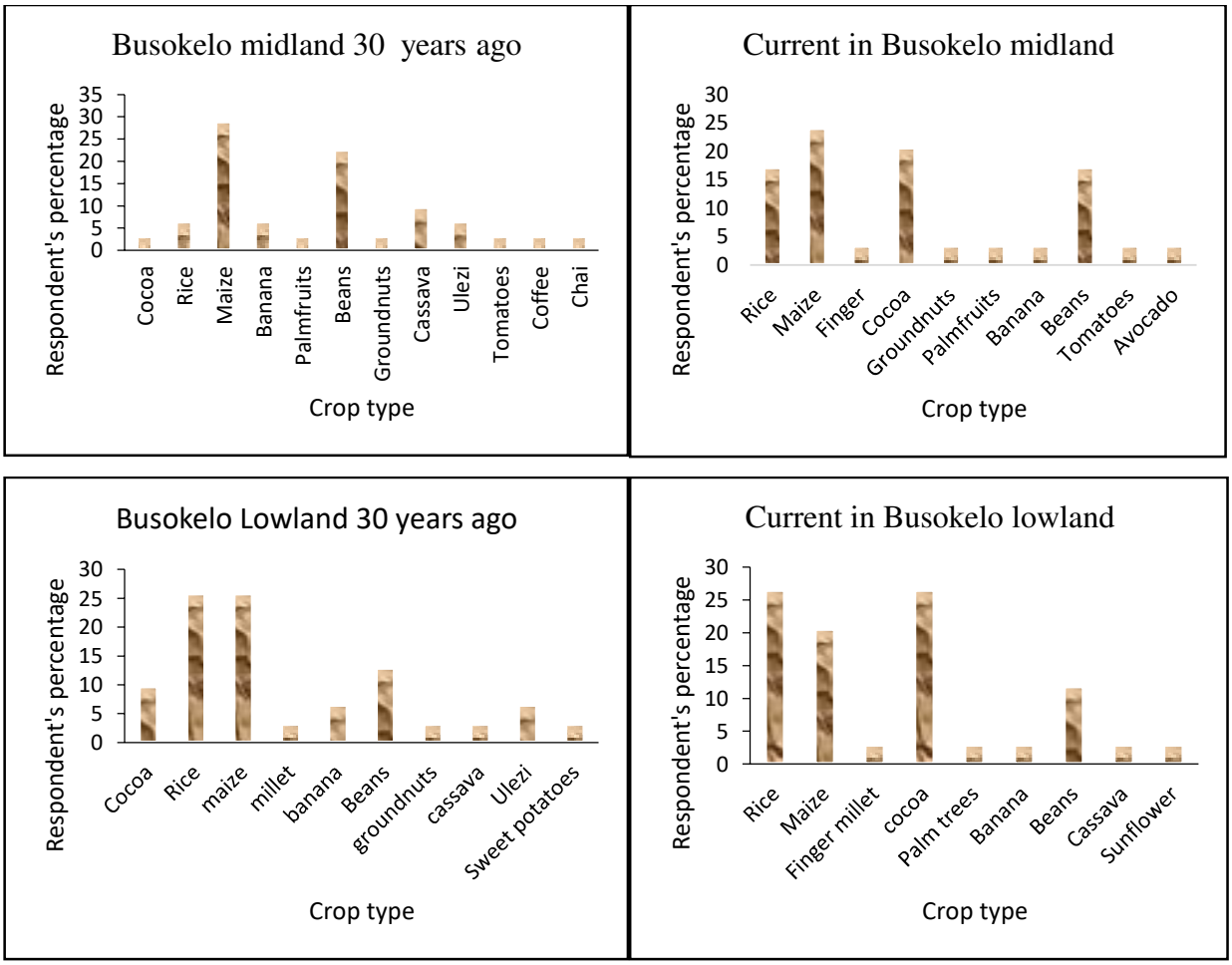


Figure 4: Dynamics of major crops over a period of 30 years in Busokelo district

The trend of crop production in Busokelo district is perceived as increasing by majority of respondents (87.5%) in all agroecological zones as compared to the previous years due the current use of fertilizers and pesticides accompanied with new hybrids of maize that tolerate the changes in climate. However, in the lowland agroecological zone, 36.4% of respondents said crop production is decreasing over time, caused by decline in soil fertility (33.3%) and unreliable rainfall (22.2%) in the upland farms. Thus influencing more land clearance uphills for fertile soil and river banks encroachment for soil moisture that strongly threaten the sustainability of the aquatic and forest biodiversity and groundwater recharge. This trend exposes river banks to erosion and collapse while uphill cultivation accelerates land/mud slide during rain season resulting in increasing river bank abrasion and sediment transport, reducing river and lake water levels, river widening and soil fertility loss in the area.

Crop production and Management in Rungwe district

Most of the respondents in lowland agroecological zone of Rungwe district said they used to grow maize (32%), beans (24%), banana (16%), groundnuts (8%), rice (8%) and Cardamon (4%) however, currently there is an increased production of hybrid avocado, cocoa, rice and ginger which has higher market demand (Figure 5). Likewise, the main crops grown in previous years in the midland agro-ecological zone were maize (35%), banana (29%), beans (18%), groundnuts (6%), cassava (6%) and tea (6%), but currently there was an introduction of market demanded crops including Irish potatoes (21%) and new hybrid of avocado (13%) while the production of maize and banana was decreasing over time (Figure 5).

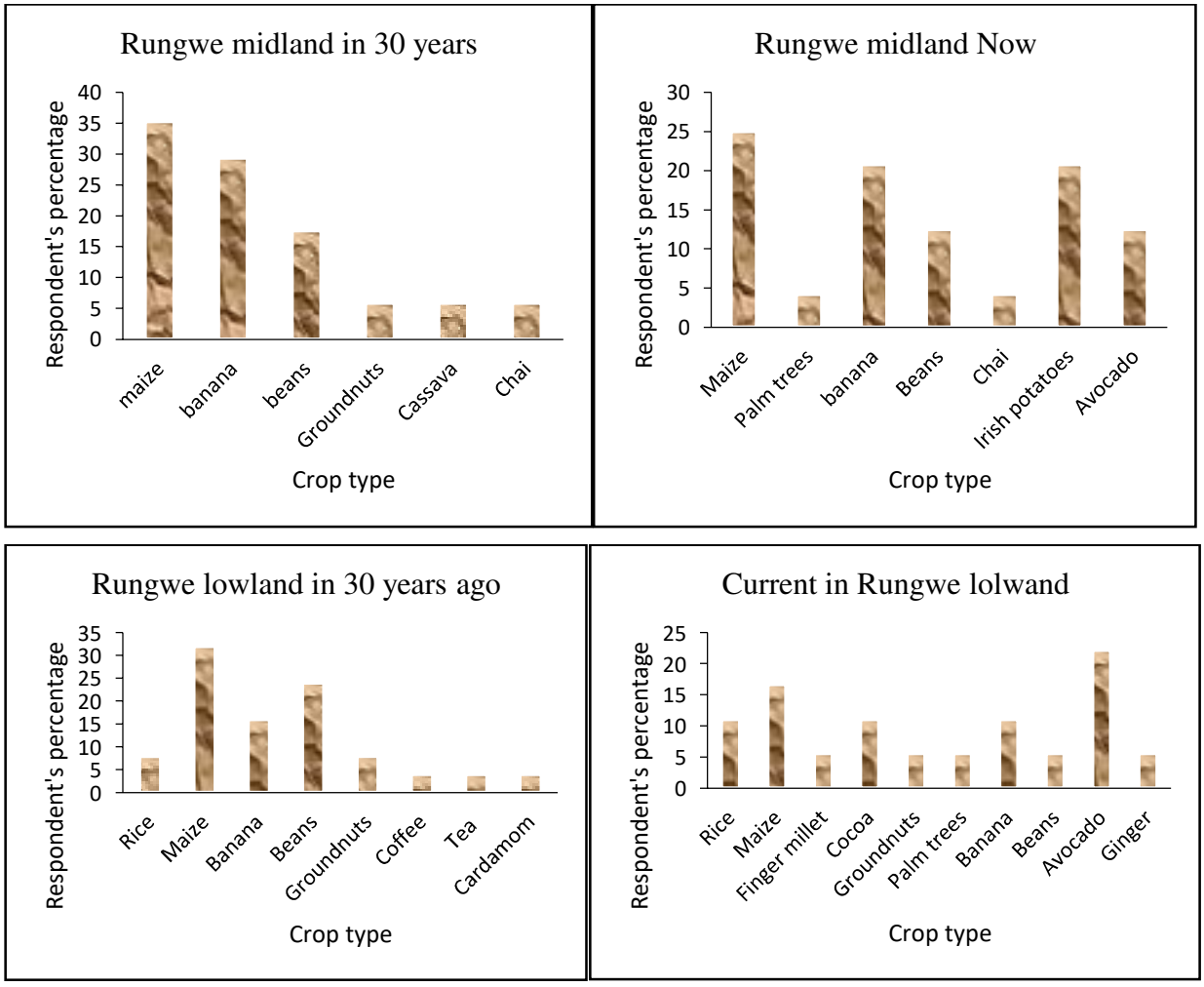


Figure 5: Dynamics of major crops over a period of 30 years in Rungwe district

Most respondents (75%) in lowland agro-ecological zone of Rungwe district perceived that crop production was decreasing while 71.4% of respondents in the midland said crop production was was increasing. Reasons for the declining in crop production in the midland were decreased in soil fertility (46.2%), unreliable rainfall (23.1%), increased pests and crop diseases (15.4%), intensive flooding (7.7%) and long drought (7.7%), while the increased crop production in the midland was due to the use of fertilizer and pesticides (50%).

The observed findings corresponds with the fact that, agricultural expansion remains one of the primary drivers of vegetation loss both in forests and wetlands globally, particularly in developing countries where population growth increases demand for food and agricultural land [2]. However, most mountain communities practice diversified farming systems that integrate crops, livestock, and trees which in turn help to maintain soil fertility and ecological stability, but commercialization and market integration have encouraged specialization in high-value crops such as coffee, tea, vegetables, and fruits, often at the expense of traditional food crops [18]. The introduction of new cash crops and crop diversity in Rungwe Volcanic Province has improved household incomes [19], but has also reduced native crop diversity such as loss of finger millet and dwindling of banana production and banana diversity in the lowlands of Kyela and Busokelo districts in expense of cocoa, palm and rice production while in the midland agro-ecological zone of Rungwe district, coffee production is decreasing in expense avocado and ginger production. The loss of genetic diversity reduces the resilience of farming systems to climate variability, pests, and diseases and increase farmers' vulnerability to market fluctuations and environmental shocks [20] due to environmental degradation led by agricultural expansion and un-managed production methods as well as the impacts of climate change.

Forest and Water Sources Management

Forest and water sources Management in Kyela District

Forest resources in Kyela district were mainly found in the highland agro-ecological zone, basically in two wards of Busale and Ngana wards (Kyela District Investment profile, 2019). The main village forest reserves in Ngana ward were Kabulu, Lolela, Nkabha and Kigali while in the lowland, Ikombe ward were Sosomala and Njungubili village forest reserves. Residential and farm's distances from forests varied with places, 85.7% of respondents in Ngana ward and 81.8% in Matema ward said residential areas were beyond 60 m from village forest reserves. Majority of

the respondents said, village forest reserves were primarily used for traditional services (49%) and firewood collection (51%) in the past 30 years ago, but currently are used for coal mining (35%), charcoal making (25%) and 25% crop cultivation in Ngana ward while in Matema ward, 75% of respondents said forests were used for crop cultivation and tree harvesting for fishing canoe making.

The surveyed villages in Kyela district were close to Lufilyo river and L. Nyasa in the lowland agroecological zone while in the highland agro-ecological zone were close to Songwe and Kiwira rivers. Majority of the respondents (75%) in highland greed that residential areas were within 60 m away from rivers and 61.5% of respondents said they had homes within 60 m away from the river in the lowland agro-cological zone. Similarly, 62.5% of respondents in highland and 69.2% in the midland said crop farms were within 60 m away from the river banks. On contrary, the lowland agroecological zone, 63.6% of the respondents' said farms were beyond 60 m away from L. Nyasa. Consequently, most of the respondents (37.5%) in the highland and 61.5% in the midland agro-ecological zones perceived that river water levels have been decreasing over time, contrary to the lowland agro-ecological zone where, most of fisheries community (63.9%) perceived that Lake Nyasa's water level was increasing over time. The main cause of the decreasing river water levels as perceived by 75% of respondents in the highland agroecological zone was due to crop cultivation along river banks and 25% of respondents land/mud slides in the highlands, similarly in midland agroecological zone, respondents perceived that river water was decreasing over time due to river bank's soil erosion, 44.4% by cutting down trees and 22.2% by low rainfall. Indicating that, river water levels in the study area has been decreasing as a result of encroachment for crop cultivation and settlements which ultimately amplifies the intensity of soil erosion and sediment transfer into river water while weakening river banks and augmenting sediment load in rivers and L. Nyasa waters downstream.

The community perception on the use of natural village forest reserves and water bodies encroachment for crop cultivation and settlements corresponds with the established land cover/use change LandSat images over 30 years with an interval of 10 years (2000, 2010, 2020) in Kyela district (Figure 6 & 7).

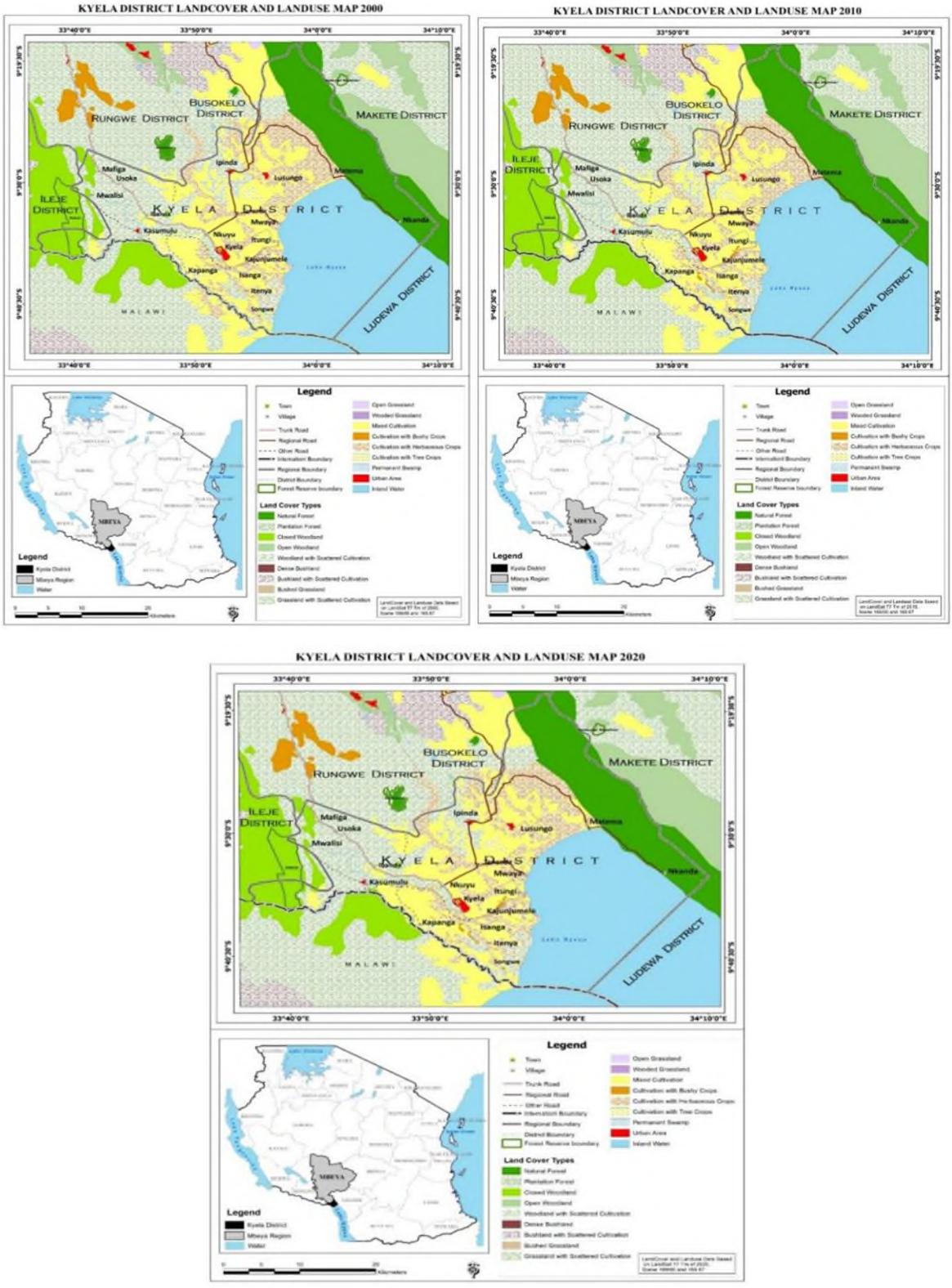


Figure 6: Land cover/use change over a period of 30 years in Kyela district

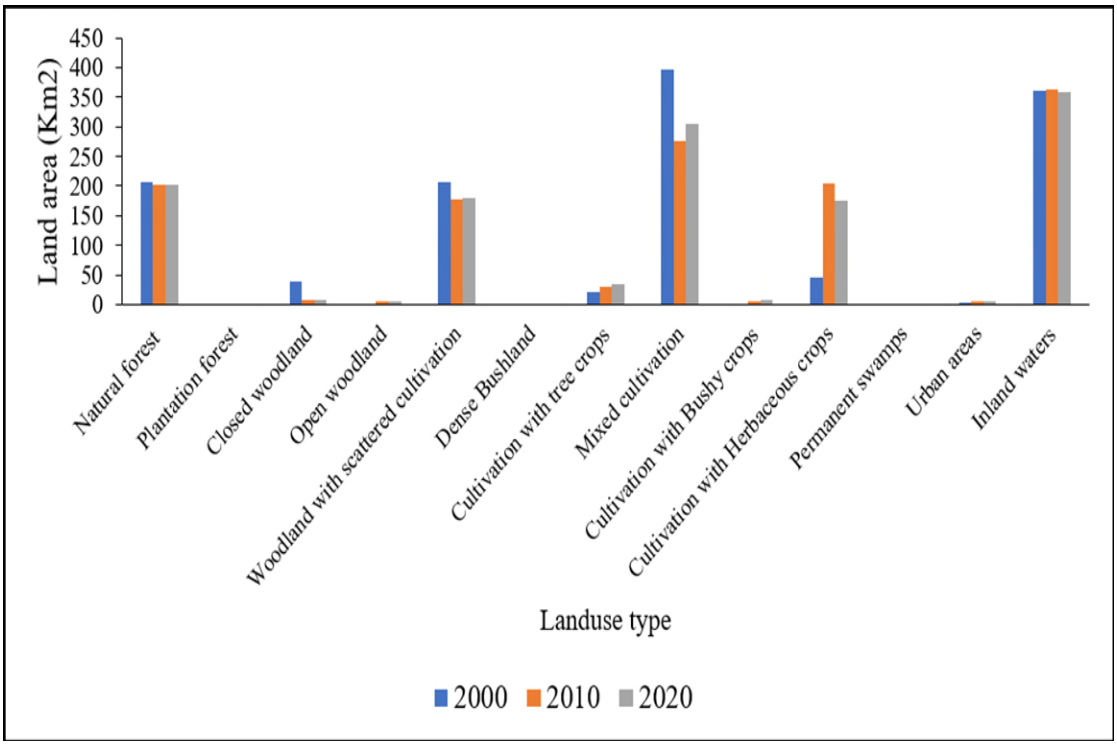


Figure 7: Trend of Land cover/use change over a period of 30 years in Kyela district

Major land cover change has been observed in Kyela district over a period of 30 years, the closed woodland has been reduced by 78.4%, open woodland increased by 94.5%, cultivation with tree crops increased by 40%, cultivation with bushy crops increased by 87.4%, cultivation with herbaceous crops increased by 73.4%, urban areas increased by 52.0%, permanent swamps reduced by 35.5% and inland waters decreased by 0.42% from year 2000 to 2020. Indicating that, most of the land with closed woodland and permanent swamps has been converted into cultivation and settlements, revealing a continuation of land cover change from one category into another such as conversion of closed woodland to open woodland, open woodland to cultivation with bushy trees, to cultivation with herbaceous crops and then crops alone.

Forest and water sources Management in Rungwe and Busokelo districts

Village forest resources in Rungwe and Busokelo districts were found in all agro-ecological zones, the highland was bordered with Rungwe mountain forest reserve in the north-east, Mporoto forest reserve in the Nort-west and to the East was Livingstone Mountain ranges. Respondents in all agro-ecological zones reported that, residents and crop farms were beyond 60 m from village forest reserves. The village forest areas were primarily being used for traditional services (50% of

respondents) and firewood collection (25% of respondents) in the highland and midland agro-ecological zones in the past 30 years ago while currently 25% of respondents said forest reserves were used for traditional services, 25% firewood collection, 25% charcoal making and 25% timber harvesting. In the lowland of Rungwe district, majority of the respondents (66.7%) said forest were used for traditional services, 16.6% for firewood collection and 16.7% for crop cultivation, but currently 33.3% of respondents reported that forests were used for traditional services, 33.3% for crop cultivation while 33.3% of respondents declared that there was no more village forest reserves in their villages. Most of the respondents (75%) in the lowland agro-ecological zones of Busokelo district reported that, forests were previously used for traditional services and 25% for firewood collection while currently 11.1% of the respondents reported that forests were used for traditional services, 11.1% for animal grazing, 11.1% for charcoal making, 55.6% crop cultivation and 11.1% said there was no more village forests in their villages.

In the highland agro-ecological zone, majority (100%) said had their homes and farms beyond 60 m from the river. Most of the farms in the highland agro-ecological zone were on the hills as compared to the midland and lowland. This might be the reason why most farms were beyond 60 m from rivers. In the midland and lowland agroecological zones, 55% and 61% of the respondents respectively reported that settlements and crop farms were within 60 m from the river banks. Consequently, 75% of respondents in the highland, 66.7% in the midland and 100% in the lowland agro-ecological zone, perceived that river water levels were decreasing over time as result of 33.3% reduced rainfall, 33.3% cultivation along river banks, 33.3% increased sediment load in rivers, and 25% diversion of river water into rice farms used for irrigation.

Crop cultivation in river banks in the highland and midland agroecological zones exposed river banks to soil erosion during rainy seasons which ultimately ends into rivers and to the L. Nyasa downstream, reducing the rivers and Lake's water level and thus augmenting the Lake's water spread into residential and crop farms along coastline areas of the lake in Kyela district. The observed community's perception on the reduced riparian vegetarians due to expansion of human settlements and crop cultivation corresponds to the findings of the land use cover/use change observed over a period of 30 years (2000, 2010, 2020) using satellite images in Rungwe and Busokelo districts (Figure 8 & 9).

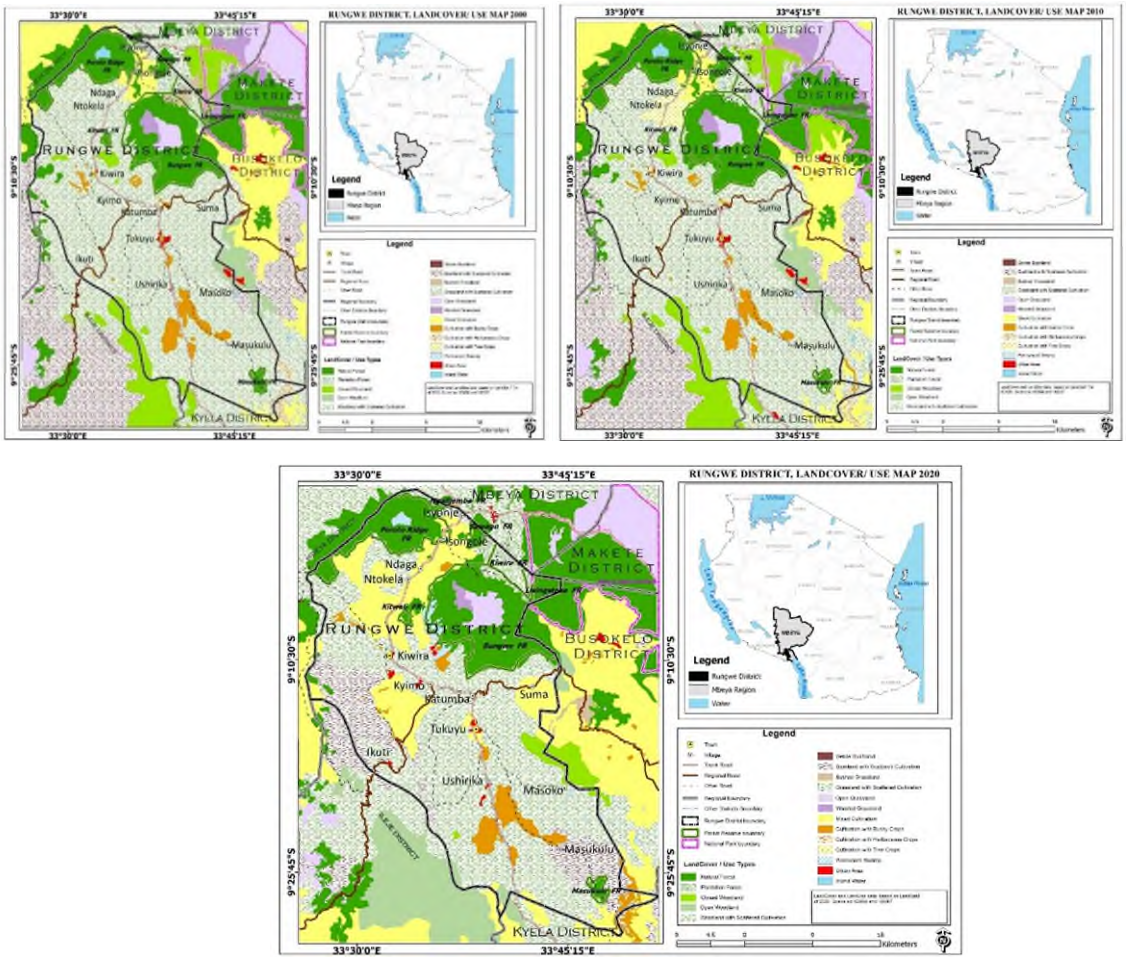


Figure 8: Land cover/use change over a period of 30 years in Rungwe district

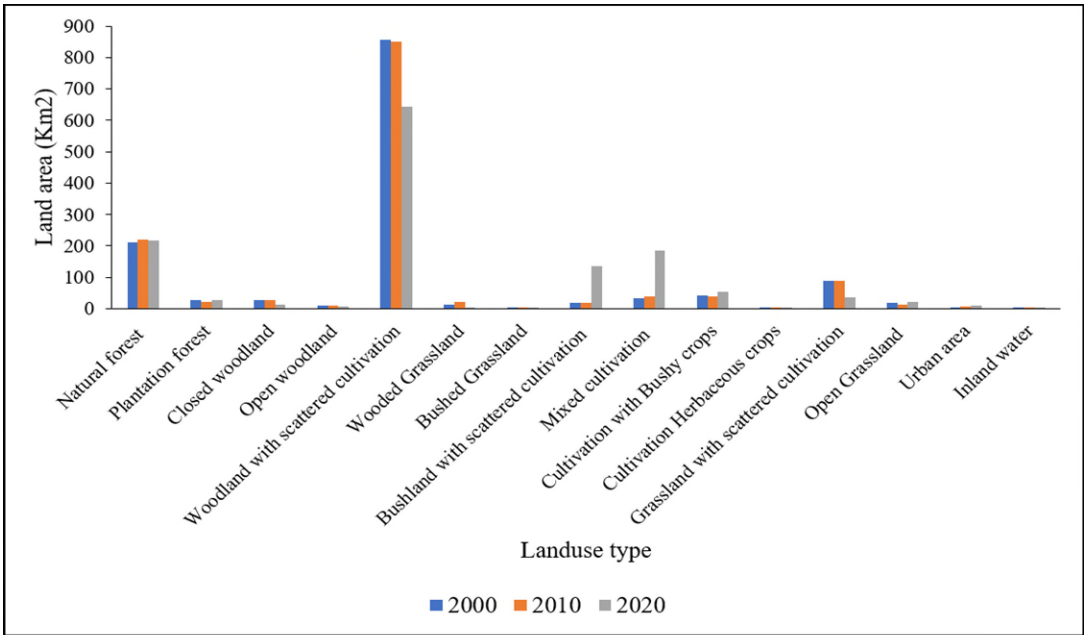


Figure 9: Trend of Land cover/use change over a period of 30 years in Rungwe district

Large land use/cover change has been observed in Rungwe district between 2000 and 2020 years, the closed woodland has been reduced by 53.4%, open woodland by 22.4%, woodland with scattered cultivation by 24.8%, wooded grassland by 58.1%, bush grassland by 96.9%, grassland with scattered cultivation by 58.5% and inland water by 2.9%. On the other hand, bushland with scattered cultivation has increased by 668.6%, mixed cultivation by 460.3%, cultivation with bushy crops by 29.4% and urban areas by 54.2 (Figure 8 & Table 3). Indicating that most of the land covered by wood trees and grassland has been converted into mixed cultivation, bushland with scattered cultivation and urban areas while inland water like rivers has been reduced in size or converted into seasonal rivers.

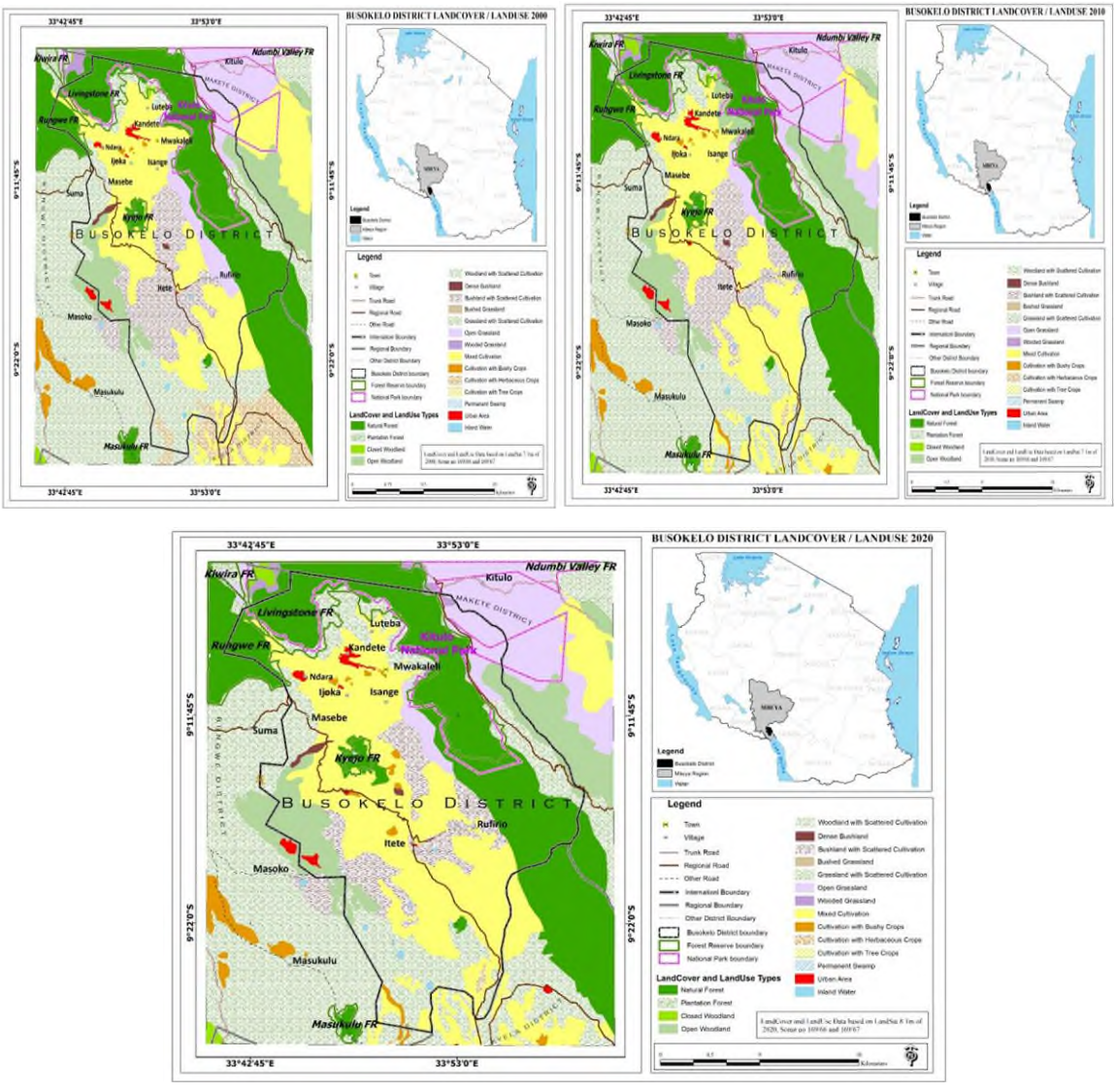


Figure 10: Land cover/use change over a period of 30 years in Busokelo district

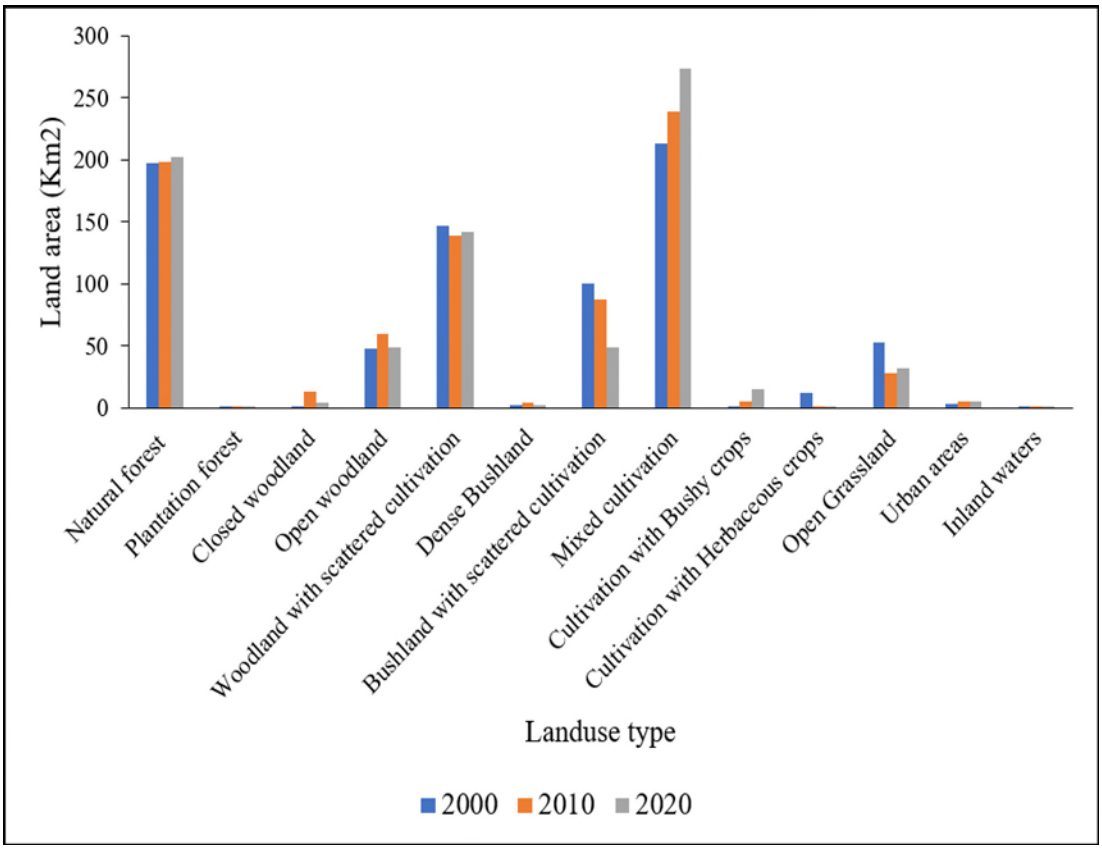


Figure 11: Land cover/use change over a period of 30 years in Busokelo district

Open grassland land in Busokelo district has been reduced by 38.2% while other land covers with woody and bushy trees and the inland waters has increased over time, revealing that the observed increase in mixed cultivation by 28.5%, cultivation with bushy crops by 1.03% and urban areas by 43.9% has been focused in open grassland.

Population growth and the impacts of climate change resulted into intensification of agricultural activities in the natural resource bases such as forest and water sources leading into land use/cover change. The results from communities and satellite images analysis reveals that there is significant evidence of land-use/cover change resulting from agricultural and settlement expansion into natural resource base including rivers, swamps and forests. However, trends of natural resource degradation differ with location and administrative area, where by Kyela and Rungwe experienced higher land cover change as compared to Busokelo district council.

The declining of the woodland and permanent swamps in Rungwe and Kyela districts in response to agricultural expansion and conversion of natural woodland to crop land passes through transition vegetation type indicated through increment of shrubs and grassland areas. This align with the

results of [21], who showed that between 2001 and 2011, built-up areas, green vegetation, and shrubs LULC classes positively increased, while wetlands and barren land decreased in Dodoma city, Tanzania. Similar to these findings, [22], reported that agricultural land replaces LULC classes at higher elevation which threaten the permanent losing of the already vulnerable native mountain biodiversity, [19] observed a constant expansion of land under mixed cultivation in expense of natural vegetation and tree categories over a period of 37 years (1973 -2010) in the highland and mid land agro-ecological zones of Rungwe district, which were reported as positive feedback of land use change, influenced crop diversification and improved community livelihoods. On contrary, land use/cover changes have negative consequences on watershed management in rivers and forests by increasing impervious ground surfaces, decrease rainfall infiltration rate and increased surface runoff rates, hence causing low base flow during the dry seasons [23][24], augmenting flood intensity in the downstream areas such as Kyela district during rainy season. Similarly, changes in land use/cover caused by increased urbanization results in an increased surface run-off, mean river flow and the reduction of base flow [25] especially in the highlands, indicating the likelihood of increased run off and flooding events downstream. [26] found that stream flow rose from 38.9 to 45.4 m^3/s during wet season while in dry season flow dropped from 13.4 to 8.3 m^3/s which were largely due to deforestation and encroachment in Mkomazi river catchment in Pangani river basin. [18] reviewed 60 case studies of which, 68% revealed forest loss due to agricultural and urban expansion, resulting in increased stream flow, surface flow, and total water yield and decreased groundwater recharge while 12% of the case studies showed the impacts of LULCC on channel morphology features through increased sediment transport and riverbank erosion. Decreased river water flows and changes in in seasonal flow regimes threatens freshwater ecosystems [27] and community reliance for clean and safe water supply.

Deforestation in the form of forest land use change increases the emission of greenhouse gases, disrupts the water cycle and dries the soil [28]. The degradation of natural resources through replacement of natural land cover by athropogenic activities results in losing ecosystem services, habitat loss, habitat fragmentation, climate change, pollution, and species invasion of the tropical rain-forests [27]. These drivers lead to ecosystem destruction and the threatened biodiversity in tropical region [26]. Hence, forest ecosystems are facing a huge threat caused by deforestation [28], which hampers the provision of ecosystem's interlinked services and human livelihood security and health safety.

The observed Land use/cover change in Runwge Volcanic Province might also been attributed by the high immigrants especially in Kyela district and the lowland agro-ecological zones of Busokelo and Rungwe districts which corresponds to [2], who observed that farmers' land use selection preferences is always associated by group identity relying on parents and ancestors for knowledge transmission whereby prestigious neighbors becomes sources of inspiration and Mestizos serve as role models for some indigenous farmers. Similarly, indigenous relies on governmental support and directions on decision making for land use selection and preferences while Mestizos are more self-reliance in their decision-making and have stronger influence on their land use decisions to the indigenous. This highlights more insights focusing on the influence of immigrants to the cultural behavioral change leading to land use/cover change in the study area. Therefore, combining the overlapping causes of land use/cover change in Rungwe Volcanic Province necessitates argent interventions focusing on the restoration of the degraded forests, swamps and riverine vegetation with further studies to ascertain the rate of sediment transport in rivers and the lake and pesticide pollution in rivers and L. Nyasa.

Acknowledgments

More appreciation goes to Rilkoto and 360 connect Ltd for the field work logistics support and the administrative authorities of Rungwe, Kyela and Busokelo districts for granting permission to collect data in areas of their jurisdiction.

Funding Decleration

Rikolto Tanzania under 3060 connect Ltd supervision provided funds for the fieldwork.

Clinical trial number: Not applicable.

Data availability

All data generated and analyzed during this study are included in this article.

Informed consent statement: Not applicable.

Conflict of interest

Authors declare that, they have no known competing financial or personal interests that plausibly appeared to influence the work on this paper.

Authors' contribution: The design, data analysis and writing of the manuscript was conducted by BM while HN participated in data collection and review of the manuscript.

Ethics, Consent to Participate:

Ethical approval for this study was obtained from Mbeya regional administrative secretary and then Kyela, Rungwe and Busokelo district' administrative secretaries. All participants were informed about the purpose of the study, the procedures involved, the voluntary nature of participation, and their right to withdraw at any time without penalty. Oral informed consent was obtained from all participants before data collection. Confidentiality and anonymity were maintained throughout the study.

Consent to Publish declarations: not applicable

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