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Research Article

Adoption of Black Plastic Mulch as a Coping Strategy to Water Conservation Among Vegetable Farmers in Kisoro Municipality, Kisoro District

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Abstract

The study was about the adoption of black plastic mulches as a copying strategy to water conservation among smallholder vegetable farmers in Kisoro Municipality, Kisoro district. Farmers in Kisoro District have increasingly adopted black plastic mulch to address these agricultural challenges. The use of black plastic mulch in this region helps in conserving soil moisture, controlling weeds, and enhancing crop yields. It was guided by three specific objectives which were to; establish the socio-economic characteristics of smallholder vegetable farmers, establish the knowledge level on the benefits of black plastic mulch among smallholder vegetable farmers and examine the factors influencing farmer's decision to adopt black plastic mulch as a coping strategy to water conservation. The study employed a cross-sectional study design that used both quantitative and qualitative approaches. The study used a sample size of 300. The study used questionnaires and interview guide to collect data. The data collected was analysed using Statistical Package for Social Scientists (SPSS). The results revealed that land ownership was a positive and significant factor at (sig. 0.000**), source of income at (sig.0.001*), credit accessibility at (sig.0.002**) and knowledge on use of black plastic mulches at (sig. 0.000**) The study concluded that vegetable farmers were characterized in terms of gender, age, farm size, marital status and level of education. The study also concluded that there was adequate knowledge level on the benefits of black plastic mulch among smallholder vegetable farmers. Such as; leads to higher yields and improved quality of vegetables, increase the growth rate of vegetables, reduce the risk of root damage, weed suppression, moisture conservation and contribute to soil health and protect the soil from wind and water erosion. The study finally concluded that there were significant and non-significant factors influencing farmer's decision to adopt black plastic mulch as a coping strategy to water conservation among smallholder vegetable farmers which included; land ownership, limited extension training, source of income, knowledge on use of black plastic mulches and credit accessibility and non-significant ones were; un-availability of labour, infrastructure development, level of education, price of black plastic mulch and farm size.

Keywords

Black Plastic Mulches, Vegetables, Quantitative Data, Questionnaire

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1. Introduction

The adoption of black plastic mulch among vegetable farmers has emerged as a critical strategy for water conservation and overall crop management on a global scale [2]. This practice involves covering the soil around plants with black polyethylene sheets, which helps in several ways, such as reducing water evaporation, controlling weeds, regulating soil temperature, and improving crop yields [2].

Globally, in the United States, black plastic mulch has been widely used since the mid-20th century. Its adoption is particularly notable in California and Florida, two states that are major producers of vegetables but also face significant water scarcity issues [9]. The use of black plastic mulch helps retain soil moisture, thereby reducing the need for frequent irrigation. It also helps in weed suppression, which is critical for reducing labor costs and improving crop health [8]. For instance, California's tomato and strawberry farmers have reported substantial improvements in yield and water use efficiency through the use of black plastic mulch [9, 14].

In Africa, the adoption of black plastic mulch has become an essential strategy for water conservation, particularly in regions facing significant water scarcity and climate variability. This practice helps farmers retain soil moisture, control weeds, and improve crop yields [3]. An overview of how black plastic mulch is being utilized across various African countries. Kenya's agriculture is predominantly rain-fed, making it vulnerable to irregular rainfall and prolonged dry periods. Smallholder farmers in regions like Central Kenya and the Rift Valley have increasingly adopted black plastic mulch to address these challenges [15]. The Kenya Agricultural and Livestock Research Organization (KALRO) promote its use as part of sustainable farming practices [15].

In Uganda, agriculture is a crucial part of the economy, with a large portion of the population dependent on farming for their livelihoods. The country faces significant challenges related to water scarcity and climate variability, which have driven the adoption of innovative agricultural practices like the use of black plastic mulch. This practice has been particularly beneficial in regions like the Kisoro District, which experiences unique climatic and agricultural challenge.

Farmers in Kisoro District have increasingly adopted black plastic mulch to address these agricultural challenges. The use of black plastic mulch in this region helps in conserving soil moisture, controlling weeds, and enhancing crop yields [16]. Farmers in Kisoro District have increasingly adopted black plastic mulch to address these agricultural challenges. The use of black plastic mulch in this region helps in conserving soil moisture, controlling weeds, and enhancing crop yields [18].

2. Problem Statement

In an ideal scenario, adoption of black plastic mulches among smallholder vegetable farmers in Kisoro Municipality would lead to improved water conservation practices, resulting in enhanced crop yields, better farm profitability, and sustainable agricultural production.

However, the reality is that many smallholder vegetable farmers in Kisoro Municipality face challenges in adopting black plastic mulches as a coping strategy for water conservation. Limited access to resources, such as financial capital, technical knowledge, and infrastructure, inhibits their ability to implement this technology effectively [10]. Furthermore, socio-economic factors, including land tenure insecurity and market uncertainties, exacerbate the barriers to adoption [13]. As a result, many farmers continue to rely on traditional irrigation methods, which are often inefficient and exacerbate water scarcity issues [11]. Despite efforts to promote the adoption of black plastic mulches for water conservation in other regions, there exists a significant research knowledge gap regarding the specific challenges and opportunities faced by smallholder vegetable farmers in Kisoro Municipality.

Previous studies have primarily focused on larger-scale commercial farms or different geographical contexts, neglecting the unique socio-economic and environmental conditions of Kisoro Municipality [1]. As a result, there is a lack of tailored strategies and interventions that address the needs and constraints of smallholder farmers in this area. Filling this research knowledge gap is essential for developing context-specific solutions that facilitate the adoption of black plastic mulches as a coping strategy for water conservation among smallholder vegetable farmers in Kisoro Municipality. Such research could provide insights into the socio-economic drivers, institutional support mechanisms, and capacity-building initiatives necessary to overcome barriers to adoption and promote sustainable agricultural practices in this municipality. This study will examine the adoption of black plastic mulches as a copying strategy to water conservation among smallholder vegetable farmers in Kisoro Municipality, Kisoro district).

3. Research Objectives

The general objective was to examine the adoption of black plastic mulches as a copying strategy to water conservation among smallholder vegetable farmers in Kisoro Municipality, Kisoro district. Specific objectives were to; establish the socio-economic characteristics of smallholder vegetable farmers, establish the knowledge level on the benefits of black plastic mulch among smallholder vegetable farmers and examine the factors influencing farmer’s decision to adopt black plastic mulch as a coping strategy to water conservation.

4. Significance of the Study

The significance of adopting black plastic mulches for water conservation extends to various stakeholders including

vegetable farmers, government/policy makers, the community, and future researchers as discussed below;

Vegetable Farmers:

Increased yield and profitability; Vegetable farmers in Kisoro municipality can benefit from increased crop yields and profitability through the use of black plastic mulches. By conserving water and optimizing growing conditions, farmers can improve their livelihoods and economic well-being.

Reduced input costs; Plastic mulches can help reduce the need for water and fertilizer inputs by maintaining optimal soil moisture levels and nutrient availability. This can lead to cost savings for farmers, especially in regions where water and fertilizer expenses are significant.

Government/policy makers:

Local water resource management; Policy makers in Kisoro municipality can promote the adoption of black plastic mulches as part of local water resource management strategies. Encouraging farmers to use water-saving practices can help address challenges related to water scarcity and support agricultural development.

Support and incentives; Governments can provide financial incentives, technical assistance, and research funding to support farmers in adopting water-saving practices such as plastic mulching. Policies that promote sustainable agriculture and water conservation can benefit both farmers and the environment.

Community:

Food security and nutrition; The adoption of water-saving practices like plastic mulching can contribute to food security and improved nutrition in Kisoro municipality. A reliable supply of high-quality vegetables benefits local communities by increasing access to nutritious food.

Environmental benefits; Communities in Kisoro municipality can benefit from reduced pressure on local water resources and improved soil health resulting from the adoption of plastic mulches. Cleaner waterways and healthier ecosystems contribute to community well-being.

Future researchers:

Innovation and optimization; Continued research into the use of black plastic mulches can lead to innovations and optimization of practices to further improve water conservation and agricultural productivity. Future researchers can explore alternative materials, application methods, and mulch management techniques to enhance efficiency and minimize environmental impacts.

Environmental impact assessment; Researchers can also assess the environmental impact of plastic mulch use, including issues related to plastic waste and pollution. Finding ways to mitigate these impacts or develop biodegradable alternatives can contribute to more sustainable agricultural practices in the future.

5. Conceptual Frame Work

The framework demonstrates the relationship between study variables. The adoption of any black plastic mulch is determined by on a multitude of factors including i) demographic factors (gender, age, educational level, household size etc.); ii) socio-economic factors (land size, and household income); and institutional characteristics (access to extension services, access to credit, and membership to a social group etc.), the independent variables would give rise to better output (dependent variable) holding other factors (intervening variables) like government policy, attitude and perception, resources to use constant.

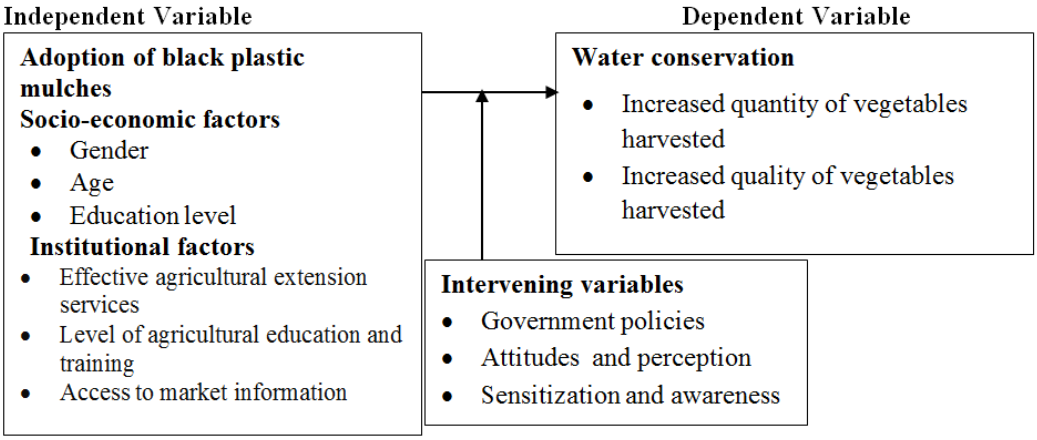

Figure 1. *Conceptual framework.*

6. Materials and Methods

The study adopted a cross sectional survey design that utilized qualitative and quantitative approaches for data collection. Cross sectional design is a kind of research design in which the data is collected at a single point in time from a sample posing homogenous characteristics to represent a large population. Quali-

tative approaches were used to collect and analyze views and opinions regarding adoption of black plastic mulches using a key informant guide while quantitative approach involved the use of quantifiable methods to capture and analyze quantifiable information generated using a questionnaire.

The population of this study comprised all women and men involved in small scale vegetable production, local leaders and agricultural extension staff at municipality level. Farmers gave original information on adoption of black plastic mulches and how it helped to conserve water in vegetable fields. Local leaders provided addition information required including official statistics about the number of vegetable farmers, how agricultural programs had been implemented in their locality and agricultural extension staff provided information on how farmers had been training on use of black plastic materials to improve water conservation.

The sample size was determined by Kish and Leslie (1965) formula.

$$n= pxq\ [z/e]^2 \quad (1)$$

Where: n = Sample size; p = population involved in different agricultural enterprises = 30% = 0.3; q = young population and those involved in other ventures = 65% = 0.65; e = standard error = 5% = 0.05; and $Z_{1/2}$= Z value of 95% confidence = 1.96 from the Z-table. Substituting the values into the formula:

$$n=0.3x0.65x\ [1.96/0.05]^2$$

$$n= 300 \text{ respondents}$$

Stratified sampling was employed and population was divided into distinct subgroups or strata based on certain characteristics and then randomly selecting samples from each stratum. vegetable farmers in Kisoro municipality were divided into different strata based on relevant characteristics such as farm size, farming experience, income level, or geographical location, determined the sample size required from each stratum based on its proportion to the total population and the desired level of precision and finally randomly select vegetable farmers from each stratum to ensure representation of entire population. Purposive sampling involved selecting participants based on specific criteria or characteristics relevant to representation from all segments of the population.

Questionnaires were a valuable data collection tool for gathering quantitative and qualitative information from vegetable farmers about the adoption of black plastic mulches as a water conservation strategy as this tool allowed data collection from a large number of respondents in a relatively short time. It also enabled the collection of quantifiable data that can be statistically analyzed. The questionnaire briefly described the objective of the survey, emphasizing the focus on water conservation through black plastic mulches.

Quantitative data was analyzed using Statistical package for social scientists (SPSS version 22.0). Basic descriptive statistics such as means, frequencies, and percentages will be calculated to summarize demographic characteristics and key variables. Inferential statistics; Statistical tests such as t-tests were used to analyze differences between groups or to assess the relationship between variables. Descriptive statistics measures such as means, standard deviation and frequency distribution were used to analyze continuous and nominal data at Univariate level. Inferential statistics were applied to generate and interpret any significant associations between dependent and independent variables at both bivariate and multivariate level.

7. Study Results

The results are presented in tables and diagrams. The analyzed data was arranged under themes that reflected the research objectives. The results indicated that the majority of respondents 53% were male while 47% were female. This showed that study had more male farmers than female counterparts.

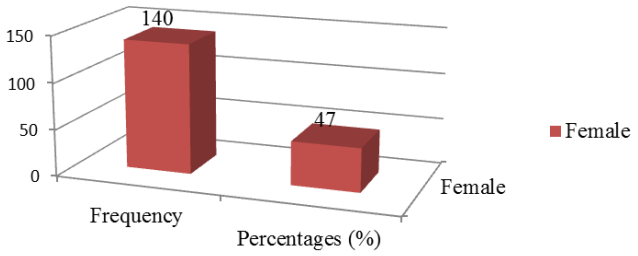

Figure 2. *Gender of respondents.*

The study results revealed that majority of the respondents constituting to 83% were married, followed by 13% were single, 3% were divorced and 1% widow.

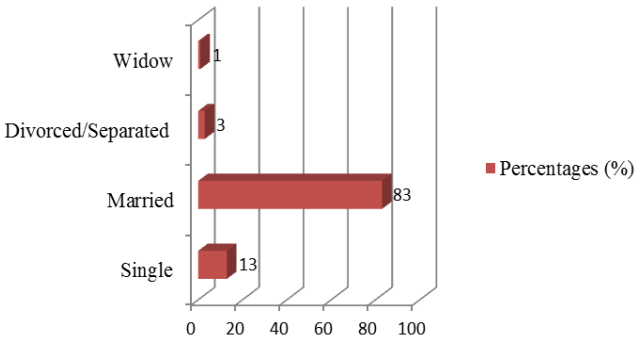

Figure 3. *Marital status.*

Table 1. Descriptive Statistics of age, education, household size and landholdings.

Category	n	Minimum	Maximum	Mean	Std. Deviation
Age in years	300	18	75	37.14	14.664
Level of education in years	300	1	16	9.42	4.468
Farming experience	300	2	12	5.63	1.942
Farm size in acres	300	1.0	14.0	2.184	4.5399
Valid N (listwise)	300				

Age

According the findings, average age distribution among respondents was 37 years and minimum age of 18 and a maximum of 75 years. The biggest number of respondents was aged 18–37 which is regarded as the economically active age ground to undertake vegetable production activities.

Education

Regarding educational attainment, average number of years spent in school were 9 with a minimum of 1 and a maximum of 16. Majority of the respondents had spent between 1–9 years in school. Level of education was considered because it enabled farmers to adopt new technologies provided through extension services and other agriculture oriented NGOs. Farmers with higher levels of education may be more likely to seek out information about innovative techniques like black plastic mulching, understand the potential benefits, and be able to effectively implement them on their farm.

Farming experience

Table 1 above showed that average number of years spent in vegetable farming were five (5) with a lowest number of years being two (2) and maximum number of years being twelve (12). On average most farmers had spent 2-5 years in vegetable farming. Farmers with more years of farming experience often have accumulated knowledge about various agricultural practices, including the benefits of using black plastic mulches to increase water conservation.

Farm size

The size of the farm was considered for its influence on household production capacity, besides it is an important factor of production. Average land size under vegetable farming was 2.18 acres with a minimum holder having an acre and the largest being14 acres. The average farm size of 2.18 hectares reinforces the fact that the majority of vegetable famers operated within smaller land holdings due to population pressure in the study area.

Respondents during questionnaire survey were asked how they knew about use of black plastic mulches, responses were captured, analysed and presented in the table 2 below;

Table 2. How vegetable farmers knew about use of black plastic mulches.

Response	Frequency	Percentage (%)	Cumulative Percent
Through extension training workshops	100	34	34
Through fellow vegetable farmers	140	47	81
Through media platforms	13	04	85
Through agricultural organizations/agencies	47	15	100
Total	300	100	

Source: Field data, 2024

According to results in table 2, majority of respondents revealed that they knew the use of black plastic mulches through their fellow vegetable farmers, followed by 100 (34%) who revealed knowing how to use black plastic mulches through extension training workshops, followed by 47 (15%) who revealed through agricultural organizations/agencies and 13 (04%) revealed knowing use of black plastic mulches through media platforms like radios, televisions, New visions and among others.

Table 3. How black plastic mulches are beneficial to vegetable farmers over other types of plastic mulches.

Response	Frequency	Percentage (%)	Cumulative Percent
Increase the growth rate of vegetables	39	13	13
leads to higher yields and improved quality of vegetables	65	21	34
Reduce the risk of root damage	20	07	41
Weed suppression	47	16	57
Moisture conservation	34	11	68
Contribute to soil health and protect the soil from wind and water erosion	60	20	88
Act as a barrier against soil-borne pests and pathogens	35	12	100
Total	300	100	

Source: Field data, 2024

The study results in table 3, revealed that majority of the respondents 65 (21%) said that black plastic mulches leads to higher yields and improved quality of vegetables, followed by 60 (20%) who revealed that black plastic mulches contribute to soil health and protect the soil from wind and water erosion, followed by 47 (16%) who revealed weed suppression, followed by 39 (13%) revealed that black plastic mulches increase the growth rate of vegetables, followed by 35 (12%) who revealed that black plastic mulches acts as a barrier against soil-borne pests and pathogens as this reduces the risk of disease transmission, followed by 34 (11%) who revealed moisture conservation and 20 (7%) who revealed that black plastic mulches reduce the risk of root damage.

Table 4. Regression estimates for factors influencing their decision to adopt the use of black plastic mulches in vegetable gardens to cope up with water conservation.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	B		
1	(Constant)	18.057	6.774		2.666	.008
	Land ownership	4.083	1.545	.206	2.642	.000**
	Limited extension training	1.068	1.038	.139	1.792	.005*
	Farm size	.261	.146	.127	1.792	.075
	Price of black plastic mulch	-.161	.298	-.038	-.540	.590
	Level of education	-1.871	1.451	-.096	-1.289	.199
	Source of income	3.935	1.531	.202	2.570	.001*
	Credit accessibility	2.657	1.584	.131	1.677	.002**
	Knowledge on use of black plastic mulches	3.531	1.565	.207	2.979	.000**
	Infrastructure development	.399	1.526	.117	.516	.234
	Un-availability of labour	1.865	1.748	.096	1.067	.287

*, **, *** statistically significant at 10%, 5% and 1% significance level

Results in Table 4 above showed the regression output for factors influencing their decision to adopt the use of black plastic mulches in vegetable gardens to cope up with water conservation. Of the 10 hypothesized factors, only five were

significant. These included; land ownership, knowledge on use of mulches, credit accessibility, limited extension training and source of income as interpreted below.

Land ownership was a positive and significant factor influencing the adoption rate at 5% level of significance (sig. 0.000**). This implied that owning the land gave farmers more opportunities to adopt to new technologies like use of black plastic materials.

Similarly, limited extension training coverage was a positive and significant factor to adopting to use of black plastic mulches at 10% level of significance (sig.0.005*). The results implied that majority of farmers would not get enough training due to few extension agents who could not cover a wider area of vegetable farmers.

Findings further indicated that source of income was a positive and significant factor to the adoption rate on use of plastic mulches at 10% level of significance (sig.0.001*). The results implied that farmers who had diversified income sources were more open to experimenting with new practices. They may view the adoption of black plastic mulches as a way to enhance their overall income streams by improving vegetable yields and quality.

Finding also indicated that credit accessibility was significant factor in enhancing the adoption rate on use of black plastic mulches to cope up with water conservation at 5% level of significance (sig.0.002**). The finding implied that this could help farmers mitigate the financial risk associated with adopting new practices like using black plastic mulches. If the investment doesn't yield immediate returns, they may still have the financial flexibility to sustain their operations.

Knowledge on use of black plastic mulches was also significant factor to adoption of black plastic mulches at 5% level of significance (sig.000**). The results implied that farmers who were knowledgeable about agricultural practices were generally more adaptable and open to innovation. They were willing to experiment with new techniques and technologies, such as black plastic mulches, if they believed it could benefit their farming operations. Other factors were non-significant and these included; farm size, price of the mulches, infrastructure development and un-availability of labour.

8. Discussion of Results

The results indicated that the majority of respondents were male while were female. Gender disparities in empowerment and agency can affect farmers' ability to adopt new technologies independently. Respondents reported that women who lack decision-making power or control over resources may be dependent on male family members to adopt technologies like black plastic mulches. This finding can be compared with Brodhagen, M. et al. who in their study revealed that in many farming communities, men typically have more decision-making power than women regarding agricultural practices and investments [6].

Respondents revealed farm size where larger farms typically have more resources and can diversify their investments. This finding can be compared with Babu, R. et al. who reported that allocating funds for black plastic mulch on a portion of the land can be part of a broader strategy to improve overall farm productivity. Large farms can better absorb the financial risk associated with the adoption of new technologies like black plastic mulch [4].

The study findings revealed that level of education was considered because it enabled farmers to adopt new technologies provided through extension services. Farmers with higher levels of education may be more likely to seek out information about innovative techniques like black plastic mulching, understand the potential benefits, and be able to effectively implement them on their farm. This finding is consistent with Babu, R. et al. who in their study reported that examining the level of formal education among vegetable farmers provides insights into their ability to understand and implement modern agricultural practices [4].

The study results also revealed source of income as most influential characteristic among vegetable farmers. Farmers with stable sources of income are more likely to adopt innovations like black plastic mulches. This finding is in line with Bergholtz, M. B who reported that examining the diversification strategies employed by vegetable farmers beyond traditional farming activities includes ventures such as agro-tourism, agri-processing, and non-farm activities as this helps to identify avenues for increasing income resilience to ensure sustainable production [5].

The study discovered that there was knowledge level on the benefits of black plastic mulch among smallholder vegetable farmers in Kisoro Municipality as discussed below;

The study results revealed that majority of the respondents said that black plastic mulches leads to higher yields and improved quality of vegetables. The results can be compared with Turyahabwe, G. et al. who reported economic benefits of adopting black plastic mulch are significant that higher crop yields translate into increased income for farmers, which can improve their livelihoods and economic stability [18].

Respondents further reported knowledge level on mulches emphasizing that they potentially reduce weed infestation and evaporation losses and enhance the percolation and retention rate of soil. This finding concurs with Smith, J. & Jones, L. who reported that plastic mulch can decrease the rate of evaporation by 35% and that non-living mulch materials had greatest capability in moisture conservation in soil as compared to un-mulched soil [17].

The study found out that there were factors influencing farmer’s decision to adopt black plastic mulch as a coping strategy to water conservation among smallholder vegetable farmers as discussed below;

Finding also indicated that credit accessibility was significant factor in enhancing the adoption rate on use of black plastic mulches to cope up with water conservation. This can be compared with Brown, M. A and Johnson, R. O. who reported that smallholder farmers in Kisoro municipality may be hesitant to adopt new technologies like black plastic

mulches due to perceived financial risks. The same authors who also reported that access to credit allows them to conduct a more thorough cost-benefit analysis and evaluate the long-term benefits of mulching for water conservation against the short-term costs which leads to a better implementation of black plastic mulching as water conservation measure to improve crop productivity [7].

The study findings revealed that limited extension training coverage was a positive and significant factor to adopting to use of black plastic mulches at 10% level of significance. The study findings can be compared with that of Mugerwa, S. et al. who in their study reported that effectiveness of extension services in disseminating information and providing training on black plastic mulch can significantly impact adoption and that well-designed extension programs can enhance farmers' understanding and confidence in adopting the technology [12].

Findings further indicated that source of income was a positive and significant factor to the adoption rate on use of plastic mulches at 10% level of significance. Farmers with stable sources of income are more likely to adopt innovations like black plastic mulches.

The results concur with Mugerwa, S. et al. who explained that the financial capacity of smallholder farmers plays a crucial role in their ability to adopt black plastic mulch. Higher-income farmers may find it easier to invest in the technology, while lower-income farmers may need financial support or alternative cost-effective options [12].

9. Conclusion

The study also concluded that there was adequate knowledge level on the benefits of black plastic mulch among smallholder vegetable farmers in Kisoro Municipality. Such as; leads to higher yields and improved quality of vegetables, increase the growth rate of vegetables, reduce the risk of root damage, weed suppression, moisture conservation, contribute to soil health and protect the soil from wind and water erosion, and acts as a barrier against soil-borne pests and pathogens.

The study finally concluded that there were significant and non-significant factors influencing farmer’s decision to adopt black plastic mulch as a coping strategy to water conservation among smallholder vegetable farmers in Kisoro municipality. The significant factors included; land ownership, limited extension training, source of income, knowledge on use of black plastic mulches and credit accessibility and non-significant ones were; un-availability of labour, infrastructure development, level of education, price of black plastic mulch and farm size.

10. Study Recommendation

There is a need to implement programs to empower women farmers, providing them with access to resources, training, and decision-making platforms.

There is a need to promote the formation and strengthening of farmer cooperatives to enhance bargaining power, bulk marketing, and access to inputs at lower costs.

There is a need to strengthen extension services to provide ongoing support and guidance to farmers in implementing black plastic mulch practices. Extension workers can offer technical advice, troubleshoot issues, and facilitate knowledge sharing among farmers.

There is also a need to advocate for policies that promote the use of black plastic mulch and support smallholder farmers in adopting sustainable agricultural practices. This could include incentives, subsidies, or regulations that prioritize soil conservation and resource efficiency.

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Conflicts of Interest

The authors declare no conflicts of interest.

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