



Economic Barriers to the Adoption of Sustainable Agriculture in Tharaka-Nithi County of Kenya

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Authors' contributions

This work was carried out in collaboration among all author. All authors read and approved the final manuscript.

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ABSTRACT

The ballooning world human population, coupled with challenges of climate change, have extensively compromised global food security and sufficiency. This has led to unsustainable intensification of agricultural activities in an effort to meet this growing demand for food. This has in turn resulted to the degradation of natural ecosystems that support agriculture and to social economic challenges such as a rise in unemployment and poverty levels. The adoption of sustainable agriculture however has the potential to mitigate this situation. However, adopting sustainable agriculture faces numerous handles among them some economic factors facing the farmers. Therefore, this study aimed at determining the economic factors that affect the adoption of sustainable agricultural practices by the small scale farmers in Tharaka - Nithi county of Kenya. It was a descriptive survey where data was collected from the residents using semi structured questionnaires and interview schedules. Secondary data was collected from journal articles, dissertations, thesis, books and conference papers. It was organized and analysed using SPSS

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version 24. The study revealed that economic factors such as lack of access to credit, high cost of farm inputs, low returns on the farm produce, inefficient markets for the produce and land rights dynamics affected the adoption of sustainable agriculture by the farmers in this area.

Keywords: Sustainable agriculture; adoption; economic; income; market.

1. INTRODUCTION

The global human population has been increasing steadily over time from about 5 billion in 1986, to 7 billion in 2010 and is estimated that it will be 9.7 billion people by 2050 (Gu et al. 2021). This increase has brought about a proportional rise in the demand for food and fiber. As Falcon et al. (2022) observes, by 2050, a 70% increase in food output will be required. This rising demand for food has led to the intensification and modernization of agriculture resulting to outcomes such as; change in the land use patterns, loss of biodiversity, water and soil pollution, change in the eating habits of communities and increased levels of poverty. This threatens the capacity of the agricultural systems to sustain the required food production in the long run.

1.1 Sustainable Agriculture

The negative trends in agriculture can be mitigated by making the farming systems of the rural poor less vulnerable through the adoption of sustainable agricultural practices. Sustainability as Rosario et al. (2022) note implies coming up with new improved products, technologies, services and processes that generate environmental, social and economic benefits.

The adoption of sustainable agriculture does not however imply scaling down of agricultural activities but rather as Akanmu et al. (2023) notes, it is an approach that embraces the optimization of expertise and technology for the longstanding strength of the agricultural enterprise by building on the existing agricultural practices so as to sustain high farm returns without compromising the fundamentals of the enterprise. Mensah et al (2019) view sustainability as a balance between the population and the ability of its environment to support it whereby the population attains development without producing irreversible adverse effects on the environment.

1.2 Why adopt Sustainable Agriculture

Ochieng et-al (2021) observe that, adoption of sustainable agriculture is critical since in the current global trend farmers are required to

increase their agricultural output on reduced land and at the same time optimize on the utilization of pesticides, fertilizers and limited resources such as water. It supports the intensified agriculture in the view of the scarcity of natural resources on which agriculture is dependent and can enrich long term crop productivity, environmental protection and the adaptive capacity of agriculture (Muhie, 2022; Carvalho, 2017). As Sridhar et al. (2023) note, embracing of sustainable agriculture ensures the security of the rural livelihoods and hence decent incomes and quality life. Ochieng et-al (2021) further note that, sustainable agriculture can contribute to reduction of poverty by raising the incomes of the poor households and by providing employment to the landless laborers. It also strengthens the food systems and helps in the attainment of food security since it makes them more resilient and productive (Pineiro, 2020; Khamung, 2015).

1.3 Economic Barriers to the Adoption of Sustainable Agriculture

Although the adoption of sustainable agriculture is crucial in ensuring food security for the growing population, it is hampered by various economic factors (Adenle et al., 2018). The agricultural markets especially in sub-Saharan Africa are usually not well structured and managed. The returns to farmers vary widely across the markets and are generally very low (Carlisle 2019; National Research Council, 2010). Farmers also face difficulties in finding markets for products such as organic food as they transition from conventional agricultural practices to some of the sustainable agricultural practices such as organic farming (Han et-al 2022; Ogemah, 2017). As such the farmers are not able to benefit economically from their farm produce.

The farmers in the less developed countries are not able to meet the required quality standards for the international markets for their produce where they fetch better prices. As Candemir et al. (2021) observe, farmers who are not in cooperatives have difficulties in meeting the required quality restrictions in terms of pesticides use of the fruits and vegetable markets.

Agriculture especially in the less developed countries is labour intensive. As such as Yigezu 2021 notes, population dynamics such as the aging of the rural farmers affects the productivity of the agricultural labour force and related aspects such as land tenure system and the community's social organizations. Older farmers will also be more affected by advancement in agricultural technology and may be discriminated against in the access to credit and other income generating resources. Consequently, they are not able to invest adequately in agricultural innovation for higher productivity.

The subdivision of agricultural land into small pieces also makes the adoption of sustainable agriculture difficult (Piñeiro et al., 2020). According to Yigezu (2021) these pieces of land end up being degraded, fragmented and infertile. It also becomes difficult to practice mechanized farming on these small pieces of land. Consequently, the rate of unemployment increases since the land is not adequate to engage the farmers on full time bases.

Good market practices that ensure fairness in agriculture trade is of great importance in ensuring sustainability (WWF, 2010). As Ochieng et-al (2021) note, farmer characteristics, and market limitations like lack of affordable credit, expensive inputs and threats to production affect the willingness of a farmer to adopt sustainable agricultural practices.

Wide spread poverty in the bigger part of the rural sub-Saharan Africa also curtails the embracing of sustainable agricultural practices. As Lawson et al. (2020) observe, factors such as inadequate capital, and poor access to credit and other financial services hamper the adoption of sustainable farming practices.

2. OBJECTIVES

1. To study the extent of adoption of sustainable agriculture by the residents of Tharaka-Nithi county of Kenya
2. To determine the economic factors that affect the adoption of sustainable agriculture by the residents of Tharaka-Nithi County of Kenya
3. To identify the solutions to the economic barriers to the adoption of sustainable agriculture by the residents of Tharaka – Nithi County of Kenya

2.1 Research Questions

1. What is the extent of adoption of sustainable agriculture by the residents Tharaka-Nithi County of Kenya.
2. What are the economic barriers to the adoption of sustainable agriculture by the residents of Tharaka – Nithi County of Kenya.
3. How can the economic barriers that affect the adoption of sustainable agriculture by the residents of Tharaka – Nithi County of Kenya be addressed.

3. METHODOLOGY

3.1 Study Area

The study was conducted in Mitheru division of Tharaka-Nithi County of Kenya as illustrated in Fig. 1. The population of the study area is 17,421 (KNBS 2019). The area of study is 33Km² with a population density of 527.9 people per Km². The residents are mainly smallholder farmers who practice mixed farming. The area is composed of four sub-locations namely; Gatua and Ruguta on the upper region, and Karimba and Ndumbini on the lower semi- arid region. The average annual rainfall in the upper zone is 2200mm and 500mm in the lower zone while the average temperature is between 14°C to 30°C in the upper region and 22°C to 36°C in the lower region. The area experiences bimodal rainfall pattern with the long rains coming from the month of April to June and the short rains from the month of October to December (Tharaka-Nithi County, 2018).

3.2 Study Design

The study was a descriptive survey where qualitative and quantitative data was collected from the respondents using semi-structured questionnaires and interview schedules. Stratified, purposive and simple random sampling methods were used in identifying the respondents. Simple random sampling was used in identifying the residents for the study to increase accuracy since the population was not uniform. Stratified sampling was used in identifying the government and nongovernmental organisations officers for the study since they belonged to different cadres. Key informants were identified using purposive sampling where two model farmers from each sub location were picked since the information that was to be collected from them was very specific.

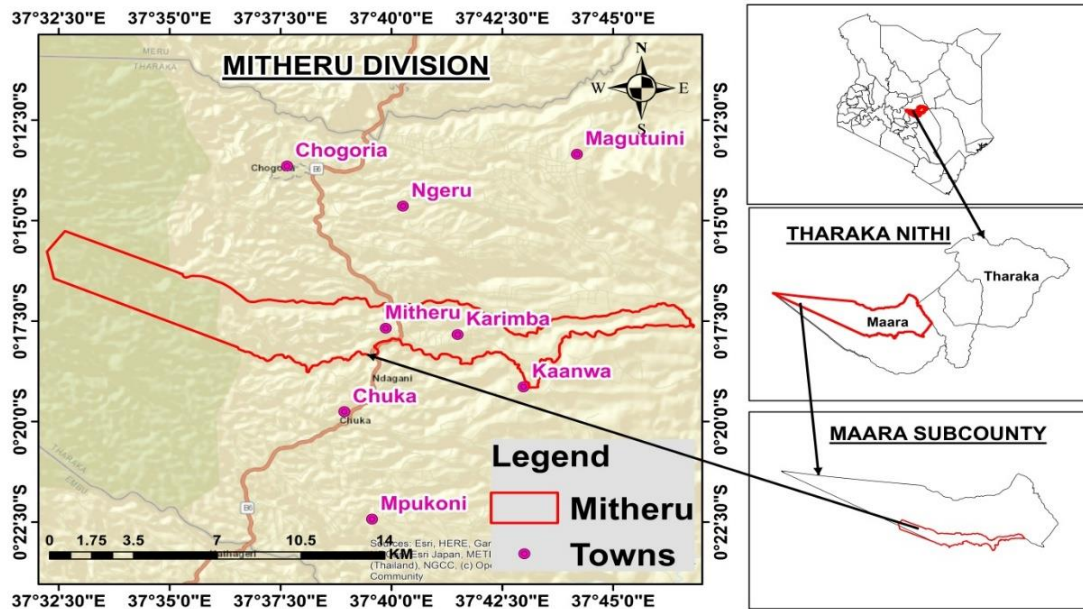


Fig. 1. Map of Mitheru Division Tharaka-Nithi County (source: Field Data 2024)

3.3 Sampling, Data Collection and Data Analysis

A sample of 96 residents was used. Primary and secondary data was collected. The primary data was collected using semi-structured questionnaires and interview schedules from the residents of the study area, government and non-governmental organisations officials. Secondary data was collected from journals, books, dissertations and conference papers. The data collection instruments were pretested for reliability and the anomalies noted were corrected before the actual study. Before analysis, the data was sorted, cleaned, and tested for the response rate, reliability, and validity of the tools. It was then organized using SPSS version 24. It was presented in tables, charts, and histograms and analysed using the chi-square, Pearson's correlation coefficient, mean, standard deviation, the Anova test, frequencies, and percentages.

4. RESULTS AND DISCUSSION

4.1 Farmers Characteristics and Their Influence on Sustainable agriculture

From the study, 55 % of the respondents were female and 45% were male. The number of female respondents was slightly higher than that of the male respondents. Given the culture of the community, women are given the full unpaid responsibility of household chores such as child care, cooking and cleaning leaving them with

little time to invest in agriculture (Rodgers et al. 2019). On the other end the men in the area go out more often to the work in other people's farms for extra income. It was thus more likely to find more women at home than the men. Chi-square statistics were used to examine the association between gender and the adoption of sustainable agriculture. There was no significant relationship at a 5 % confidence level between the two variables ($\chi^2 = 2.230$, $df = 3$, $p = .118$) indicating that gender did not significantly influence the adoption of sustainable agriculture.

From the study, 29% of the respondents were above 60 years of age while 21% were aged between 50 to 59 years, 24% between 40 to 49 years, 16% between 30 to 39 years and 10 % were below 30 years of age. This indicated low participation of the youth in agriculture. Chi-square statistics were used to examine the association between age and adoption of sustainable agriculture where there was a significant relationship at a 5 % confidence level between the two variables ($\chi^2 = 10.470$, $df = 4$, $p = .008$) indicating that age influenced the adoption of sustainable agriculture with more older farmers practicing sustainable agriculture as compared to the young farmers.

A Cross tabulation of the age of the farmers and their gender as shown in Table 1 established that, women formed the highest percentage of the youthful farmers below the age of forty years (17.5%) and the older farmers above sixty years

Table 1. A cross tabulation of gender and age of the farmers

		What is your age (Years)					Total
		Below 30	30 - 39	40 - 49	50 - 59	Above 60	
What is your gender (%)	Male	0	5.6	19.7	8.4	11.3	45
	Female	6.6	10.9	15.4	6.6	15.4	55
Total		6.6	16.5	35.1	15.0	26.7	100

(15.4%). On the other hand the proportion of the men farmers was higher in the middle aged farmers' category (40 to 59 years) at 28.1%. This was an indication that much of the agricultural work was left to the women and children while men engaged in non-agricultural activities.

On the level of education of the respondents, it was established that only 6 % had completed university education, 14 % had completed middle level college education, 26 % had completed high school and 45% had attained primary education while 10 % had not received any formal education. Chi-square statistics was used to examine the relationship between the level of education and adoption of sustainable agriculture where there was a significant relationship at a 5 % confidence level between the two variables ($\chi^2 = 11.471$, $df = 4$, $p = .002$). This indicated that the level of education influenced the adoption of sustainable agriculture with more educated people practicing sustainable agriculture.

The study established that most of the respondents (64%) earned below Ksh 20,000 (USD155)¹ per month. Given the agro-based economy of the area and the relatively low levels of income, the issue of economic sustainability could be compromised. Chi-square statistics were used to examine the relationship between the income of the farmers and the adoption of sustainable agriculture where there was a significant relationship at a 5 % confidence level between the two variables ($\chi^2 = 7.827$, $df = 4$, $p = .037$) indicating that the amount of income of the people influenced the adoption of sustainable agriculture with more high-income earners practicing sustainable agriculture.

The sample size was evenly distributed in all the sub-locations based on the population and the number of people practicing agriculture as shown in Fig. 2. It was noted that some agricultural issues were location specific. For instance, Areas within a 5 Km radius of towns and market centres such as Mitheru, Karimba, and Kaanwa were

mostly practicing commercial agriculture while areas far from the towns and lacking efficient transport infrastructure such as Mikuu, Gatua and Nkururu mostly practiced subsistence agriculture. The analysis shows that 76 %, 81%, and 69% of the farmers around Mitheru, Karimba, and Kaanwa practice commercial farming respectively. On the other hand, only 48 %, 35% and 44 % of the farmers in Mikuu, Gatua, and Nkururu practiced commercial agriculture.

4.2 Adoption of Sustainable Agricultural Practices in Mitheru Division

Sustainable agriculture is an integrated system of plant and animal production practices that in the long run will satisfy human food and fiber needs, enhance environmental quality, sustain economic viability of farm operations and enhance the quality of life for the farmers and the society at large (Muhie 2022). The study investigated the presence of these elements of sustainable agriculture in Mitheru division. As discussed in the analysis below, it was clear that some farmers practiced sustainable agriculture while some did not. Some of the outstanding indicators of sustainable agriculture include:

4.2.1 Type and reason for practicing agriculture

It was established that 51.7 % of the people practiced subsistence farming, 16 % practiced commercial agriculture and 31.5 % practiced both commercial and subsistence agriculture. About 78 % of those practicing both commercial and subsistence agriculture indicated that their primary purpose for agriculture was to provide food for the household and to get income from the sale of the surplus and their cash crops.

Given the rural economy is largely agro-based and the fact that 64 % of the people have an income of less than Ksh 20,000 a month, economic sustainability of their agricultural systems may be compromised in a model where only 16 % of the farmers have invested in commercial agriculture. To test if the adoption of sustainable agriculture varies depending on the type of agriculture practiced, an ANOVA test for

¹ Online exchange rate 1\$= Ksh. 129: <https://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=KES> [accessed 11/06/2024].

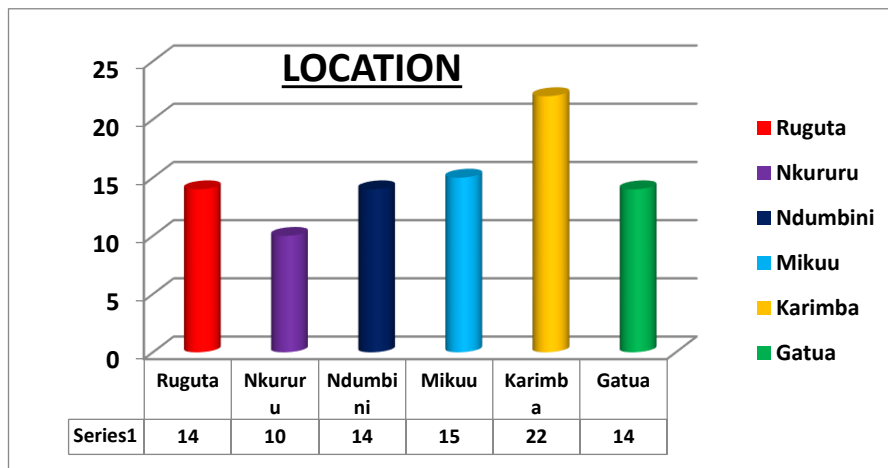


Fig. 2. Distribution of the respondents in the study area

Table 2. ANOVA test for type of agriculture and sustainable agriculture

Type of agriculture Practiced/ adoption of sustainable agriculture					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.196	1	.196	2.743	.023
Within Groups	70.163	87	.806		
Total	70.360	88			

Source: Field survey data, 2024

the two variables was run. As indicated in Table 2 above, the results suggest that there are significant differences in the adoption of sustainable agriculture between commercial and subsistence farmers ($f = 2.743$, $p = .023$) at a 95 % confidence level. The likelihood of a farmer practicing sustainable agriculture was higher among subsistence farmers ($M = 1.92$, $SD = .996$) compared to commercial farmers ($M = 1.78$, $SD = .883$).

4.2.2 Familiarity with sustainable agriculture

Although with few gaps, the community was aware of the concept of sustainable agriculture with 86.5 % of them indicating that they are familiar with the concept. When asked to define sustainable agriculture, 37.1% of the respondents argued that it is an economically, socially and environmentally self-sustaining model of farming while 30 % of them argued that it was an agribusiness and modern method of farming. A cross-tabulation between familiarity with sustainable agriculture and the community

definition of the concept revealed that 21.7 % of those who said that they are familiar with the concept could not define or explain what it is about. In their view, agriculture is sustainable as long as it is economically profitable and can provide sufficient food throughout the year. These dynamics on the level of awareness about sustainable agriculture influenced the acceptance of sustainable agricultural practices in that the community could not implement a concept that they were not fully aware of. According to the ANOVA test shown in Table 3 below, familiarity with the concept of sustainable agriculture did not contribute significantly to its adoption ($f = .772$, $p = 0.79$) at a 95 % confidence level. There was not adequate statistical proof to suggest a relationship between the adoption of sustainable agriculture and its familiarity given that the likelihood of a farmer practicing sustainable agriculture was equal among the farmers who were familiar with the concept ($M = 1.50$, $SD = .501$) and the ones who were not ($M = 1.45$, $SD = .798$).

Table 3. ANOVA test for familiarity with sustainable agriculture and its adoption

Familiarity with sustainable agriculture/adoption of sustainable agriculture					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.021	1	.021	.772	.079
Within Groups	26.091	87	.300		
Total	26.112	88			

Source: Field survey data, 2024

4.2.3 Interview’s insights on adoption of sustainable agriculture

According to the county department of agriculture, livestock, and fisheries majority of the farmers are involved in subsistence farming and the excess output is sold within the local market centers. The major food crops cultivate in the area of study were; maize, beans, and bananas while the Cash crops farmed were mainly tea and coffee. Agriculture was the main source of employment for the residents. The agricultural produce not however sufficient to cater for the food and economic demands of the farmers resulting in food insecurity at times.

A representative from the meteorological department indicated that most of the farmers relied on rain-fed agriculture. This was not a sustainable model of farming. The agricultural extension officer indicated that the main challenges faced by farmers include lack of information on proper planting seasons, practices, seeds, appropriate farm inputs, and financial management. This was attributed to inadequate agricultural education programs and funding. To address these challenges, the farmers especially the women had organised themselves into groups that help them consolidate their resources and exchange ideas on agriculture thereby boosting their capacity.

4.3 Main Challenges Facing Sustainable Agriculture

In the view of the respondents, an agricultural enterprise that could not enable them to meet their food sufficiency and financial goals was not sustainable. A majority of the respondents (60 %), indicated that practicing agriculture had not enabled them to meet their goals. Fifty one (51%) of the respondents cited financial constraints related to the high cost of farm inputs, low returns on produce, lack of efficient markets for their produce and small pieces of land as the main barrier to achieving their goals. This is in agreement with the observation by Mgomezulu et al. (2023) that, the probability of a household to adopt sustainable agricultural practices depended on its level of income. Setsoafia et al.

(2022) further notes that, income from off-farm activities enables the farmers to invest in innovative technologies that improve the performance of their agricultural enterprises. The ANOVA test as shown in Table 4 revealed that there was enough statistical evidence that farmers who faced major challenges did not adopt sustainable agriculture ($f= 5.897, p = .000$). It was more likely to find farmers who experienced fewer challenges adopting sustainable agriculture ($M = 1.33, SD = .442$) compared to those who experienced major challenges ($M = 1.26, SD = .492$).

4.3.1 Economic challenges to the adoption of sustainable agriculture

The study as shown in Fig. 3 established the main economic challenges that affected the adoption of sustainable agriculture by the farmers in the study area. These challenges included: the high cost of agricultural inputs cited by 36.7 % of the farmers, market dynamics related to low production, fluctuating market demand and unpredictable prices of farm outputs cited by 31 % of the farmers, Lack of financial capacity to support sustainable agriculture cited by 16.4 % of the farmers, and land dynamics cited by 15.6 % of the farmers. This is in agreement with the findings of Takahashi et al. (2019) that local farmers face high input prices as well as low output prices that make them use less inorganic fertilizers and improved seed varieties. Lack of capital hampers the ability of the farmers to invest in sustainable agricultural activities as well as the necessary knowledge to search for the relevant new technologies (Menozzi et al. 2015, Shah et al. 2021).

To establish the relationship between these economic challenges and adoption of sustainable agriculture, the respondents were requested to indicate the degree to which they were in agreement or disagreement with statements relating to economic challenges affecting sustainable agriculture on a scale of 1-5 (with 1= strongly disagree 2= Disagree 3= Neutral 4= Agree 5= strongly agree) and circle (O) the option that best represented their opinion. The results were summarized in Table 5.

Table 4. ANOVA test for challenges facing sustainable agriculture and its adoption

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.757	1	.757	5.897	.000
Within Groups	25.356	87	.291		
Total	26.112	88			

Source: Field survey data, 2024

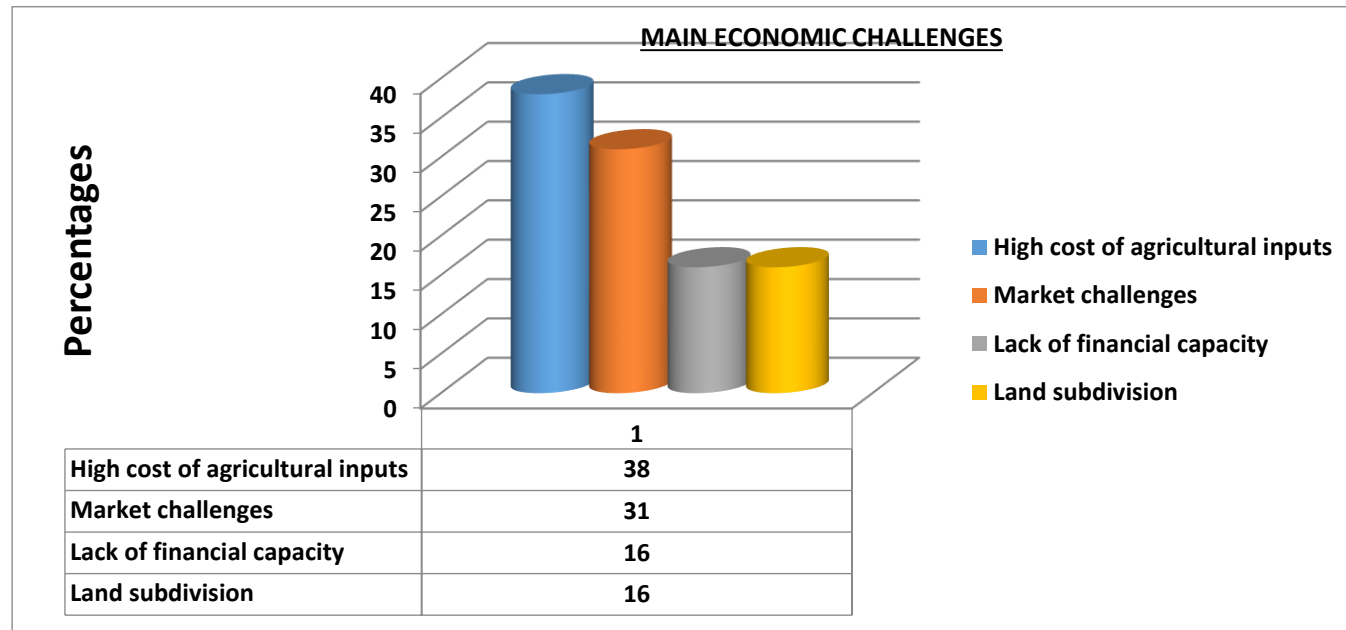


Fig. 3. Main economic challenges facing sustainable agriculture

Source: Field Survey data, 2024

Table 5. Descriptive statistics on economic challenges facing sustainable agriculture

Statement	Agree (SA+A)	Disagree (SD+D)	Mean	STD DEV
There is an enabling economic environment in this area to practice sustainable agriculture	26.6 %	58.8 %	1.86	1.332
I would account my inability to practice sustainable agriculture to economic challenges	43.2 %	24.3 %	2.82	1.276
I have access to affordable financial credit and reduced cost of farm inputs for agriculture	28.4 %	53.6 %	2.06	1.304
There is a ready and reliable market for the farm produce that facilitates high profitability	42.3 %	31.3 %	2.76	1.303
My land is large enough and properly located enabling me to practice crop rotation and diversification.	38.9 %	43.8 %	2.39	1.024
Average	35.88	42.36 %	2.38	1.248

Source: Field Survey data, 2024

As shown in Table 5 above, 26 % of the farmers feel that there is need for an enabling economic environment to practice sustainable agriculture. Majority of the farmers (58.8 %) with a mean and a standard deviation of 1.86 and 1.332 respectively feel that the economic environment is not favourable for sustainable agriculture. 43.2 % of the farmers blamed their inability to practice sustainable agriculture on economic related challenges while 24.3 % of them believed that their inability to practice sustainable agriculture was caused by other factors other than the economic ones. According to the data, 53.6 % of the farmers were not able to access financial loans and could not afford basic farm inputs, especially fertilizers, therefore making agriculture financially unsustainable. Myeni et al. (2019) observe that, smallholder farmers with low incomes are unable to adopt sustainable agricultural practices that are labour intensive and those that require sophisticated equipment. Lawson et al. (2020) further notes that the farmers are not able to access inputs such as fertilizers and improved seed varieties due to financial handles.

Market dynamics were a major challenge to 31.3 % of the farmers who stated that they only rely on the local market for their agricultural produce. On the other hand, 42.3 % of the farmers stated that there was market for their farm produce and the main challenge was inadequate farm produce to meet the demand for the produce. This is in line with the sentiments of Serote et al. (2023) that, better markets and product prices improve farmers' motivation to produce more. Farmers also argued that there is no market within the areas for traditional food crops such as yams, cassava, sweet potatoes, and arrow roots among others which forced them to transport them to Chuka town hence incurring transportation costs. This is in agreement with the findings by Bottazzi et al. (2023) that, sustainably produced foods are in low demand from local consumers, who prefer cheap imported products to the locally and ecologically grown products. Land dynamics also presented a major challenge with land fragmentation being the major barrier to the adoption of sustainable agriculture for 43.8 % of the farmers. In their view, their land sizes were too small to allow sustainable agricultural practices such as agroforestry, planting cover crops and perennial crops, practicing crop rotation, and diversification of crops.

This is in agreement with the sentiments of Zerssa et al. (2021) that, there is a higher likelihood of the farmers with large farms

adopting sustainable agricultural practices when compared to the farmers with smaller farms since they are able to set aside part of their farms for experimentation of the new techniques as they continue with the conventional farming practices on the other parts of the farm.

The aggregate mean and standard deviation of 2.32 and 1.248 respectively indicated that economic challenges are major barriers to adoption of sustainable agriculture by 42.36 % of the farmers.

4.3.2 Solutions to the economic challenges facing adoption of sustainable agriculture

The study sought to determine ways in which the economic barriers to the adoption of sustainable agriculture by the farmers could be addressed. In this case, 44.9 % of the farmers argued that, proper financial planning was the best way to address their challenges. In their view, such plans included; joining credit facility institutions, doing away with middlemen in the market, and providing labour in the farms to reduce the cost of production. As Serote et al. (2023) observe, training farmers on skills such as price determination and knowledge of the markets can enable them obtain better returns from their investments. On the other hand, 28.1 % of the farmers felt that, the adoption of proper farming methods such as irrigation through rainwater harvesting, drilling of boreholes, and use of locally available farm inputs such as manure was the way to address these challenges.

4.3.3 Community cohesion as a Solutions to the economic challenges facing sustainable agriculture

Farmers felt that the social networks within the community offered solutions to some of the economic challenges that hindered the adoption of sustainable agriculture. This is by providing labor through communal work (13.5 %), provision of a huge local market base for the produce (10.1 %), capital mobilization through social groups (7.9 %), and sharing of farming tools (9 %). This is in agreement with the sentiments of Donkoh (2019) that, membership to farmers associations increased their probability to access credit and adopt sustainable farming practices. Dessart et al. (2019) further observes that, neighboring farmers may share such knowledge as the real cost of production, benefits and risks of adopting a given sustainable agricultural practice. On the other hand, some farmers felt that these social

Table 6. ANOVA test for social cohesion and sustainable agriculture

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.672	1	1.672	.369	.063
Within Groups	92.710	87	1.066		
Total	94.382	88			

Source: Field survey data, 2024

networks contributed to the farmers not adopting sustainable agricultural practices in different ways. This was by; theft of farm products and inputs by neighbours (7.9%), farmers in the social groups influencing one another to resist new agricultural innovations (16.7 %), and destruction of crops by animals from the neighbours (4.5 %). On the other hand, 17 % of the farmers indicated that their relationship with other members of the community did not influence their decisions on the adoption of sustainable agricultural practices. An ANOVA test as shown in Table 6 above indicated that there was no significant association between community relationships and adoption of sustainable agriculture ($f = 0.369$, $p = .063$). The social linkages did not influence adoption of sustainable agriculture to a great extent given that both the united ($M = 1.78$, $SD = .590$) and disunited farmers adopted sustainable agricultural practices to the same degree ($M = 1.71$, $SD = .490$).

4.3.4 Government assistance

About 40 % of the farmers indicated that they rarely apply sustainable agricultural practices to address their challenges out of which, 8 % believe that they cannot solve these challenges locally and have to rely on the government and other organizations within the agricultural sector.

5. CONCLUSION

About 78% of the farmers in the area of study indicated that their main purpose of practicing agriculture was for provision of food and income through the sale of the surplus produce and their cash crops. However, a majority of these farmers argued that the income from agriculture was not adequate to sustain their needs hence their agriculture enterprises were not economically sustainable. Also, despite majority of the farmers earning less than Ksh. 15, 000 per month, only 16 % of them were practicing commercial agriculture. Given that the economy of the area is largely agro-based, this shows that adoption of economically sustainable agriculture was still low in this region. Additionally considering that some

of the sustainable agricultural practices were capital-intensive, the income of the farmers was too low to support it.

It was established that the adoption of sustainable agriculture in the area was largely affected by economic factors such as the level of income of the farmers, cost of inputs, access to credit, efficiency of the markets for the produce and land issues. Managing these factors would therefore go a long way in enabling the farmers adopt sustainable agriculture practices.

In efforts to adapt to the climate change and coping with the economic barriers Farmers have adopted farming methods such as efficient use of water by using drip irrigation, mulching, timely planting and proper soil management techniques such as tilling across the slope. The social networks of the farmers have also enabled them to address the economic barriers that hinder them from adopting sustainable agricultural practices. These networks enable the farmers to save on labor costs through communal work, provide them with local market base for their produce, facilitate capital mobilization through membership in social groups and reduction of operational costs through sharing of farming tools.

Some of the farmers believe that they cannot solve the economic challenges to the adoption of sustainable agriculture locally and have to rely on the government and other organizations within the agricultural sector to help them out. The government should consequently come up with the appropriate programmes to help farmers achieve agricultural sustainability such as; farmers training on sustainable farming practices, regulating prices of agricultural inputs, sourcing for efficient markets for the produce and providing affordable credit to the farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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