

Assessing Status of Agroecological Biodiversity in Smallholder farming: Evidence from FAO TAPE Tool Localization in Busia County, Kenya

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Abstract

Agroecological biodiversity is the variety and variability of above ground organisms, that is crops, livestock, trees, and activities considered under agricultural systems. This study investigated the extent of above ground agroecological biodiversity among small-scale farmers in Busia County. Agroecological diversity (above ground) was measured using four indicators of the FAO's Tool for Agroecology Performance Evaluation-TAPE: crop, livestock, tree, and activity diversity. Administrative wards were purposively selected where a sample size of 210 was sourced. Households were randomly selected, top 35 households, within those administrative wards. For administrative wards with less than 35 households, snowballing was conducted to reach the required number of households. Snowballing was also conducted to households that were unavailable and to those who did not give consent. Data was collected through structured questionnaires and administered to respondents by trained enumerators. The results revealed that the agroecological biodiversity scores recorded: 40.5%, 31.25%, 45.5%, and 41.75%, for crops, livestock, trees, and activities, respectively, with an overall score of 39.75%. This interprets to unsustainable extent of practice, reflecting missed opportunities to harness agroecological biodiversity. Farmer education and technical extension by up to date standardized trained officers on agroecological biodiversity can be strengthened through mass media, agricultural shows, and farmer school centres. Additionally, promoting practical guidance on integrating locally appropriate species and practices can help unlock the full extent and adoption of agroecological biodiversity.

Keywords: Agroecological biodiversity, agroecology, Busia County, crop diversity, FAO TAPE tool, livestock diversity, smallholder farmers

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Introduction

Current climate change exposes farmers in developing countries to more uncertainty in their livelihoods (Fujimoto & Suzuki, 2025). Climate change will increase unpredictable weather events and destabilize agricultural production and crop prices in markets, threatening smallholders who rely on agriculture as a primary means of livelihood (IPCC, 2022). The growing climatic uncertainty has raised the interest in livelihood strategies for rural farmers to address shocks (Amare & Balana, 2023, Eder *et al.*, 2024, Lal, R. (2015)). Smallholders farmers account for 84% of all farms worldwide contributing 70 to 80% of food production and about 60% of household income (Lowder *et al.*, 2019; Fan and Rue, 2020; Musafiri *et al.*, 2020). Yet smallholder farms are the most vulnerable to extreme climatic events and often suffer significant yield gaps due to reliance on rain-fed agricultural practices and limited socioeconomic and institutional capacity. Moreover, the majority of them grapple with a myriad of challenges, including unpredictable weather patterns Ofori *et al.* (2021), land fragmentation due to population pressure

Giller *et al.* (2021), high costs of technologically advanced inputs Assefa *et al.* (2020), and endemic soil fertility decline (TerAvest *et al.*, 2015).

Consequently, smallholder agriculture is viewed as a crucial pathway for maintaining diversity for achieving sustainable food security and income (Guarín *et al.*, 2020). Smallholder farmers can conserve and use diversity in their farming practices to build farmer resilience and enhance agricultural productivity, thereby increasing food production and income Quieti (2007), and improving ecosystem services (Bravo-Peña & Yoder, 2024; Altieri, M. A, 1999). This can be done through growing more than one crop species at a time is a commonly practiced production strategy observed among smallholder farmers throughout sub-Saharan Africa (Isbell *et al.*, 2021). The strategy is known as crop production diversification; it involves simultaneously or alternatively on same land cultivating a variety of crop species that suit local conditions, serving as an approach to mitigate and cope with both socioeconomic and environmental shocks and risks (Labeyrie *et al.*, 2021). It reduces

the vulnerability to complete crop failure associated with relying solely on one crop species (Renard & Tilman, 2019; Bellon *et al.*, 2020).

Livestock diversity is one of the key components of sustainable agricultural system that provides a multitude of benefits such as income earning, food security and soil health resilience (Sekaran *et al.*, 2021). Heterogeneous livestock systems promote resource use intensification through biomass conversion (such as crop residues, grasses, and agricultural by-products) into valuable outputs like meat, milk, manure, and draft power (Kronberg *et al.*, 2021). In addition, the inclusion of other livestock production species (e.g., cattle, goats, poultry, pigs) enhances farm resilience through the diversification of risk across different productions and resistance to economic damage due to climate variability or market events (Bilotto *et al.*, 2024).

Despite its importance, livestock diversity in smallholder systems is often limited due to constraints such as land scarcity, inadequate feed resources, and limited access to veterinary services (Valbuena *et al.*, 2015). In many cases, because of their perceived greater economic yield, farm owners concentrate on one or two species (i.e., cattle or poultry). Nevertheless, research has indicated that more-diverse livestock systems play a major role in agroecosystem sustainability through boosting soil fertility via utilization rate of manure, pest-control benefits, and income generation (Niamir-Fuller, 2016). Upscaling livestock diversity requires interventions to overcome the constraint related to resource availability, including improving grazing lands availability, fodder production, and extension services that implement integrated livestock management systems.

Tree diversity is important for agricultural productivity, sustainability, and ecosystem resilience (Keprate *et al.*, 2024).

Trees provide a range of ecosystem services such as soil health restoration, slope stabilization, carbon capture sequestration, and microclimate regulation, thus they play an essential role in agroecosystems (Singh *et al.*, 2024). In agroforestry, not only the trees contribute to biodiversity conservation, but also the trees are habitat for species and breeding pollination and pest control (Udawatta *et al.*, 2019). However, tree diversity remains limited in smallholder agriculture (Nyaga *et al.*, 2015). Insecure land title, a lack of knowledge about agroforestry practices and competition for space with crops, limit tree planting (Rahman *et al.*, 2017). Planting multispecies tree in farming systems provides a solution to climate risks generates household income through timber, fruit and non-timber forest product sales and contributes to the long-term sustainability.

There is evidence that increased tree diversity can make farming systems more resilient through the increased soil organic matter, reduced water flow, and the stimulation of the nutrient cycle (Mbow *et al.*, 2014). Hence, the enhancement of tree diversity through specific policies such as the government campaign to plant 15 billion trees in ten years from 2022 in a bid to reach 30% tree cover in Kenya, extension services and incentives such as bonuses, recognition programs, carbon credit and professional development is a key component in the promotion of sustainable agriculture and rural livelihoods.

The complementarity between field crops, livestock, and trees represents the agroecological principles of emphasizing above-ground biodiversity and the interdependence of ecosystem components (Gliessman, 2015). Enhancing diversification at each the component level can reinforce livelihoods and promote, on one hand, sustainable and resilient agricultural systems, on the other.

The Food and Agriculture Organization (FAO) developed an all-in-one model to rate agroecology through various dimensions: the Tool for Agroecology Performance Evaluation (TAPE) (Wordofa *et al.*, 2024). It is not just a tool for evaluation but also acts as a piece of evidence and guideline for creating evidence about the effect on the agroecology performance (Bicksler *et al.*, 2021). The range comprehends different types of production systems, including agriculture and livestock production, aquaculture, fisheries, and forestry. Also, various implementation and translation to potential uses are possible allowing for flexibility in its application (Namirembe *et al.*, 2022).

One of the applications of TAPE is to policy advocates, assisting them in understanding the literature on the contributions of agroecology to sustainable development goals (SDGs). It encourages smallholders by allowing them to assess themselves and encourages interpretation of the findings to change resource allocation to practices that focus on protecting the environment (Mottet *et al.*, 2020). It has been tried-out in various countries including Benin, Ethiopia, Kenya and Madagascar among others (Geck *et al.*, 2024). While TAPE provides for a neat structure for the process, there might be some constraints in its use requiring adjustments to specific present local settings and further improvement for some regions where necessary (Mottet *et al.*, 2020). This not only refers to the use of the method as it was developed, more or less, in France, where the critical conclusion was that it did not fit well within the local conditions and context (Anthonioz, 2021). Also, although there has been application of TAPE for the purposes of assessment and some results have been shared, there is very little documentation related to the

experiences of the technology or its critical review (Namirembe *et al.*, 2022).

With comprehensive study done by Namirembe *et al.* (2022), there is still insufficient localized data to show agroecology above-ground biodiversity practice presence and extent in Kenya and particularly in Busia County. The study has not only added to the literature on agroecology above-ground biodiversity but has filled the gap of evidence in evaluating and scoring the diversity principles of diversified farming systems using a global tool, FAO TAPE tool.

Methodology

Study Area

The project was carried out on smallholder farmers in Busia County, one of the forty-seven (47) counties with a medium high potential area for agriculture, located in Western region of Kenya, it is adjacent to other three counties that is Bungoma to the north, Kakamega to the East and Siaya to the south west. Part of the Lake Victoria is in Busia County on the South East and borders the lake with the Republic of Uganda to the west. Busia County lies between latitude 0° and 0° 45 north and longitude 34° 25 east. Busia County receives an annual rainfall between 760mm and 2000mm, experiences temperatures range of 14°C to 30°C and has altitude of 1130m to 1500m asl. It has two (2) growing seasons that is long rain season between mid-March and Late May and short rain season between August and October. Its major soil type is Acrisols. The agriculture in Busia County is primarily rain-fed with maize, sugarcane, beans, sorghum, cotton as the major crops grown; chicken, pigs, goats, cows as the major livestock reared and Cyprus and eucalyptus tree varieties as the major tree varieties planted.

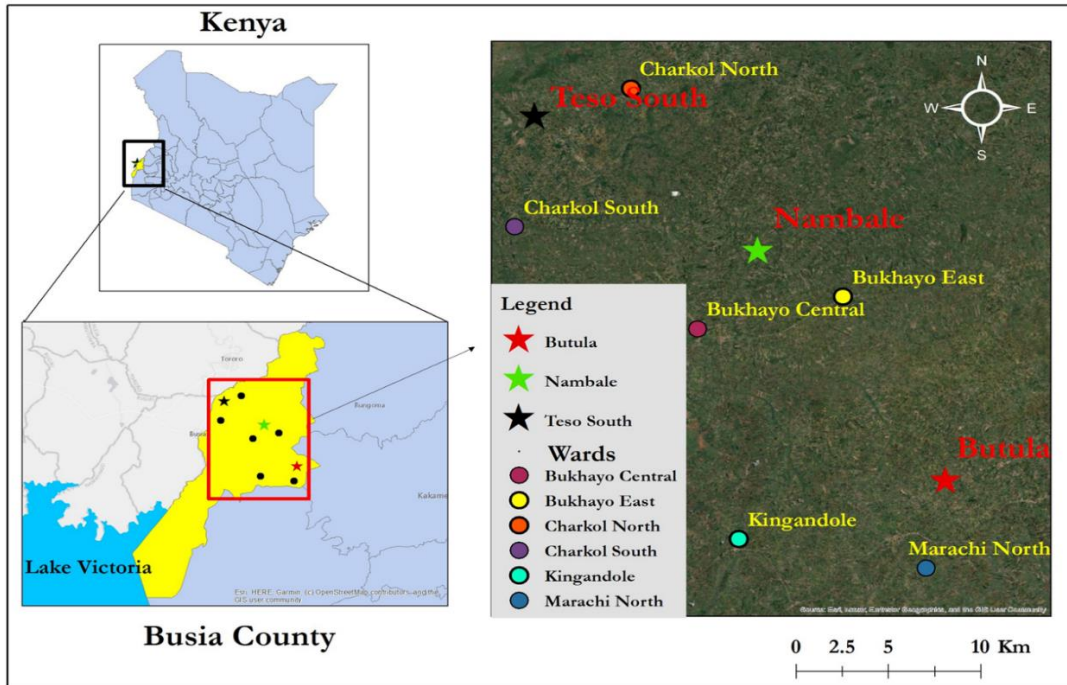


Figure 1: Map of Busia County and the selected administrative wards, indicating the study area

Research Design

A descriptive survey was employed to respondents, by trained enumerators, to generate both qualitative and quantitative data, observations combined with farmers' response, from smallholder farmers specifically in Charkol North and Charkol South of Teso South subcounty; Kingandole and MaArachi North of Butula subcounty and Bukhayo Central and Bukhayo East of Nambale subcounty. These locations were purposively selected, with the data set acquired from the Ministry of Agriculture, Livestock and Fisheries, for the households were previously exposed and practice since the year 2020, through trainings workshops and centres, by private sector and the county projects, to farming practices that align to agroecological biodiversity principles. The Fischer formula was used to identify the sample size, a value of 210, from the total number of households exposed to agroecological biodiversity practices. This value was then divided by 6, the total number of administrative wards that got the agroecological biodiversity exposure.

Meaning, each administrative ward produced 35 households. Random sampling on wards with more than 35 households was used to select households, top 35 were selected. For wards with less than 35 households, snowballing was conducted to achieve the number. For households who did not consent to the survey or were unavailable, snowballing was conducted to reach the required number of households.

Target Population

The target population included smallholder farmers engaged in agricultural activities. Key characteristics of the population were farmers exposed by the county government or private stakeholders who were aligned to agroecological principals.

Sampling Techniques

The study used a combination of snowballing and purposive sampling where snowballing sampling was applied in areas where the targeted number of farmers per ward ($n=35$) were not met during the

purposive sampling of the farmers from the registered list.

Sample Size

The desired sample size was determined using the formula of Fischer *et al* (1998). In which population for more than 10,000 was used to calculate the constant.

$$n = \frac{z^2 pq}{d^2}$$

Where;

n= the desired sample size in case population targeted is more than 10,000

Z= A standard normal deviation at the required confidence level (given as 1.96 for 95% Confidence level)

p= proportion of the target population estimated to have characteristics being measured (0.5)

q= statistical notation for (1-p) = (1-0.5)=0.5

d= degree of accuracy (acceptable error margin) = 0.05

q= 0.5

d= 0.05

z =1.96

$$\text{Thus } n = \frac{(1.96)^2 \times (0.5) (0.5)}{(0.05)^2} = 384.16$$

Since the population was less than 10000 to be studied, fisher’s method of 1998 was used to determine the sample size.

$$n_{adjusted} = \frac{n}{1 + \frac{n-1}{N}}$$

$$n = \frac{384}{1 + \frac{384-1}{10000}} = 209.60$$

n = 210 respondents

Data Collection Methods

Quantitative Data Collection

Structured surveys, using digital data collecting application Kobo Toolbox, were administered to smallholder farmers to gather data on the types and extent of diversification practices. The Kobo Toolbox is an open-source tool with both online and offline functionalities enabling data collection using any device or browser.

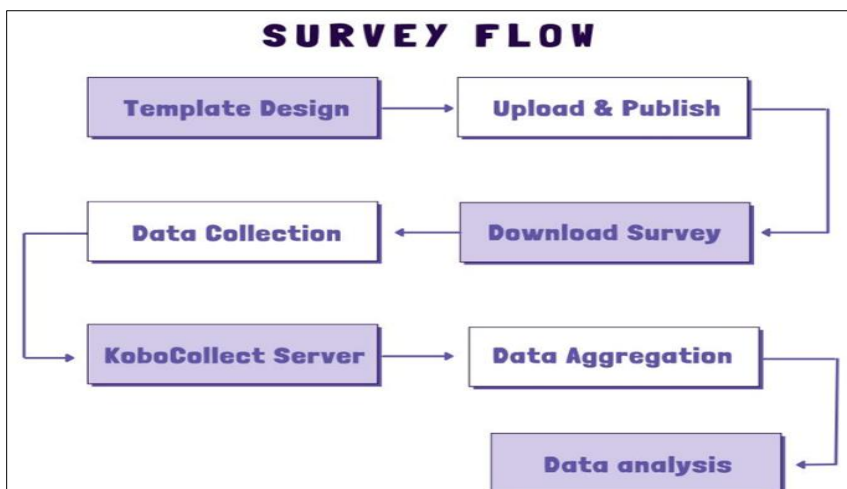


Figure 2: Survey flow, demonstrating development of the survey on the KoboCollect tool

The scoring framework, the FAO TAPE tool, was modified to fit local context and quantitatively evaluate the application

of the diversity principle based on predefined FAO TAPE tool indicators, that is, crop variety, activities, and livestock.

Tape Tool Scoring Framework

Characterization of Agroecological Transitions (FAO, 2019)

Table 1: FAO TAPE Tool

Crops	
Scores	Diversity
0	Monoculture (or no crops cultivated)
1	One crop covering more than 80 percent of cultivated area.
2	Two or three crops with significant cultivated area
3	More than 3 crops with significant cultivated area adapted to local and changing climatic conditions.
4	More than 3 crops of different varieties adapted to local conditions and spatially diversified farm with multi-, poly- or inter-cropping.
Animals (Including Fish and Insects)	
0	No animals raised.
1	One species only
2	Two or three species, with few animals.
3	More than three species with significant number of animals.
4	More than three species with different breeds well adapted to local and changing climatic conditions.
Trees (and other Perennials)	
0	No trees (nor other perennials)
1	Few trees (and/or other perennials) of one species only
2	Some trees (and/or other perennials) of more than one species.
3	Significant number of different species of trees (and/or other perennials).
4	High number of trees (and/or other perennials) of different species integrated within the farm land.
Diversity of Activities, Products and Services	
0	One productive activity only (e.g. selling one crop only)
1	Two or three productive activities (e.g. selling 2 crops or one crop and one type of animals)
2	More than 3 productive activities
3	More than 3 productive activities and one service (e.g. processing products on the farm, ecotourism, transport of agricultural goods, training etc.)
4	More than 3 productive activities, and several services

Table 2: Modified FAO TAPE Tool as per the researcher (2025)

Crops	
Scores	Diversity
0	Monoculture of one variety/or no crops cultivated/at least 2 crops with insignificant cultivated area
1	One crop/monoculture of two varieties covering more than 80 percent of cultivated area.
2	Two or three crops with significant cultivated area
3	More than 3 crops with significant cultivated area adapted to local and changing climatic conditions.
4	More than 3 crops of different varieties adapted to local conditions and spatially diversified farm with multi-, poly- or inter-cropping.

Animals (Including Fish and Insects)

0	No animals raised/ 1 specie with few number animals
1	One species only with significant number of animals
2	At least Two species, with few animals
3	At least three species with significant number of animals.
4	More than three species with different breeds well adapted to local and changing climatic conditions.

Trees (and other Perennials)

0	No trees (nor other perennials) >>>> / one species
1	Few trees (1-50) of one or different species.
2	Some trees (51-100) of more than one species
3	Significant number of trees (101-150) of different species.
4	A high number of trees (>151) of different species are integrated within the farmland.

Diversity of Activities, Products and Services

0	One productive activity only (e.g. selling one crop only).
1	Two or three productive activities (e.g. selling 2 crops or one crop and one type of animals)
2	More than 3 productive activities
3	More than 3 productive activities and one service (e.g. processing products on the farm, ecotourism, transport of agricultural goods, training etc.)
4	More than 3 productive activities, and several services

Data Analysis**Quantitative Data Analysis**

Descriptive statistics data from surveys were analyzed (means, percentages, and frequencies) using R to score the diversity principle. The values were then converted to percentages, by dividing the total score per farmer by 16 and multiplying by 100, and the percentage values were interpreted.

The score interpretations use the simple traffic light approach, similar to Sustainable Development Goals scoring. Scores of less than 50% are coded red, meaning undesirable. Scores of more than or equal to 50% and less than 70% are coded yellow, meaning acceptable. Scores of more than or equal to 70% are coded green, meaning desirable.

Ethical Considerations

All participants were informed of the study's purpose, their rights, and the voluntary nature of participation,

participant data was anonymized to protect privacy and ethical approvals was obtained from National Commission for Science, Technology and Innovation (NACOSTI).

Results**Total Area Production**

The total area under production in Table 3 showed the dominance of ancestral land, accounting for 61.16% of the total cultivated area.

Table 3. Type of land ownership for production

Type_of_Land	Total	Percent
Ancestral_Land	455.24	61.16
Leased_Land	194.93	26.19
Freehold_Land	94.23	12.66

This indicated a reliance on traditional landholdings. This finding aligns

with studies that emphasize the role of inherited land in smallholder agricultural systems in Sub-Saharan Africa (Chamberlin *et al.*, 2014). Leased land constituted 26.19%, overlapping with ancestral land, implying some farmers may diversify their sources of production. Freehold land, making up 12.66%, suggested limited private ownership and raises questions about land tenure security for smallholder farmers. Additionally, it reflects constraints in private ownership, consistent with findings by Jayne *et al.* (2016) on the land tenure challenges facing smallholders in Africa.

Demographic Characteristics of the respondents

According to Table 4, majority of households were male-headed, most household heads were aged between 18–35 years (67.0%), suggesting an increasingly youthful farmer population. 42.7% had attained tertiary education and Primary source of income for the majority of respondents (87.9%) was farming.

Table 4: Demographic characteristics of the respondents

Demographic character	Attribute	Frequency	Percent
Gender of the household head	Female	83	40.3
	Male	123	59.7
	Total	206	100.0
Household head's age	18-35	138	67.0
	36-60	56	27.2
	Above 60	12	5.8
	Total	206	100.0
Level of education of the household head	Primary	38	18.4
	Secondary	80	38.8
	Tertiary	88	42.7
	Total	206	100.0
Average annual household income from the farm	Above Ksh. 100,000 (per year)	38	18.4
	Ksh. 20,000-40,000 (per year)	86	41.7
	Ksh. 40,500-60,000 (per year)	37	18.0
	Ksh. 60,500-80,000 (per year)	21	10.2
	Ksh. 80,500-100,000 (per year)	24	11.7
Total	206	100.0	
Main source of income	Business in farming (this involves sell or transportation of farm produce that was not produced by the farmer)	17	8.3
	Business of other commodities	3	1.5
	Employment	5	2.4
	Farming	181	87.9
	Total	206	100.0

Animal Diversity

The livestock diversity analysis in Figure 3 highlighted significant variability in the types and numbers of livestock kept by farmers: Kienyeji (local poultry) had the highest average of 36 birds per farmer, reflecting its suitability to local conditions, exotic broilers/layers followed with 20

birds per farmer, showcasing a shift towards commercial poultry farming and average numbers of other livestock like cows (4), goats (4), and pigs (3) suggested moderate integration of diversified livestock farming systems. (Mottet & Tempio, 2017).

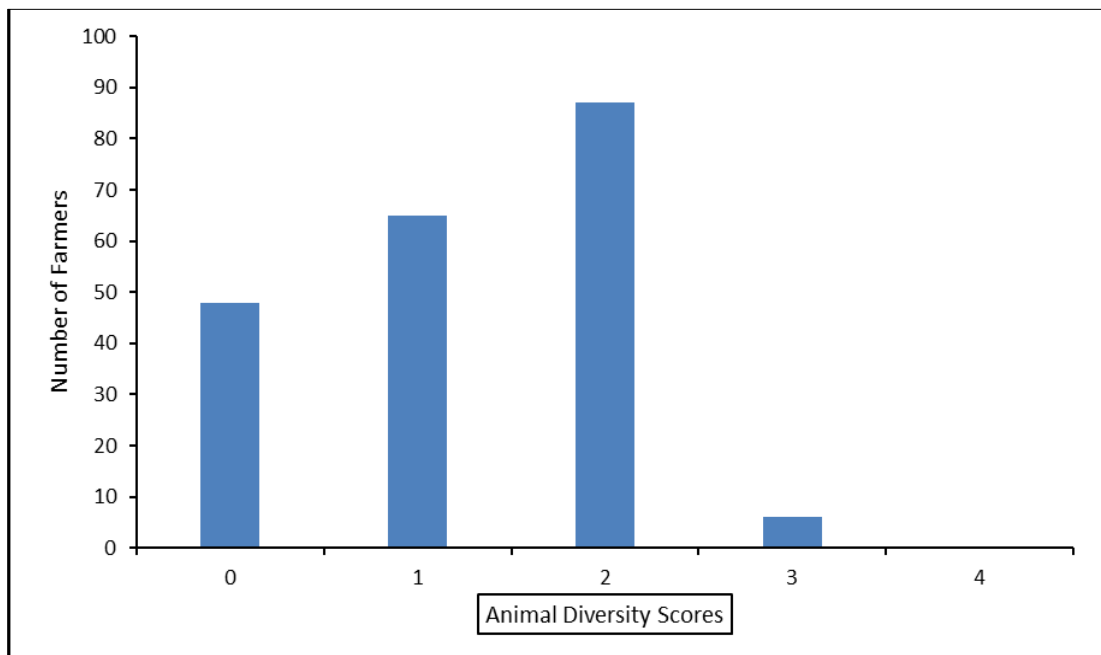


Figure 3: Livestock diversity score frequency

The diversity scoring revealed that 42.23% of farmers had one species with significant animal numbers, while only 2.91% managed three or more species with substantial populations. The average livestock diversity score of 1.25 (31.25%), meaning extent of the diversity is unsustainable, indicated limited diversity in livestock farming, with a heavy dependence on one or two species. This mirrors findings by Thornton et al. (2007), which argue for diversified livestock systems to improve resilience to climate shocks and enhance productivity.

Tree Diversity

Tree diversity in Figure 4 showed moderate adoption among farmers in that a mean tree diversity score of 1.82 (45.5%), meaning unsustainable, reflected the presence of at least one species per farmer on average while 22.33% scored the highest (100%, diverse tree systems), more than half (51.46%) had only one species, indicating low agroforestry diversity. The fact that 22.33% of farmers maintained diverse tree systems aligns with the growing recognition of trees in improving soil fertility, regulating microclimates, and providing additional income (Garrity et al., 2010).

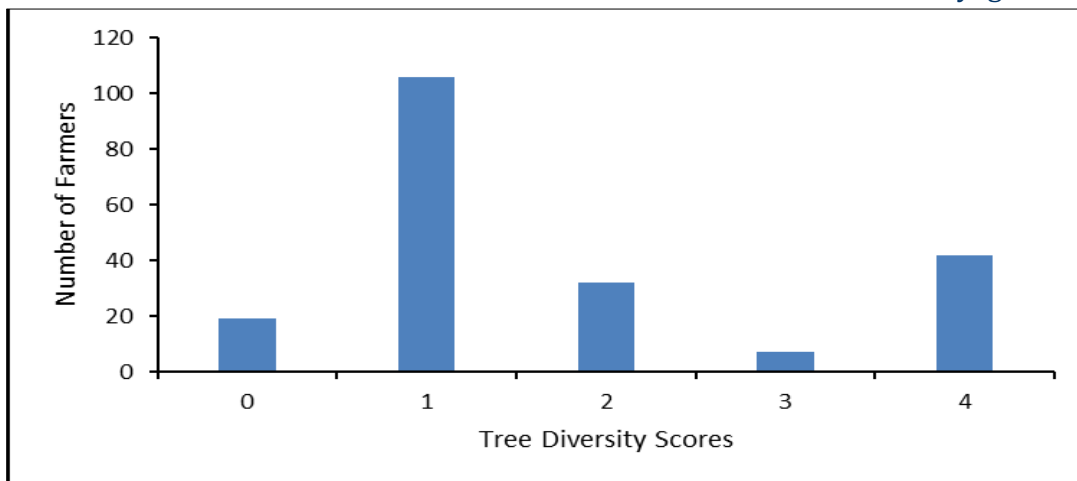


Figure 4: Tree diversity score frequency

Activities Diversity

Farmers' activity diversity in Figure 5 scores showed a moderate spread such 56.80% of farmers scored 2 (50%, meaning unsustainable), engaging in multiple activities but often focusing on one or two primary enterprises but Only 6.31% scored 3 (75%, meaning desirable), indicating engagement in three or more substantial

activities. This finding aligns with Reardon *et al.* (2007), who highlight the importance of livelihood diversification for rural households. The average activity diversity score of 1.67 (41.75% meaning unsustainable) underscored the need to broaden farm-level activity diversification to strengthen livelihoods and economic stability.

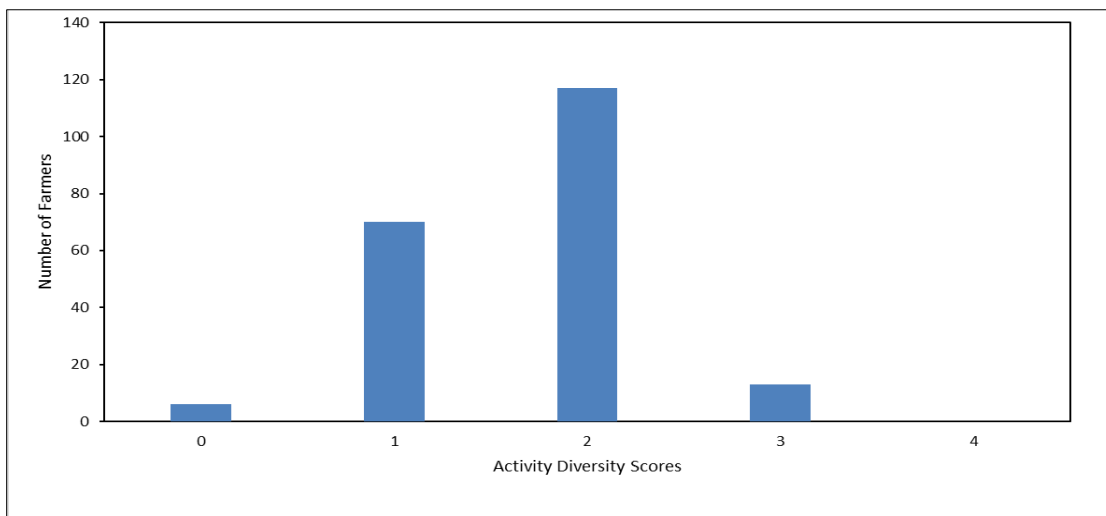


Figure 5: Activity diversity score frequency

Crop Diversity

In Figure 6, out of two hundred and six (206) farmers, eighteen (18) farmers scored zero (0), fifty six farmers (56) scored one (1), one hundred and twenty (120)

farmers scored three (3) and two (2) farmers scored four (4). Crop diversity indicated a wider variability such that 58.89% of farmers scored 1 (25%) and 2 (50%) cultivated one or two primary crops, and 23.43% grew three or more

crops. The average crop diversity score of 1.62 (40.5%, meaning unsustainable) suggested that farmers primarily relied on monoculture or limited intercropping. The most crops grown by farmers was maize, maize is a staple food in Kenya and most farmers are engaged in planting it. The

average crop diversity score of 1.62 is consistent with findings by Altieri and Nicholls (2018), who emphasize the need for diversified cropping systems to reduce risks from pests, diseases, and climate change impacts.

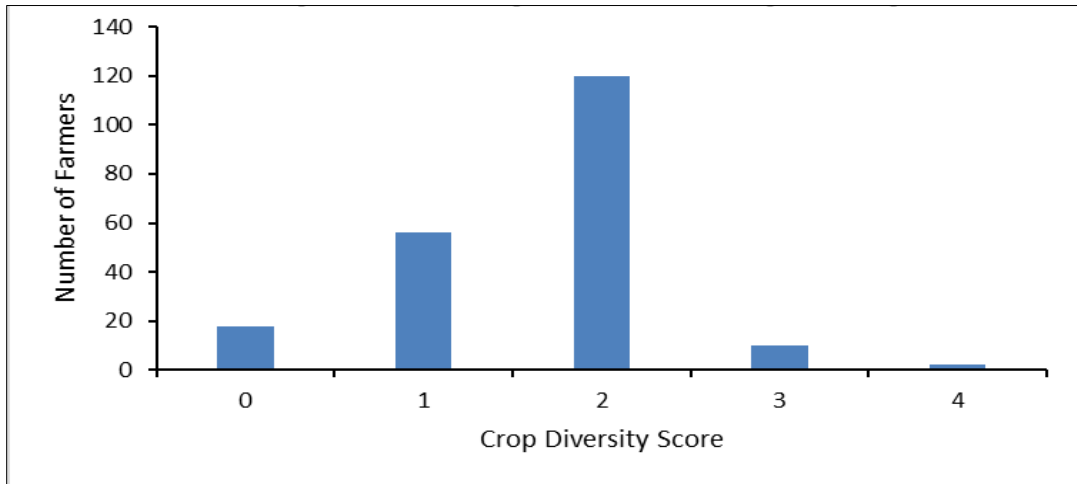


Figure 6: Crop diversity score frequency

Overall Diversity Score

This is a composite score based on the average of the animal, tree, crop, and activity scores. Only one (1) farmer attained the desirable extent of practice, one hundred and fifty-one (151) of them

are unsustainably practicing agroecological biodiversity and fifty-four (54) of them are acceptably practicing agroecological biodiversity practices as illustrated in Figure 7.

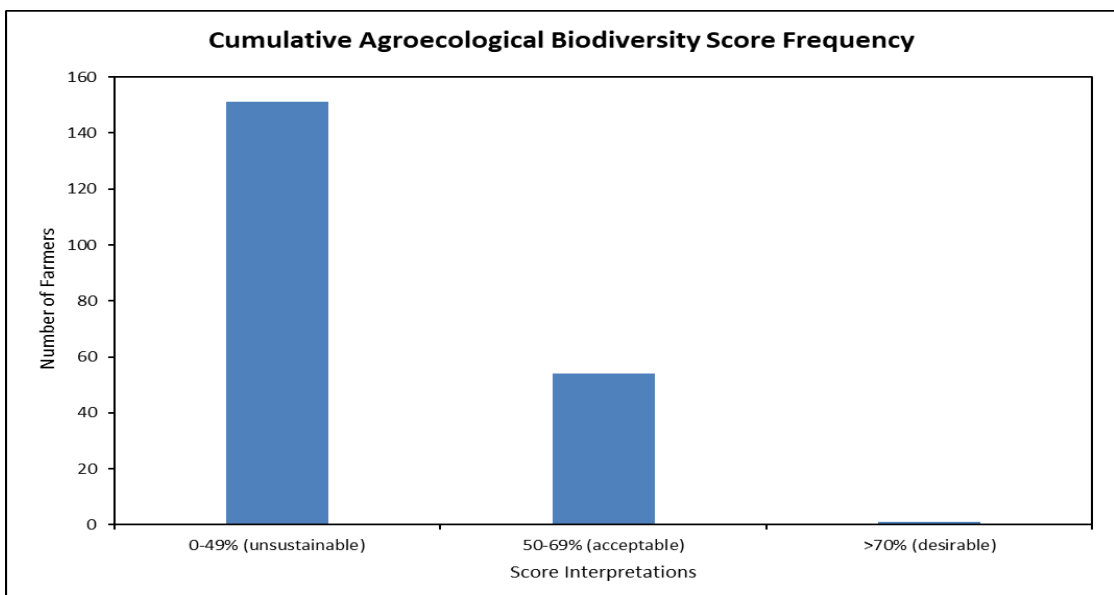


Figure 7: Cumulative agroecological biodiversity score frequenc

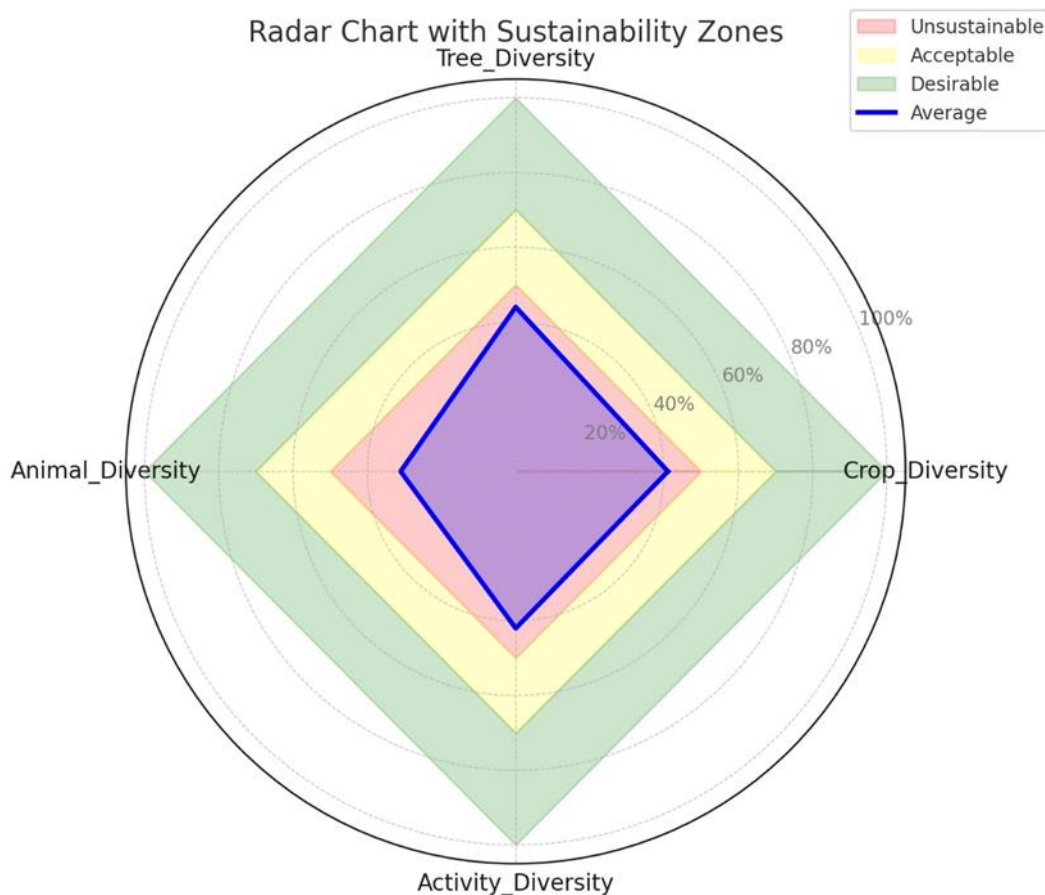


Figure 8: Overall agroecological biodiversity indicator scores

The overall diversity score of 1.59 (39.75%, meaning unsustainable) reflects limited diversity in integrating crops, livestock, trees, and activities. Most farmers were engaged in single or dual enterprises, leaving room for improvement in adopting a holistic agroecological biodiversity model. These are similar to findings by Gliessman (2015), who argues that holistic agroecological systems require stronger integration of crops, livestock, and trees for sustainability.

Discussions

Demographic Characteristics of Respondents

The results showed that most of the households in the study were male-

headed, but there were also a good number that were female-headed. This trend reflects the stereotypes associated with gender roles observed in rural Kenya, where men are often acknowledged as heads of households because of culture and land ownership structure. This aligns with past work by (Kabubo-Mariara et al., 2009) who discovered that land tenure systems, and their associated ownership and control of agricultural decisions, favor men over women, which is reflected in the delineation of heads of households.

It is interesting to observe that most head of households are relatively young adults. This was an unanticipated yet positive observation for the regional profiles, given that a similarly young population in many other parts of sub-Saharan Africa appear to view agriculture

as an 'old generation' endeavor. The outcome of the findings suggests that young people's engagement with farming in the study area is positive by improving perceptions of the agricultural sector, specifically at the production level, for a future generation of farmers. These outcomes align with FAO (2021) observations regarding incentive programs, and access to education, that are beginning to influence a positive perception of youth engaging with farming. This is promising for the future of agroecological aligned practices, as younger generation farmers are likely to be more prone to experimenting and engaging in innovative sustainable practices.

The education levels of the household heads were relatively high; many respondents had completed tertiary education. This education level potentially has an impact on the ways that farmers receive and engage with agroecological biodiversity aligned knowledge and adopt the practices. Earlier research such as that by (Mango et al., 2018) supports the argument that educated farmers are more likely to comprehend environmental risks and apply adaptive strategies that will potentially improve resilience and productivity. The implication is that a knowledge capacity among farmers could play a significant role in how households adopt sustainable land use, and biodiversity conservation practices.

Furthermore, farming was seen as the main economic activity by most respondents. This again reinforces the important role that agriculture plays for rural livelihoods, especially in places like Busia County. The Kenya National Bureau of Statistics (KNBS, 2022) also reported that farming is still the backbone of the household economies of many rural counties in Kenya. The significance of being involved in farming is important, but can also add vulnerability when soil productivity is low or climatic variability is a

challenge, and showcases the importance of integrated strategies that conserve agroecological biodiversity (above ground) and enhance productivity, improving income stability of smallholder households.

Agroecological Biodiversity Among Smallholder Farmers

The results of this study showed a generally unsustainable to acceptable level of agroecological diversity among smallholder farmers, with considerably unsustainable agroecological diversity was reported in terms of animals, trees, crops, and farming activities. In terms of livestock diversity, local poultry species (especially kienyeji chickens) were found to be the most diversified among farms. This is possibly due to their better adaptation to the local conditions on diverse farms, as well as lesser input, which makes them favorable for smallholder farmers. This evidence supports earlier findings presented by (Bett et al., 2012) that local poultry is mostly chosen by rural households because of better economic resilience as well as cultural importance. There is minimal soil nutrition, ecological and nutrition safety that livestock diversity can offer with the focus on one or two species on livestock. There is more enhanced nutrient availability with varied livestock species. As an illustration, poultry waste has high nitrogen however the amount is in smaller amount when compared to cattle waste. This enables a bigger land area coverage (Thornton & Herrero, 2015).

Similar pattern, unsustainable diversity, is also reflected by diversity of trees, despite it was the highest scored indicator. A few farmers (45 farmer) had varied tree species such as timber, fodder, firewood or shade and majority of the smallholder farmers (106) had an overwhelming dependence on one kind of tree, that is the timber trees. Farming systems with arable trees have shown to

have a positive impact on soil health (Garrity, 2004). Limited technical extension services is being highlighted by the limited tree variability and over dependence of the timber tree species, where information dissemination channels or techniques are not simplified or effective or there is misinformation, that is wrong information being communicated to the smallholder farmers. Resulting to a knowledge gap within the smallholder farmers on the valuable benefits of agroforestry with varied tree species.

Majority of farmers (118 farmers) highly dependent on one or two crop type with maize as the to go crop for it is the staple crop. Only a small number of smallholder farmers (5) practiced diversified crop farming having legumes and root crops. It was reported by Altieri (M. A. Altieri et al., 2015) that monoculture continues to be entrenched in the agroecological diversity of smallholder farmers in Africa, despite well-known risks like soil degradation and putting farmers at risk of pests and climate stresses. The high overreliance on maize crop by smallholder farmers point out the role of structure and policies privileging cereal production and overlooking nutritional and ecological diversity.

On farm activity diversity also scored unsustainable extent of practice. The farmers (117 farmers) remained anchored to one or two main activities. A variety of on-farm activities can offer protection against market protection unpredictability and environmental uncertainty (Pretty, 2011).

The results communicate that agroecological biodiversity in the study area is unsustainable level of practice. These results resonate recently discovered results by FAO in the Soil Protection and Rehabilitation for Food Security (ProSoil) global project that reported diversity score of 51%, incipient stage. (FAO, 2025). This means that the advancement of

agroecological biodiversity in this landscape is dependent upon the implementation of targeted interventions aimed at supporting integrated, knowledge-based and place-based agroecological biodiversity practices. This resonated with FAO (FAO, 2025) for they identified apart from underlying issues of high levels of degradation and limited access to ecological inputs and markets, conflicting technical information by various organizations leading to confusion among farmers and farmer cooperatives hindering adoption of most appropriate farming practices.

Conclusions

In order to suit local context, the tape tool modification was done based on nature of farming in Busia County and population density which most of time informs the diversification of farms. The modifications changed the interpretation of the scores within the indicator. These changes were unavoidable due to the nature of the location and farming culture. Once the modification was done, comparison was made to the original tool by FAO. The modification made the principal indicator assessment process more relevant to the specific location and farmer community.

The diversity scores ranged between unsustainable and acceptable, with animal diversity scoring the least, 31.25%, and tree diversity scoring the most, 45.5%. Crops diversity scored 40.5% while activity diversity scored 41.75%. This reflects missed opportunities to sustainably adopt agroecological biodiversity since it was introduced to the farming community, three years ago. Generally, the results indicated that agroecological biodiversification still at its infancy in the study area as seen from its overall score of 39.75% meaning unsustainable.

Recommendations

1. The FAO TAPE tool is not relevant to our local contexts; therefore, it needs modifications for it to be relevant in the different farming cultures in our country. With this modification, it will be clear when it comes to comparing agroecological biodiversification within our country, regionally and globally.
2. Promote agroecological diversification by encouraging, through practical ways and simplified data monitoring, to farmer understanding level, the cultivation of varied crops, rearing multiple livestock species, plantation of variety and various tree species and conducting of various farm service and product activities.
3. Support farmers in transitioning to advanced agroecological biodiversity practices through various channels (mass media) and platforms (sponsored or commercialized training workshops, seminars, demonstration farms)

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