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Climate Smart Soil and Water Conservation Practices: A Way Forward for Increasing Crop Production Among Smallholder Farmers in South Western Uganda

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Abstract: The purpose of this study was to establish the appropriate climate smart soil and water conservation practices that enhance crop production for smallholder farmers in South Western Uganda, focusing on Mbarara, Isingiro and Ntungamo districts. This preliminary study focused on the following research questions: 1. What are the commonly used climate smart soil and water conservations practices in the region? 2. What are the smart soil and water conservation practices preferred by smallholder farmers in the region? 3. What are the challenges faced by smallholder farmers in application of climate smart soil and water conservation practices in the region? Both open-ended and closed ended questionnaires were used to answer the set research questions. Data was analyzed using SPSS version 23. Results show that smallholder farmers commonly use and prefer mulching (71%), application of organic manure (51.7%), digging trenches (21%); while the least commonly used practices included application of coffee husks (9.4%) and agroforestry (8.4%). The major challenges smallholder farmers were facing were limited capital to apply appropriate climate smart soil and water conservation practices. Capacity building and establishment of farmer-field groups to promote learning among peers were recommended. Further studies on nutrients and water holding capacities in Climate smart agriculture practices need to be conducted in south western Uganda.

Keywords: Climate Smart, Soil, Water, Conservation, Organic Manure

1. Introduction

Soil degradation and water shortage are among the major challenges facing smallholder farmers in Sub Saharan Africa (SSA). Agriculture and soil management practices play an important role in climate change mitigation, adaptation and crop production [1]. Soil is one of the major carbon sinks and improper soil management promotes global warming [2], reduces crop production and enhances loss of soil macro and micro biota. Soils store more carbon compared to both aquatic and vegetative terrestrial sinks combined [3]. Climate influences soil formation and soil degradation enhance climate change through emission of greenhouse gases [4]. Land degradation and poor soil management in SSA has increased greenhouse gas (GHG) emissions to the atmosphere hence enhancing climate change [5, 6]. Climate change has affected soils and water conservation practices in developing countries in the 21st Century including the East African region. Uganda in particular, is highly vulnerable to the impact of climate change and the country has faced severe droughts and insufficient rainfall resulting into crop failure, poverty and food insecurity [7]. South western Uganda (SWU) is vulnerable to the impact of climate change [8], and the water and food sectors are negatively affected. Majority of the smallholder farmers in this region are peasant with limited soil inputs during agriculture, which is done on slopping landscape. Prolonged droughts and unreliable rainfall have resulted into food shortage in the region [8, 10]. In extreme western region, heavy rains have caused flooding, landslides and soil erosion, which lead to loss of soil nutrients hence reduced crop yield. Uganda is vulnerable to climate change impact due to the limited capital to invest into mitigation measures and inadequate policies to guard against environmental degradation [10]. The available policies are sometimes weak while in other cases they are poorly implemented due to increased levels of corruption [11]. Agriculture practices used by smallholder farmers in South Western Uganda (SWU) have increased soil loss and soil degradation hence reducing food production in the region. Agriculture contributes 14-17% of the emissions and traditional methods are unsustainable [12] especially where soils are fragile. Traditional agriculture methods such as slash and burn promote nutrient and water loss and are not sustainable. Transformation of agriculture from traditional methods to appropriate Climate Smart Agriculture (CSA) practices such as soil-water conservation is pertinent in addressing some of the country's challenges and minimizing damages to the resource base [13] in the present century. Climate-smart agriculture (CSA) is an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change [14]. Increasing awareness about the benefits of CSA practices among smallholder farmers has a potential to boost crop production and improve food security in the region. Conservation of soil and water is feasible if smallholder farmers are willing to embrace (CSA) practices that have a potential to mitigate the impact of climate change and enhance crop yields. The approach is tandem with conservation agriculture and UN Sustainable Development Goals 2015-2030 that aim at transforming our world for the better livelihood [15]. Sustainable agriculture methods are essential to promote production and enhance environmental conservation [16]. The call for transformation is beneficial to both developed and developing countries for a better sustainable future world. Previous studies in SWU examined the impact of policies on banana production [17] and financing [18] but climate smart soil and water conservation practices are not clearly documented. The effectiveness of CS and non-CS soil and water conservation practices in South Western Uganda need to be studied and documented. This study aimed at establishment of the most appropriate climate smart soil and water conservation practices that enhance crop yield for smallholder farmers in SWU focusing on Mbarara, Isingiro and Ntungamo districts. Specifically, the study determined CS soil-water conservation practices used by smallholder farmers; assessed the smallholder farmers' preference to CS soil-water conservation practices for increased crop production and identified the challenges faced by smallholder farmers in implementing CS soil-water conservation practices for increased crop production in South Western Uganda.

1.2. Description of the Study Area

Figure 1 presents the map of Uganda showing location of three districts of Mbarara, Ntungamo and Isingiro where this study was conducted. The study area lies between geographic coordinates: 00°56′27″S and 30°45′06″E in South Western Uganda. The focus area borders with the following: In the South-Tanzania; Noth West - Kabale district; North-Ibanda and Kiruhura districts; West-Bushenyi, Kanungu and Rukungiri district; East-Rakai and Kiruhura. The three district are located in the cattle dry corridor and receive less than average annual rainfall (Alex, et al., 2013; Goulden, 2008). The inhabitants of the selected districts are predominantly agriculture dependent for their livelihoods. Water is a scare resource and majority of the soils have been degraded by cultivation with limited fallow periods for decades. Climate change has affected food security and the economy of the population in the region. Temperatures in the region are generally high, especially during the months of June and July and rainfall is unpredictable which affects the agriculture and livelihoods. The sub counties of Isingiro T/C, Ndeija and Itojo are hilly hence making the landscape prone to soil erosion and land degradation. The region has suffered inadequate food production, poverty and malnutrition culminating into food insecurity over the years [20]. As a result, more than 70% of smallholder farmers practice continuous cultivation without fallow and do not have effective strategies for soil and water conservation on their landscape, which affects soil health and enhances nutrient loss.

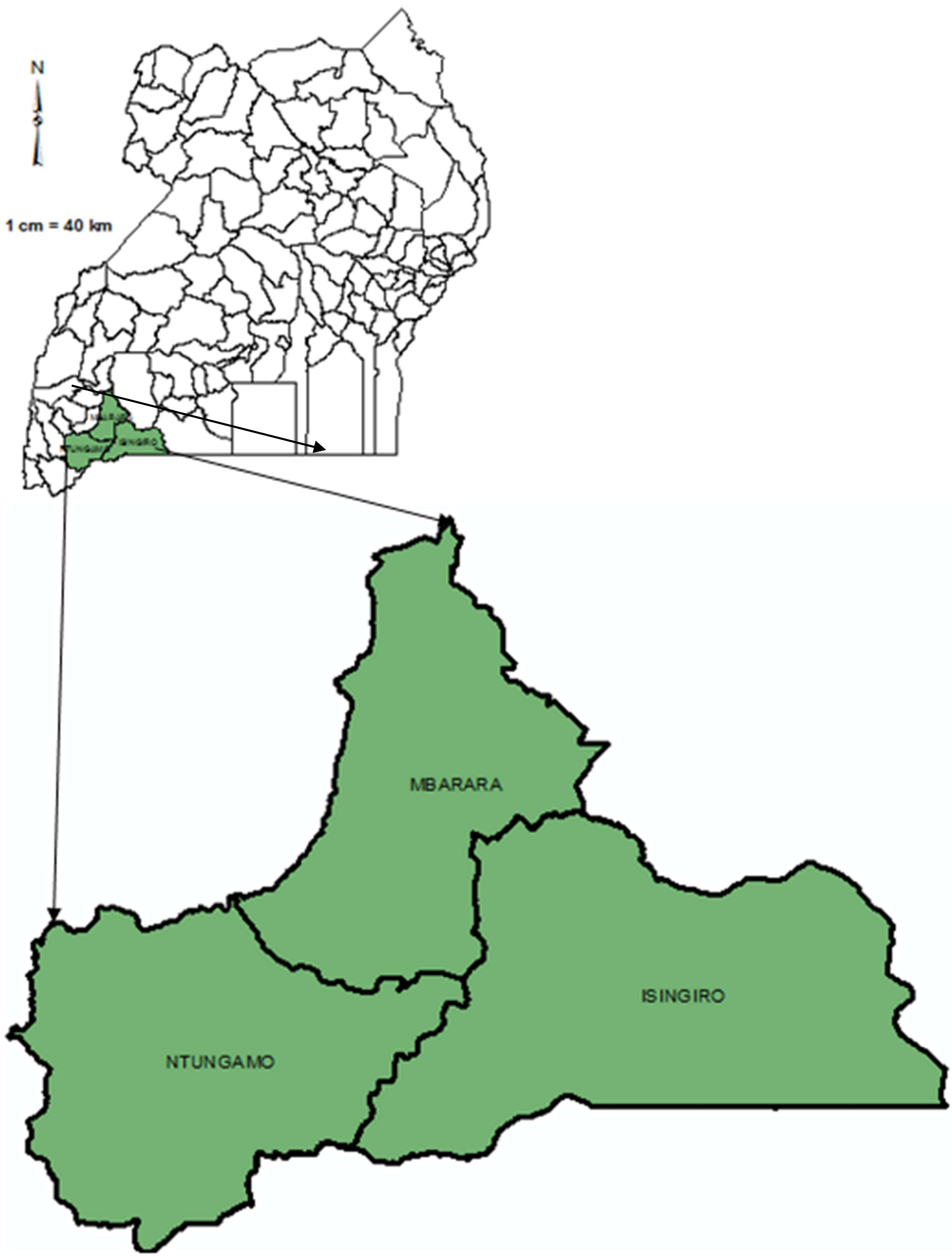

Figure 1. *Map of Uganda showing location of study area: Districts of Mbarara, Isingiro and Ntungamo.*

2. Methods and Approach

Three districts of Isingiro, Mbarara and Ntungamo were purposefully selected for this study. The selection was based on the hilly landscape and vulnerability of the landscape to soil erosion, and nutrient loss. One sub county was selected per district (Table 1) based on the hilly landscape. The households per sub county from the selected three districts were obtained from the

Uganda Bureau of statistics report 2014 [21]. Table 1 shows the number of households per Sub County where smallholder farmers for interview:

Table 1. *Determination of households for sample size.*

District	County	Sub county	# Households	% of Total population	Sample size
Isingiro	Isingiro	Isingiro TC	6,844	36	140
Mbarara	Rwampara	Ndeija	6,881	37	133
Ntungamo	Ruhaama	Itojo	4,774	27	100
Total			18,499	100	373

2.1. Sampling Strategy

Mixed method sampling approach that involved both qualitative and quantitative was used for this study [22]. Key informants that included: District Agriculture Extension Officers, National Agriculture Research Organization (NARO) officers and Environmental Officers from each district were interviewed in focus group discussions per district. The experts provided baseline information about CS soil and water conservation practices in the region before the survey was conducted with farmers. Smallholder farmers for interview were systematically selected with the help of key informants. The numbers of smallholder farmers per sub county were calculated using Krejcie & Morgan (1970) sample size determination table, as a percentage of the total sample size for the entire households of each sub county. A total of 373 smallholder households were interviewed using structured, open and closed-ended questionnaires. Additionally, personal observations, expert opinion and secondary data from, National agriculture Organization (NARO) and other government agriculture offices were be used to supplement the study findings.

2.3. Data Analysis

Data from the household survey (373 households) were analyzed using descriptive statistics and parametric Models in SPSS version 23 [24]. Microsoft Office Excel workbooks were used to create graphs and pie charts for the study findings. Personal observations and expert opinions were also used during the study to document results for the study.

3. Results

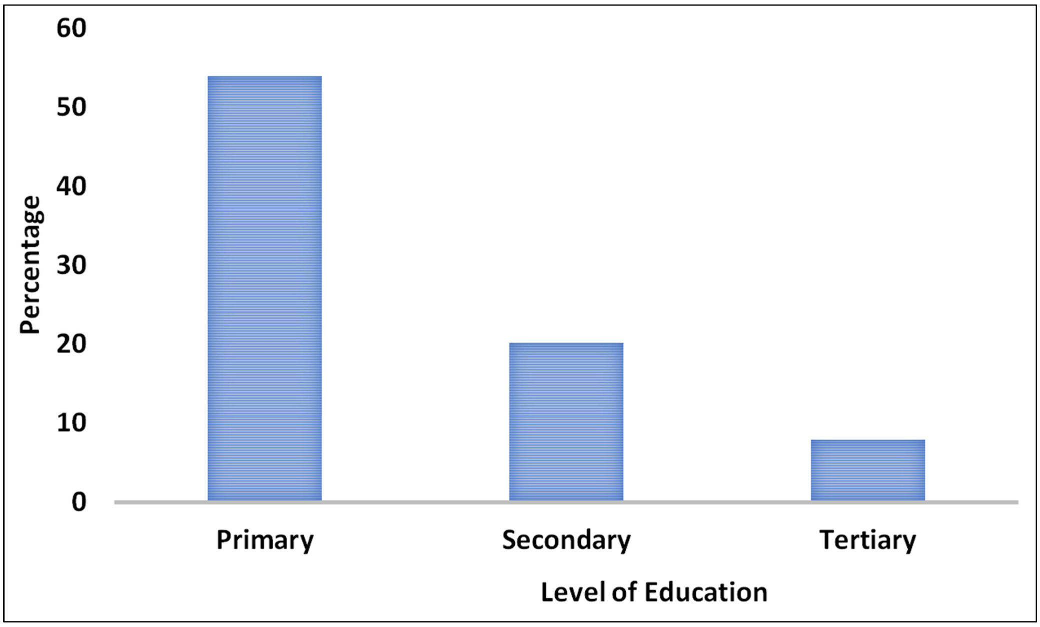

Figure 2. *Education level for SHF in SWU.*

Figure 2 shows the education level for the smallholder farmers in SWU. The majority of the farmers 53.9% completed Primary Education while the least number 7.8% completed Tertiary level.

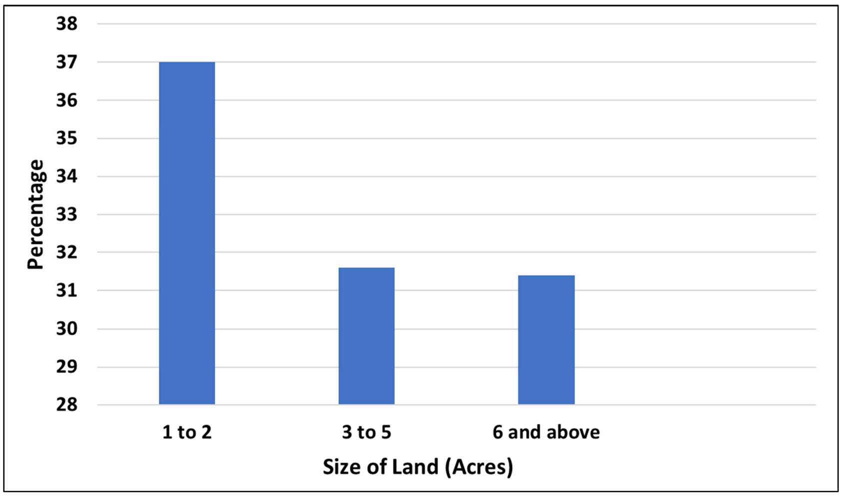

Figure 3. *Size of Land ownership per household.*

Figure 3 presents the size of land owned by each household. Majority (37%) of the farmers own 1-2 acres of land and the minority (31.4%) own 6 or more acres of land.

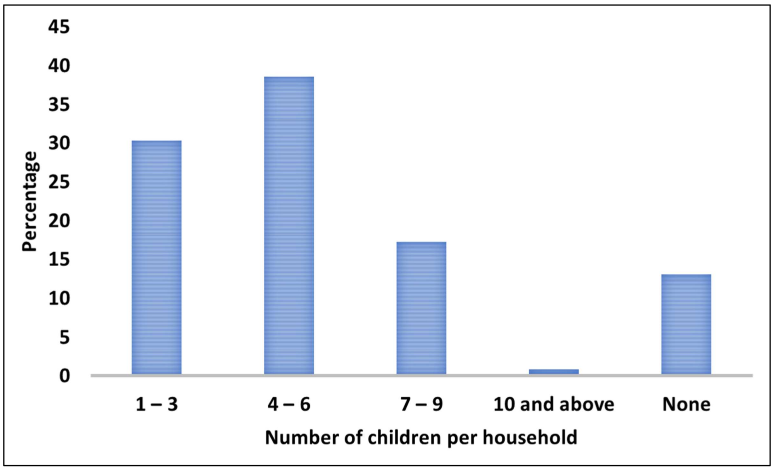

Figure 4. *Size of families in SWU.*

Figure 4 presents the number of children per household. Majority of the households (38.6%) have 4-6 children and the minority 0.8% have 10 and above number of children.

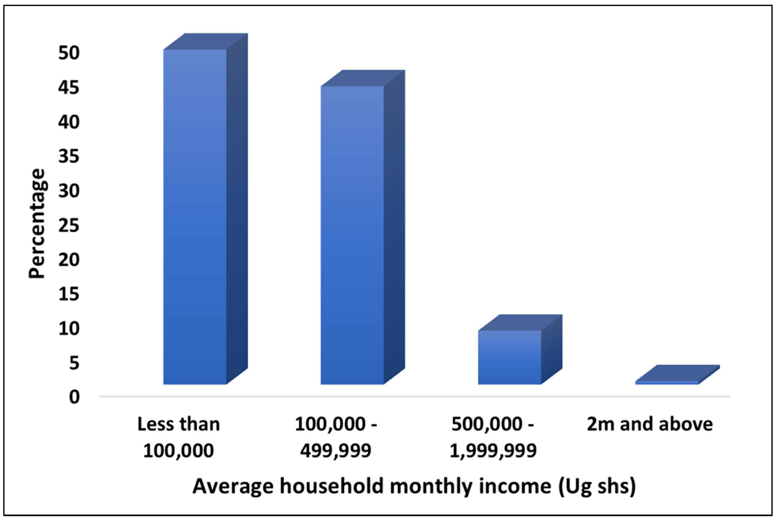

Figure 5. *Average household monthly income.*

Figure 5 presents average monthly income per smallholder farmer. The majority (48.5%) get less than 100,000/= implying that the financial capacity is limited in regard to the farm inputs to conserve soil and water and increase crop production. The minority (0.5%) get 2 million and above as monthly income.

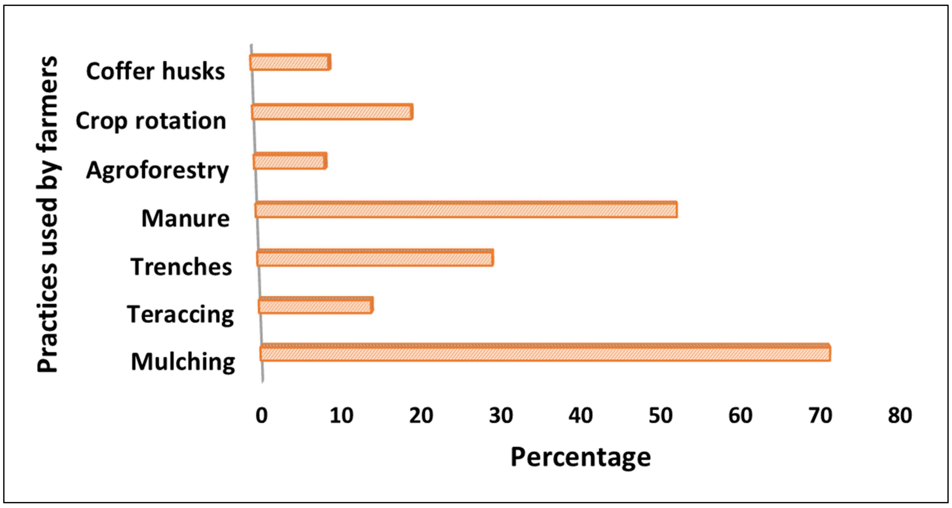

Figure 6. *Climate Smart Soil and Water Conservation Practices (CSSWCPs) used in SWU.*

Figure 6 shows the commonly used agriculture methods by smallholder farmers for soil and water conservation on their farms. The figure shows that majority 70% use mulching and 50.5% apply organic manure. The minority 10% use agroforestry and 10.5% use terraces in hilly landscapes.

The CSSWCP are used for different reasons. Majority of the farmers (81%) reported that soil and water conservation improves on the crop production (yield) on the farm, 16.9% reported that it increases on the income and food security, 35.4% reported that it improves on soil fertility on the farm, 5.6% of the participants said that it prevents soil erosion, 4% of the participants said that it prevents drought, and 16.6% of the participants said that it keeps water in the soil. This means that soil and water conservation is highly important in improving soil fertility, increasing on crop production, prevents soil erosion, drought and keeps water in the soil.

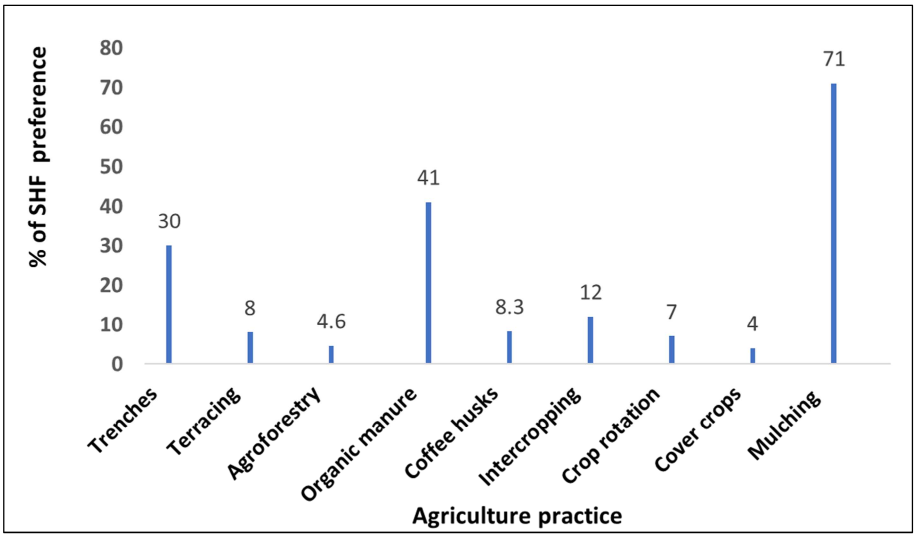

Figure 7. *The most preferred CSSWC practices in the South-Western Uganda.*

Figure 7 presents the CSSWCI preferred by smallholder farmers in SWU. These preferences range from best, good, fair and poor. From the figure, mulching method is highly preferred (71) followed by organic manure (41%) while agroforestry (4.6%) is the least preferred by farmers in the region. This shows that mulching is the most preferred method in the region since it keeps water in the soil, improves on the soil fertility and increases on the crop yield on the farm.

Most of the farmers prefer to practice mulching as well as application of organic manure in the plantations since they are important in improving crop production, soil fertility by adding nutrients in the soil, keeps water in the soil as well as controlling the rate of soil erosion in the region.

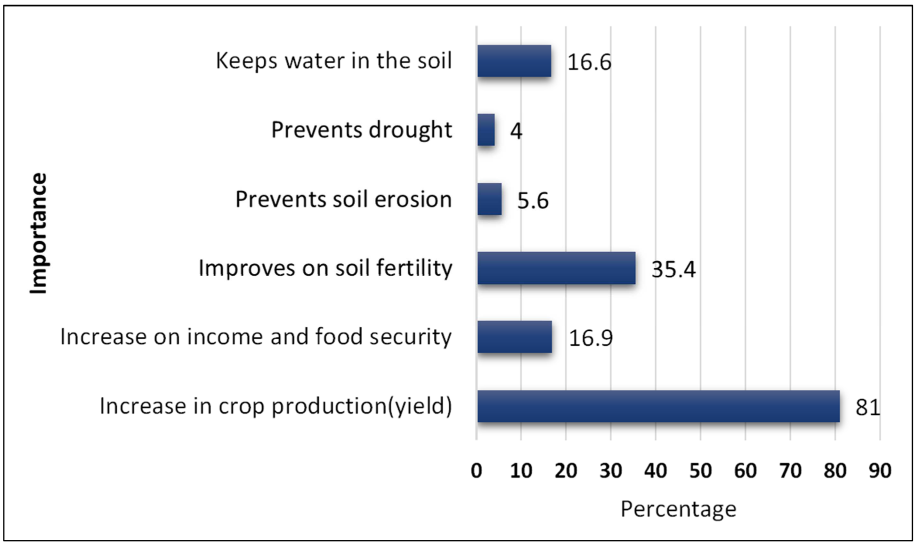

Figure 8. *Importance of soil and water conservation practices in SWU.*

Figure 7 presents importance of soil and water practices in SWU. The majority (81%) of the farmers reported that it helps in increasing crop production and yield, followed by 35.4% who said that it improves soil fertility and the least (5.6%) reported prevention of soil erosion. The least percentage (4%) of smallholder farmers reported that the practices prevent soil erosion.

4. Discussion

4.1. Education and Poverty

Majority of the Small holder farmers completed Primary education level. Previous studies show that many children in homes with limited financial resources are unable to get far in education [25]. This affects the entire family linage and results in chronic poverty because the elder children will have no capacity to support their young ones. Majority of the children who were going to school were boys and those from families with both parents. This is consistent with previous studies conducted in USA, which concluded that male children acquire higher education than their female counterparts in SSA [26]. Early marriages should be discouraged because they are a major roadblock to the girl education in the SWU (Hutchinson et al (2018) noted that early marriages undermines girls health and productivity. Additionally, previous studies show that children from disadvantaged and poor households perform poorly in schools compared to their counterparts from well-to-do and rich families [28]. Education has potential to inculcate democracy and reduce poverty levels among smallholder farmers in Africa [29].

4.2. Land Ownership and Poverty

Land is an essential resource for the smallholder farmers in SWU because majority of the families depend on agriculture for their livelihood support. Families with small pieces of land are poor because they have limited monthly income. They are food insecure and in most cases they are not educated and have poor health. The families in such category of land ownership do not meet the basic needs for Uganda's vision 2040 [30] hence cannot satisfy the family necessary requirements. The rich people have vast amount of land on which they can obtain food and other requirements to meet the needs of their households. Majority of the smallholder farmers in the region are also poor and cannot afford to by big pieces of land for supporting their family members.

4.3. Family Size and Household Poverty

Majority of smallholder farmers own small pieces of land where they cannot grow sufficient crops to support their livelihood. Many children in a homestead need a large pieces of land for smallholder farmers to support their livelihood including healthcare, education, feeding and clothes. Many children per household are a result of high fertility rate and early marriages among women in the region [31]. A household with many children may fails to meet all the basic needs for children upbringing hence undermining their welfare [32]. Majority of the peasant parents do not like to hear about family planning because they call it “a bad omen”. This undermines both food and income security for the households in the region. The findings this study contradicts previous studies which show that family planning supports the UN sustainable development goals and ensures that a few children help parents provide the required basic needs to the their children [33].

4.4. Household Monthly Earnings and Poverty

Majority of the smallholder farmers in SWU are peasant farmer with neither formal employment nor commercial businesses to boost their monthly earnings. Limited monthly earnings result into household increased poverty levels. Household poverty is a major contributor towards land degradation and nutrient loss thus making smallholder farmers poorer and food insecure [34]. Poor farmers have limited capacity to provide the basic needs to the family members and the situation is passed on to the future generations in the family linage. Smallholder farmers should be encouraged to engage in appropriate agriculture activities, team work through cooperatives [35], which can help poor families get out of chronic poverty and live better lives [36]. Agriculture and practices in SWU are constrained by inadequate policy framework and access to credit financing in the region [37]

4.5. Climate Smart Soil and Water Conservation Practices in SWU

Agriculture in Uganda accounts for more than one-third of the total gross domestic product (GDP) [38] and employs 90% of the population [39]. Women participate more in agriculture than men and in each household, the numbers that consume outweigh those that produce food. This leads to food shortage in many smallholder farmers' households in SWU. Slash and burn, continuous cultivation and related traditional methods of agriculture enhance land degradation, nutrient loss and food insecurity among the majority of smallholder populations in SWU. Researchers have a role to play in regard to providing information to farmers and policy makers for sustainable agriculture [40]. Appropriate methods of soil and water conservation can improve crop production while mitigating and adapting to climate change [3]. CSSWCPs have potential to reduce poverty, improve livelihood and boost GDP for the entire country [36]. Farmers reported that CSSWCPs were capable of increasing crop yields in the region.

4.6. Factors Influencing Smallholder Farmers' Agriculture Practices

The major factor that hinders smallholder farmers from using appropriate soil-water conservation strategies in limited capital [16]. For instance, they have limited capacity to apply organic manure, dig trenches, mulching or practice other sustainable agriculture practices that have potential for improving crop production and conserve soils and water on their farms. Additionally, they have limited capacity for adding inputs to their infertile land hence enhancing reduced crop yield that increase household poverty in the area. Poverty, food security and climate change are closely linked and they affect each other among smallholder farmers [41].

4.7. Most Preferred CSSWCP in SWU

Mulching is the most preferred CSSWCP for smallholder farmers in SWU. The practice conserves both soil and water, and adds nutrients to the soil thus increasing crop production. The practice is most preferred but not used by all the smallholder farmers in the region due to the associated cost implications. It has been recommended by the World bank for improving crop production and farmers' livelihood [42]. In addition, application of organic manure and terracing were as well preferred by majority of the smallholder farmers for improving their crop production and reduce household poverty in the region. On the other hand, agroforestry and growing of cover crops were the least CSSWCP preferred by smallholder farmers in the region. This might be due to lack of information about the benefits for these practices in the area.

Figure 9. *Mulching conserves soil and water in the garden mulchingvation practices in SWU.*

4.8. Challenges Faced by Farmers in Implementing CSSWCPs

Smallholder farmers are prevented by different challenges from implementing CSSWCPs in the region. To some, the practices are expensive and not affordable by smallholder farmers, to others it is limited size of land that stop them from applying the practices while others reported that the practices are time consuming for the farmers.

It was reported by Isingiro district agriculture officer that some farmers are conservative and unwilling to adopt new and innovative practices such as CSSWCPs that would enhance crop yield and reduce poverty.

Very sleepy landscapes pose a challenge to farmers in regard to soil and nutrient management thus enhancing soil degradation in the region [5]

Limited by laws and bylaws that undermines soil and water conservation practices in the region. In presence of such, there is poor implementation due to corruption and other vices that causes leaders accept inappropriate farming practices that enhance land degradation [10].

5. Conclusions

Although some of the farmers apply CSSWCPs, they do not properly comprehend the concepts involved. They apply the methods without knowing their implications on soil-water conservation. Mulching, organic manure application and terracing are commonly used and preferred by smallholder farmers while agroforestry and growing of cover crops are the least applied methods in soil-water conservation in the region. Farmers face challenges related with financial constraints and this undermines application of appropriate CSSWCPs in the region.

Recommendations

There is need for capacity building of farmers in regard to CSA and CSSWCPs in the region. This can be done through churches, Local Councils, Savings and Credit Cooperative Organizations (SACCOs) and other community gatherings in the area.

Farmer field groups and SACCOs should be established to enable farmers learn from each other the best farming applications that can increase crop yield and production. Farmers learn most from their peers than leaders or international trainers who come to provide trainings in workshops/seminars. Farmers' SACCOs and Banks should provide loans to farmers at reduced interest rates to enable them make profit from their agriculture produce.

Government should remove large mortgages from agriculture loans to enable peasant smallholder farmers get loans to promote CSSWCPs, enhance crop production and fight poverty in the region.

Smallholder farmers need to diversify their income sources to reduce the unpredictable disasters on single crop yields which results into severe income reduction resulting into chronic poverty. This was the case in Isingiro district where smallholder farmers predominantly depend on banana production and in presence of severe drought, most household heads vacated their families to other countries looking in for ways of feeding their family members during the drought season.

Further studies in SWU about the effectiveness of CSSWCPs in regard to nutrient enhancement, soil conservation and water retention are recommended.

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