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Impacts of agroforestry technologies on livelihood improvement in Vihiga County, Kenya

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Abstract

The adoption of agroforestry technologies remains an important strategy to reduce poverty and hunger among resource-constrained rural farmers. However, the potential contribution of agroforestry technologies to the economy and sustainable development goals in Vihiga County, Kenya, is yet to be fully exploited. This study determined the impacts of agroforestry technologies on livelihoods and the socio-economic factors influencing the adoption of agroforestry technologies. A multi-stage sampling technique was used to sample four major villages in Hamisi and Sabatia sub-counties; Shamakhokho, Kaimosi, Sabatia, and Mago. A total of 110 households were interviewed. Semi-structured questionnaires and observation checklists were used to collect quantitative data, while key informant interviews were conducted to collect qualitative data. Data was analyzed using both descriptive and inferential statistics. Significant level was expressed at P≤ 0.05. The Chi-square test of association indicated that the socioeconomic factors influencing the adoption of agroforestry technologies were income ($\chi 2 = 20.951$) and land size ($\chi 2 = 23.282$). The study showed that 85% of respondents reported over 30% monthly income increase from the sale of agroforestry products, such as; firewood (57%), timber (27%), fruits (15%), and charcoal (1%). In light of the benefits realized, 57% of the respondents affirmed that they were able to meet their basic needs from agroforestry technologies. In conclusion, this study established that agroforestry technologies positively impacted the livelihoods of farmers in the study area. The study recommends strengthening extension service delivery, intensifying agroforestry production through diversification of agroforestry products and harmonizing the market structures.

Keywords: Agroforestry technologies; Adoption level; Sustainable Agriculture; Vihiga

1 Introduction

With current threats to the world's natural resources, a high rate of resource use has resulted in increased poverty, food security crises, and unsustainable livelihoods in many developing countries. According to FAO (2013), rural communities are the most affected by high poverty levels accounting for almost 70% of the population in developing countries. Since most conventional development approaches, such as sustainable use of resources and participatory development, have always viewed low income as the main cause of rural poverty, developing income-generating activities is vital in fighting poverty in rural areas.

Small-scale farming is the main livelihood activity among many rural communities in Africa. Small-scale farmers manage approximately 80% of small world farms (IFAD, 2013). However, small-scale farming, especially in Sub-Saharan African countries, has been profoundly negatively impacted by declining soil fertility and climate change (Sakho-Jimbira &

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Hathie, 2020). Such impacts call for the implementation of pragmatic steps that support the three pillars of sustainability: environmental, social, and economic. In response to the challenges faced by small-scale farmers, sustainable agriculture is universally recognized as an essential strategy in the fight against poverty and environmental protection. As highlighted by Purvis et al. (2018), this strategy was acknowledged during the 1987 United Nations Conference on Environment and Development (UNCED).

Agroforestry technologies, part of sustainable agriculture, have emerged as one of the positive responses that can help alleviate poverty and hunger and ameliorate soil degradation. Agroforestry technologies closely associate trees and shrubs with crops and pasture (Rose et al., 2009). Several agroforestry technologies with proven economic benefits have been developed among farmers. These technologies include alley farming, boundary tree planting, woodlots, home gardens, and fodder banks (Mayele et al., 2019). Agroforestry technologies yield timber and non-timber products. According to Dhakal et al. (2022), non-timber products provide goods and services, including food security and health, and supports the socio-economic welfare of rural communities. Timber products are used to produce paper and building materials.

Globally, scientists and policy makers support agroforestry technologies as the solution to the developmental needs of rural communities (Chaturvedi, Mishra & Kaushal, 2016). To underscore the importance of agroforestry technologies in livelihood improvement, in developing countries, approximately 1.2 billion rural population solely rely on agroforestry for their livelihood (Nyong & Martin, 2019). According to Noordwijk (2020), agroforestry technologies contribute to Sustainable Development Goals (SDGs) 1 and 2, which seek to eradicate poverty and end hunger. Agroforestry technologies drive towards achieving SDGs mainly through boosting land productivity, diversifying farm produce, and promoting stability in revenue for farmers, while ensuring environmental sustainability. Castle et al. (2022) purport that agroforestry technologies control soil erosion, improve water and nutrient cycling and provide several socio-economic benefits for improving farmers' livelihoods. With Such positive impacts, agroforestry technologies have been given credence as a sustainable land use strategy that can help address the impacts of climate change and environmental degradation while simultaneously providing numerous socio-economic benefits.

In Kenya, it is estimated that 74% of the total population lives in rural areas ((World Bank, 2018). A significant proportion of this rural population depends on agricultural activities for their livelihoods (Chambers, 2014). However, agricultural production faces many challenges, including low productivity due to declining soil fertility, insecurity of land tenure systems, high dependence on rain-fed agriculture, and unsustainable agricultural practices (Kibugi, 2017). As a result, smallholder agricultural production remains low, leading to a high incidence of poverty. Therefore, there is a need to take drastic measures that will help improve smallholder agricultural productivity. Moreover, understanding that poverty is not only an economic process, but also embedded in environmental and social processes, is instrumental in taking radical measures that yield sustainable solutions for economic viability and ecological sustainability (RoK, 2013).

Over the years, the economic activities carried out by the residents of Vihiga County in Kenya have had devastating effects on the environment. Land degradation is increasing due to land subdivision and encroachment into fragile areas such as river banks, hills and forested regions, thus escalating poverty among the residents. Most of the poverty reduction strategies in the County are directed towards the development of industries, for example, the local artisan sector, brick making and the exploitation of mineral resources like gold in Vihiga and Kaimosi forests (RoK, 2018). These activities are not sustainable since they only benefit a small proportion of the population, leaving out most of the others who are peasant farmers. Moreover, industrialization has the potential for environmental degradation by emitting pollutants into the air and water and further bringing up informal settlements.

Due to these numerous environmental problems, there is an urgent need to review the current development policies and approaches. This review will help develop ecologically sound, economically viable and socially compatible natural resource management systems that will optimize the land owned by marginalized farmers to increase agricultural production for income generation and achieve sustainable development. This study was motivated by the need to understand currently adopted agroforestry technologies in Vihiga County, Kenya and their impacts on livelihoods, as well as the significant challenges that hinder the development of these technologies.

2 Material and methods

2.1 Study site

Vihiga County lies between longitude 34°, 30° and 35°, 0° east, and latitude 0° and 0°, 15°' north (Figure 1). The equator cuts across the southern tip of the County . The County covers a total area of 531.0 Km^2, comprising five sub-counties:

Sabatia, Hamisi, Emuhaya, Luanda and Vihiga. Vihiga County, borders Kakamega County district to the north, Nandi County to the east, Kisumu County to the south and Siaya County to the southwest. The estimated population of Vihiga County in 2019 was 590,013, with a population density of 1,046 persons per square kilometer. Of the total population, 48.1 % are males while 51.9% are females (KNBS, 2019).

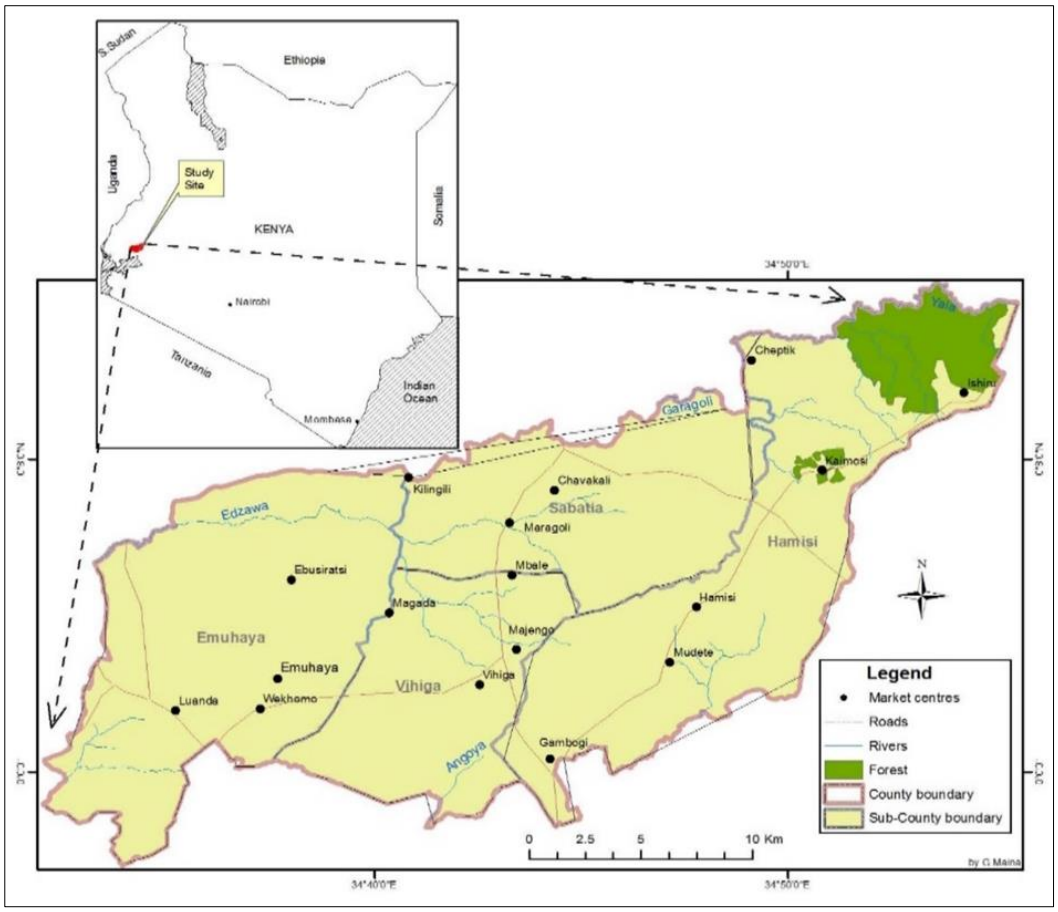


Figure 1 Map of Vihiga County (Source-www.diva-gis.org)

Agriculture is the main economic activity that drives Vihiga County's economy. The average farm size is 3 hectares for large-scale farming and 0.4 hectares (ha) for small-scale farming. The main crops planted include maize, beans, millet, sorghum, cassava, sweet potatoes, and bananas. Tea and coffee are the major cash crops. Livestock rearing is also practiced in the County, with cattle and poultry farming being significant livestock farming. Other economic activities undertaken within the County include; quarrying and mining as well as cottage industries. The County experiences an equatorial climate. Rainfall is well distributed throughout the year with an annual average precipitation range of 1800 – 2000mm (RoK, 2018). Average temperature is 23 ℃. Vihiga County has two cropping seasons. Long rains are experienced from March-April, and short rains are experienced from September to November.

2.2 Sampling design

The study adopted a social survey design that employed a semi-structured questionnaire, key informants and observation to collect primary data. Secondary data was collected from literature reviews on published work. The survey was used to assess the impacts of agroforestry technologies on the livelihoods of farmers in Vihiga County. The target population of the study consisted of the Vihiga County community. The sample frame was a list of households living within the Sabatia and Hamisi sub-counties. Households were selected from a list generated using county population statistics and the respondents were household heads. A multi-stage sampling technique was used. Two (2) sub-counties in Vihiga County (Hamisi and Sabatia) were purposely selected because of topography, socio-economic condition and agro-ecological zone supporting agroforestry technologies and other farming activities. Two (2) major villages from each sub-county that formed the strata were chosen randomly. For the four (4) villages, a list of households was obtained, and the households were randomly chosen. A total of 110 household heads were chosen as respondents based on the assumption that they are landowners and command livelihood activities, including land-use systems.

2.3 Data analysis

Data analysis was done using Statistical Package for the Social Sciences software (SPSS). Descriptive and inferential statistics were used to analyze data at a confidence level of 0.05 ($p<0.05$). Pearson's Chi-Square test was run to establish whether, statistically, a significant relationship existed between socio-economic factors and the adoption of agroforestry technologies. Results were presented using frequency distribution tables, charts, text boxes, figures, and plates.

3 Results

3.1 Socio-economic factors influencing the adoption of agroforestry technologies

Table 1 Socio-economic factors influencing the adoption of agroforestry technologies

Variable	**Sub-county**				
	Hamisi (%)	**Sabatia (%)**	**Mean%**	**Chi-square value**	**p-value**
Gender				5.339	0.254
Male	56	58	57		
Female	44	42	43		
Age				8.490	0.387
21-35	29	40	34		
36-50	49	33	41		
>50	22	27	25		
Marital status				7.486	0.824
Married	61	75	68		
Single	17	19	18		
Divorced	10	4	7		
Widowed	12	2	7		
Level of education				17.683	0.126
No formal education	5	6	6		
Primary education	39	18	29		
Secondary education	36	43	39		
Tertiary education	20	33	26		
Household size				8.057	0.428
1-5	56	63	59		
6-10	39	33	36		
>10	5	4	5		
Size of land (ha)				23.282	0.025
<1	26	39	32		
1-2	56	43	50		
3-5	15	10	13		
>5	3	8	5		
Monthly income				20.951	0.05
<10000	28	14	21		
10000-20000	56	50	53		
21000-40000	3	18	11		
41000-60000	13	18	15		

From the analysis of socio-economic variables, only land size (χ^2 = 23.282) and income levels (χ^2 = 20.951) were found to influence farmers' decisions in the adoption of agroforestry technologies (Table 1). The other socio-demographic factors such as; age (8.490), gender (5.339), marital status (7.486), level of education (17.683), and household size (8.057) did not influence the adoption decision of farmers.

3.2 Impact of agroforestry technologies on livelihood improvement

3.2.1 Reasons for the adoption of agroforestry technologies and their benefits

The results showed that firewood was the main product for most farmers who operated the various agroforestry technologies accounting for 57% of the respondents (Table 2). In comparison, timber was the second most-produced product accounting for 27%, while fruits and charcoal were the least produced commodity from the operated technologies accounting for 15% and 1%, respectively.

Although firewood was the common product produced by most farmers who undertook the various agroforestry technologies, it was evident that source of income, accounting for 42% of the responses, was the primary reason most farmers decided to try out or adopt these technologies. Other reasons for choosing and operating these technologies included the source of firewood (37%), source of construction material (8%), shade (6%) and food production (5%).

The study also shows that 53% of farmers reported that agroforestry technologies had had significant impacts on their livelihood improvement since they could obtain products for subsistence and sale. However, 47% of the respondents said that agroforestry technologies' contribution was insignificant because of the small land sizes and competition for land-use systems.

Table 2 Reason for the adoption of agroforestry technologies and their benefits (n=110)

Variable	Frequency	Percentage
The main commodity produced		
Timber	28	27
Firewood	60	57
Fruits	16	15
Charcoal	1	1
Reason for growing trees		
Income	46	42
Firewood	40	37
Construction material	9	8
Medicine	2	2
Food	5	5
Shade	6	6
Provision of basic needs		
Yes	58	53
No	52	47

3.2.2 Monthly income from agroforestry technologies

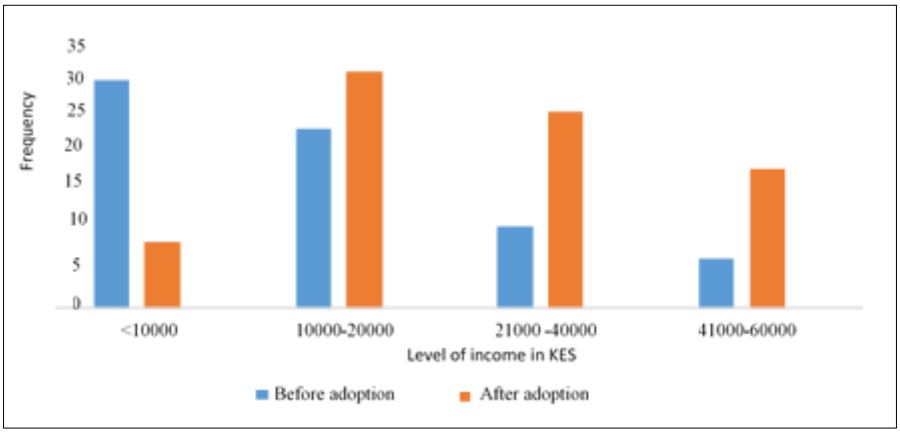
The results show that nearly half of the respondents (47%) received between Kenya Shillings (KES) 1000 and KES 5000 from the sale of agroforestry products monthly (Table 3). Another 34% of the respondents earned income between KES 5001 and KES 10000, 5% made over KES 10000, and 13% received less than KES 1000. The mean income of the respondents from agroforestry technologies was KES 4500. This income helped the poor farmers to meet their basic household needs such as food, shelter and clothing.

Table 3 Distribution of respondents according to income from agroforestry technologies

Monthly income from A.F. technologies (KES)	Frequency (n)	Percentage (%)
<1000	10	13
1000-5000	36	47
5001-10000	26	34
>10000	4	5
Mean 4500		

3.2.3 Income increase from agroforestry technologies

An income comparison before and after adopting agroforestry technologies was made, and the percentage increase in income was calculated using the comparison. Results indicate that a total of 35 farmers reported a more than 30% increase in revenue, which is more than a quarter of their monthly income that accrues from non-agroforestry activities, whereas 23 farmers reported a margin of between 10-30% increase in income (Figure 2). In contrast, only ten respondents reported less than a 10% increase in revenue.



<10%=10 10-30%=23 31-50%=24 50%=11

Figure 2 Respondents' income before and after the adoption of agroforestry technologies

4 Discussion

4.1 Socioeconomic factors influencing the adoption of agroforestry technologies

This study focused on socioeconomic factors influencing the adoption of agroforestry technologies, such as age, household size, gender, household income, education level and land size. From the multiple socio-economic factors analyzed, only land size and income level influenced the adoption of agroforestry technologies. Various studies provide evidence that adopting agroforestry technologies is influenced by socio-economic factors, mental processes, and environmental factors (Amare et al., 2019; Meijer et al., 2014; Kabwe et al., 2009; Thangata & Alavalapati, 2000).

4.1.1 Size of land

The mean land size for the respondents in the study area was approximately 1.4 ha implying most of the respondents are small-scale farmers. The current study agrees with earlier results by Shimeles et al. (2018), who highlighted that more than half of Africa's smallholder farmers utilize less than 2 ha for agricultural production. The land size was found to have a significant relationship with the adoption of agroforestry. The respondents attributed their inability to adopt multiple agroforestry technologies to their limited land, hence prioritization of food production. From a wider perspective, farmers with larger land sizes had embraced multiple agroforestry technologies compared to farmers with small land sizes. Several studies (Liliane et al., 2020: Beyene et al,2019;, Lambert & Ozioma, 2012; Ajayi, 2007; Nkamleu & Mayong, 2008) corroborates with the current results. They argue that the weight of tradeoffs between immediate needs, such as food production and long-term production projects, such as tree production on the same land compel farmers to choose short-term production strategies, such as food production.

These strategies eliminate the prospects of tree production, which is deemed a long-term project. Additionally, as posited by Mugure & Sorre (2013), the influence of land size on the adoption of agroforestry technologies is further affected by land tenure issues such as land inheritance, right of land use and inequality in gender land ownership. If land tenure issues are addressed more smallholder farmers will adopt agroforestry technologies as a form of livelihood.

4.1.2 Income level

Farmers with higher income readily adopted and operated more agroforestry technologies than those with lower income. A recent study by Wordofa et al. (2021) contends that farmers with more income have the capacity to access factors of production such as land, labor, seedlings and afford other management costs. Furthermore, the study strengthens the position that the availability of assets and income streams significantly influence farmers' capacity to adopt new farming technologies since farmers with higher income levels can readily take risks associated with new farming technologies. Previous studies by Nkonya et al. (2008) affirm that farmers with assets and higher income are less prone to risks of uncertainty in adopting new farming practices. Therefore, they are more likely to engage in these new technologies than low-income households.

Similarly, Kabwe (2010) argues that the lack of monetary income limits smallholder farmers from acquiring the necessary inputs to implement and manage agroforestry technologies. However, an earlier study by Holden et al. (2004) refutes these establishments by claiming that farmers' access to non-farm income reduces their adoption rate of agroforestry technologies. The study unearths that agroforestry technologies take longer periods to yield returns and are labour intensive. Such notion reduces the incentives of most farmers with adequate income levels to commit their resources to the technologies, and instead, such farmers resolve to uptake agricultural technologies and practices that yield benefits within shorter periods. Therefore, there is need to incorporate the income level of farmers as a socio-economic factor influencing the adoption of agroforestry technologies in strategies and programs geared at enhancing the adoption rate of agroforestry technologies in the study area.

4.2 Impact of agroforestry technologies on livelihood improvement

The study identified the contribution of agroforestry technologies to the livelihoods of farmers in the study area. The benefits accrued to farmers because of practicing agroforestry technologies include; income generation from the sale of various agroforestry products, medicine production, fruit production, food production and firewood, which contributed to the well-being of farmers in the study area.

4.2.1 Fruits and food

Fruit production in the Homegardens was identified as one of the major income earners in the study area. The respondents reported that they were able to harvest avocados and bananas regularly for subsistence use. Such results suggest that adopting agroforestry technologies among farmers in the study area contributed to sustainable production to achieve food security and improve nutrition. In support of these findings, Garrity (2004) emphasizes the importance of the contribution of agroforestry technologies of indigenous fruit production in eradicating hunger and extreme poverty as an essential strategy for achieving the sustainable development goals.

4.2.2 Firewood

Wood fuel (firewood and charcoal) was among the reported benefits among farmers in the study site. In Kenya, 70% of the total energy supply is catered for by wood fuel (Njogu & Kung'u, 2015). The authors emphasize wood fuel production as an essential energy source, especially in rural areas where farmers cannot afford alternative energy sources. Farmers in the study area stated that one of the significant reasons for agroforestry technologies was to meet firewood demand, which is the primary source of household energy in the study area. Some farmers also sold firewood for income generation, contributing to their livelihoods. Firewood is even sold in the open market in small bundles showing that there is serious shortage in the study area.

4.2.3 Medicine

Medicine production was one of the multiple benefits of agroforestry production. Farmers reported that they were able to treat various ailments from the trees and shrubs in their farms without relying on conventional treatments, which are relatively costly. This significantly reduced their expenditure on drugs and hospital bills. The growing of medicinal plants among rural communities has been rising over the years (Kinyanjui, 2007). Findings by Otieno & Analo (2012) reported that agroforestry technologies had increased indigenous knowledge of medicinal trees and shrubs for livelihood improvement. For instance, earlier studies by Viswanath et al. (2018) propose *Prosopis cineraria* as a multipurpose tree that has yielded multiple medicinal values in India.

4.2.4 Income

Agroforestry technologies have contributed substantially to the farmers' livelihood in the study area in terms of income earned. The data analysis indicated that the respondents had noticed monthly increment in their earnings since they began operating agroforestry technologies. Fruit production in the home gardens was identified as one of the primary income earners. The respondents reported substantial gains from the sale of avocados and bananas regularly. Farmers reported that these agroforestry products were easy to transport to the town markets and generated income throughout the seasons because of constant production. Other agroforestry products that generated income included timber, charcoal and firewood. Various research works to support the present study include those by Ruheza et al. (2012) and Bunyiza et al*.* (2008), who indicate that economic benefit is the primary reason for adopting agroforestry technologies among farmers. Therefore, farmers can exploit agroforestry technologies to stabilize their livelihood economically.

Multiple studies underscore the importance of agroforestry technologies in income improvement. For instance, most recent study by Korir et al. (2022) and earlier ones by Iskandar & Partasasmita (2016) establish that agroforestry technologies provide off-farm job opportunities for rural communities, such as furniture making and wood cuttings. Similarly, when it comes to income, a recent study by Gori Maia et al. (2021) observes that agroforestry technologies increase the benefit-to-cost ratio. Essentially, the cultivation of woody plants that require low inputs such as fertilizer and pesticides drastically reduce production cost and boosts income accrued to farmers. In an earlier study by Otieno and Analo (2012), it is evident that agroforestry technologies significantly increase farmers' income by selling diverse agroforestry products, thereby contributing to poverty reduction. Congruent to this, a recent study by Mukhlis et al. (2022) illustrates that agroforestry technologies strengthen the economic resilience of smallholder farmers through product diversification and reducing losses from crop failure.

4.2.5 Timber and Poles

Other benefits included timber and poles for construction. Farmers reported that they were able to cut down the cost of construction by harvest*ing Eucalyptus* and *Grevillea* species from their farm woodlots and other agroforestry technologies. A similar study in Ethiopia indicated that farmers in Tigray benefit from the sustainable harvest of *Eucalyptus spp* from household-managed woodlots for timber production (Jagger et al*.,* 2003). An earlier study conducted in Embu, Kenya, by Kiptot (2015) points out that tree enterprises can be managed for multiple benefits, whereby men benefit from the sale of timber and poles while women benefit from the harvest of firewood.

5 Conclusion and recommendations

The different types of agroforestry technologies adopted in the study area have significantly impacted the livelihoods of households through the provision of products for subsistence and commercial purposes. Such products include; firewood, timber, fruits, and medicine. Firewood and timber are the major agroforestry products in the study area, contributing significantly to livelihood improvement. The level of income and land sizes were the only socio-economic factors that significantly influenced farmers' decision to adopt agroforestry technologies. Famers with more income readily adopted and operated agroforestry technologies since they could afford the operational costs. Similarly, farmers with large pieces of land selected and operated more agroforestry technologies than farmers with small land sizes. Such establishment indicates that, when exploited correctly, agroforestry has a huge potential for improving the livelihood of rural communities.

More extension programs should be encouraged to educate farmers on the importance of agroforestry to the local households for improved adoption. Farmers should also be encouraged to intensify agroforestry production through diversification of agroforestry products and harmonizing the market structures.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no conflict of interest as pertains to this paper.

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