



## The effects of agroforestry on farm productivity of smallholder farmers in Karatu District, Tanzania

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### ABSTRACT

Smallholder farmers are among the most disadvantaged and vulnerable classes in the developing countries and are facing a problem of persistent low crop productivity. Agroforestry is seen by many as a response to environmental problems and as a sustainable endeavour which is specifically suited to farmers with poor resources. However, the multiple roles that trees can play, in most cases at a landscape scale, are less studied and usually do not persuade the farmers to adopt agroforestry. Furthermore, there is doubt of agroforestry systems on their productivity and economic benefits. The objective of this study was to examine the effects of agroforestry on farm productivity of smallholder farmers. Diffusion of Innovations theory by E.M. Rogers framed the concept of this study. The mixed-methods cross-sectional design was applied in this study to obtain deep insights into the farm productivity of the smallholder farmers practising agroforestry. The targeted population was smallholder farmers. Snowball sampling was also used to select households practising agroforestry for interview. Also, key informants were selected purposely based on information sought. The total of 59 respondents interviewed included smallholder farmers who practised agroforestry and key informants. Content analysis was used to analyse data for open-ended questions. The findings showed that agroforestry has the potential to foster farm productivity of smallholder farmers. However, most of the respondents have not taken full advantage of agroforestry. Therefore, it is recommended to promote and integrate tree species that replenish soil fertility as well as fruit trees in the farms in order for farmers to realise the productivity potential of agroforestry.

**Keywords:** Agroforestry, Farm Productivity, Karatu District, Smallholder Farmers, Tanzania

### I. INTRODUCTION

Smallholder farmers are among the most disadvantaged and vulnerable classes in the developing countries (Altieri & Koohafkan, 2008). The increase in soil degradation which resulting from soil-nutrient mining and erosion, desertification, deforestation, water logging, falling water tables, over-salinization, and, possibly, climate change increasing infertility to the marginal cropland the poor had depended on for survival (Pinstrup-Andersen & Watson, 2011). Smallholder farmers in sub-Saharan Africa (SSA) are facing a problem of persistent low crop productivity due to declining soil fertility and poor crop management (Parwada *et al.*, 2022).

Agroforestry systems and technologies have played a crucial role in the implementation of sustainable development of rural areas (Abbas *et al.*, 2021). Also, agroforestry systems offer smallholder farmers cheap alternative sustainable option to high-priced chemical fertilisers which they cannot afford (Musokwa *et al.*, 2019). Agroforestry is widely practiced and promoted across the countries of Africa, Asia, and Latin America. It is estimated that agroforestry practices take place on nearly 50% of agricultural land in developing country countries (Castle *et al.*, 2021). Agroforestry is a diversity of production systems in which crops and trees or grass production are integrated for production of a range of food and non-food products. Such systems can vary depending on soil and climatic conditions. Multifunctional role of agroforestry includes improved soil fertility and microclimate, nutrient cycling and soil conservation, increased productivity, among others (Lehmann *et al.*, 2020).

Agroforestry has demonstrated its potential for poverty alleviation and creating sustainable economic opportunities, especially in rural areas (Dissanayaka *et al.*, 2023). There is an increase of evidence that agroforestry systems increase overall agricultural productivity (Castle *et al.*, 2021; Ramil Brick *et al.*, 2022). Several studies report higher productivity of agroforestry systems compared to the monocultures (Rosati *et al.*, 2020). The most of agroforestry systems strive to enhance or sustain or land productivity and output of the desired commodities. Agroforestry provides various opportunities to increase output, among those are enhanced productivity of tree products, increased production of related crops and lower input costs for cropping systems (Tamrakar & Shivam, 2024). The productivity objective considers the increased economic profit that can be harvested from the agroforestry system, which includes direct performance metrics (crop, tree, and livestock yield) among others (Ramil Brick *et al.*, 2022). Therefore, integrating perennial components in agricultural fields contributes to higher crop productivity which increases incomes among the smallholder households and reduces poverty by providing food, wood, fodder, and fruits directly (Fahad *et al.*, 2022).



However, it is important to note that there are negative tradeoffs to agroforestry, for example a reduction in area of crop cultivation and negative tree-crop interactions which reduce production and profitability (Castle *et al.*, 2022). On the other hand, before integrating any species on a farm, the suitability of any crop combination, as well as the competing behaviour for light, moisture, and nutrients between trees and crops, should be taken into account before integrating any species on a farm. Also, practices such as the pruning of tree canopy, the use of wide spacing to minimize competition, or increasing the plant density of mixing crops can be carried out for appropriate management. In addition, farm management practices such as thinning, trimming, and mulching should be applied. So, combining species with various root depths, integrating shade tolerant species beneath the canopies of the foundational trees, including nitrogen-fixing species to enhance soil nitrogen provision improves the resource-use efficiency of the system (Fahad *et al.*, 2022).

The complexity of agroforestry systems with their multiple components can be challenging, as can balancing the resource demands of all the components through competition for light, water, and nutrients. Substantial knowledge and skills is required by farmers to successfully manage such complexity. However, guidance and technical assistance are often absent due to the limited research and extension support for agroforestry (Dissanayaka *et al.*, 2023). As a result, the productivity of agroforestry can suffer.

Tanzania, which is a primarily agricultural based economy, is facing issues of low agricultural productivity and declining soil fertility. A majority of people in Tanzania live in rural areas and are mostly smallholder farmers. Nevertheless, despite the emphasis, successful cases and observed benefits of agroforestry, the widespread adoption of agroforestry by smallholder farmers remains limited in Tanzania with an uneven success which normally vary from location to location (Jha *et al.*, 2021).

According to Parmar *et al.* (2022), agroforestry depends on nature, climate, and geographical conditions of a region, which differ from one country to another. Therefore, this underscores the need to conduct further studies to various parts of a region/country to unlock its agroforestry potentials. Hence, this study sought to assess the effects of agroforestry on farm productivity of smallholder farmers in Karatu District, Tanzania. This would enable to understand whether the agroforestry has effects to farm productivity of smallholder farmers in the study area.

## 1.1 Research Objective

The objective of the study was to assess the effects of agroforestry on farm productivity of smallholder farmers in the study area.

## II. LITERATURE REVIEW

### 2.1 Theoretical Review

#### 2.1.1 Diffusion of Innovations Theory

Diffusion of Innovations theory by E.M. Rogers framed the concept of this study. Its origin can be traced from agriculture, where in 1928 researchers started to study the adoption patterns of farmers using hybrid corn (Garcia-Aviles, 2020). Developing and disseminating new technology is widely considered to be essential for increasing the productivity, sustainability and resilience of small-scale farming systems in the global South. The concept of technology *adoption*, along *diffusion*, is usually used in designing development interventions, framing impact evaluations and informing decision-making about new investments in development-oriented agricultural research. However, adoption simplifies and characterises wrongly what happens during processes of technological change. Furthermore, technological change is seen to include encounters and exchanges between actors residing different worlds of knowledge and practice. Therefore, knowledge changes as it moves between different social worlds and biophysical contexts to create specific, local configurations of technological practice (Glover *et al.*, 2019).

The adoption of innovations, such as growing trees with traditional crops or grazing land, has been the subject of extensive study to determine how and why populations accept new or different ideas or technologies. Rogers' theory also provides insight into the probable success of agroforestry adoption by examining agroforestry systems as an innovation (Baig *et al.*, 2005). Multifunctional role of agroforestry includes improved soil fertility and microclimate, nutrient cycling and soil conservation, increased productivity, among others (Lehmann *et al.*, 2020).

Therefore, integrating perennial components in agricultural fields contributes to higher crop productivity which increases incomes among the smallholder households and reduces poverty by providing food, wood, fodder, and fruits directly (Fahad *et al.*, 2022). However, it is important to note that there are negative tradeoffs to agroforestry, for example a reduction in area of crop cultivation and negative tree-crop interactions which reduce production and profitability (Castle *et al.*, 2022). Also, according to Dissanayaka *et al.* (2023), the complexity of agroforestry systems with their multiple components can be challenging. In Tanzania, the widespread adoption of agroforestry by smallholder farmers is limited with uneven success which normally varies from location to location (Jha *et al.*, 2021). In that regard, it necessitated this study to assess the effects of agroforestry on farm productivity of smallholder farmers who adopted agroforestry systems in the study area.



## 2.2 Empirical Review

### 2.2.1 Agroforestry and Farm Productivity

A main supposition in agroforestry is that productivity is higher in agroforestry systems than to monoculture systems. Interactions between tree and crop components in agroforestry may be positive, negative or neutral, and the productivity of a system is a net result of such interactions. In addition, agroforestry systems provide various products.

The study conducted on characterization of agroforestry systems and their effectiveness in soil fertility enhancement in South-west region of Cameroon by Tsufac *et al.* (2021) found that most farmers perceived agrosilvopastoral system is characterized by the highest level of soil fertility. Also, according to Islam *et al.* (2021) study on analysis of socio-economic and ecological perspectives of traditional agroforestry system in Bangladesh revealed that the system enhanced farm productivity by enhancing soil fertility and diversifying products among others. Another study by Saha *et al.* (2018) on farmers' perception and adoption of agroforestry practice in Bangladesh showed that 82% of respondent's perceived agroforestry can improve their farm productivity when compared to monoculture. Similarly, study by Thorlakson and Neufeldt (2012) on evaluating the potential contribution of agroforestry in western Kenya showed that agroforestry improves household's standard of living through improvements in farm productivity. Apart from increase in farm productivity, agroforestry systems can generate off-farm incomes and wealth for smallholder farmers. However, it was observed only a small improvement in farm productivity as few farmers used intensive agroforestry techniques in their fields, with low adoption of intercropping of nitrogen-fixing trees among farmers.

Lehmann *et al.* (2020) study on productivity and economic evaluation of agroforestry systems showed that the agronomic productivity based on crop and tree yields was higher in integrated food and non-food systems (IFNS) than monoculture, despite of the differences in crop types, environmental zones, production systems, management regimes and soil types. Also, the crop and tree yields in IFNS are dependent on the particular crop and tree species, production systems, environmental zones and the management regimes applied. Also, the study conducted by Parwada *et al.* (2022) on the role of agroforestry on farmland productivity in semi-arid farming regions of Zimbabwe showed that, crop yields were significantly higher under the nitrogen fixing trees when compared to under other tree species of grass fallow; as a result restore soil productivity. Furthermore, Niyomfura *et al.* (2022) study on net benefits of silky oak (*grevillea robusta*) for small farmers in Musanze District, Rwanda reported for crops integrated with *grevillea* yields were more than crops planted without trees in the field, due to combined crop fields of maize, beans, and potato. It was reported that, the mean yield was 1.6 times more than the crops cultivated without trees in the farms.

The study by Parmar *et al.* (2022) on potential interventions of hedge and alder-based agroforestry systems to better crop productivity in Indian sub-Himalayas showed that, crop productivity was significantly in all the agroforestry systems (Hedge-, alder-, and guava based with maize-mustard-potato cropping pattern) than control (without any tree). It was found that, agroforestry systems had significant effect on soil organic matter pools and crop productivity. Furthermore, study by Samrin *et al.* (2024) on land productivity of agroforestry system in South Sulawesi Province, Indonesia found that application of agroforestry systems can increase land productivity from various commodities produced when compared to monoculture system. However, Tadesse *et al.* (2021) study on crop productivity and tree growth in intercropped agroforestry systems in semi-arid and sub-humid regions of Ethiopia found no significant difference between crop yields under tree and crop yield in the sole crop treatments, but crop yields under *Acacia abyssinia* had the lowest crop yields compared to the rest of treatments in the sub-humid areas. On the other hand, teff yield increased under *Faidherbia* in semi-arid areas. Another study by Staton *et al.* (2021) on productivity, biodiversity trade-offs, and farm income in an agroforestry versus an arable system had mixed results, where apples were integrated with arable crops. The study revealed that, arable yields were lower up to 11% in agroforestry than in arable systems, which were associated with weed cover in both systems. Also, apple yields in agroforestry were similar to typical yields from comparable orchards.

Despite that agroforestry is practiced globally, such farming system depends on nature, climate, and geographical conditions of a region, which differ from one country to another. Also, agroforestry systems require effort, technical expertise and economic reliability for successful adoption in the potential region. Therefore, they are more complex in nature when compared to monoculture (Parmar *et al.*, 2022). The reviewed literature revealed that, productivity of agroforestry systems to be successful depends on various factors. Also, a success case in one area cannot be guarantee to other areas with different geographical conditions. Moreover, tree and crop species integrated in agroforestry systems have effects on their productivity. Therefore, it is imperative to conduct various studies in different geographical regions within a country in order to identify and determine the appropriate agroforestry system(s) for a certain area, and how best the existing agroforestry systems can be utilized to increase its productivity to farmers.



### III. METHODOLOGY

#### 3.1 Study Area

Karatu is one of districts in Arusha Region, situated in northern Tanzania. It lies on latitudes 3°10'–4°00'S and longitude 34°47'E. Based on the criteria of relief, land physiography and drainage pattern, Karatu can be classified into three zones, which are uplands, midlands and lowlands-with altitude ranging from 1000 to 1900 m (Mkomwa *et al.*, 2011). The selection of the study area was based on the declining agricultural productivity in the district due unreliable rainfall infertility of the soil (Karatu District Council [KDC], 2001). As a result, these have caused a decline in farm yields and increasing food insecurity among subsistence farmers. The decline of farm productivity has negatively impact the livelihoods of smallholder farmers. Also, the agroforestry is being practiced in Karatu District, therefore make the study viable.

#### 3.2 Study Design

Mixed methods cross-sectional design was applied in this study to obtain deep insights of the farm productivity of the smallholder farmers practicing agroforestry. Therefore, the design was used to explore and understand the issues under the study concerning agroforestry farm productivity.

#### 3.3 Population and Sampling

The target group for this study was smallholder farmers practicing agroforestry in the Karatu District. The study employed a multistage sampling technique starting with district level through divisions, wards, villages to household level, the survey subjects. During this research two villages were studied which are Bashay and Rhotia. Purposive sampling was used to select these villages because agroforestry is practiced in these villages. According to Mwamhanga (2005), Bashay was among the project villages of Tanzania Association of Foresters (TAF) Karatu Agroforestry Project, while Rhotia Village adopted agroforestry practices as a result of visit to the project villages. Also, the two villages situated in different location, Bashay is in the midland while Rhotia located in highland/upland. Hence, they experience different climatic condition, the latter being wetter than the former.

Snowball sampling was also used to select households practicing agroforestry for interview. Snowball sampling technique is where the researcher identified a small number of individuals who have the required characteristics. These people were then used as informants to identify others who qualify for inclusion in the sample. Therefore, this technique used in this study due to the fact that there was no register of farmers practicing agroforestry in the study area, hence other methods like random sampling was not possible. In addition, due to financial and time constraints, it was difficult for the researcher to identify and have the list of smallholder farmers practicing agroforestry in those villages for probability sampling. Therefore, snowball sampling enabled to select participant households which practice agroforestry.

Key informants were also selected purposely based on information sought. The sample was selected from a group of people with specific expert and experience related to the study. These were people with experience and knowledge in farming, forestry, and the local environment. Key informers included village leaders, agricultural officers and extension workers.

#### 3.4 Sample Size

Households were used as units of the study under the household survey. The criteria used to reach sample size was based on Creswell (2007) and Warren (2002) who recommended that the minimum number of interviews need to be between twenty (20) and thirty (30) for an interview-based qualitative study. Therefore, a total of 44 households were selected through a snowball sampling method for interview, 21 households from Bashay Village and 23 households from Rhotia Village.

**Table 1**

*Sample Composition*

		Gender of Respondents		Total
		Female	Male	
Name of Village	Bashay	8	13	21
	Rhotia	9	14	23
Total		17	27	44

##### 3.4.1 Sample Size for Key Informants

A total of 15 key informants were selected purposively and interviewed based on information thought. They comprised of 2 agricultural officers, 1 environmental officer, 1 forestry officer, 2 agricultural extension officers, 2



village leaders, 4 hamlet leaders, and 3 villagers who have experience in agroforestry. This sample was considered adequate for key informant interview considering the suggestion by Kumar (1989) who suggested a range of between 15 and 33 respondents.

### 3.5 Data Collection Methods

Semi-structured interview was used to collect primary data, whereby snowball technique was used to select the respondents who were visited in their homes or farms. The snowball sampling was used because the population of farmers practicing agroforestry was not well enumerated, therefore making it difficult to select samples by other sampling methods. This method targeted household heads as respondents. Responses were recorded on paper copies of questionnaire guide of the study.

Also, data was collected from key informants in which group of people with specific expertise and experience related to the study was interviewed. The key informant interviews enabled to get information from different informants with particular knowledge, experience and understanding. This enabled to check and clarify ideas and information provided by respondents. In addition, were used to acquire deeper understanding of agroforestry in relation to smallholder farmers in Karatu.

On farms observations were incorporated into the household interview to increase the validity of data collected. Observations served to supplement, and validate or nullify information collected through interviews. They provided insight of agroforestry aspects that may go unreported by participants, hence gives the researcher direct experience of phenomena being studied rather than focusing solely on narrative descriptions of participants. During the study, 8 transect walks were made, 4 to each villages under the study for observation.

### 3.6 Data Analysis Methods

Data collected through interview from the respondents were coded and summarized for analysis. Content analysis was used to analyse open-ended questions, whereby responses were coded and analysed. Content analysis is a procedure for the categorization of verbal or behavioural data for the purposes of classification, summarization and tabulation (Hancock, 1998). Closed-ended responses, which are qualitative, were dealt with in a quantitative way by presenting them in frequencies and percentages. Statistical analysis was used for quantitative analysis. Statistical Package for Social Science (SPSS) was used to compute statistical analysis. Frequencies methods of SPSS were used to analyse categorical or nominal variables.

## IV. FINDINGS & DISCUSSION

### 4.1 Agroforestry Systems in the Study Area

Agroforestry systems can be categorised depending on the combination of the tree and the other elements; Silvopastoral systems (trees plus pasture and/or animals), silvoarable (also called agrisilviculture) systems (trees plus agricultural crops) and agrosilvopastoral systems (trees plus crops and livestock/pasture). Trees in agroforestry can be of any kind and with any function, including wood, biomass or fruit production (Rosati *et al.*, 2020). The identification of agroforestry systems practiced in the study area was also among aspects of this study. This enable to assess different types of agroforestry systems/practices how they can help smallholder farmers in farming productivity.

The study found that, most of the respondents practiced agrosilvopastoral and alley cropping under silvoarable systems while few practice home gardens or/and silvopasture besides alley cropping. Agroforestry systems involving both trees and crops in alleys between two crops can lead to higher productivity in tropical conditions (Bathore *et al.*, 2022). In the study area, the main concern of practicing alley cropping for majority of the respondents was to control erosion, hence preserves soil fertility. Therefore, most of trees are planted in contours in the farms of the respondents. Similarly, the study by Tsufac *et al.* (2021) on characterization of agroforestry systems and their effectiveness in soil fertility enhancement in South-west region of Cameroon showed that most farmers perceived agrosilvopastoral system is characterized by the highest level of soil fertility.

### 4.2 Agroforestry Species in the Study Area

As the trees are crucial components of any agroforestry practices, it was important for this study to identify trees/agroforestry species in the study area. This helped to observe and assess tree-crop interactions and tree-animal interactions as well as trees use and production function in an agroforestry system. Hence, the study can assess rationally agroforestry as practiced by the respondents in relation to its contribution in increasing farm productivity of smallholder farmers.

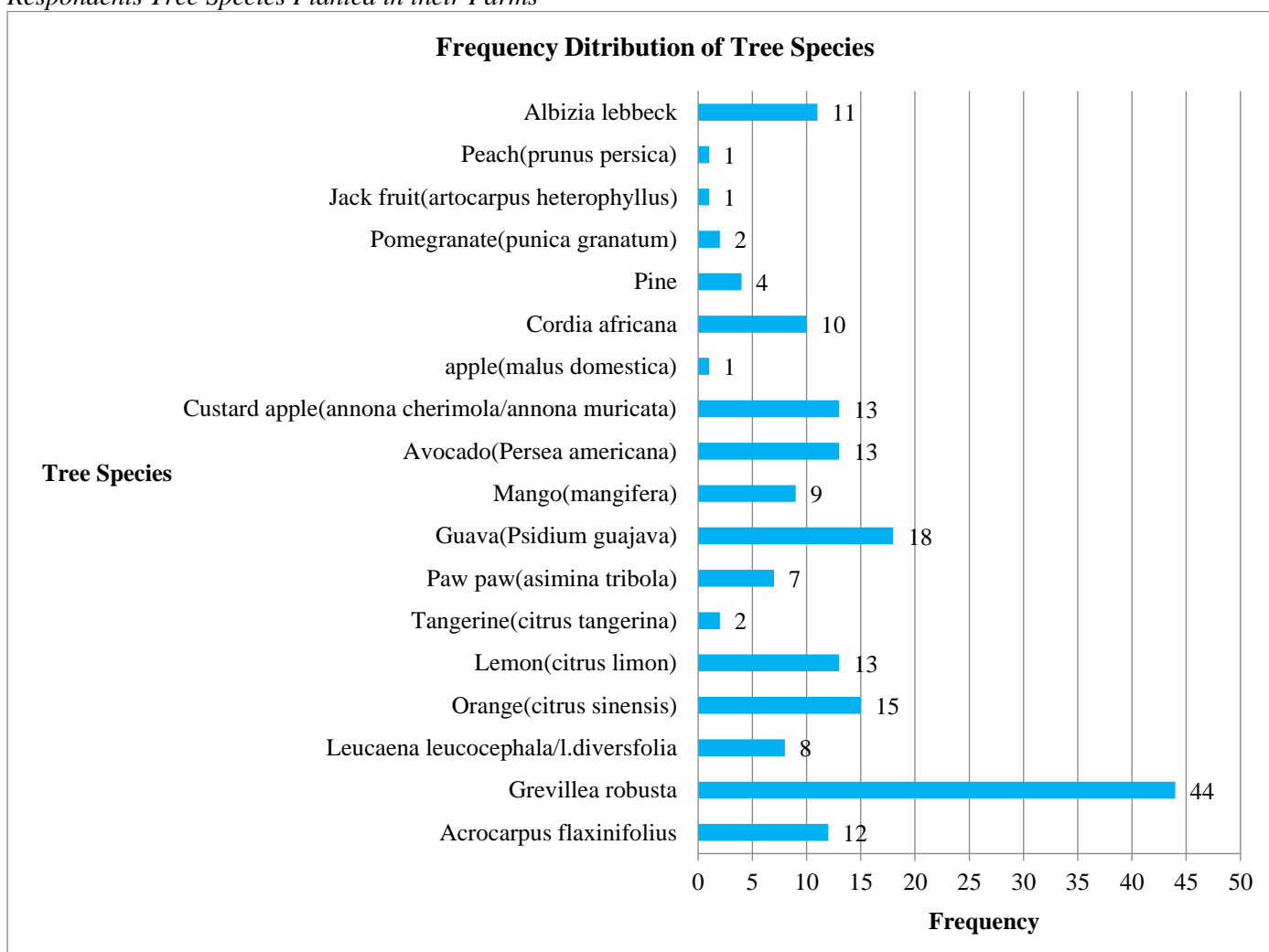
The term agroforestry species most often used to mean woody species, which have come to be known as multipurpose trees (MPTs), or multipurpose trees and shrubs (MPTS). Generally, the perennial and taller plant components of agroforestry systems are referred to as trees. However, the multipurpose trees are woody species that are



intentionally kept and managed for more than one preferred use, product, or service. Several of such trees are designated by single-purpose-sounding terms such as fodder trees, fruit trees, fuelwood species, and other special-purpose trees, but they provide multiple products and services. Important woody species classes in agroforestry are fruit trees, fodder trees, and firewood species, however the term MPTs includes all these, mostly the fodder and firewood species. In addition, the herbaceous species are also crucial in agroforestry (Nair, 1993; Nair *et al.*, 2021). The mostly cultivated crops in the agroforestry systems of the respondents in the study area include maize, beans, pigeon pea, and wheat. Other crops which were cultivated by some of the respondents include sun flower, lablab, sorghum, finger millet, banana, coffee and cassava. According to Musokwa *et al.* (2019), pigeon pea is recommended in agroforestry systems with maize due to its higher land equivalent ratio (LER) and combined production of grain for human and livestock consumption as well as firewood.

**Figure 1**

*Respondents Tree Species Planted in their Farms*



Findings indicated that, 100% of the respondents planted *grevillea robusta* in their farms. This specie dominated the majority of the respondents' farms. This is due to the fact that, according to Orwa *et al.* (2009), has deep rooting system of *grevillea* minimizes competition with shallow-rooted crops. Other species were found in farms around homes of respondents or smallholder farmers practicing homegardens, especially fruit trees. Fruit trees mostly cultivated by the respondents are guava, orange, avocado, custard apple, and lemon. These trees were found in the respondents and other smallholder farmers' farms in the study area which were around their homes, hardly found on farms which are away. Nair (1984) argued that fruit trees are one of the most worthy groups of agroforestry trees. Therefore, they can help smallholder farmers, as they are essential to the diet, and in some cases even the economy of the farmer.

*Leucaena leucocephala* and *leucaena diversifolia*, which were planted by 18.2% of the respondents, their uses include fodder, fuelwood, contour hedgerows, green manure and pulpwood. Also, it was observed that, *Leucaena* trees were few and rarely seen planted in contours. Like the fruit trees, these trees were found around farms of the respondents close or around their homes, in most cases on boundaries. According to Kidd and Pimentel (1992), one of the most



successful examples of alley cropping is the combination of *Leucaena leucocephala*, a nitrogen-fixing tree, with maize. *Leucaena* when planted on contours are effective in controlling soil degradation on steep slope land (Banda *et al.*, 1994). Therefore, its inclusion in contour will add advantage to farmers in terms of adding fertility as well as fodder apart from controlling erosion.

As shown in this study, tree planting was perceived by the variety of their uses either for controlling erosion, fuel wood, fodder, timber, fruits or income. The findings of this study are related to other studies. The analysis of the integrated food and non-food systems by Lehmann *et al.* (2020) study demonstrated that there is a diversity of production systems possible with various combinations of tree and crop with different productivity frontiers. Also, in Niyomfura *et al.* (2022) study on net benefits of *grevillea robusta* for small farmers in Rwanda, farmers reported importance of *grevillea* such as control soil fertility and improving soil fertility.

### 4.3 Effect of Agroforestry on Farm Productivity

#### 4.3.1 Agroforestry Farm Products

Agroforestry can increase agricultural productivity (Castle *et al.*, 2021). The productivity objective considers the increased economic profit that can be harvested from the agroforestry system, which includes direct performance metrics (crop, tree, and livestock yield) among others (Ramil Brick *et al.*, 2022). To that end, this study also seeks to assess wide range of products from agroforestry and their role in improving farm productivity of smallholder.

**Table 2**

*Agroforestry Products to Respondents*

Agroforestry Products	Frequency	Percent
Food	44	100.0
Fodder	43	97.7
Fertilizer	43	97.7
Timber	43	97.7
Fuel	43	97.7

Findings of the study showed that, agroforestry provided the respondents with food, fodder, fertilizer, timber and fuel. All of the respondents benefited from food, while 97.7% of the respondents benefited from fodder, fertilizer, timber, and fuel wood. It was also revealed that, those who did not benefit from the mentioned products they recently planted trees on their farms, so they have not grown enough to offer timber and fuel wood and one respondent did not keep livestock. Food resulted from cultivated crops, fruits, and animals/livestock. Trees provided timber, fuel wood and fodder especially from *Leucaena* and other shrubs or grass planted on contour/boundaries with trees, however, majority of fodder reported from remains of crops after harvesting. Also, majority of the respondents applied farmyard manure, while few uses compost manure.

A variety of benefits of agroforestry products found in this study are in line also with other studies. For example, a study by Samrin *et al.* (2024) on land productivity of agroforestry system found that application of agroforestry systems can increase land productivity from various commodities produced when compared to monoculture system. Similarly, Islam *et al.* (2021) study on analysis of socio-economic and ecological perspectives of traditional agroforestry system in Bangladesh reported that agroforestry systems enhanced farm productivity by enhancing soil fertility and diversifying products among others.

#### 4.3.2 Perceptions of Farmers on the Effects of Agroforestry on Farm Productivity

**Table 3**

*Perceptions of Respondents on the Effects of Agroforestry on Farm Productivity*

Farm Productivity	Low		Average		High		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Food	0	0	0	0	44	100	44	100
Fuel	0	0	39	88.6	5	11.4	44	100
Fodder	10	22.7	34	77.3	0	0	44	100
Timber	18	40.9	26	59.1	0	0	44	100
Fertilizer	21	47.7	23	52.3	0	0	44	100
Crop Yields [overall]	1	2.3	7	15.9	36	81.8	44	100



Having considered different products to respondents from agroforestry, this study went further to assess perceptions of respondents on the effects of agroforestry on farm productivity based on farm products. Findings show that, food and crop yields were reported to have increased due to practicing agroforestry, with 100% and 81.8% of the respondents respectively. When asked how agroforestry was able to increase the productivity of crop yields and food, the majority of the respondents said that it because of various crops can be grown, such as maize, beans, and pigeon peas. These increase the overall farm production of crops. Other respondents claimed that because of controlled erosion they do harvest more. Also, the integration of pigeon pea in the respondents' farm it likely has contributed to increased farm productivity. According to Frimpong *et al.* (2025) and Musokwa *et al.* (2019), there is growing recognition of pigeon pea as a valuable agroforestry crop due to its ability to improve soil fertility, when intercropped with maize, pigeon pea offers numerous farm benefits, including biological nitrogen fixation, and enhanced soil structure.

While, agroforestry was reported by respondents to have average influence on farm productivity on fuel (88.6%), fodder (77.3%), timber (59%), and fertilizer (52%). The respondents gave reasons on such average contribution to farm productivity. Some said that they have small land, therefore few trees planted, to provide both fuel and timber. Reason which was given on fodder is that, fodder was mostly from remains of crops after harvesting, also few respondents practiced silvopastoral systems and in small area as observed in the field. Also, majority of the respondents applied farmyard manure, while few uses compost manure. This indicates that, there is little application of green manure from fertilizer trees or other plants. According to Parwada *et al.* (2022), the biomass from trees can be used as green manure.

These findings are consistent with other studies. Niyomfura *et al.* (2022) study on net benefits of silky oak (*grevillea robusta*) for small farmers in Musanze District, Rwanda found that crops integrated with *grevillea* had more yield than crops planted without trees in the field, due to combined crop fields of maize, beans, and potato. Also, a study by Saha *et al.* (2018) on farmers' perception and adoption of agroforestry practice in Bangladesh showed that a significant proportion (82%) of respondent's perceived agroforestry can improve their farm productivity when compared to monoculture.

However, Tadesse *et al.* (2021) study on crop productivity and tree growth in intercropped agroforestry systems in semi-arid and sub-humid regions of Ethiopia found no significant difference between crop yields under tree and crop yield in the sole crop treatments, but crop yields under *Acacia abyssinia* had the lowest crop yields compared to the rest of treatments in the sub-humid areas. On the other hand, the study also reported an increase in teff yield cultivated under *Faidherbia* in semi-arid areas.

From these findings, while most of them acknowledge that agroforestry can help to increase farm productivity, there is need for smallholder farmer in the study area to practice more productive and diversified agroforestry systems. For example, the intention of majority of the respondents to practice agroforestry is for control erosion, consequently they practice alley cropping. This finding is similar to that of Thorlakson and Neufeldt (2012) study which found that most farmers practiced less-intensive agroforestry systems, with only a small improvement in farm productivity was observed because of low adoption of intercropping of nitrogen-fixing trees among farmers. Therefore such practices lack significant effect on increasing the productivity of the farm.

The study by Parwada *et al.* (2022) on the role of agroforestry on farmland productivity noted that crop yields were significantly higher under the nitrogen fixing trees compared to under other tree species or grass fallow; as a result restore soil productivity. Moreover, Parmar *et al.* (2022) study showed that there was significant higher crop productivity in agroforestry systems (Hedge-, alder-, and guava based with maize-mustard-potato cropping pattern) than control (without any tree) due to its effects on soil organic matter pools.

#### 4.3.3 Farmers System Design and Management Practices of Agroforestry

Study by Lehmann *et al.* (2020) showed that the tree and crop yields in integrated food and non-food systems depend on the particular tree and crop species, production systems, environmental zones and the management regimes applied. For this reason, the study also intended to examine system design and management of the respondents in order to make concrete conclusion on assessment of productivity benefits of agroforestry to smallholder farmers.

**Table 4**

*Respondents System Design and Management Practices of Agroforestry*

System Design and Management Practices	Frequency	Percent
Appropriate selection of woody and crop or livestock species	36	81.8
Spatial design	37	84.1
Pruning/pollarding	39	88.6
Weed control	44	100.0
Protection from animals	16	36.4
Pruning of tree roots through management practices	0	0.0

It was found out from the study, 100% of the respondents control weed in their farms, and 88.6% of the respondents do prune/pollard the trees. Whereas, 84.1% of the respondents consider spatial design for trees and crops in their farms, while 81.8% said that they appropriately select woody and crop or livestock species to be included in their agroforestry systems, and 36.4% of the respondents protect trees from animals. Findings indicate that majority of the respondents manage and design their agroforestry systems in order to maximize productivity. Nonetheless, the study found that all respondents do not prune tree roots in order to lower the competition between trees and crops in the alley.



**Plate 1**

*Grevillea* Branches Regrow after Being Pollarded

In agroforestry practices, productivity of each component may be manipulated by management practices such as pruning, weed control and protection from animal damage (Devkota *et al.*, 2009). In the study area researcher observed that, some of the trees in the farms were not pruned or pollarded. When the study investigate why some of the farmers do not prune trees in their farms through key informants and some of the respondents, it was found out they know the importance of pruning or pollarding the trees. Some of the respondents said it is cost to prune/pollard trees; therefore they do that when they have money or find some to help them. Also, researcher explores the respondents and some of the key informants on why root pruning is not practiced in study area. It was known that respondents were not aware of root pruning, hence lack the knowledge of doing it.

The findings of this study on the importance of agroforestry system management practices is justified by another study by Staton *et al.* (2021) on productivity, biodiversity trade-offs, and farm income in an agroforestry versus an arable system that reported that, arable yields were lower up to 11% in agroforestry where apples were integrated with arable crops than in arable systems, which were associated with weed cover in both systems.

## V. CONCLUSION & RECOMMENDATIONS

### 5.1 Conclusion

The study observed the agroforestry systems in the study area. Alley cropping was mostly practice by smallholder farmers who practiced agroforestry, while home gardens were practiced by few. The main intention for them to plant trees in the farms is to control erosion, and *grevillea* were mostly planted. The study found that, agroforestry has potential to enhance farm productivity of stallholder farmers through various products it offers and combined crop yields. However, most of the respondents have not taken full advantage of agroforestry as few practiced intensive agroforestry techniques. This is due to the fact that, most of the respondents depending on annual crops, mostly maize, pigeon pea, beans and wheat as their income sources besides food. This has an implication that, other income sources of agroforestry such as fruits, banana, milk, fodder, among others, are not utilized well.



## 5.2 Recommendation

The study findings on farm productivity of agroforestry are vital for informed decision making by agricultural officers, extension officers, advisory services, farmers and policy makers. With regards to the findings of this study, it is recommended the integration of tree species in farms that add or replenish soil fertility in alley cropping such as nitrogen fixing trees, for example *gliricidia sepium*, in order to maximize positive interactions. Also, smallholder farmers should be encouraged to include/integrate fruit trees in the alley cropping in order to diversify farm products and supplement income of smallholder farmers. Furthermore, home gardens systems which have a mix of diversified agricultural crops and multipurpose trees should be promoted. In these systems there is almost continuous food production throughout the year. Lastly, it was found that there are fewer fertilizer trees species planted. Therefore there should be further research to find out various species of fertilizer trees that will be suitable for the agro-ecological zone of the study area.

## REFERENCES

- Abbas, G., Ali, A., Khan, M., Mahmood, H. F., Wahab, S. A., & Amir ud Din, R. (2021). The transition from arid farming systems to agroforestry systems in Pakistan: A comparison of monetary returns. *Small-scale Forestry*, 20, 325–350. <https://doi.org/10.1007/s11842-020-09470-5>
- Altieri, M., & Koohafkan, P. (2008). *Enduring farms: Climate change, smallholders and traditional farming communities*. Third World Network.
- Baig, M. B., Straquadine, G. S., Whiteman, M. R., & Naeem, M. A. (2005). Assessing probable success: Applying Rogers' "Diffusion of Innovations" theory to agroforestry. *International Journal of Agriculture & Biology*, 7(6), 1040–1043.
- Banda, Z., Maghembe, A., Ngugi, N., & Chome, A. (1994). Effect of intercropping maize and closely spaced *Leucaena* hedgerows on soil conservation and maize yield on a steep slope at Ncheu. *Malawi Agroforestry System*, 27, 17–22.
- Bathore, S. S., Babu, S., El-Sappah, A. H., Shekhawat, K., Singh, V. K., Singh, R. K., Upadhyay, P. K., & Singh, R. (2022). Integrated agroforestry systems improve soil carbon storage, water productivity, and economic returns in the marginal land of the semi-arid region. *Saudi Journal of Biological Sciences*, 29, Article 103427. <https://doi.org/10.1016/j.sjbs.2022.103427>
- Castle, S. E., Miller, D. C., Ordonez, P. J., Baylis, K., & Hughes, K. (2021). The impacts of agroforestry interventions on agricultural productivity, ecosystem services, and human well-being in low- and middle-income countries: A systematic review. *Campbell Systematic Reviews*, Article e1167. <https://doi.org/10.1002/cl2.1167>
- Castle, S., Miller, D. C., Merten, N., Ordonez, P. J., & Baylis, K. (2022). Evidence for the impacts of agroforestry on ecosystem services and human well-being in high-income countries: A systematic map. *Environmental Evidence*, 11, Article 10. <https://doi.org/10.1186/s13750-022-00260-4>
- Creswell, J. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed.). Sage.
- Devkota, N. R., Kemp, P. D., Hodgson, J., Valentine, I., & Jaya, I. O. (2009). Relationship between tree canopy height and the production of pasture species in a silvopastoral system based on alder trees. *Agroforestry Systems*, 76, 363–372.
- Dissanayaka, N. S., Udumann, S. S., Nuwarapaksha, T. D., & Atapattu, A. J. (2023). Agroforestry: An avenue for resilient and productive farming through integrated crops and livestock production. In D. I. Kiba (Ed.), *Transitioning to zero hunger* (pp. 115–136). Transitioning to Sustainability Series 2. MDPI. <https://doi.org/10.3390/books978-3-03897-863-3>
- Fahad, S., Chavan, S. B., Uthappa, A. R., Chichaghare, A. R., Kumar, M., Kakade, V., Pradhan, A., Jinger, D., Rawale, G., Yadav, D. K., Sawant, A. K., Kumar, V., Saud, S., Farooq, T. H., Ali, B., Chen, S., & Poczai, P. (2020). Agroforestry systems for soil health improvement and maintenance. *Sustainability*, 14, Article 14877. <https://doi.org/10.3390/su142214877>
- Frimpong, F., Danquah, E. O., Frimpong, T., Adu, J., Amponsah, S. K., Danquah, F. O., Amengor, N. E., & Amankwa-Yeboah, P. (2025). Diversifying cropping systems to enhance productivity using agroforestry trees: A case study of maize–pigeon pea intercropping in Ghana. *Explora Environment and Resource*, 2(3), Article 025130026. <https://doi.org/10.36922/EER025130026>
- Garcia-Aviles, J. A. (2020). Diffusion of innovation. In J. V. den Bulck, D. R. Ewoldsen, M. Mares, & E. Scharrer (Eds.), *The international encyclopedia of media psychology* (pp. 1–8). John Wiley & Sons.
- Glover, D., Sumberg, J., Ton, G., Andersson, J., & Badstue, L. (2019). Rethinking technological change in smallholder agriculture. *Outlook on Agriculture*, 48(3), 169–180. <https://doi.org/10.1177/0030727019864978>
- Hancock, B. (1998). *Trent Focus for research and development in primary health care: An introduction to qualitative research*. Trent Focus Group.



- Islam, K. K., Saifullah, M., & Hyakumura, K. (2021). Does traditional agroforestry a sustainable production system in Bangladesh? An analysis of socioeconomic and ecological perspectives. *Conservation*, *1*, 21–35. <https://doi.org/10.3390/conservation1010003>
- Jha, S., Kaechele, H., & Sieber, S. (2021). Factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: Case studies from Morogoro and Dodoma. *Land Use Policy*, *103*, Article 105308. <https://doi.org/10.1016/j.landusepol.2021.105308>
- Karatu District Council [KDC]. (2001). *NAEP II annual progress report for 2001, plan and budget for 2002/2003*. KDC.
- Kidd, V., & Pimentel, D. (1992). *Integrated resource management: Agroforestry for development* (Ed.). Academic Press.
- Kumar, K. (1989). *Conducting key informant interviews in developing countries*. Agency for International Development.
- Lehmann, L. M., Smith, J., Westaway, S., Pisanelli, A., Russo, G., Borek, R., Sandor, M., Gliga, A., Smith, L., & Ghaley, B. B. (2020). Productivity and economic evaluation of agroforestry systems for sustainable production of food and non-food products. *Sustainability*, *12*, 5429. <https://doi.org/10.3390/su12135429>
- Mkomwa, S., Mzoba, H., Wilfred, M., & Weldone, M. (2011). Conservation agriculture in Tanzania: A case study of Karatu District. *African Conservation Tillage Network*.
- Musokwa, M., Mafongoya, P., & Lorentz, S. (2019). Evaluation of agroforestry systems for maize (*Zea mays*) productivity in South Africa. *South African Journal of Plant and Soil*, *36*(1), 65–67. <https://doi.org/10.1080/02571862.2018.1459898>
- Mwamhanga, J. (2005). Impact evaluation of agroforestry project in six villages of Karatu - Arusha, Tanzania, implemented by Tanzania Association of Foresters. *The Open University of Tanzania*.
- Nair, P. K. R., Kumar, B. M., & Nair, V. D. (2021). *An introduction to agroforestry*. Springer. [https://doi.org/10.1007/978-3-030-75358-0\\_13](https://doi.org/10.1007/978-3-030-75358-0_13)
- Nair, R. (1984). Fruit trees in agroforestry. Working Paper. Environment and Policy Institute, East-West Center.
- Nair, R. (1993). *An introduction to agroforestry*. Kluwer Academic Publishers.
- Niyomfura, R., Kapp, G., Mugunga, C. P., & Niyomugabo, J. D. (2022). Net benefits of silky oak (*Grevillea robusta*) for small farmers in Musanze District, Rwanda. *Reforesta*, *14*, 46–62. <https://doi.org/10.21750/REFOR.14.05.100>
- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009). *Agroforestry database: A tree reference and selection guide (version 4.0)*. World Agroforestry Centre.
- Parmar, B., Vishwakarma, A., Padbushan, R., Kumar, A., Kumar, R., Kumari, R., Yadav, B. K., Giri, S. P., Kaviraj, M., & Kumar, U. (2022). Hedge and alder-based agroforestry systems: Potential interventions to carbon sequestration and better crop productivity in Indian Sub-Himalayas. *Frontiers in Environmental Science*, *10*, 858948. <https://doi.org/10.3389/fenvs.2022.858948>
- Parwada, C., Chipombo, J., Mapope, N., Masama, E., & Simango, K. (2020). Role of agroforestry on farmland productivity in semi-arid farming regions of Zimbabwe. *Research on World Agricultural Economy*, *3*(2), 39–47. <https://doi.org/10.36956/rwae.v3i2.515>
- Pinstrup-Andersen, P., & Watson, D. (2011). *Food policy for developing countries: The role of government in global, national, and local food systems*. Cornell University Press. <https://doi.org/10.1111/1467-8489.12004>
- Ramil Brick, E. S., Holland, J., Anagnostou, D. E., Brown, K., & Desmulliez, M. P. Y. (2022). A review of agroforestry, precision agriculture, and precision livestock farming—The case for a data-driven agroforestry strategy. *Frontiers in Sensors*, *3*, Article 998928. <https://doi.org/10.3389/fsens.2022.998928>
- Rosati, A., Borek, R., & Canali, S. (2020). Agroforestry and organic agriculture. *Agroforestry Systems*, *95*(5), 805–821. <https://doi.org/10.1007/s10457-020-00559-6>
- Saha, S., Sharmin, A., Biswas, R., & Ashaduzzaman, M. (2018). Farmers' perception and adoption of agroforestry practices in Faridpur District of Bangladesh. *International Journal of Environment, Agriculture and Biotechnology (IJEAB)*, *3*(6), 1987–1994. <http://dx.doi.org/10.22161/ijeab/3.6.5>
- Samrin, S., Millang, S., Ridwan, & Daud, M. (2024). Land productivity and land equivalent ratio of agroforestry system in Marena Customary Forest, Enrekang Regency, South Sulawesi Province, Indonesia. *Journal Sylva Lestari*, *12*(2), 532–548. <https://doi.org/10.23960/jsl.v12i2.877>
- Staton, T., Breeze, T. D., Walters, R. J., Smith, J., & Girling, R. D. (2022). Productivity, biodiversity trade-offs, and farm income in an agroforestry versus an arable system. *Ecological Economics*, *191*, Article 107214. <http://dx.doi.org/10.1016/j.ecolecon.2021.107214>
- Tadesse, S., Gebretsadik, W., Muthuri, C., Derero, A., Hadgu, K., Said, H., & Dilla, A. (2021). Crop productivity and tree growth in intercropped agroforestry systems in semi-arid and sub-humid regions of Ethiopia. *Agroforestry Systems*, *95*(3), 487–498. <https://doi.org/10.1007/s10457-021-00596-9>



- Tamrakar, P., & Shivam. (2024). Introduction to agroforestry: Concept and principles. In M. Murali, M. Gayathri, M. K. Mankur, M. M. Dange, & A. S. Bargah (Eds.), *Advancements in forestry: Exploring contemporary perspectives* (Vol. 2, pp. 1–21). Stella International Publication.
- Thorlakson, T., & Neufeldt, H. (2012). Reducing subsistence farmers' vulnerability to climate change: The potential contributions of agroforestry in western Kenya. *Agriculture & Food Security*, *1*(15), 1–13. <https://doi.org/10.1186/2048-7010-1-15>
- Tsufac, A. R., Awazi, N. P., & Yerima, B. P. K. (2021). Characterization of agroforestry systems and their effectiveness in soil fertility enhancement in the south-west region of Cameroon. *Current Research in Environmental Sustainability*, *3*, Article 100024. <http://dx.doi.org/10.1016/j.crsust.2020.100024>
- Warren, C. A. B. (2002). Qualitative interviewing. In J. F. Gubrium & J. A. Holstein (Eds.), *Handbook of interview research: Context and method* (pp. 83–101). Sage.