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EXPLORING AGROFORESTRY PRACTICES ADOPTED AMONG SMALLHOLDER FARMERS IN THE HANANG DISTRICT, TANZANIA

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ABSTRACT

This study aimed at identifying Agroforestry systems, technologies and assessing adoption level in Hanang' District Manyara region in the mainland Tanzania. Three divisions were randomly selected from the district. In each division, one village was selected and in each village, nine households were selected making 270 households for the whole study. Data were collected through questionnaires, checklists, and direct observation. Statistical Package for Social Science (SPSS) was used to analyze the collected data sets. Findings revealed that 74.81% of local communities adopted agroforestry, utilizing four systems i.e. Agrosilviculture (51.49%), Agrosilvopasture (30.69%), Silvopasture (13.39%) and Aposilviculture (4.46%) and seven technologies namely; mixed intercropping, integrated tree/pasture management, home gardens, alley farming, contour-ridge planting, live fences, and beekeeping/tree-bee interaction. Agroforestry adoption should be promoted among smallholder farmers in the Hanang' District through training and capacity building initiatives focusing on the identified systems and technologies. Further research is needed to explore socio-economic impacts, implementation challenges faced by farmers, and strategies to overcome these obstacles. These comprehensive investigations would contribute to evidence-based decision-making and sustainable agricultural practices in Manyara Region and elsewhere in Tanzania.

Keywords: Agroforestry practices; Adoption; Smallholder Farmers; Agroforestry, Home garden, land use

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INTRODUCTION

The contribution of agricultural sector to Gross domestic product (GDP) in most developing countries cannot be overemphasized. Agriculture serves as a crucial pillar for Tanzania's economy and engages nearly all of the impoverished population residing in rural areas, which accounts for over 70 percent (Magesa *et al*., 2020). However, availability of land remains fixed despite the growing demand placed upon it due to high rate of human population increase (Maja and Ayano, 2021). Continuous cultivation of same crops for prolonged periods leads to a decline in agricultural land fertility and consequently results into low yield (Peng, 2023). This has resulted into farmers to target forest areas which are more fertile due to their inherent fertility resulting from litter production, decomposition, and increased soil biological activity (Sauvadet *et al*., 2020). However, foresters exhibit reluctance in allocating

forestlands for farming activities due to limited availability of land for forestry purposes. Conversely, considering recent spikes in world food prices, concerns regarding anthropogenic climate change, and challenges posed by a growing global population, concept of multiple land use is being explored as a solution to meet increasing demands for various land uses, including agriculture, forestry, industrial development, urban settlement and recreation (Kumar and Singh, 2020).
Agroforestry, a land-use approach that intentionally combines trees, agricultural crops, and/or domestic animals within the same land management unit, presents a potential solution in addressing climate change, food insecurity, and challenges posed by a growing human population (Jha *et al.*, 2020). Extensive evidence demonstrates multiple benefits of agroforestry for farmers, including improved livelihoods through enhanced food security, increased income, and ability to cope with impacts of climate change (Jahan *et al., 2022).* Furthermore, agroforestry contributes to environmental well-being by offering diverse ecosystem services, such as essential pollination for food plant production (Varah *et al.,* 2020).

For the past three decades, farmers and researchers from Different national and international institutions led by the World Agroforestry Centre (ICRAF) have been using their expertise and resources to make sure that agroforestry is implemented in the sub-region. Agroforestry has been an integral part of traditional and contemporary practices among various tribes in Tanzania. Notable examples include Chagga tribe's home gardens in Kilimanjaro, *Obohochere* home gardens in Mara Region, and ngitili (enclosure) silvopastoral technologies utilized by Sukuma tribe (Manyanda and Kashaigili, 2022). In Hanang' District, agroforestry has been widely implemented across different areas, yielding numerous benefits. Quandt (2010) conducted research on the potential of agroforestry on household lands outside the Mt. Hanang National Forest Reserve, focusing solely on Barjomot Village within Hanang' District. However, a knowledge gap remains unclosed concerning the extent of agroforestry practices and adoption of different systems and technologies in Hanang' District. This study aimed at addressing this gap by identifying adoption of agroforestry systems and technologies, as well as assessing the overall prevalence of agroforestry practices within the district. The findings from this study would contribute to sustainable development efforts and promote effective agroforestry practices. Moreover, it would help mitigate community conflicts, leading to improved livelihoods for the rural poor. Policy and decision makers could utilize the study's findings to develop short, medium, and long-term strategies for sustainable agroforestry management and for climate change adaptation. Additionally, the public would gain awareness of the on-ground situation, fostering positive changes in their behaviour, attitudes, and thinking towards agroforestry practices.

MATERIALS AND METHODS

Description of the Study Area

Hanang' District is situated between Longitudes 34º 45’ to 35º 48’ East of the Greenwich meridian and Latitudes 4º 25’ and 5º 00’ South of the equator (Mwakipesile, 2015). It is one of the six districts of the Manyara Region of Tanzania and is comprised of five divisions namely Katesh, Endasaki, Simbay, Basotu, and Balang'dalalu (Figure 1).

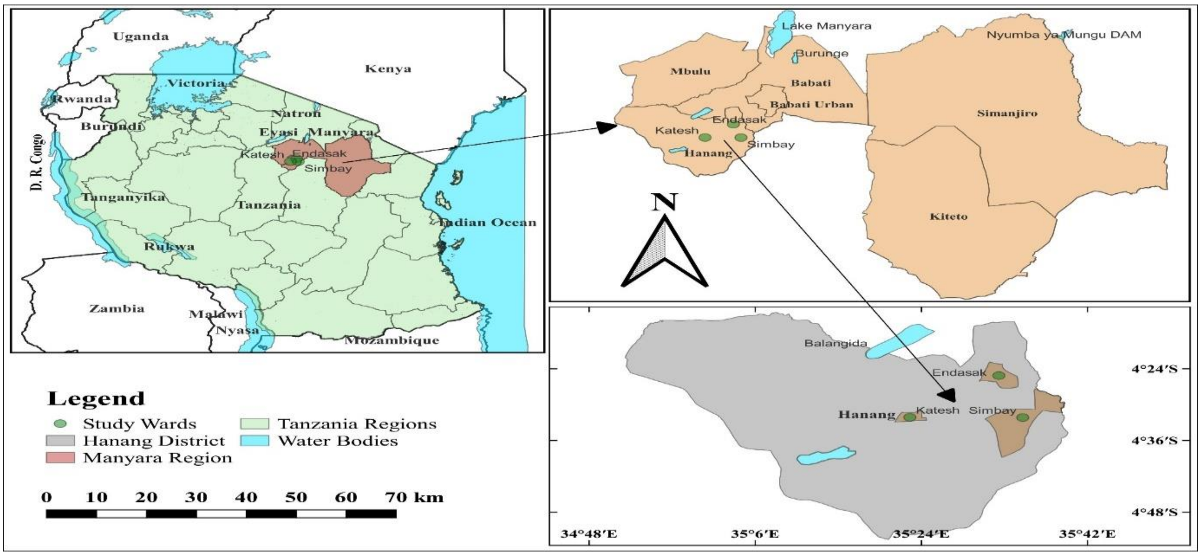

Figure 1: Study area map showing the location of study wards

The district experiences a bimodal rainfall pattern, with an annual precipitation ranging from 500 to 2000 mm. The short rainy season occurs from December to January, while the long rainy season extends from February to May. The temperature in the district fluctuates between 20°C and 30°C throughout the year. The coolest months are typically June and July, while the warmest months are from September to November (Patil, 2004). Moreover, the district has an average elevation of 1244 meters above sea level, characterized by significant relief with steep slopes reaching approximately 3418 meters above sea level. The soil composition in the area predominantly consists of acrisols, alisols, and plinthosols (ac), characterized as acidic soil with clay-enriched lower horizons and low saturation of bases. Various streams and seasonal rivers originate from Mount Hanang', providing water supply to the surrounding villages (Mwakipesile, 2015).

Miombo trees, accompanied by shrubs and grasses, forms the dominant vegetation type in the area. Miombo woodlands are specifically found in the southern part of the district, particularly in Dimra and Gisambala villages (Shirima, 2019). The main economic activities in the area revolve around subsistence farming and livestock keeping, with cattle, goats, sheep, and donkeys being the most commonly raised animals (Tarimo, 2020). On the other hand, Iraqw and Datoga forms the dominant local people in the district. Iraqw people are subsistence farmers (Patil, 2004) while Datoga are agro pastoralists depending on livestock keeping as their main source of livelihood (Sieff, 1999). Cattle, goats, sheep and donkeys are the most commonly kept animals. Many people also keep chicken, ducks, dogs and some own pigs. Cattle have the highest economic and social values for the Datoga and Iraqw people, (Mwakipesile, 2015).

Sampling Design

The study employed a multistage random sampling design in selecting farmers in the study area. In the first stage, three divisions i.e. Endasaki, Katesh and Simbay were selected in the district. From each of these divisions, three villages were randomly chosen in the second stage, resulting into nine sample villages. Subsequently, 30 households were randomly selected from each village during third stage, resulting into a sample size of 270 households. The utilization of a random sampling technique was crucial to minimize researcher bias and ensure an equal opportunity for all divisions, villages, and households to be represented.

Data Collection

Both qualitative and quantitative data were collected through a formal survey. Interviews were conducted with representatives from 30 selected households in each village, utilizing semi-structured questionnaires containing a combination of closed and open-ended questions. The collected data encompassed various aspects, including demographic information, land use and size, agroforestry systems and technologies in use. Additionally, adoption rates of agroforestry practices, products obtained from agroforestry components, factors influencing the adoption of agroforestry, and insights on measures necessary for improving the adoption of agroforestry practices in the study area were also collected. Moreover, key informant interviews were conducted using predefined probe questions to complement the household survey. Furthermore, observations were carried out to verify and supplement the information gathered during the household survey and key informant interviews.

Data Analysis

To ensure data quality, all collected data underwent a filtering process. Subsequently, the data were entered into the Statistical Package for Social Science (SPSS) computer program for analysis. Descriptive methods were employed to examine the adoption of various agroforestry technologies and systems by smallholder farmers. Charts and tables were created to present the results. The Chi-Square test was utilized to determine whether there were statistically significant differences between variables of interest. The test used the following equation;

$$\chi^2 = \sum \frac{(F-f)}{f} \text{ ………. (1)}$$

Where; χ^2 is the Chi-Square test, F and f is the observed and expected frequency of variable of interest

RESULTS

The results of the Agroforestry adoption among the local communities in Hanang' District are presented in Table 1. The study found that 74.81% of the local communities in the district have adopted agroforestry practices. Among the divisions selected, Katesh Division exhibited the highest level of agroforestry adoption, with 84.44% of the local communities practicing Agroforestry. In contrast, Endasaki Division followed and Simbay Division showed the lowest levels of adoption. Moreover, Chi-Square test revealed a statistically significantly differences between adopters and non-adopters of agroforestry in the study area.

Table 1: Extent of agroforestry adoption by local communities in Hanang' District

Adoptions status	Endasaki (n=90)	Katesh (n=90)	Simbay (n=90)	Total
Adopters	70 (77.78)	76 (84.44)	56 (62.22)	202 (74.81)
Non-adopters	20 (22.22)	14 (15.56)	34 (37.78)	68 (25.19)
Grand Total	**90 (100)**	**90 (100)**	**90 (100)**	**270 (100)**

Note: Number in the brackets indicate percentages of each group

Furthermore, the communities in the study area adopted Agroforestry with their systems. The Agroforestry systems are unequally adopted. Among the adopted agroforestry systems, Agrosilvicultural system was most adopted (51.49%) followed by Agrosilvopastoral system (30.69%) and Silvopastoral system (13.37%) while Aposilvicultural system was the least adopted with only 4.46% of the people practicing the system (Fig. 2). The application of the Chi-Square test to the data revealed significant differences among the adopted agroforestry systems in the study area.

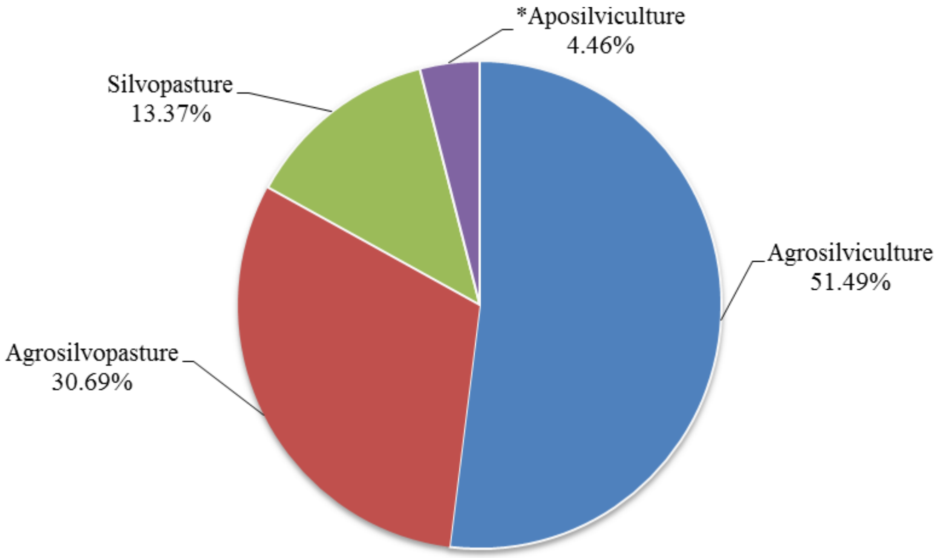

Figure 2: The agroforestry systems adopted by the local communities in study area

Additionally, Table 2 shows seven distinct agroforestry technologies adopted in the study area. Among these technologies, mixed intercropping emerged as the most commonly adopted, followed by integrated tree/pasture management, Home gardens, alley farming and contour-ridge planting. Conversely, tree-insect management technology, specifically beekeeping, had the lowest adoption rate and was solely adopted in Katesh Division within the study area. The application of the Chi-Square test revealed statistical significant differences among the adopted agroforestry technologies in the study area.

Table 2: The agroforestry technologies adopted by local communities in Hanang' District

Technologies	Code	Frequency	Percent of responses (%)
Mixed intercropping	1	146	31.74
Integrated tree (pasture management)	2	80	17.39
Home gardens	3	62	13.48
Alley farming	4	59	12.83
Contour-ridge planting	5	58	12.61
Live fences	6	46	10.00
Beekeeping (tree-bee interaction)	7	9	1.95
Total		**460**	**100.00**

DISCUSSION

The smallholder farmers in Hanang district practice Agroforestry systems and their technologies. It was revealed that Katesh Division has highest number of adopters compared to other divisions in the district. This could be attributed by presence of numerous extension officers, availability of small individual tree nurseries, and sufficient water supply. The adoption rate observed in this study (74.81%) is higher than what has been reported in other studies elsewhere in Tanzania. For instance, Kyamani (2008) reported a 10% adoption rate in Uyui District, Tabora Region, Mgeni (2008) found a 65% adoption rate in Mufindi, Iringa, Shilabu (2008) documented a 22% adoption rate in Maswa, Shinyanga and Lugendo (2003) reported a 36% adoption rate in Tarime District, Mara Region. Higher adoption rate in this study could have been attributed by various factors, including the expectation of forest products such as timber, firewood, and poles, income generation opportunities, and soil erosion control measures. However, adoption rate in the current study falls short of the rates reported by Chija (2013) with 91% adoption in Kasulu, Tabora, Bonifasi (2004) with 90% adoption in Lushoto, Tanga, and Luumi (2014) with 87.5% adoption in Kilosa, Morogoro. This disparity could be be attributed by limiting factors such as inadequate knowledge, insufficient extension services in certain parts of the district, small land holdings, inadequate water supply, lack of quality tree seeds and seedlings, and prolonged dry seasons. Regarding Agroforestry systems, agrosilvicultural system emerged as the most widely adopted system throughout the entire district, followed by agrosilvopastoral, silvopastoral, and lastly, aposilvicultural system. Key reason for adopting agrosilvicultural system was the community's heavy reliance on agricultural crops for food and income generation (Kwesiga et al., 2003).

Another reason was the presence of a significant number of agricultural extension officers who facilitated the integration of trees with herbaceous crops, animals, or a combination of both to farmers. Furthermore, the findings are in line with those reported by Maduka (2007) in Misungwi District, where agrosilvicultural system (62.5%) and silvopastoral system (15.2%) were most commonly adopted. The findings conform also with that reported by Chija (2013) in Kasulu, Kigoma Region Tanzania that showed that agrosilviculture (42%), followed by agrosilvopasture (32%), and silvopasture (26%) were most adopted. Furthermore, similar patterns were observed by Sebukyu and Mosango (2012) in Masaka District, Uganda, who reported that farmers adopted five types of agroforestry systems: agrosilvopasture (45.5%), agrosilviculture (32.9%), silvopasture (16%), aposilviculture (4.5%), and agroaquosilviculture (1.1%). Zeleke (2009) also found that in Oromia, Ethiopia, the agrosilvopastoral system (86%) was predominantly practiced, with the silvopastoral and agrosilvicultural systems accounting for a smaller proportion (2.7%).

In terms of agroforestry technologies adopted, mixed intercropping emerged as most widely adopted, followed by integrated tree/pasture management and home gardens while tree-insect management technology, particularly beekeeping, had lowest adoption rate. According to the respondents interviewed, mixed intercropping emerged as most preferred technology among local communities due to its ability to yield a diverse range of products from trees, cereal crops, and leguminous crops and it is ease to practice and manage. These findings are consistent with research conducted by Chija (2013) in Kasulu District, which also highlighted widespread use of mixed intercropping.

Integrated tree/pasture management was also highly adopted, particularly in areas where pastoralism was prevalent. This finding aligns with the observations made by Patil (2004) and Sieff (1999) that Hanang' District's societies relied heavily on livestock keeping as a primary source of livelihood. Chija (2013) also reported the significant adoption of integrated tree/pasture management (17%) in Kasulu District, indicating farmers' desire to optimize pasture and livestock production while supporting their cropping activities.

The adoption of agroforestry home gardens technology in the study area suggests that farmers valued practices that ensured continuous production and a consistent supply of food products throughout the year. This observation is supported by Chija (2013) who reported that farmers in Kasulu District adopted agroforestry home gardens due to their ability to provide year-round food production. Similar motivating factors were also identified by Zeleke (2009) in Burkitu, Ethiopia, where adoption of agroforestry home gardens was driven by their effectiveness in ensuring food supply. The ease of management and the compatibility of labour requirements with household and childcare responsibilities were additional factors contributing to the preference for home gardens. Moreover, the rapid benefits obtained from home garden practices were seen as encouraging factors. Alavalapati et al (1995), also noted that subsistence farmers are more likely to adopt technologies that offer tangible benefits within a shorter timeframe. However, alley farming (12.83%) and contour ridge planting (12.61%) were adopted specifically for soil erosion control in steep slope areas such as Jorodom and Nangwa in Katesh Division and Gitting Village in Endasaki Division. These findings are consistent with Mgeni's (2008) research in Mufindi District, where contour ridge farming (4%) and alley cropping (3%) were practiced in steep slope areas to address soil erosion concerns.

In the study area, 10% of the local communities adopted living fences technology, primarily for animal control and direction. These findings align with Maduka's (2007) research in Misungwi District, where 20.8% of local communities practiced living fences. Maduka emphasized that while the specific purposes of live fences may vary, generally they are used to keep domestic and wild animals out of farms. Rocheleau et al (1988) also noted that living fences might serve the purpose of demarcating areas where general access is discouraged.

The present study revealed that least adopted technology among the local communities in the study area was tree-insect management, specifically beekeeping technology (1.96%). However, similar findings were reported by Maduka (2007) in Misungwi District, Mwanza Region, where integrated tree-insect management, including beekeeping (1.9%), was found to contribute to improving household needs, income, and poverty reduction. Beekeeping also plays a vital role in biodiversity improvement and increasing crop production through pollination, as emphasized by Ngate (2001) in Mwanza region.

CONCLUSION AND RECOMMENDATION

This study demonstrates that a significant proportion of smallholder farmers in Hanang District have adopted agroforestry practices to varying degrees. The overall extent of agroforestry adoption by the communities in Hanang District stands at approximately 74.81%, with Katesh Division exhibiting a higher adoption rate compared to other divisions. Furthermore, the study identified four different types of agroforestry systems, namely agrosilvicultural, agrosilvopastoral, aposilvicultural, and silvopastoral systems, each with varying levels of adoption. Moreover, seven agroforestry technologies were observed to be adopted, with mixed intercropping being the most frequently adopted technology. To maintain current level of adoption, it is recommended that further sensitization efforts be undertaken and emphasis be placed on promoting the agroforestry systems and technologies that are favoured by the local communities. Farmers should be encouraged also to diversify their agroforestry components in order to provide a wide range of products and services. This approach would enhance their capacity to ensure a sustainable supply of food and generate income.

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