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Assessing livelihood strategy choices among spice farmers in the Eastern Arc Mountains of Tanzania

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In Tanzania, spice farming is primarily concentrated within the Eastern Arc Mountains, a designated conservation area presenting a unique interplay of economic sustenance, environmental conservation, and geographical challenges. This study aimed to identify and understand the livelihood strategies employed by spice farmers, as well as to examine the various determinants influencing their decision-making process in adopting these strategies. Data were collected from 542 randomly selected spice households in the Uluguru and East Usambara mountains. Cluster analysis was utilized to categorize households into distinct livelihood strategies, while multinomial logistic regression was employed to assess the determinants of these strategies. The findings unveiled five types of livelihood strategies among spice farmers in the study area. Determinants included total land ownership, age, education, sex, marital status of the household head, number of working-age members, location district, altitude, distance to the district capital, extension and research/NGO interaction, and durable asset ownership. Given the heterogeneity among spice farmers, interventions should be tailored to accommodate the diversity of their livelihood strategies. Policymakers should prioritize market stability, crop productivity, and income diversification through entrepreneurship to enhance household income and resilience. Promoting improved seeds and modern farming techniques can render spice farming more financially appealing to young farmers.

Key words: Livelihood strategies, cluster analysis, spice production, Eastern Arc Mountains, Tanzania.

INTRODUCTION

Spice farming in Tanzania not only plays a crucial role in the livelihoods of many rural communities but also makes

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a significant contribution to the nation's economy (Bullock et al., 2017; Dev, 2021; Garu, 2017; Maerere and Noort,2014; Mhagama, 2016; Mmasa, 2017; REPOA, 2018). Concentrated primarily within the Eastern Arc Mountains, spice farming represents a unique blend of economic sustenance, environmental conservation, and geographical challenges (Dev, 2021).

The Eastern Arc Mountains, including regions like the Uluguru and Usambara Mountains, are renowned for their exceptional climatic conditions and fertile soils, making them ideal for spice cultivation (Rayes, 2009). Major spices cultivated in these areas include cloves (Karafuu), black pepper (Pilipili manga), cardamom (Iliki), and cinnamon (Mdalasini), serving as key sources of income for local communities (Kajembe et al., 2024; Abdalla, 2021). However, this advantageous environment comes with restrictions, mainly driven by conservation efforts and the mountainous landscapes (Mtashobya, 2014; Dev, 2021).

The Eastern Arc Mountains, recognized as one of the world's biodiversity hotspots, serve as an exceptional reserve for numerous plant species, mammals, and birds (Gereau and Menegon, 2016; Nielsen et al., 2022). According to Iddi (1998) and Burgess et al. (2007), the Eastern Arc Mountains are among the most crucial areas globally for the conservation of endemic birds, plants, and various taxonomic groups. The significance of these mountains extends beyond ecological richness, deeply intertwining with the culture and sustenance of local communities. Therefore, balancing the conservation of these vital ecosystems with the needs of human populations becomes a matter of utmost concern. Consequently, the livelihood strategies adopted by spice farmers in this region become a subject of importance for comprehensive analysis. Understanding the choices made by these farmers is not only economically significant but also crucial for poverty alleviation, sustainability of the spice sector, and the preservation of conservation areas.

Rural households often diversify their sources of income through a broad range of income-generating activities, encompassing both on-farm and off-farm endeavors, as well as non-farm ventures. This diversification is driven by several factors, including diminishing returns on investments in specific activities, synergies arising from concurrently pursuing different activities, and the absence of accessible markets to sell their products, which can compel households to produce goods or services for their own consumption (Abera et al., 2021; Alemayehu et al., 2018). Additionally, households may adopt a particular strategy as a means of addressing unforeseen shocks or proactively mitigating risks by participating in activities with returns that are not perfectly correlated. The selection of a livelihood strategy at the household level is perceived as a result of dynamic adaptation to the various constraints and opportunities encountered by smallholder farmers, as outlined by Loison (2015). The capacity of households to choose different livelihood strategies are dependent upon the characteristics of their livelihood assets or capitals, encompassing natural, physical, financial, social, human, and vulnerability context of the household as well as institutional factors (Mukwedeya and Mudhara, 2023). Therefore, under the unique ecological setup of the Eastern Arch Mountains, it is important to explore the local community's livelihood strategies and what determines their choices. The primary objective of this study is to analyze the livelihood strategies employed by spice farmers in the Eastern Arch Mountains and provide valuable insights into effective interventions that can reduce poverty, vulnerability, enhance household income, and support the sustainability of conservation efforts. The specific objectives of the study are twofold: first, to identify and understand the livelihood strategies utilized by spice farmers, and secondly, to examine the various determinants that influence their decision-making process when adopting these strategies. By gaining a comprehensive understanding of the strategies, policymakers and development organizations can design targeted interventions to uplift the livelihoods of these farmers while promoting biodiversity conservation efforts.

Theoretical frameworks

Livelihood strategies

Livelihood strategies encompass a diverse range of activities undertaken by individuals to not only survive but also meet their various needs (Rehan et al., 2019; Abera et al., 2021). According to Negash et al. (2023), livelihood strategies refer to the various activities that individuals engage in to convert their available resources into desired outcomes. Understanding and classifying these strategies are essential for identifying distinct patterns and creating specific interventions to alleviate poverty (Cai et al., 2019). Sun et al. (2019) provide a holistic methodological framework to classify livelihoods in a more intuitive way. They suggest that approaches to classify livelihoods can be asset-based, activity-based, or income-based, depending on the perspective and components. The asset-based approach focuses on inputs, analyzing how livelihood assets are distributed across various activities or asset portfolios. Several studies have used this approach to analyze household strategies (Brown et al., 2006; Wei et al., 2019). However, this approach faces challenges in capturing income-generating activities that do not require substantial asset inputs or assets that are difficult to quantify, such as investments, retirement plans, or transfer payments (Mishi et al., 2020).

The activity approach refers to all income-generating activities carried out by households within and besides farming. This means the activity approach combines

multiple factors to explain household livelihood's ability to adopt certain types of livelihood strategies to achieve their goals. The activity approach involves identifying and promoting specific income-generating activities that are well-suited to the local needs. Recent literature acknowledges that non-farm activities play a significant role in the context of inadequate and rain-fed dependent agricultural income households (Gebru et al., 2018; Akyoo and Lazaro, 2007).

According to Msumba et al. (2021), diversification into non-farm activities is the most common change of household livelihood and should be promoted in rural areas for poverty alleviation and livelihood improvement for sustainable income.

However, both assets and activities are only intermediates of the process and do not necessarily provide the picture of the relative significance of the livelihood to household welfare. For instance, some activities may be mostly practiced for traditional purposes only while being less effective in improving the overall welfare of the household.

The income-based approach examines livelihood strategies from an output perspective, focusing on the income obtained from specific sources such as non-farm activities, forest-related income, cash transfers, or earnings from various income streams (income composition) (Sun et al., 2019). Economists often group households based on the proportion of income earned from different sectors of the economy. This approach is simple yet effective in categorizing households into distinct livelihood groups (Volpenhein et al., 2022) and provides more insight into the relative importance of activities and livelihood strategies to household welfare. Using the income approach, more effective policies can be designed and implemented to have a maximum improvement in the overall welfare of the household, such as poverty reduction.

Therefore, the income-based approach was selected for this study because it offers a practical means of assessing livelihood strategies and their impact on household welfare. It allows for the identification of key income sources, the categorization of households into distinct groups, and the design of more effective policies for poverty reduction and overall improvement in household well-being. This method provides valuable insights into the complex dynamics of rural economies and livelihoods, ultimately contributing to more targeted and impactful development efforts.

The sustainable livelihoods framework (SLF)

The Sustainable Livelihoods Framework (SLF) (DFID, 2001) provides a valuable theoretical framework for understanding the livelihood strategies adopted by spice farmers in Tanzania. Originating from the field of development studies, this framework offers a comprehensive lens through which to examine livelihoods, exploring the interaction of various components. These components include capital assets such as natural, physical, financial, human, and social capital, along with livelihood strategies, institutions, vulnerability, risk, and livelihood outcomes (Figure 1). Leveraging the SLF enables us to untangle the complex web of factors that shape the livelihoods of spice farmers and gain insights into their sustainability and resilience in the face of constraints and opportunities.

At the heart of this framework are livelihood strategies, which result from the combination of income-generating activities aimed at achieving livelihood goals. In the context of spice farming, these income-generating activities encompass on-farm activities, or a combination of on-farm and off-farm activities, with livelihood goals including increased income, enhanced food security, sustainable natural resource utilization, and overall well-being. The selection of a specific activity or combination of activities depends on a household's access to and ownership of livelihood assets.

Human capital factors, such as labor availability (e.g., household size and age) and knowledge levels (e.g., education level), exert influence over spice farming households' decisions regarding their choice of livelihood strategies. Physical capital, including aspects such as land holdings and ownership of durable assets and machinery, may likewise shape the livelihood choices of spice farmers. Similarly, social capital, which encompasses access to market information through participation in social networks or membership in farmers' associations, and financial capital, indicating access to credit, plays pivotal roles in influencing livelihood choices. Natural capital, represented by the availability of arable land, forests, landscape characteristics, and other natural resources, forms the environmental context for these livelihood choices. Spice farming households may also choose particular livelihood strategies in response to vulnerabilities such as climate variability, price fluctuations, and changing market conditions, which can be considered shocks, trends, or seasonality. These external disturbances influence both outcomes and capital assets, significantly affecting the household's vulnerability level and thus influencing livelihood selection.

Similarly, institutions, including both formal (such as government policies and regulations) and informal (such as community norms), play a central role in mediating access to resources and opportunities for households. For instance, the availability of extension services, access to infrastructure, and proximity to goods and labor markets create opportunities for making livelihood choices. The Sustainable Livelihood Framework (SLF) offers a structured methodology for analyzing the core components of livelihood strategies and the determinants influencing the selection of these strategies. Generally, these determinants can be categorized as either "push

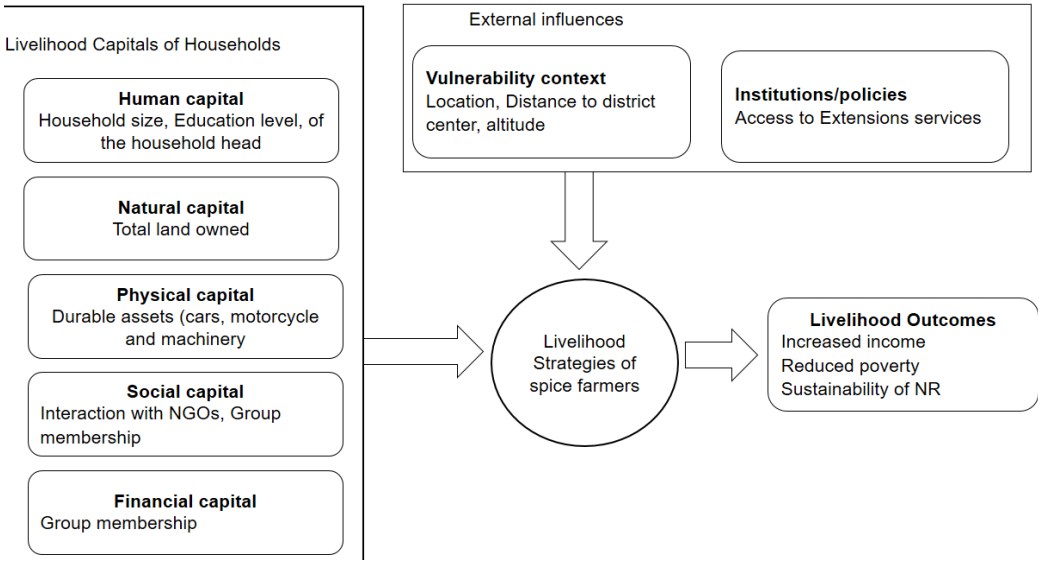

Figure 1. Theoretical framework of sustainable livelihood for spices farmers.
Source: DFID (2001).

factors" or "pull factors", depending on how they shape the process of livelihood selection (Loison, 2015). Push factors are conditions that may compel farming households to engage in specific livelihood activities due to limited opportunities or high vulnerabilities. Push factors tend to prevail in high-risk and low-potential agricultural environments characterized by factors such as drought, flooding, environmental degradation, limited infrastructure, and constrained goods or labor markets. Conversely, pull factors attract farming households to explore additional livelihood activities within or beyond farming to enhance their living standards, due to the availability of opportunities. Such factors tend to dominate in less risky, more dynamic agricultural environments with improved institutional infrastructure and accessible goods and labor markets. Therefore, the SLF serves as the basis for the analysis in this study.

MATERIALS

Description of study area

This study was conducted in the East Usambara and Uluguru Mountains of the Eastern Arc mountains in Tanzania. The Uluguru Mountains are situated in the Morogoro district, approximately 180 km west of the Indian Ocean. Covering a total area of about 1,300 km^2, the district has altitudes ranging between 1,000 and 2,638 m above sea level. The eastern slope of the mountains receives a mean annual rainfall of 1,200 mm/year, with an average annual temperature of 26.5°C (Yamane et al., 2018).

In contrast, the East Usambara Mountains are located in the Muheza district within the Tanga region, around 40 km from the coast. Similar to the Uluguru Mountains, they cover an area of about 1,300 km^2 and reach altitudes of up to 1,250 m. The mean annual rainfall in this region is 1,918 mm, with a bimodal rainfall pattern. The average annual temperature is 20.6°C (Reyes et al., 2009).

These areas boast agro-ecological characteristics and microclimates, including fertile soils, diverse topography, favorable climates, and rich biodiversity, which make them ideal for spice cultivation. Major spices grown in these areas include black pepper, cardamom, cinnamon, and cloves, which play essential roles in the livelihoods, cuisine, and culture of the Uluguru and Usambara regions. These spices not only serve as sources of income but also contribute to flavoring dishes and traditional medicine practices (Kimaro et al., 2024). The spice trade has been a significant economic activity in these regions for centuries, and spice cultivation remains an important livelihood strategy for many smallholder farmers (Kajembe et al., 2024). Figure 2 shows the area of the study.

Sampling strategy

Multistage sampling was utilized to sample both the districts and households for this study. In the first stage, two districts were purposively selected due to their high involvement in spice farming under agroforestry. As no previous studies had been conducted on the determinants of livelihood diversification strategies among spice farmers in these areas, they were chosen based on this criterion.

In the second stage, a total of eleven wards within the selected districts were identified. From each ward, villages were purposively selected based on the active engagement of households in spice farming under agroforestry.

In the third stage, a random sampling technique was employed to select respondents from the households identified in the selected villages. The total number of respondents sampled was 542, with 339 from Muheza and 203 from Morogoro. These respondents were interviewed using a structured questionnaire.

The sample size was determined using Cochran's sample size formula, as recommended by Bartlett et al. (2001). This formula ensured that the sample size was adequate to yield statistically reliable and meaningful results. Subsequently, random sampling

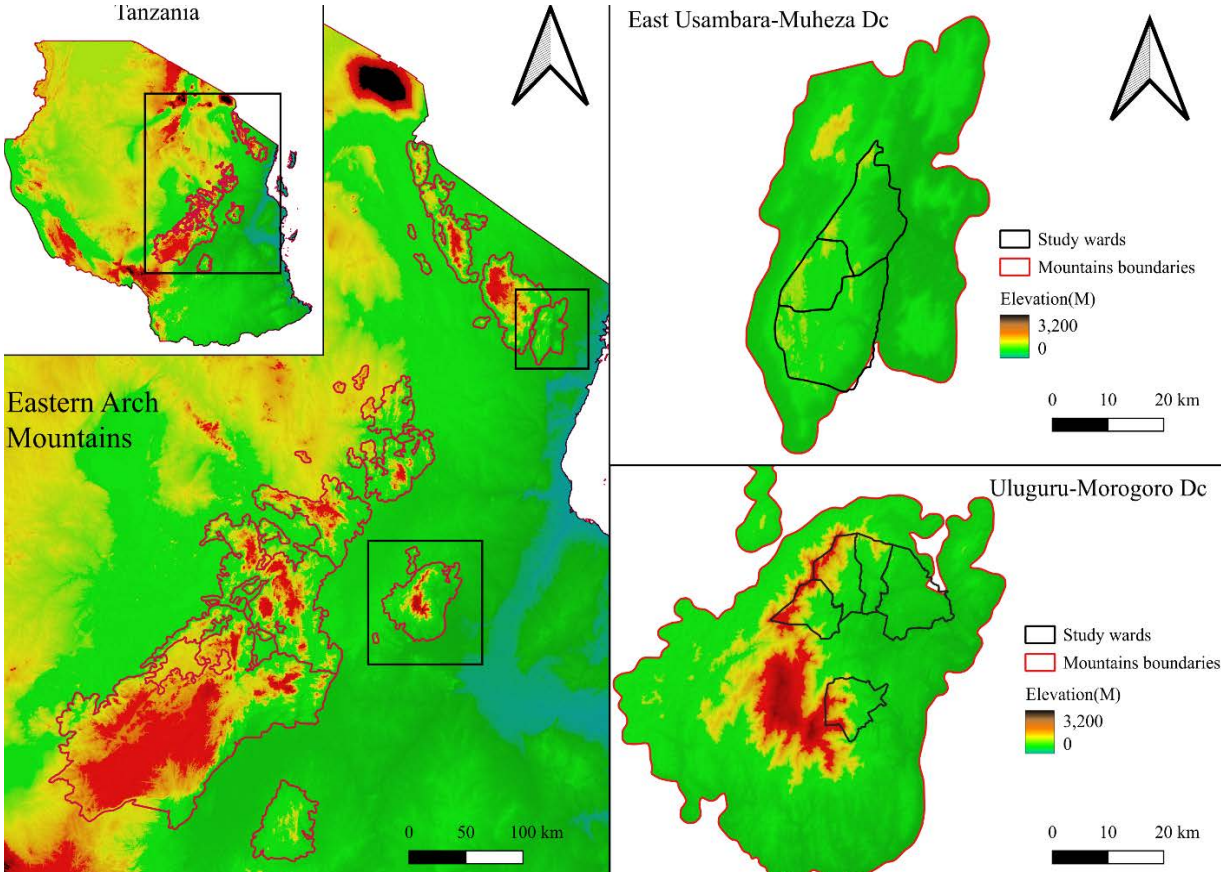

Figure 2. Study areas.
Source: Author (2024).

was employed to implement the determined sample size, thereby minimizing selection bias and increasing the likelihood that the sample accurately represented the entire population of spice farmers.

$$n = \frac{n_0}{1 + \frac{n_0}{N}} \quad (1)$$

where n is the sample size for finite population, N is population size and n_o is the sample size for infinite population, which is given by the Equation 2:

$$n_0 = \frac{t^2 \times pq}{E^2} \quad (2)$$

where t is the value for the selected alpha[1] level, e.g. 1.96 for (0.25 in each tail) at 95% confidence level, p = proportion of respondents who will give a positive response, q = proportion of respondents who will give an incorrect response, pq = estimate of variance of the population, that is, p = 0.5, q = 0.5 (pq = 0.25) that is (maximum possible proportion (0.5) × 1- maximum possible proportion (0.5) produces maximum possible sample size) and E = acceptable margin of error for proportion being estimated.

When E = 0.05, Equation 1 gives:

$$n_0 = \frac{(1.96)^2 \times (0.5) \times (0.5)}{(0.05)^2} = 384$$

The population size used for spice farmers at Muheza and Morogoro District Council was 2 880 and 430, respectively.

Substituting values (n_0) = 384 and N values for Muheza 2880 and Morogoro 430 in Equation 2 then the final sample size for each district was calculated.

Data collection methods

The study utilized a combination of primary and secondary data, incorporating both qualitative and quantitative elements. Primary data were gathered directly from selected households using household survey questionnaires. These questionnaires consisted of a mix of open-ended and closed-ended questions aimed at collecting demographic and socio-economic information, as well as details on existing livelihood activities and factors influencing the diversification of livelihood choices in the study areas. The administration of the questionnaires was carried out by researchers and trained enumerators.

In addition to primary data collection, secondary data were obtained from published and unpublished sources to complement

[1]Alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error (Cochran, 1977)

the findings gathered from the household surveys.

METHODS

To investigate the livelihood strategies of spice farmers and their determinants, the analysis was conducted in three stages. First, all major income-generating activities engaged in by households were identified, considering the significance of the income sources in shaping livelihood strategies. This involved calculating the percentage rates of engagement and income generation, income levels, and the percentage share of contribution to the total household income for each activity.

In the second stage, a cluster analysis was employed to classify all sampled households into distinct livelihood strategies based on their income-generating activities.

Finally, a multinomial logistic regression was conducted to assess the factors influencing the choices of livelihood strategies.

Data processing, descriptive statistics, and multinomial regression analysis were performed using Stata version 16 (Stata SE 16), while R programming language (R version 4.2.2) was utilized for the cluster analysis.

Cluster analysis

Cluster analysis is a method that categorizes data based on their similarities while minimizing differences within groups and maximizing differences between them (Cai et al., 2019). In practical applications, researchers often employ cluster analysis to classify households into livelihood strategies, aiming to group those with similar patterns and potentially shared strategies. Several recent studies have used cluster analysis to classify households into household livelihood strategies (Peng et al., 2017; Cai et al., 2019; Sun et al., 2019; Negash et al., 2023). However, selecting the right clustering method and determining the optimal number of clusters can be challenging. It is essential that the resulting clusters not only have good statistical properties but also make theoretical sense (Brock et al., 2008; Shi et al., 2020; Chowdhury et al., 2020).

Good statistical properties in cluster analysis are essential for creating meaningful and useful clusters (Brock et al., 2008). This involves ensuring that clusters exhibit characteristics such as compactness (that is, data points within a cluster are close to each other in terms of distance or similarity), separability (that is, different clusters are distinct with dissimilar data points), stability (that is clusters are robust and not overly sensitive to minor changes), homogeneity (that is, data points within a cluster share similar characteristics or patterns), and validity (that is, clusters accurately represent the data's underlying structure, as assessed by various validity indices). These properties collectively contribute to the creation of statistically sound and interpretable clusters, enhancing the utility of cluster analysis for data analysis and interpretation.

To address this challenge, researchers often perform multiple cluster analyses using different methods and cluster numbers and evaluate the results to find the best-fit clusters for the data. The best-fit clusters are obtained using "internal," "stability," and "theoretical" validation measures (Brock et al., 2008). Internal validation reflects the compactness, connectedness, and separation of the cluster partitions, and the most common measures include the Dunn Index and Silhouette Width (Brock et al., 2008). Stability validation evaluates the consistency of clustering, and the most common measures include the average proportion of non-overlap (APN), the average distance (AD), the average distance between means (ADM), and the figure of merit (FOM).

For this purpose, Brock et al. (2008) developed the R package clValid, which streamlines this process by allowing users to explore various clustering algorithms - which use the distance in order to separate observations into different groups, validation measures, and cluster numbers in a single step. This tool helps identify the most suitable method and cluster number for the dataset according to the criteria mentioned above. This study used this approach, and it was determined that the k-means method with five clusters was the best fit for this data based on "internal," "stability," and "theoretical" validation.

The household livelihood strategies were identified by clustering households based on the share of household income generated by different livelihood activities. The variables used in the cluster analysis include the share of spice income, share of non-spice crops income, share of livestock income, share of income from businesses (self-employed such as shops, bars, food vending, etc.), and share of income from casual labor. Thus, a total of six variables were used in the analysis. Two variables (income from employment and remittances) were not included due to small proportions.

Considering the importance of subsistence farming among farmers in Sub-Saharan Africa in general and Tanzania in particular, the share of food from own production was included to account for dependence on the source of food for household consumption. Due to the skewedness of the distributions, all the variables were categorized into five groups: 0, 1-25, 26-50, 51-75, and 76-100%. The cluster analysis process can be summarized into five steps as follows (the cluster search process dived the process in):

1) Initially, data were divided into *k* categories (*k* = 5) as the initial cluster centers.
2) Distances (Euclidean distance) between data points and cluster centers were calculated.
3) Data points were assigned to categories based on their proximity to the nearest cluster center.
4) New cluster centers were determined by calculating the average of data points within each newly formed cluster.
5) The algorithm continued until the cluster centers converged and all data points are classified (Cai et al., 2019).

The identified household livelihood strategies from this step were then used in the subsequent analysis.

A multinomial logistic regression (MNLR)

A multinomial logistic regression (MNLR) was then used to assess the determinants of household livelihood strategies. The MNLR regression models household livelihood strategy choice under the maximum utility framework, which assumes that farmers choose a certain livelihood strategy to maximize households' benefits given the households capability assets and enabling environment. Given the determinants variables, a MNLR estimates the probabilities of households on choosing a strategy, given the alternatives. The probability of households to choose a specific livelihood strategy was given as:

$$\text{Prob}(S_i = j) = \frac{e^{x_i^j \beta_{ij}}}{1 + \sum_{k=0}^{m} e^{x_i^j \beta_{ij}}} \quad (3)$$

$j = 0,1,2,\ldots,m; i = 1,2,3,\ldots,N$ and $\beta_0 = 0$

where $\text{Prob}(S_i = j)$ is the probability of household *i* to choose a livelihood strategy *j* out of m strategies, x_i^j if a vector of factors that influence selection of household livelihood strategy and β_{ij} are the

Table 1. Variables used in MNL regression as derived from the sustainable livelihood framework.

Components	Contents	Indicators
Respondents	Demographic characteristics	Age, gender, marital status of the household head
Livelihood capitals of households	Human capital	Household size, education level of the household head
	Natural capital	Total land owned
	Physical capital	Fixed assets ownership (Machineries)
	Social capital	Interaction with NGOs, Group membership
	Financial capital	Group membership
External influence	Institutions/Policies	Access to extensions services
	Vulnerability context	Location, distance to district center, altitude

Table 2. Livelihood activities practiced by spice farmers.

Activity	Participation		Income generation		Income values (TZS)		
	N	%	N	%	Mean	SD	% share
Spices	530	100	530	100	1.778.882	2.628.464	57
Non spice crops	496	94	414	78	451.264	763.139	14
Major food crops	487	92	374	71	365.516	547.352	10
Other non-spice crops	300	57	196	37	255.716	703.810	3
Livestock production	445	84	149	28	358.446	529.239	4
poultry production	419	79	92	17	122.864	145.140	1
Other livestock	161	30	73	14	576.781	655.404	3
Off-farm activities	316	60	316	60	1.498.603	2.431.706	25
Self employed	195	37	195	37	1.911.509	2.834.658	16
Casual labor	92	17	92	17	571.517	620.790	6
Remittance	37	7	37	7	251.914	157.703	2
Employment	18	3	18	3	2.181.333	1.469.599	2
Total					3.292.099	4.307.986	

1USD = 2,537.84484TZS (12 February, 2024).
Source: Author (2024).

corresponding parameters to be estimated from the model.

To estimate the model, 13 independent variables were selected to reflect five aspects of factors that influence household livelihood strategies bases on the sustainable livelihood framework as presented in Table 1. These factors not only influence income generation, but also relate to the local social, institutional, and ecological contexts in which household livelihood decisions are embedded.

RESULTS AND DISCUSSION

Household livelihood activities

Four main activities with sub-categories were identified among spice farmers (Table 2). Income from spices averaged about TZS 1,778,000 (equivalent to approximately USD 710, as of November 2023), contributing roughly 57% to the total income. This contribution exceeded that of other livelihood options for the average household in the sample. Ngolle (2021) similarly found that spices were the primary contributors to household income among spice farmers in the Uluguru Mountains, underscoring the significance of spice production for farmers' economic development and livelihood in the study area.

The second most practiced activity was non-spice crop cultivation, engaged in by 94% of participants, followed by livestock production (84%) and off-farm activities (60%). However, in terms of contribution to total income, off-farm activities emerged as the second most important, contributing approximately 25% of income for the average household, followed by non-spice crops (14%) and livestock keeping (4%). These results indicate that while farmers do cultivate non-spices and keep livestock, they heavily rely on off-farm activities as an alternative or complement to spice production. This finding aligns with

Anang et al. (2020), who observed the increasing prominence of off-farm work among farm households as an income diversification strategy.

Push factors such as climate variability, land productivity, lack of sustainable markets, and a shortage of value addition skills may limit spice farmers' ability to derive income from non-spice crops, thus explaining its lower contribution to total household income. This observation is consistent with Mwanamwenge and Cook (2019), who argued that diversification positively impacts income and creates more resilient communities. Conversely, the availability of opportunities within the community may drive farmers to opt for off-farm activities such as business or working on plantations if they realize greater benefits compared to producing non-spice crops. Additionally, farmers may engage in livestock keeping and non-spice crop farming for personal consumption or traditional purposes.

Household livelihood strategy classification

The cluster analysis identified five types of mutually exclusive household livelihood strategies as indicated in Table 2. These five strategies are categorized as: “Fully-spice dependent” (25% of the sample), “Business (self-employed) dependent” (14%), “Spice and non-spice crops dependent” (29%), “Spice and business dependent” (12%), and “Diversified (Spices, Non-Spice crops, Casual labor and livestock-dependent” (20%)).

Fully-spice dependent

These households rely entirely on spice production for their livelihoods, with an average of about 86% of household income derived from spices. Their annual income per capita is approximately TZS 696,800 or about USD 278 (November 2023). These households primarily rely on purchasing food for household consumption, as only an average of 24% of their food comes from their own production. They are specialized in spice production and stand to benefit significantly from improvements in productivity or market availability for spices. However, these households are highly vulnerable to any fluctuations in climate or spice markets. For example, any shocks affecting spice yields or decreases in spice prices would significantly impact their livelihoods compared to other livelihood strategies. This vulnerability is also highlighted in a study by Daniel (2020), which suggested that the economic impact of climate change and price fluctuations on spice producers is negative. Additionally, changes in food prices would have similar effects due to their heavy dependence on purchasing food.

Business dependent

These households primarily rely on self -employed small business activities, such as shops, bars, food vending, and artisan craft making. On average, about 70% of their household income comes from these activities, compared to about 17% from spices. Despite relying less on spices compared to other strategies, approximately 56% of their food comes from their own production, indicating an emphasis on food crop production for security purposes. This group earns the second-highest annual income per capita, averaging about TZS 864,800 (approximately SD 345, November 2023).

Spice and non-spice crop dependent

These households rely entirely on crop production, encompassing both spices and non-spices, as their primary source of livelihood. On average, about 79% of their income comes from spices, 12% from non-spice crops, and they derive 69% of their food from their own production, the highest proportion among all strategies. The annual income per capita for this group is approximately TZS 774,700 (approximately USD 309, November 2023). This strategy may be chosen due to favorable climate, soil fertility, ample land availability, and other productivity factors such as altitude and landscape slope. While dependence on crops can benefit these households with improvements in crop productivity and favorable market conditions, they are highly vulnerable to climate variability or price shocks, as noted by Daniel (2020).

Spice and business dependent

These households mainly depend on spice production and self-employed business activities. On average, approximately 45% of household income comes from spice production and about 43% from self-employment, while roughly 56% of their food comes from their own production. This group earns the highest annual income per capita, amounting to about TZS 1,288,500 (approximately USD 514 as of November 2023), which is almost 49% higher than the Business-dependent group.

Diversified

This strategy demonstrates the most diversified approach compared to the others. The study found that, on average, about 29% of income in this group comes from non-spice crops, 27% from spices, 18% from waged casual labor, and 11% from livestock, with more than half (53%) of food sourced from their own production. These households receive the minimum annual income per capita, approximately TZS 534,900 (USD 213 as of November 2023). Despite receiving the lowest income per capita, they exhibit greater resilience to shocks compared to other strategies, as they can sustain their

Table 3. Household livelihood strategies of spice farmers (relative percentage share).

Variable	Strategy 1 N=130 (25%) Fully spices dependent (SD, %)	Strategy 2 N=74 (14%) Business dependent (BD, %)	Strategy 3 N=156 (29%) Spices and Non spice crops dependent (SNSD, %)	Strategy 4 N=65 (12%) Spices and Business dependent (SBD, %)	Strategy 5 N=105 (20%) Diversified-non-business (D, %)
Share Spice income	**83**	17	**79**	45	**27**
Share of Non-spice crops income	8	9	**12**	8	**29**
Share of Livestock income	2	3	3	2	**11**
Share of Businesses income	2	**70**	2	**43**	3
Share of Casual labor income	2	1	3	1	**18**
Source of food=Own production	26	56	**69**	44	53
Annual income per capita					
Mean	696.783	864.778	774.744	1.288.520	534.857
Standard deviation	968.754	1.019.708	1.667.730	2.201.560	659.100

% are relative percentage share to total income of the livelihood strategy category Bold and underlined numbers highlight higher reative contribution to total income.
Own source (2024).

livelihoods through income from four different sources.

Factors influencing the livelihood choices among spice farmers

The multinomial regression results are presented in Tables 3 and 4. Table 3 displays the coefficients of the regression, with strategy 1 (Fully spice dependent) serving as the base category, while Table 4 presents the percentage change in odds when comparing all strategies for significant variables. To maintain brevity, only the results from Table 4, which delineates the factors influencing strategy choices, are discussed.

Significant determinants of strategy choices include total land owned, age, gender, marital status, and education of the household head, as well as the number of working-age members, district of residence, interaction with extension services, altitude, distance to the district capital, and ownership of durable assets.

Total land owned

Total land owned, representing the farmers' natural capital, significantly determines the household livelihood strategy. Holding other variables constant, a one-acre increase was associated with a 16.6% increase in the odds of being fully spice-dependent (strategy 1) compared to business-dependent households. Similarly, a one-acre increase was associated with a 29% increase in the odds of being fully spice-dependent (strategy 1) compared to diversified households (strategy 5). This indicates that households fully dependent on spices tend to have access to more land compared to those dependent on businesses or employing diversified strategies. A similar trend is observed when comparing spice-dependent households to non-spice-dependent households versus those dependent on businesses or employing diversified strategies.

Moreover, a one-acre increase increases the odds of choosing strategy 4 (spice and business dependent) by 23% and 36%, respectively, compared to households dependent solely on businesses or employing diversified strategies. These results suggest that land plays a significant role in integrating spices into household strategies. Households dependent on businesses or diversification may opt for these strategies due to limited land available for incorporating spices as a source of income. These findings align with those of Negash et al. (2023), who found that land ownership is a significant factor influencing households' livelihood options.

Age of household head

The age of the household head reflects the quality

Table 4. Multinomial logistic regression results, on factors influencing livelihood choices among spice farmers with base category = strategy 1 (Fully spice dependents.

Variable	Business ependent (BD)	Spices and non spice crops dependent (SNSD	Spices and business dependent (SBD)	Diversified-non-business
	2	3	4	5
Total land	-0.154** (0.063)	0.020 (0.048)	0.054 (0.063)	-0.256*** (0.072)
Age of the HH	-0.025** (0.012)	0.010 (0.009)	-0.018 (0.012)	0.005 (0.010)
Gender of the HH	-0.857 (0.690)	-0.851 (0.623)	-1.376** (0.697)	-1.029 (0.647)
Married	-0.321 (0.561)	0.228 (0.501)	0.739 (0.597)	0.080 (0.561)
Education=Primary	0.385 (0.557)	0.864** (0.399)	1.658** (0.789)	0.452 (0.395)
Education= Secondary	0.543 (0.783)	0.993 (0.619)	2.041** (0.926)	0.520 (0.648)
District= Morogoro	-1.304* (0.775)	-2.709*** (0.698)	-1.398* (0.839)	-0.384 (0.701)
Working Age	0.207** (0.100)	0.070 (0.077)	-0.079 (0.109)	0.053 (0.091)
Extension yes	1.001*** (0.354)	0.365 (0.303)	0.782** (0.351)	0.394 (0.334)
Group membership	-0.252 (0.604)	-0.239 (0.415)	-0.021 (0.473)	-0.325 (0.451)
NGO interaction	2.307** (0.956)	1.382 (0.979)	0.377 (1.264)	1.706* (0.918)
Altitude	-0.002** (0.001)	-0.001* (0.001)	-0.001 (0.001)	-0.001 (0.001)
Distance	0.002 (0.027)	0.082*** (0.022)	0.030 (0.027)	-0.010 (0.024)
Durable assets (cars, motorcycle and machinery)	0.199 (0.416)	-0.497 (0.349)	-0.067 (0.436)	0.294 (0.373)
Constant	2.533* (1.320)	-1.807* (1.055)	-1.116 (1.380)	1.858* (1.115)
Observations	520	520	520	520
Pseudo R-squared	0.0868	0.0868	0.0868	0.0868

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Own source (2024).

of human capital and plays a vital role in shaping livelihood choices, with older households being less likely to engage in business-related strategies. For instance, a one-year increase in household age decreases the odds of pursuing a business-dependent strategy by 2.5, 3.5, and 3% compared to the "fully spice-dependent", "spices and non-spices", and "diversification" strategies, respectively. Similarly, a one-year increase in household age decreases the odds of pursuing a "spice and business-dependent" strategy by 2.8 and 2.3% compared to the "spices and non-spices" and "diversification" strategies, respectively.

It is plausible that older households may prefer more stable or traditional agricultural livelihoods, such as crop cultivation, casual labor, or livestock dependence, rather than engaging in business-related activities, while younger respondents may prefer the opposite.

This conclusion aligns with Abebe et al. (2021), who also state that livestock ownership has a significant influence on livelihood diversification. Table 5 shows the percentage change in the odds of selecting strategies due to unit change in dependent variables.

Education of household head

Education level exhibits strong associations with livelihood strategies between spice and non-spice dependent versus "fully spice dependent" and between "spice and business" versus "fully spice dependents". A family whose head has primary education, compared to no formal education, increases the odds of pursuing a "spice and non-spice" strategy by 137% over "fully spice dependent". This suggests that education plays a crucial role in choosing strategies that expedite household food security. This result is consistent

Table 5. Percentage change in the odds of selecting a strategies due to unit change in dependent variables P<0.10.

Variable	b	z	P>|z|	%	%StdX
Total land owned (Acres)					
Strategy1 vs Staregy 2	0.154	2.447	0.014	16.622	50.519
Strategy 1 vs Strategy 5	0.256	3.581	0.000	29.195	97.621
Strategy 3 vs Strategy 2	0.174	2.884	0.004	19.002	58.824
Strategy 3 vs Strategy 5	0.276	3.970	0.000	31.830	108.525
Strategy 4 vs Strategy 2	0.208	2.937	0.003	23.076	73.698
Strategy 4 vs Strategy 5	0.310	3.858	0.000	36.344	128.053
Age of the HH (years)					
Strategy 1 vs Strategy 2	0.025	2.011	0.044	2.514	44.484
Strategy 3 vs Strategy 2	0.035	2.848	0.004	3.538	67.400
Strategy 3 vs Strategy 4	0.028	2.354	0.019	2.794	50.449
Strategy 5 vs Strategy 2	0.030	2.513	0.012	3.064	56.399
Strategy 5 vs Strategy 4	0.023	1.874	0.061	2.324	40.561
Sex of the HH=Male					
Strategy 1 vs Strategy 4	1.376	1.973	0.049	295.806	50.075
Married (1=Yes)					
Strategy 4 vs Strategy 2	1.061	1.669	0.095	188.910	42.731
Education=Primary education					
Strategy 3 vs Strategy 1	0.864	2.164	0.030	137.317	42.206
Strategy 4 vs Strategy 1	1.658	2.103	0.035	425.139	96.543
Education=Secondary and above					
Strategy 4 vs Strategy 1	2.041	2.205	0.027	669.956	80.652
District==Morogoro rural					
Strategy 1 vs Strategy 2	1.304	1.683	0.092	268.283	86.915
Strategy 1 vs Strategy 3	2.709	3.884	0.000	1401.635	266.855
Strategy 1 vs Strategy 4	1.398	1.668	0.095	304.859	95.602
Strategy 2 vs Strategy 3	1.405	1.666	0.096	307.740	96.269
Strategy 5 vs Strategy 3	2.325	2.918	0.004	922.464	205.078
Number of working age					
Strategy 2 vs Strategy 1	0.207	2.076	0.038	23.019	40.392
Strategy 2 vs Strategy 4	0.286	2.371	0.018	33.105	59.731
Extension interaction					
Strategy 2 vs Strategy 1	1.001	2.826	0.005	172.013	60.202
Strategy 2 vs Strategy 3	0.636	1.984	0.047	88.811	34.894
Strategy 2 vs Strategy 5	0.606	1.776	0.076	83.354	33.044
Strategy 4 vs Strategy 1	0.782	2.229	0.026	118.525	44.506
Interact with research/NGO					
Strategy 2 vs Strategy 1	2.307	2.413	0.016	904.654	59.181
Strategy 2 vs Strategy 4	1.930	1.722	0.085	588.817	47.525
Strategy 5 vs Strategy 1	1.706	1.858	0.063	450.418	41.006
Altitude (m)					
Strategy 1 vs Strategy 2	0.002	2.258	0.024	0.179	54.608

Table 5. Contd.

Strategy 1 vs Strategy 3	0.001	1.716	0.086	0.113	31.513
Distance to district capital					
Strategy 3 vs Strategy 1	0.082	3.682	0.000	8.501	202.251
Strategy 3 vs Strategy 2	0.080	2.884	0.004	8.321	195.520
Strategy 3 vs Strategy 4	0.051	1.811	0.070	5.252	100.150
Strategy 3 vs Strategy 5	0.092	3.641	0.000	9.644	248.364
Dura**ble assets (cars, motor cycles and machinery)**					
Strategy 2 vs Strategy 3	0.696	1.706	0.088	100.557	30.889
Strategy 5 vs Strategy 3	0.792	2.164	0.030	120.696	35.823

b = Raw regression coefficients, z = z-score for test of b=0, % = percent change in odds selecting a stratergy for unit increase in independent variable, %StdX = percent change in odds for SD increase in independent variable. Strategy 1=Spice dependent; Strategy 2=Business dependent; Strategy 3=Spice and non-spice dependent; Strategy 4=Spice and business dependent; Strategy 5=Diversified.
Source: Author (2024).

with the findings of Gebissa and Geremew (2022), who found that the general education of the household head was among the drivers of the choice of livelihood strategies concerning the food insecurity of households.

On the other hand, education is associated with pursuing a "Spice and business" strategy over "Fully spice dependent". For instance, having a secondary education or above, as opposed to no formal education, increases the odds of pursuing "Spice and business" by 667% compared to "Fully spice dependents". These results suggest that higher education levels foster entrepreneurial inclinations, leading to an increased likelihood of venturing into business-related livelihoods in the study area rather than solely depending on spices.

Gender and marital status of the household head

Gender of the household head has a significant effect only on choosing between "Fully spice dependent" versus "Spice and business". A male-headed household, compared to a female-headed one, increases the odds of choosing "Fully spice dependent" by 295% over the "Spice and business" strategy. This suggests that female-headed households are more likely to integrate business with spice compared to male-headed households.

On the other hand, married farmers are more likely to pursue spice and business compared to unmarried ones, who are more likely to pursue a pure business strategy.

Number of working age members in the household

The number of household members aged between 15 to 60 years plays a role in the choice of pursuing a "business-dependent" strategy versus fully spices and spices and business. The number of household members in the working age range can act as a pull factor, indicating the availability of labor, which facilitates households in engaging in business activities, as opposed to those who depend solely on spices. We observe no significant association between working age and other strategies.

Location district, altitude and distance to district capital

Location plays a significant role in the choices of household livelihood strategies. Households in Uluguru (Morogoro), compared to those in East Usambara (Muheza), are more likely to pursue a "Fully spice-dependent" strategy over "Business-dependent," "Spice and non-spice," and "Spice and business-dependent" strategies. For instance, being in Morogoro increases the odds of pursuing a "Fully spice-dependent" strategy by 267, 140, and 302% in reference to "Business-dependent," "Spice and non-spice," and "Spice and business" strategies, respectively. This suggests that households in Morogoro are more exclusively dependent on spice and are less diversified compared to households in Muheza.

The higher dependence of households in Morogoro on spice farming can be attributed to several factors. First, Morogoro's geographical conditions, such as its climate, soil quality, and topography, since Uluruguru have higher altitude compared to Usambara. Second, a longstanding tradition and accumulated expertise in spice farming in Morogoro could have played a pivotal role in this specialization. Furthermore, better market access and higher demand for spices in the region have likely encouraged farmers to focus on spice production to meet market requirements. This concentration on spice farming may also stem from a perception of reduced risk associated with spices compared to diversifying into other businesses or non-spice crops. Resource constraints,

such as limited access to land, capital, or labor, could also influence households in Morogoro to specialize in spice farming, as it may require fewer resources than other livelihood strategies. Lastly, government policies or agricultural support programs in Morogoro might be more geared towards spice cultivation, offering incentives or assistance to spice farmers, which could further encourage this specialization. Consequently, these multifaceted factors collectively contribute to the heightened dependence on spice farming in Morogoro compared to Muheza.

Similarly, altitude increases the odds of depending solely on spices compared to "Business-dependents" and "Spices and non-spice" strategies. As altitude increases by 1 m, the odds of depending solely on spices increase by 0.18% compared to business dependence, while the odds increase by 0.11% compared to "Spices and non-spices" dependence. Households situated at higher altitudes may be compelled to rely primarily on spice farming for several reasons. First, the suitability of the terrain for traditional cereal crops or other non-spice agricultural activities may diminish with increasing altitude due to factors like cooler temperatures, shorter growing seasons, and less fertile soils.

As a result, spice cultivation, which can thrive in these conditions, becomes a more viable option for generating income and ensuring food security. Consequently, the increasing odds of households depending solely on spices with higher altitudes can be attributed to the limited agricultural alternatives available in these challenging environments.

The proximity to the district capital significantly influences the adoption of a "spice and non-spices" strategy compared to other approaches. This could be attributed to the fact that households located closer to the capital are compelled to prioritize the cultivation of non-spice crops, particularly for food security purposes. Limited opportunities for alternative activities may also contribute to this trend. Furthermore, areas located at such distances may enjoy favorable climatic conditions for the cultivation of various non-spice crops, including food crops.

Extension and research/NGO interaction

Access to extension services and NGOs interaction are found to be positively associated with business-related strategies compared to other strategies. This finding is somewhat contradictory to theory, as one might expect extension services to promote more agricultural-related activities, thereby contributing to household income. Several hypotheses could explain this finding. First, extension services may be more effective in promoting entrepreneurial skills than agricultural-related services. Additionally, extension services may be biased toward individuals engaged in business activities who may be wealthier and/or have higher status among farmers, or this group may be more eager to learn and therefore seek interaction with extensions or NGOs. These hypotheses warrant further investigation to better understand the dynamics at play.

Durable assets ownerships

Finally, the presence of durable assets, such as cars, motorbikes, and machinery, is associated with "Business-dependent" and "Diversification" strategies compared to the "Spices and non-spices" strategy. There is no significant influence of this variable on other strategy choices. Household ownership of durable assets (e.g., cars, motorcycles, and machinery) increases the odds of pursuing business or diversification by 100 and 120%, respectively, over pursuing a "Spices and non-spices" dependent strategy. This is reasonable, as relatively wealthier households may be in a better position to facilitate business activities or have the ability to engage in a wider range of diversified activities.

CONCLUSION AND RECOMMENDATION

The study has revealed that spice farming households in the study area can be classified into five distinct livelihood strategies, shedding light on their disparities in income generation processes. Among these strategies, households integrating spice cultivation with entrepreneurial endeavors outperform others in terms of per capita income, closely followed by those primarily engaged in business. In contrast, fully spice-dependent and diversified households exhibit the lowest annual income, revealing potential areas for improvement. The significance of off-farm, self-employed activities in contributing to household income, compared to waged off-farm labor, is a noteworthy finding. Promoting entrepreneurship among spice farmers and encouraging business diversification alongside spice cultivation can be instrumental in enhancing their income and overall welfare. Another key insight is that the majority of spice farmers heavily rely on one or two income sources, leaving them vulnerable to market and climate shocks, as well as policy changes. Diversified households, while earning lower incomes, demonstrate greater resilience in the face of such challenges. Therefore, policymakers should prioritize market stability and the productivity of both spice and non-spice crops, while also promoting income diversification, particularly through entrepreneurship, to boost household income and resilience among spice farmers. Conclusively, these categories analyzed are not static; individuals may transition from one category to another over time. As time progresses, diversification is expected to become increasingly popular.

This anticipation stems from the likelihood that the older generation, traditionally involved in these activities, will no longer be actively participating. Consequently, the younger generation is expected to take over, and their interests lean towards exploring various pursuits beyond spice cultivation. Thus, the trend toward diversification is likely to grow.

Additionally, while current data highlights the financial benefits of spice and business-dependent livelihoods, younger generations may have different aspirations. As rural areas modernize, attracting younger individuals to spice farming may require a balance between traditional practices and innovative approaches. Encouraging the adoption of improved seeds and contemporary farming techniques to enhance spice yields can make spice farming more appealing to young and aspiring farmers, ensuring the sector's sustainability. Emphasizing the importance of creating value-added products from spices, such as processing and packaging, can open new market opportunities and elevate the profitability of spice farming.

LIMITATION OF THE STUDY

This study has its limitations, primarily stemming from the reliance on cross-sectional data analysis at the farmer level. A more comprehensive understanding of the dynamics within the spice farming communities would have been enriched by incorporating data from a broader spectrum, including community-level, institutional, and ecological factors. Such data would offer insights into the long-term trends and influences that shape spice farming practices and livelihood strategies over time. Moreover, a longitudinal approach that tracks changes and developments within the spice farming sector could provide a more in-depth perspective on the evolving challenges and opportunities faced by farmers. Future research endeavors in this area should consider a multi-dimensional approach, encompassing various data sources and longitudinal analyses to capture the holistic dynamics of spice farming and its sustainability in the long run.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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