TOWARDS AGRICULTURAL TRANSFORMATION: TRENDS IN GENDER WORK PATTERNS, PERCEPTIONS AND ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES. A MIXED METHODS

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ABSTRACT

Soil and water conservation (SWC) programs have been increasingly promoted to control erosion, yet the success of their adoption has remained far below the anticipated level. SWC adoption and perception studies have been largely documented with mixed results, but they have not examined trends and gender differences in the perception and adoption of SWC decision-making. This study employed mixed methods of data collection in Northern Rwanda. GIS mapping and t-test were used for analysis. GIS results show that cropland increased from 24% to 48% by 2010 and then % in 2020. Over the years, women have increased their participation in SWC thanks to land and gender policies that granted them equal rights as men. Cultural beliefs remain a limitation for women's overall decision-making. *Organic manure* (85%), *ridge farming* (65%) and *NPK* (52%) were SWC practices adopted on plots close to the homestead. More women (60%) than men jointly participate in SWC decision-making, whereas more men (65%) participate in off-farm employment decision-making. Socio-economic and market factors significantly influence gender differences in SWC decision-making. The study recommends including social norms in the process of empowering female farmers; initiating agricultural extension education targeting women; and promoting incentives aimed at adopting multiple SWC practices.

Key words: Soil and water conservation, Agricultural transformation, Gender work patterns, Adoption decisions, Mixed Methods, Northern Rwanda.

1. INTRODUCTION

Soil and water conservation (SWC) programmes have been increasingly promoted to control land degradation, particularly soil erosion; increase agricultural productivity and food security; and reduce poverty. Population increase, poor land management, vulnerable soils and hostile climates are major causes of soil erosion and land degradation (Sahoo et al. 2016). Since the 1930s there has been worldwide concern about the effects and impacts of land degradation (De Graaff et al. 2013). Land degradation impacts negatively the productivity of agricultural land and contributes to the intensification of socio-economic imbalances through increases in poverty and social inequalities. Wolka et al. (2018) indicated that an estimated 280 million tons of crop yield is lost annually due to land degradation in Africa. Economic losses resulting from land degradation range from US$4.3 to US$20.2 trillion of terrestrial services and between US$6.3 and US$10.6 trillion of ecological services (Prăvălie 2021).The negative effects of land degradation on human population and agricultural development is likely to cause migration of 50 to 70 million people by

2050; changes in land use; and cropping patterns (UNCCD 2019; Liu and Han 2020; Prăvălie et al. 2020).

Understanding trends in SWC practices in relation to agricultural transformation is vital to reduce soil erosion and contribute to sustainable agricultural development (Pang et al. 2020; Mekonnen 2021). Agricultural transformation is explained by the transition from farming to the non-farm sector whereby more men are taking up non-farm jobs or migration to urban centres leaving farming activities to women (Asadullah and Kambhampati 2021). Agricultural transformation involves the process by which an agri-food system transforms over time from being subsistence-oriented and farm-centered into a more commercialized, productive, and off-farm-centered (Dawe 2015; Jayne et al. 2019). SWC interventions offer an important element to sustainable agricultural practices as a pathway for fostering agricultural transformation through increasing resource use efficiency (Anantha et al. 2021). Based on the theory of agricultural change, landscape change has been as well an explanatory tool for agricultural transformation, for example through agricultural commercialisation (Zomeni et al. 2008).

Currently, women presence in agriculture and specifically in soil and water conservation practices is rising. Female participate in conservation practices as farmers, unpaid workers on family farm as well as labourers in agricultural entreprises (Slavchevska et al. 2019). This to mean that women and men engage in adoption of agricultural technologies (such as SWC practices) with unequal access to resources, information and markets, and with different rights, labour demands or food consumption (Ashby and Polar 2019). However, with the process of agricultural transformation, women appear to be more instrumental in SWC decision-making. Thus, it is vital to consider factors of women empowerment that are embedded in resources, agency and achievement, and transforming power relations to achieve sustainable agricultural transformation, (Haug et al. 2021). Such changes in SWC adoption and technology use or other behaviour arising from empowering women provides economic benefits for women themselves, the entire household and the society. Moreover, the benefits from leveraging gender risk, time, and social preferences, and eradicating gender differences in inputs access can provide women with innovative ways to allocate resources for SWC adoption and decision making (Anderson et al. 2020).

Traditionally, SWC measures have long been practiced in Rwanda where methods of erosion control dated since 1937. The introduction of rural extensionists known as agricultural monitors (MONAGRI) in 1947 widened the erosion control program. The period between 1966-1970 was marked by intense adoption of soil and water practices through a massive government program. This period was followed by adoption of infiltration ditches and bench terraces in 1973; and soil fertility management and integrated agroforestry practices (Rushemuka et al. 2014). Despite the overtime widespread implementation of SWC practices, the success of adoption in SWC practices has long been remained far below anticipated level particularly in the Northern Rwanda. Major factors were hypothesised in Bewket (2007) to discourage farmers from adopting include gender differences in roles and farm labour allocation, technology fitness to the farmers' requirement, farming systems and land tenure insecurity. Correspondingly, farmers inability to maintain previously constructed SWC practices is a justification for ineffective adoption in Northern Rwanda. Bizoza (2014) found that SWC practices do not fit in the capacities of farmers to invest in complementary and complementary practices (e.g. fertilisers, lime and organic manure). Most adoption studies show that SWC adoption decisions are interdependent, thus farmers should adopt multiple practices to deal with erosion constraints (Bayene and Kasssie 2015; Ochieng et al. 2021).

The objective of this paper is to assess trends in gender work patterns, perceptions and adoption of soil and water conservation practices in Northern Rwanda. Despite the considerable impact SWC practices have in reducing soil erosion and increase food productivity (Hengsdijk et al. 2005; Mekonnen 2021; Weldegebriel et al. 2021), studies on SWC investment have shown mixed results in terms of effectiveness (Mukai et al. 2021; Rutebuka et al. 2021), adoption (Bewket 2007; Betela and Wolka 2021) and perception (Biratu and Asmamaw 2016). Studies that combine trends, perception and adoption of SWC decision making are scanty, particularly in the context of Northern province. The study contributes to the analysis that links gender in SWC decision making and agricultural transformation to explain feminisation as a pathway to women empowerment. Unlike previous studies that used econometric models such as duration analysis, joint analysis, and multivariate probit (Beyene and Kassie 2015; Kpadonou et al. 2017;Ochieng et al. 2021) , this study used mixed methods involving both qualitative and quantitative techniques, and GIS mapping to assess adoption of multiple SWC practices with a gender perspective. To the best of our knowledge, this is among the pioneer studies that employ a combination of different methods to analyse gender differences in SWC practices in Rwanda. Including gender analysis is crucial to understand the feminisation of labour and SWC management practices that will inform the process of agricultural transformation.

In line with the Sustainable Development Goals (SDGs) that promote gender equality in agriculture (SGD5) and zero -hunger (SDG2), the study builds on various agricultural-led reforms that were adopted to guide the agricultural transformation in Rwanda. The Rwandan vision 2020 aimed to convert the economy from an agrarian to a private led sector, knowledge-based economy and to transform the agricultural sector from subsistence-based to market-oriented, and the vision 2050 provides a pathway to become an upper-middle income country (UMIC) by 2035, and a high income country (HIC) by 2050. The transformation process was marked by poverty reduction and agricultural transformation (PSTA1-4) strategic interventions, and the current national transformation strategy (NT1, 2018-2024). Rural development policies were developed to accommodate SWC practices and cover other strategies that increase land productivity. Before 2010, the crop intensification program (CIP) was followed by complementary strategies on agricultural extension services, mechanization (AMS), and the post-harvest staple crop (2011-2020). The agriculture gender strategy (AGS, 2018) developed formed a foundation for equal rights and opportunities for mainstreaming gender in policies and programs. In this period, there was further decentralisation and a focus on market liberalisation which led to more diverse SWC practices and sustainable land management approaches (De Graaf et al. 2013).

The rest of this paper proceeds as follows. Section 3.3 describes the study area, sampling procedure, and data description. Section 3.4 discusses results, and section 3.5 concludes and provides recommendations.

2. MATERIALS AND METHODS

2.1. Study Area

Rwanda is a landlocked country located in Eastern Africa. The study area is in the Northwest volcanic (agro-ecological) zone that covers Burera and Musanze districts. Burera (located at 1° 25' S and 29° 44' E), Musanze (lies at 1°29'S and 29°38'E) and Gakenke (is at 1°69' S and 29° 26') districts in the Northern Province. The Northwest volcanic zone is situated along Rwanda's boarder with Democratic Republic of Congo (DRC) and the Uganda Southwest potato, sorghum and vegetable zone. Musanze and Burera comprise some parts of West Congo-Nile Crest zone and the Northern/Buberuka highland zone. Additionally, the study area extends to a small part of East Congo-Nile Highlands in the Gakenke district (Figure 1).

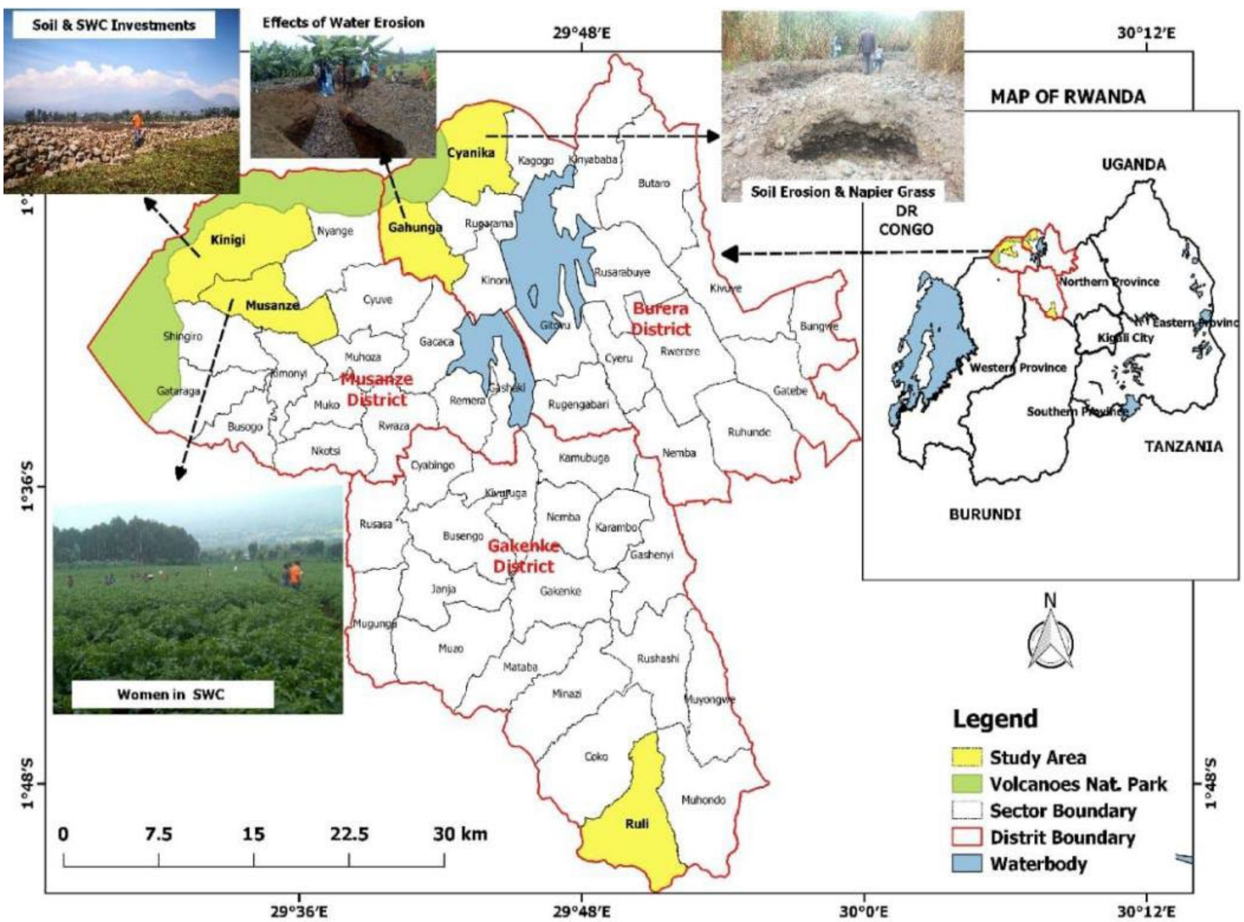

Figure 1. Map of the study area

Over 80 % of the population is engaged in small-scale agriculture characterised by disadvantageous labour conditions as explained by the dominance of female labour and a gender gap in livelihood activities. This area is rich in volcanic soils and high altitude; and predominated by intense cultivation of Non-Traditional Agricultural Export (NTAEs) crops such as potatoes, beans, maize, sorghum, and cassava. NTAEs crop farming can help monetise women's labour, link them to value chains, and improve labour standards in agriculture (Asadullah and Kambhampati 2021). High production potentials in NTAEs make this area a distribution hub for the local, national, and East and Central Africa markets (Larochelle *et al*., 2015). Maize supply accounts for 45 % of national maize production. Beans are the second most cultivated crop with annual yields topping 330,000 MT, and productivity stands at 1.8 MT per Ha. Adoption of climbing beans is close to 100%. The area has potential potato production (12MT/Ha) with an expected increase to 25 MT/Ha. The production system is on small and fragmented land. Over time, land conversion to agricultural land use has stood as the catalytic agent for accelerating the rate of soil erosion. The study area has recorded a considerable decline in per capita availability of agricultural land per household from 3 Ha to less than 1 Ha. Rain-fed agricultural production serves as the basis for household livelihoods. Frequent heavy rains mixed with stones are the features of high erosion risks and severe gullies in the proximity of the Volcanoes National Park.

2.2. Study Design and Sampling Techniques

The study used a multistage sampling procedure to select three districts out of five in Northern Province: Burera, Musanze and Gakenke. In the first stage, the three districts were purposively selected based on the concentration of farming activities related to the production of NTAEs. The second stage consisted of a proportionate sampling of five administrative sectors including two in Burera, two in Musanze, and one in Gakenke. Stage three involved randomly selecting two administrative cells within the sector, and two villages were selected within each cell. In the final stage, the study used a systematic random sampling to select male and female respondents. The data was collected in two phases using mixed methods that involve qualitative and quantitative approaches, and GIS mapping. Table 1 illustrates the phases and various techniques used for data collection.

Table 1. Data collection techniques

		Musanze		**Burera**		**Gakenke**	**Sex (%)**	
		Musanze	**Kinigi**	**Cyanika**	**Gahunga**	**Ruli**	**Female**	**Male**
Qualitative survey	**PRA techniques**							
Transect walk (# participants)	12	3	3	3	3	-	33.0	66.0
Gender resource mapping (# sessions)	8	2	2	2	2	-	52.0	48.0

Focus Group Discussion (# FGDs)	8	2	2	2	2	-	50.0	50.0
Key Informants (# participants)	12	4	3	2	3	-	42.0	58.0
Quantitative survey	**Sample size**							
Number of households	422	58	62	122	139	41	47.2	52.8
WEAI respondents	653	92	97	192	207	65	58.6	41.4

The first phase employed qualitative approaches mainly Participatory Rural Appraisal (PRA) techniques, and took place between August and September 2019). In each administrative sector, three local leaders/farmer-promoters participated in the exercise of transect walks. Overall, 12 local leaders comprising 66% male and 34% were available for this exercise. In very sector, two sessions of both Focus Group Discussions (FGDs) and gender resource mapping were conducted.

The resource mapping, which was complemented by FGDs, helped to characterise gendered work patterns in soil and water conservation. The number of participants per session was between eight to 12. In FGDs, male and female represented 50% each, while the proportion of male participants was 53 % against 47% female for the gender resource mapping. Finally, the study conducted Key Informant Interviews (KIIs) with managers of local banks and micro finances, sector officials, leaders of farmer cooperatives, and representatives of non-governmental organisations (NGOs) operating in the study area. Female represented 42 % against 58% male. Data from qualitative interviews were transcribed, coded, and categorised based on the grounded theory to identify response categories and develop themes (Creswell 2009). A thematic content analysis helped identify cross-references and provide flexibility for approaching patterns (Alhojailan 2012).

The second phase, which took place from October to December 2019, adopted a quantitative research design using a semi-structured questionnaire. The questionnaire was administered to a sample of 653 male and female respondents from 422 households in three districts, five sectors, ten cells, and 19 villages. Fourteen recruited and well-trained enumerators conducted the data collection using tablets. The study adopted a descriptive analysis (with mean, standard deviations) and t-test to assess male and female differences in socio-economic variables and SWC decision-making processes. The study used a scale of 1= no-decisions to 4=all decisions for gender differences in SWC decision making

The study quantified land use and land cover during the last 30 years using remote sensing digital image processing. With Landsat TM (1990 and 2000), Landsat ETM+ (2010), and Landsat OLI (2020), land use and land cover maps were generated for the periods 1990–2000, 2000–2010, and 2010–2020 using an unsupervised pixel-based classification technique. Similar pixels were grouped to establish clearly recognizable land use or land cover classes. As a result, the five classes comprising settlement, forestland, grassland, farmland, and wetland were identified based on physical characteristics and spectral values.

3. RESULTS AND DISCUSSION

3.1. Gendered Socio-Economic Characterisation of Household Decision-makers

Gender differentiated socio-economic characteristics of household decision makers is shown in Table 2. Results indicate that nearly 80 % of households are headed by both male and female decision-makers. Within these households, the proportion of female decision-makers was slightly higher than men. Results show that there are significant gender differences in *age*, *education*, participation in off-farm activities, and time used to access different services. *Age* differences signals the increasing female-headed households such as widows due to war, and males out-migration in town or to neighbouring countries of DRC and Uganda. This scenario imposes multiple burden to women, making them adopting innovative technologies and land use options that provide quick and high return on investment, such as high value crops (HVCs).

Table 2. Gender differentiated socio-economic characteristics of decision makers.

Variables	Female	Male	Combined
Household type (%)			
Male and female adult	51.5	48.5	79.88
Female adult only	100.0	0.0	20.01
Socio-economics (average)			
Household income (US$)	1,335.5	1,630.6	1,493.9
	(1295.3)	(1405.6)	(1363.5)
Age of the respondents (years)	45.5	44.8	45.2**
	(14.9)	(13.7)	(14.5)
Years of education (number)	2.5	5.1	3.9***
	(3.3)	(3.7)	(3.7)
Off-farm occupation (yes=1, 0 otherwise)	0.2	0.4	0.3***
	(0.4)	(0.5)	(0.5)
Access to services (average minutes)			
Access to input market	26.9	23.2	24.9***
	(28.6)	(25.2)	(26.9)
Access to product market	32.8	25.7	29.0***
	(35.8)	(26.6)	(31.4)
Access to farm plot	53.4	66.2	58.4***
	(79)	(73.1)	(77.0)
Participation in agriculture and other economic activities (%)			
Food crop farming	62.2	37.8	633
Cash crop farming	63.3	36.7	109
Livestock raising	60.4	39.6	407
Non-farm economic activities	50.7	49.3	150
Wage and salary employment	37.8	62.2	45
SWC investment	62.7	37.3	362

Results reveal that men completed five years of primary *education*, whereas women had completed at least two years of primary education. Differing education levels between men and women could be associated with less access to extension information which limits women's appreciation of the potential benefits of adopting SWC practices (Catacutan and Villamor 2016). Men have higher participation in off-farm occupation than women. Men compared to women have easy access to services such as *input markets, product markets, and farm plots*. The results suggest that socio-economic and institutional barriers may refrain women's progress to invest in soil conservation and agricultural transformation (Ndiritu *et al*., 2014). Gender specific constraints affecting technology adoption and sustainable intensification of production are an indication of socio-economic inequalities in female farmers. The socio-cultural context of farming indicates that a femalefarmer is less likely to adopt yield-enhancing and soil restoring strategies (Theriault *et al*., 2014).

Further, results indicate that more women (about 60%) than men (40 %) participate in agriculture activities, which include *food and cash crop farming, livestock raising* and *soil and water conservation practices*. The women's rising involvement in agriculture is an indication of feminisation of farming, which has an impact on household food security (Asadullah and Kambhampati 2021). Results show no gender differences in non-farm activities. On the other hand, there are gender differences in wage and salary employment as explained by 62% of men and 38 % of women in the sample. The results indicate that empowering women could be mediated by women's involvement not only in agricultural production to improve food security, but also in women's employment outside the household can improve women's power and agency. These results are backed by FGDs where participants highlighted that: "…Norms and culture still play a role in explaining gender differences in the ferminisation of farming activities. Women are mostly in charge of low-revenue staple crops, which are characterised by uneven gender roles and responsibilities. Typically, female farmers are involved in most household chores and but, males' involvement in more farming activities is pronounced in production of value cash crops mainly Irish potatoes…" Consistently with Chayal et al. (2013), women undertake various farming activities such as clearing fields, field preparations, sowing, intercultural practices, weeding, harvesting, picking, cleaning, and drying of grains unlike men who can perform a few of them.

The results show that, with agricultural transformation, female roles are changing as compared to how they used to be before. This is because men and women are equally getting involved in the farming business of high-value crops (HVC) from preparation to harvesting and market search. It was witnessed by a 48-year KII (local leader) that:

"…Both females and males equally participate and allocate tasks regarding farm investment and management practices, and decide jointly on the use of resources and incomes from the farm. However, male have greater participation in commercial activities and off-farm businesses than female…" Consistently with Ingabire et al. (2017), in the study area, the number of women involved in farming HVCs has increased in the last decade. However, Bigler et al. (2017) argued that, despite this women's engagement, the transformation process is limited by low market participation and negotiation power over agricultural income. Asadullah and Kambhampati (2021) argued that, despite the new opportunity presented by the feminisation of farm work, the impact women's participation in agriculture production and SWC on household welfare can be achieved when farming increases women empowerment.

3.2. Trends in Land Use Patterns and Effects on Soil and Water Conservation

Figure 2 indicates land use change from 1970 up to 2020. Results indicate that, since the introduction of soil and water conservation measures started in 1970s, the area of forest, grassland, cropland and settlement changed significantly until 2020. The period between 1990 and 2000 showed a decreasing trend in forestland and grassland. This period that involved deforestation was marked by a massive land conversion from forest to commercial agriculture. However, after 2000 it showed an increasing trend in forestland, cropland and settlement. According to the FGDs participants, "…policy enforcement permitted the reallocation of land uses to farms resulting in a shift in the relative proportion of land devoted to crops, trees, and animals. It also motivated the expansion of cultivation to valleys, grasslands, marginal lands, and high-altitude regions…"

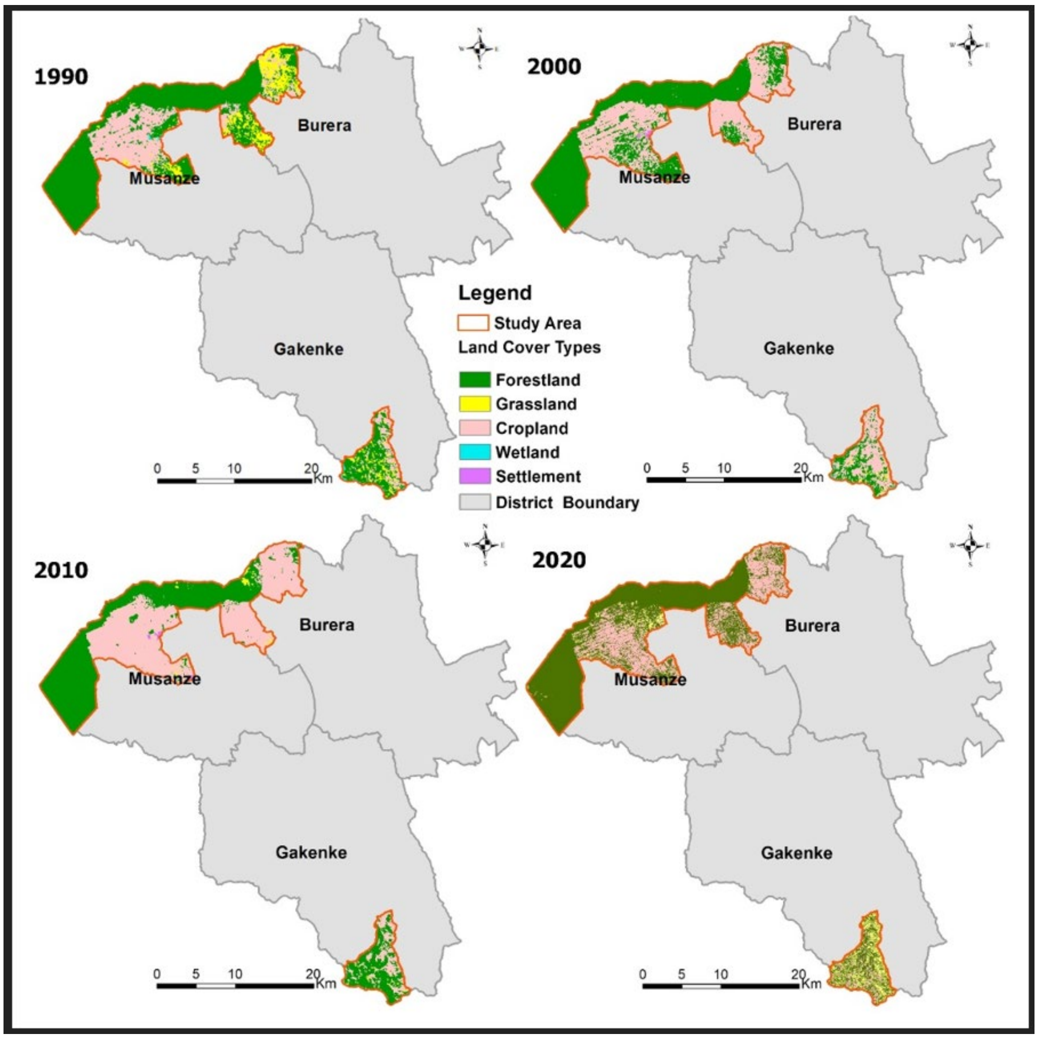

Figure 1. Land use patterns and soil degradation in Rwanda
Source: Landsat TM (1970-1990 and 1990-2000), Landsat ETM+ (2010) and Landsat OLI (2020) downloaded from https://earthexplorer.usgs.gov/

Additionally, a 55-year old male KIIs revealed that: " … Overtime, this region has been characterised by dynamics in land uses and shifts in gender specific roles in relation to changes in farming practices due to the growth of HVCs such as maize, beans and Irish potatoes…". These changes in agricultural system were followed by a reduction in the production of animal products, legumes, and cereals resulting in a change in gender roles for reproductive, productive and community activities (Vallamor et al. 2015). Disparities between men and women in terms of gender-assigned roles, perception and resources endowment have affected land uses over time. Additionally, female participants in FGD argued that changes in forestland, grassland, cropland and settlement were driven by multiple factors. These include: "…the intensification of the farming system which they think it began earlier in Rwanda compared to the rest of Africa. And, the rapid population growth, overgrazing, and over-cultivation which saw the emergence of new land-use policies where the Government imposed penalties or fines and imprisonment for burning bushes…"

Table 3.indicates that the area under forestland decreased from 54% to 51% between the periods from 1970-1990 and 1990-2000, and further decreased up to 38 %. Since 1990. the area under forest cover increased from 38% to 45% of the total land area.

Table 3. Change in land use/land cover in the study area for the periods from before 1990 to 2020.]

Land cover types	Before 1990 (Km^2)	% change	1990-2000 (Km^2)	% change	2000-2010 (Km^2)	% change	2010-2020 (Km^2)	% change
Forestland	167.02	54.17	157.17	50.97	117.13	37.99	137.34	44.54
Grassland	45.10	14.63	36.06	11.69	32.06	10.40	53.34	17.30
Cropland	90.05	29.20	106.45	34.52	149.03	48.33	106.23	34.45
Wetland	1.07	0.35	1.34	0.44	1.12	0.36	1.21	0.39
Settlement	5.10	1.66	7.33	2.38	9.01	2.92	10.23	3.32
Total	**308.35**	**100.00**	**308.35**	**100.00**	**308.35**	**100.00**	**308.35**	**100.00**

Results indicate that the trend in grassland decreased from 15% before 1990 to 10% by 2010, and the trend increased to 17% of the total land by 2020. The area under cropland significantly increased up to 48% in 2010 from 24% in 1990, and reduced to 34% in 2020 thanks to the expansion of forestland and grassland. Land use change has transformed agricultural towards diversification of agricultural products and livelihoods (Thanh et al. 2021). The trend in settlement increased from 1.6% (before 1990) to 3.3% in 2020. Consistent with Li et al. (2021), before 2000 land use transfer in Rwanda mainly consisted of the conversion of both forestland (72%) and grassland (28%) to cropland then after the transfer was balanced. Trends in forestland, cropland, and grassland was driven by the Rwanda program of villagization and resettlement in early 1997 (Van Leeuwen 2001). Participants in FGDs and resource mapping stressed that "…The interaction between policy changes, economic transformations, population growth, and redistribution had implications on the viability of the land-use system and increasingly smaller farms. For instance, the commercialisation of agriculture led to the intensification of land uses (with reduced fallows, labour-intensive management…". Land use transition towards intensive and market-oriented agriculture has been linked to the adoption of sustainable farm management practices such as use of chemical fertilisers and soil conservation measures, as well as improvement in overall income and livelihood security for smallholders (Burra et al. 2021).

3.3. Gendered Work Patterns in Soil and Water Conservation

Figure 3 provides a gendered work pattern in soil management and water conservation practices over time. In Rwanda, methods of erosion control dated since 1937. This period was marked by the intense adoption of soil and water practices. For instance, the introduction of rural extensionists known as agricultural monitors (MONAGRI) in 1947 widened the erosion control program was followed by the adoption of infiltration ditches between 1966-1970; bench terraces in 1973; and soil fertility management and integrated agroforestry practices (Rushemuka et al. 2014). Respondents revealed that gendered activities in soil conservation and soil fertility management practices have seen significant changes since 1970s. Between 1970 and 1980, more men compared to women, adopted soil conservation measures to combat effects of climate change and increase forest cover. This period was marked by significant gender inequalities and lack of attention to men and women specific needs, which were associated with the low use of agricultural innovations. For instance, respondents stressed that women had little access to and decisions on household resources such as cows, bananas, sorghum, and related products. Meinzen-Dick et al. (2019) and Ndeke et al. (2021) argued that gender disparities in the adoption of innovations were associated with social and cultural forms of inequalities linked to social perceptions of different roles for men and women, land tenure insecurities, and women's deprived access to education and training as well as control of household assets.

Farmers believed that investment in conservation was one of the major strategies employed towards mitigating the threats of climate change. Forest restoration and water conservation practices (waterways and anti-erosion ditches) were introduced between 1980 and 1994, and up to 2000. These investments in SWC practices reduced exposure to shocks and climate change effects (Bezabih et al. 2013). Participants in resource mapping stressed that "…Over the years, local communities have invested a lot in restoring farmland subjected to soil erosion and water flows. Famine or food shortage during this period has seen women increase their participation in forest plantations. Between 1980 and 1990, both men and women were aware of the benefits of forest plantations and erosion control measures. End of the 1980s, they controlled water flow using agroforestry, anti-erosive ditches, and Napier grasses/vetiver…".

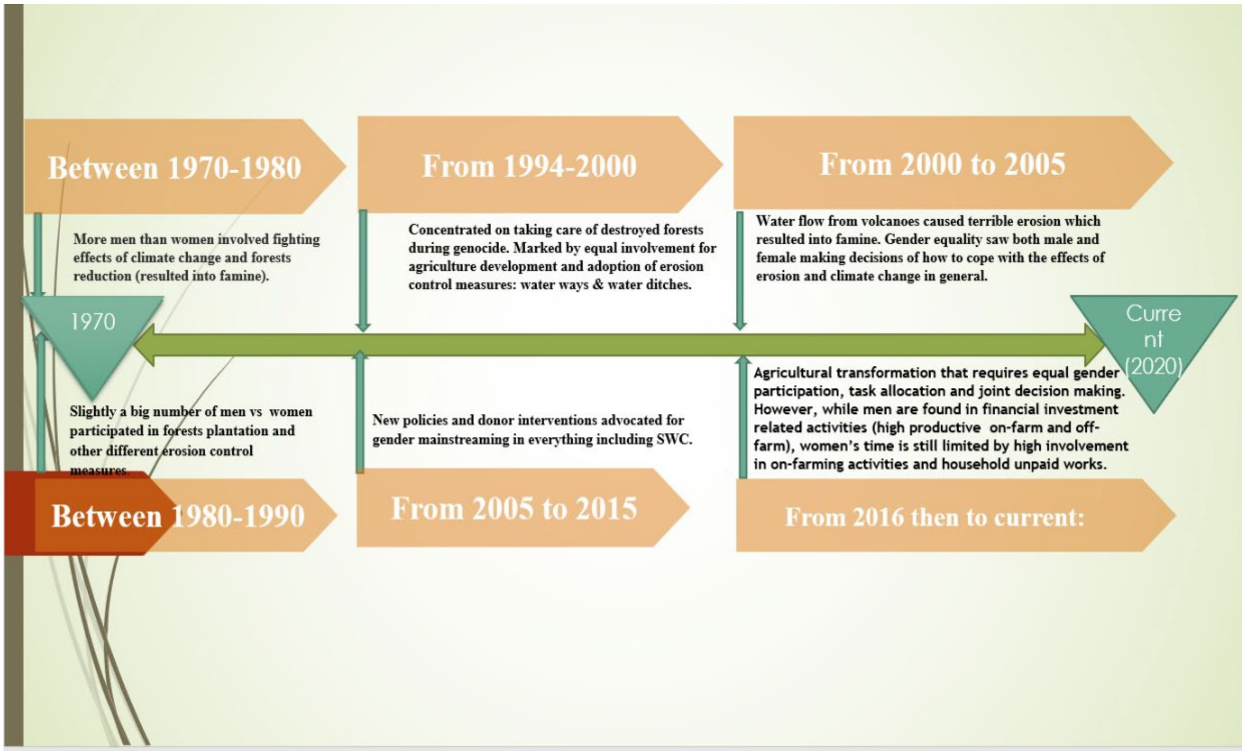

Figure 2. Patterns of gender activities in soil and water conservation practices

Gender differences in land rights are limiting factors in the process of agricultural transition (Okpara et al. 2019). An integrated conservation approach that has seen equal involvement of women and men in farm investment took place from 2010 on-wards. Between 2005 and 2015, the GoR ratified land policies and donor interventions that advocated for gender equality in agricultural protection and natural resource conservation to close gender biases in land rights, access to resources, incentives, and other opportunities. Due to social and economic disadvantages that women face, men were more likely to legally own land or property because they had greater resources to purchase or construct, because they are favoured for inheritance. These policies, which awarded formal rights to women, helped improve their ability to buy, own, sell and obtain titles on land (Feyertag et al. 2021). This is an indication that women's access to property rights makes them less economically vulnerable and provides various pathways to poverty reduction (Fafchamps and Quisumbing 1999; Meinzen-Dick et al. 2019). Participants indicated that: "...land policies and gender programs provided women and men with equal rights and decision-making regarding the use of income, land, and other productive resources…" According to 65-year woman, "… national and programs have increased access to bank loans whereby both husband and wife have to decide together about their land being the collateral…". Incentives related to secured land rights and access to inputs and finance increase adoption and investment in soil and water conservation practices (Tarfasa et al. 2018).

Another factor that accelerated agricultural investment was the development of different projects including tourism and crop intensification programs. Since 2007, Rwanda has created an interface between SWC, SFM, and agricultural transformation through the CIP and land use consolidation

(LUC). Specific interventions were put in place to reduce soil degradation by promoting investment in soil conservation in the study area. There was already more diversity in SWC practices but participatory were not yet developed or successful (De Graaf et al. 2013). For instance, a 42-year-old woman KII stated that: "…After 1990s, farmers were encouraged to create different organisations or cooperatives to improve our participation in agricultural farming, which increased understanding of SWC issues in Rwanda...". In line with Kampmann and Kirui (2021), the role played by agricultural organisations in the transformation of agriculture is related to the transfer of knowledge, training members on innovations, and creating value addition through the processing of agricultural produce. However, it was found that the Government of Rwanda and NGOs have not yet integrated aspects of SWC in the mountain gorilla tourism scheme (where the park is 100 % government-controlled). The scheme provides 10 % of annual revenues to the surrounding communities in projects related to the construction and rehabilitation of roads, water and schools, with a tiny proportion going to agricultural projects. It was indicated by FGD participants that: "…Tourism has been one of the off-farm activities for men who work as tourist guides and use tourism revenues to support our farming activities. In addition, since the park is protected by the Government, the issue of human-wildlife conflict has been quite solved because farmers are paid for crops damaged by buffaloes. Generally, although women representation in the tourism activities is not significant, tourism has increased business activities in our area whereby both male and female farmers reap benefits from it…"

3.4. Gender Differences in Soil Conservation Decision Making

Results indicate that more than three quarters participated in joint decision making (from some to most decisions) whereas less than 20% of respondents make sole (all) decisions regarding *food and cash production, livestock raising* and *SWC investment*. The data indicate that, although men and women jointly participate and make decisions with their wives, women's participation in decision making is at a higher rate than men. Increasing participation of women in agricultural labour force relative to men is compounded with female's increasing decision-making power on production, income use and management roles. According to Ajani et al. (2011), women are increasingly becoming primary decision makers on the farm and they gain greater access to agricultural income for both food crops and NTAEs. Thus, women are increasingly achieving both the feminisation of labour and feminisation of farm management mainly because fewer men are working in agriculture. Zhllima et al. (2021) concluded that women 's decision making power affects farm structure in the context of transition economic. Thus, feminisation of farming is to improve female empowerment, increase food production, farm family income and improve household food security (Asadullah and Kambhampati 2021).

Table 4. Male and female in agricultural and SWC investment decision making

	Female (%)	Male (%)	Overall (%)
Food production (n=633)			
No decisions	55.1	44.9	13.2
Some decisions	53.1	46.9	41.9
Most decisions	66.4	33.6	27.9

All decisions	90.6	9.4	17.0
Cash crop production (n=129)			
No decisions	64.3	35.7	10.9
Some decisions	60.9	39.1	49.6
Most decisions	63.3	36.7	23.3
All decisions	61.9	38.1	16.3
Livestock raising (n=512)			
No decisions	68.9	31.1	25.8
Some decisions	49.5	50.5	38.3
Most decisions	63.1	36.9	25.4
All decisions	92.6	7.4	10.6
Non-farm businesses (n=210)			
No decisions	37.5	62.5	7.6
Some decisions	49.1	50.9	25.2
Most decisions	32.6	67.4	45.2
All decisions	69.6	30.4	21.9
Wage and salaries (n=45)			
No decisions			
Some decisions	28.6	71.4	12.3
Most decisions	25.6	74.4	75.4
All decisions	42.9	57.1	12.3
Investment SWC practices (n=362)			
No decisions	50.2	49.8	18.2
Some decisions	50.6	49.4	42.1
Most decisions	61.8	38.2	21.4
All decisions	90.1	9.9	18.3

Results show that majority of the respondents participate in joint decisions (some to most) regarding wage and salaries (87 %) and non-farm businesses (68 %). A greater number of men participate in decision making. The growing involvement of male outmigration from agriculture (often for seasonal employment) and off-farm employment can increase the need for women to expand their engagement in agricultural production vis-s vis household works (Zhllima et al. 2021). Increasing migration of men out of agriculture affect's women's roles in agriculture and related activities, which in turn affects their productivity and gender equity. Both male and female participants in GFDs believe that about 90 % of men collaborate with their wives in making land and household decisions. However, cultural beliefs remain a limiting factor for the joint-decision-making process and agricultural development. Also, there is still an uneven distribution of financial investment and household assets-related decisions. For example, in some cases, the husband can rent out land without the consent of his wife. A young aged KIIs said that women are involved in activities such as farming, household, and unpaid activities. Men are in commercial activities, which include the supervision of farmworkers, contract and price negotiations. Men also do trading activities, motorbike transport services, and construction while leaving women in farming works.

Findings also revealed that income from the non-farm business could partly finance farm investment.

3.5. Gendered Perception on Soil Degradation and SWC Practices Adoption

Soil degradation is one of the challenges facing agricultural production. Both male and female participants in FGDs highlighted the causes of land degradation and stressed that "…Soil degradation is due to erosion by soil and water or natural hazards triggered by heavy rainwater from the park that led to mass wasting, landslides, and severe gullies. Erosion takes away crops and soil nutrients and causes impairment on the quality and productivity of the farms around the park…" In line with Atnafe et al. (2015), the causes include population pressure on resources, poverty, limited access to inputs by farmers, land tenure and security, and limited access to financial services. Another factor is that, during transect walk both middle-aged male and female participants highlighted the following: "…Last year (2018), there were efforts to establish soil and water conservation practices for erosion control with stone fences, AED, and waterways. In May (2019), these measures were destroyed by heavy rain with stones from the park which created wide and deep gullies..." (Plate 1). It was indicated that, in the Kinigi sector, soil erosion occurs through the detachment, transportation, and deposition of soil particles by rain, gullies, and runoff water. Participants were aware of the on-site and off-site effects of soil and water erosion on soil productivity and nutrients loss, unproductive degraded land, and a drop in potential agricultural productivity. Gullies constitute the most severe environmental threat in highly populated or urbanised areas with high rainfall intensity.

Plate 1. Gully erosion observed during transect walk in Gahunga, Burera District

Another factor that accelerate soil degradation and deforestation is land conversion to agricultural land. Additionally, inappropriate cultivation and land management practices cause severe sedimentation of water resources, loss of soil fertility, productivity, and health. One middle -aged man associated severe land degradation with economic development, urbanisation, and over-cultivation. These factors have made traditional techniques such as fallow, open grazing practices, and huts (traditional houses) less effective for water retention. Severe soil degradation in agriculture causes a decrease in farm productivity and slows down commercialisation efforts. Farmer-promoters who participated in the transect walk argued that adoption of integrated soil management and water conservation comprising crops, livestock, forests, fodder, and compost reduces soil degradation. Continuous adoption of the practices and rotational grazing systems with moderate stocking rates can benefit soil health (Xu et al. 2018). The system also serves as a source of livelihood, providing food and income while performing other social and cultural functions (Onakuse 2012).

Results indicated that majority (between 76% and 92 %) of farmers have no conservation practices (*bench terraces, hedgerows, anti-erosion ditches, waterways, and water harvesting*) adopted even on a single plot. Between 10 % and 20 % of farm households adopted conservation practices on a single plot. The adoption of conservation practices on two or three farm plots was below 10 %. Farmers have limited means to establish conservation practices to fight erosion caused by heavy erosion despite farmers' knowledge of various conservation strategies to reduce soil degradation. The perception of specific traits of conservation practices influence their decisions to invest in SWC, which are positively associated with higher yield; but negatively affected by the risk of crop failure and labour requirements (Coffie et al. 2016; Alwang et al. 2017; Sumner et al. 2017). A 55-year-old man in the Gahunga sector hired farm labour to remove stones brought by erosion in the form of severe gullies. "…I have paid RWF 300,000 (about US$ 350) to farmworkers to remove stones – that had been transported by erosion or rainwater - from the farm and put them into trenches. Hence, soil erosion control practices in our area require an extra investment those individual farmers cannot afford. In addition to these measures, I will need to apply for fertilisers and pesticides as soil fertility measures to improve the productivity of this plot. Generally, investment in soil erosion control is expensive…" (see Plate 2).

Plate 2. Removing stones that had been transported by erosion from the park

Results show that about 65% of farmers adopted *grassed contour bank terraces* or *ridge farming* as conservation practices making it the most applied practice in the area. "…Ridge farming with grasses retains heavy water from the park. On the ridges, grasses can fertilise the farm, protect the soil from erosion, and provide fodder for animals…," said a middle-aged woman. These practices increase crop yields, water use efficiency, and weed control (Gosar et al. 2010). Together with Napier grass, ridge practices can optimise soil moisture, boost crop yield, facilitate forage conservation and enhance animal performance (Maleko et al. 2019). Hedgerows combined with agroforestry or fertilisers increase crop productivity and reduce soil loss (Ng et al. 2008).

Table 5. Gender adoption of soil conservation and management practices at plot level

	Soil conservation practices			Soil fertility management practices		
	Female (%)	Male (%)	Overall (%)	Female (%)	Male (%)	Overall (%)
Ridge farming				**DAP**		
No plot	58.4	41.6	35.8	59.6	40.4	59.8
One plot	66.9	33.1	27.4	66.9	33.1	19.1
Two plots	55.5	44.5	18.0	60.9	39.1	9.5
Three plots and more	63.5	36.5	18.8	60.2	39.8	11.6
Bench terraces				**Urea**		
No plot	61.3	38.7	89.2	62.4	37.6	86.8
One plot	77.9	22.1	5.1	58.1	41.9	8.9
Two plots	26.9	73.1	3.1	50.6	49.4	1.9
Three plots and more	65.3	34.7	2.7	37.7	62.3	2.5
Anti-erosion ditches (AED)				**NPK**		
No plot	63.2	36.8	76.1	66.2	33.9	48.7
One plot	49.3	50.7	16.9	68.0	32.0	21.9
Two plots	68.5	31.5	2.0	49.8	50.2	14.7
Three plots and more	68.2	31.8	5.0	46.0	54.0	14.7
Agroforestry				**Liming**		
No plot	62.7	37.3	91.8	61.2	38.8	95.2
One plot	44.6	55.4	5.0	58.8	41.2	3.9
Two plots	33.3	66.7	0.5	100.0	-	0.2
Three plots and more	44.5	55.5	2.7	61.4	38.6	0.8
Hedgerows				**Organic manure**		
No plot	62.7	37.3	79.5	57.4	42.6	14.9
One plot	58.7	41.3	13.2	70.7	29.3	38.9
Two plots	60.4	39.6	3.1	50.1	49.9	20.6
Three plots and more	41.4	58.6	4.2	57.8	42.2	25.6
Trenches				**Pest management**		
No plot	61.3	38.8	94.6	65.9	34.1	54.9
One plot	58.7	41.3	4.5	55.3	44.7	22.8
Two plots	96.4	3.6	0.3	57.2	42.8	8.7
Three plots and more	50.9	49.1	0.6	54.6	45.4	13.6
Waterways						
No plot	63.5	36.5	77.7			
One plot	51.2	48.8	15.2			
Two plots	58.7	41.3	2.2			
Three plots and more	56.4	43.7	5.0			
Water harvesting management						
No plot	62.7	37.3	86.3			

One plot	49.7	50.3	8.2	
Two plots	52.7	47.3	3.3	
Three plots and more	57.1	42.9	2.2	

Results also reveal that 85% and 52% respectively adopted and *applied NPK and compost and organic manure* as soil fertility management practices on at least one plot. *Lime, pesticides, and fertilisers (DAP and Urea)* were adopted by less than 20% of household in their farms. Results show a higher concentration of these practices on the first three main cultivated plots, implying that farmers' participation in multiple SFM decreases as the number of farm plots increases. This also implies that the farther the location of the farm from home, the less the adoption of conservation and fertility practices. Both male and female participants in FGDs revealed that: "…Farms too close to the park have difficulties in managing conservation practices due to the heavy water erosion from the volcano park area. For example, in Mitobo or Nyabigoma cells of the Kinigi sector, the closest locations have no trees, ditches, and grasses such as French Cameron and Napier. Farmers are discouraged from planting grasses/vetiver grazed by buffaloes and other wild animals from the park since they are tasty and very nutritious. Thus, farm conservation investment in the proximity to the volcano park area is very costly as it requires wealth, money, planning, and a lot of information…"

The study show that farmers were aware of the benefits of combining different soil fertility management practices and stressed that some farm plots have combined practices of soil conservation and soil fertility management. Various combinations of modern agricultural inputs, which supply nutrients in the soil, are essential for crop growth and yield (Liu et al. 2020) and helps maintain the soil properties (Purbajanti et al. 2019). Adoption of multiple soil fertility management practices with soil conservation practices forms an integrated SWC (Grabowski et al. 2014; Kakaire et al. 2016). The combined use of fertilisers and pesticides contributes to crop quality and ensures stable and high crop yields (Wang et al. 2013).

4. CONCLUSION AND RECOMMENDATIONS

This study assessed trends in gender work patterns, perceptions and adoption in soil and water conservation practices using mixed methods that include qualitative and quantitative approaches, and GIS mapping to triangulate information from various sources. Descriptive results, based on a household survey data collected on 653 male and female, show that socio-economic (age, education and off-farm occupation) and access to services (input-output markets and farm plots) were factors explaining gender differences and socio-economic inequalities in soil and water conservations and agricultural transformation in the area. The importance of education, off-farm employment and access to services advocates the need for developing agricultural innovation pathways in SWC to facilitate the process of agricultural transformation for women and female-headed households. This would require, for example, promotion of agricultural extension education targeting women for SWC and other off-farm innovations. Findings indicate that more female involvement in low-value (staple) and high value crops is an indication of feminisation of farming, but less female participation and decision making in employment outside the household hinges the development of agricultural feminisation as a pathway to empowering female farmers.

Information acquired from land use dynamics, policy changes and economic transformations was found to be an important factor in explaining how land conversion contributed to the intensification of land uses and agricultural commercialisation of smaller farms, which resulted in a shift in gender roles and perceptions regarding SWC as well as resources endowment. This highlights the importance for enforcing land and gender-based policies to accommodate women decision making in the farming sector.

Findings on gendered work patterns in SWC reveal that over time gender inequalities could be explained women deprived access to resources, incentives, and other opportunities including property rights and lack of attention to men and women specific needs. This constitutes social and economic disadvantages that women face, which may lead to low adoption of SWC innovations. The study advocates for policy changes that include social norms which encourage shared roles and equal opportunities between men and women in a household would serve as an effective pathway to poverty reduction. The study found that women's participation in decision making regarding food and cash crops, livestock and SWC is at a higher rate than men, and that, although majority of the respondents participate in joint decisions regarding wage and salaries, and non-farm businesses, a greater number of men participate in decision making. These findings suggest that by increasingly achieving both the feminisation of labour and feminisation of farm management for female farmers, incentives that creates women's participation in the non-farm sector would bring changes in the farm structure.

Findings on gendered adoption of SWC show that grassed contour bank terraces or ridge farming is the most conservation practice used, adopted by 65% whereas NPK and compost and organic manure are amongst the most soil fertility management practices used, adopted by 85% and 52% respectively. This is an indication that despite farmer's awareness of causes of soil degradation, their level of perception of SWC practices does not reflect the actual adoption and field implementation. Similarly, findings reveal that number and concentration of these practices vary with number of plots owned by the households and location of the plot from home. This suggests the design of interrelated and complementary strategies for SWC practices. Extension programs should focus on introducing incentives aimed at adopting multiple SWC practices even in plots that are far from the households.

The current study is based on cross sectional data but the qualitative information captured is dynamic. Additionally, both adoption of SWC practices and decision making are dynamic and involve ongoing processes. It is important for future studies to collect data over time to assess intertemporal and dynamic participation and decision-making in SWC. Further studies should focus on complementary and variability of conservation management and water conservation and use different economic models (bio-economic and bio-decision) which require logit longitudinal data. Longitudinal studies can also evaluate possible changes and adaptation to conservation practices that complement qualitative findings.

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