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Perceptions of smallholder farmers on nature-based income generating activities as potential livelihood and biodiversity conservation strategies in Uluguru Mountains, Tanzania

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Nature-based Income Generating Activities (NIGAs) can enhance livelihoods of smallholder farmers and biodiversity conservation in highly degrading ecosystems. These practices are promoted by various development and conservation partners worldwide to combat land degradation and biodiversity loss. However, their adoption remains low for reasons not well understood by their promoters. This can largely be attributed to the failure of the promoters to recognise and acknowledge the perceptions and priorities of target communities. We use the case of Uluguru Mountains to investigate the perceptions of farmers regarding the NIGAs that have potential to enhance both livelihoods and biodiversity conservation. Specifically, we use the Kendall's Coefficient of Concordance (*W*)/Kendall's tau, the Spearman correlation/Spearman's (rho), and the Likert scale methods to identify the highly ranked NIGAs and test the hypotheses that: (a) the smallholder farmers in the study area did not agree among themselves about the ranking of potential livelihood and biodiversity-enhancing NIGAs, (b) the promotion of agroforestry has reduced the communities' reliance on firewood, building poles and wood from the Uluguru Forest Reserve (UFR). We used the latter as an indicator of improved biodiversity conservation. We found that agroforestry and beekeeping were the highly ranked NIGAs and the communities in the study area had moderately reduced their reliance on timber products from UFR. We conclude that NIGAs can significantly enhance livelihoods and conserve biodiversity in mountain areas. However, future efforts to promote them should be guided by a thorough understanding and recognition of the real needs and priorities of target beneficiaries. This is imperative for winning their support and for designing the right outreach package.

Key words: Uluguru Mountains, Uluguru Forestry Reserve, Kendall's coefficient of concordance, Likert scale analysis, nature-based income generating activities.

INTRODUCTION

Globally, the management of natural ecosystems while simultaneously enhancing livelihoods of rural communities who rely on these ecosystems is increasingly viewed as an important pathway to sustainable development (Sunderlin and Huynh, 2005; Tole, 2010; Surkin, 2011; Sutherland et al., 2014; Chevallier, 2016). Using the case of community-based approach in Southern Africa, for example, Chevallier (2016) provides a historical overview of natural resource management by examining to what extent this approach has been successful in achieving the objective of enhancing rural livelihoods through benefit sharing, income generation, as well as, biodiversity conservation and sustainable resource use. Chevallier (2016) concluded that the development of innovative income generating activities from natural resources is critical for fostering economic growth and sustainable natural resource management. She recommends a new thinking that includes integrated landscape-level natural resource management and the use of ecosystem service accounting to justify land-use choices about conservation. In their paper, Sutherland et al. (2014) identified several topics of special focus, including unsustainable cultivation practices that may increasingly affect conservation of biodiversity. Similarly, the publication by Surkin (2011) indicates that natural resource governance improvement can lead to positive impacts for livelihoods and biodiversity conservation. Tole (2010) identified the key institutional and incentives that appear to significantly affect the success or failure of rural forestry management initiatives as including, among others, the consideration of institutional and socio-economic factors along with personal characteristis of key stakeholders, such as, perceptions, attitudes, and availability of financial resources. It is important to note that, farmers' decisions to adopt 'new' practices depend on many complex factors. One such factor is their perception of characteristics of the practices (Negatu and Parikh, 1999; Bagheri et al., 2008; Emmanuel, 2014) and the successful promotion of these practices is likely to be more influenced by farmers' preception and attitudes than any other factors (Smathers, 1982). Therefore, a thorough understanding of these factors and their impact on livelihoods and biodiversity conservation provides valuable information to promoters of these practices (Bhatia and Buckley, 1998; Ruheza et al., 2012; Ayubu, 2017; Thompson et al., 2019). We attribute the current low rate of NIGA adoption to the lack of this understanding, though this would vary from one farmer to another due to different interactive factors (Moges and Taye, 2017). In fact, farmers' perception is generally renowned as the best predictor of the adoption of Good Agricultural Practicers (GAPs) (Alonge and Martin, 1995; Rogers, 2003).

The literature provides some useful case studies to illustrate this. Musinguzi et al. (2018), for example, provide the case of a community-based initiative that used a cooperative-driven organic certification of honey producers in Mwingi, Eastern Kenya to achieve the goal of improving livelihoods and acacia woodland management in the study area. This initiative performed poorly because of the failure to take into consideration the issue of long-term project sustainability as perceived by the project farmers. According to Musinguzi et al. (2018), this initiative registered minimal to no significant impacts of certification on household's incomes, honey quantity, and sales prices. Just as important, many governments, development partners and researchers have designed and launched programmes and initiatives that aim to effectively balance conservation goals and livelihood needs but the outcomes have been disappointing (Bhatia and Buckley, 1998; Sunderlin and Huynh, 2005; Ruheza et al., 2012; Ayubu, 2017), for reasons not very well known by their proponents. Most of these previous initiatives have focused on the implementation of sustainable income generating activities that concurently promote livelihoods and nature conservation. We dub these activities as NIGAs. These have the potential to create opportunities for communities to productively use locally available resources to generate income without endangering biodiversity (Coche, 1991; FAO, 2000).

As for many other mountain areas in the tropics, the Uluguru Mountains in Tanzania have also attracted several NIGA initiatives (Bhatia and Buckley, 1998). Examples of these initiatives include the Uluguru Mountains Agricultural Development Project (UMADEP), Uluguru Mountains Biodiversity Conservation Project (UMBCP), and the Uluguru Mountains Payment for Watershed Services Project (UMPWSP), just to mention few. UMADEP was initiated in 1993 as a research and extension project based in the Department of Agricultural Education and Extension, Faculty of Agriculture of Sokoine University of Agriculture (SUA). It was a community-based research and extension project which worked in partnership with government extension officers and farmers using the multidisciplinary approach. UMBCP was implemented starting from 1999 to 2002 under financial support from DANIDA through the Danish Ornithological Foundation (DOF) of Denmark in partnership with the Wildlife Conservation Society of Tanzania (WCST). UMPWSP was funded by the Department for International Development Civil Society Challenge and supported by the Royal Society for the

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Protection of Birds (RSPB) in partnership with the Wildlife Conservation Society of Tanzania (WCST).

Most of the introduced NIGAs in Uluguru Mountains aimed at increasing productivity per area, hence reducing pressure on forest resources, while at the same time increasing farmers' income (Malisa et al., 2016; TFCG, 2017). Examples of these NIGAs include beekeeping, aquaculture, tree planting, agroforestry (intercropping of trees and/or shrubs with crops), contour farming, natural fallow, soil and stone bunds, terraces, use of composite manure and crop rotation, just to mention few. If adopted, the benefits of these NIGAs can be enormous. Agroforestry and beekeeping, for example, can provide outputs for home consumption as well as for sale to earn income and thus enhance food security and livelihoods of smallholder farmers. NIGAs can significantly improve income and capacity of smallholders to conserve ecosystems, especially in mountain areas where land degradation is renowned as a major cause of biodiversity loss. The complex nature and interrelated relationships between humans and ecologies in these areas needs a systematic and simultaneous understanding, especially with regard to sustainability, constraints for adoption of NIGAs, and scaling-up them to better guide agricultural strategy and policy interventions (Jha et al., 2020). This implies understanding of local settings through the eyes and perceptions of the farmers themselves, who are the primary actors in the uptake process of agricultural technologies (Baccar et al., 2020). This understanding is currently lacking. The previous studies in mountain areas have focused mainly on other aspects, such as, the institutional, policy and livelihood studies (Hartley and Kaare, 2001), and the contribution of GAPs to socioeconomic and nutritional status (Mhina, 2015). The studies which assess the perceptions of local communities regarding the role of NIGAs are limited. This study was therefore an endeavour to fill this knowledge gap and inform policies and strategies to achieve sustainable livelihoods and biodiversity conservation in mountain areas.

METHODOLOGY

Theoretical frameworks

The study is based on the expected utility maximization theory which suggests that an individual farmer *i* will perceive a specific NIGA as a potential livelihood and biodiversity enhancing strategy if the expected utility from implementing it, U_{ij}^* is greater than the expected utility from any other alternative activities or projects, U_{ij}, that is $y_{ij}^* = U_{ij}^* - U_{ij} > 0$; where y_{ij}^*, is the net benefit (latent variable) that the farmer can receive from practising the *j*th NIGA. This utility will in turn have an influence on the farmer's attitudinal behaviour. In this regard, perception is considered to relate to famer's own view or interpretation of utility. Perception (attitude) and behaviour are viewed to be mutually influencing each other (Reibstein et al., 1980).

Having the utility theory in mind, we assessed the perception of farmers on the role of introduced NIGAs in the study area as livelihoods and biodiversity strategies using the approach described by Legendre (2010) which requires the computation of Kendall's coefficient of concordance (*W*). In the context of NIGAs, perceiption is defined as an understanding of the characteristics of these activities specified to include relative advantages, compatibility, complexity, trialability, and observability (Oo and Usami, 2020). These characteristics are considered to play a crucial role in farmers' decision making on adopting a new farming practice (ibid).

Kendall's *W* ranges from 0 (that is, no overall trend of agreement among the respondents) to 1 (perfect or complete agreement, that is, all the judges or survey respondents have been unanimous). Intermediate values of *W* indicate a greater or lesser degree of unanimity among the various judges or respondents.

Specifically, the Kendall's *W* statistic was calculated using the IBM SPSS software (versions 20 and 26). The first step entailed the calculation of sum-of-squares (*S*) over the low sums of rank (R_i), and the mean of R_i values ($\bar{R}$) as in Equation 1.

$$S = \sum_{i=1}^{n}(R_i - \bar{R})^2 \; or S' = \sum_{i=1}^{n} R_i^2 = SSR. \tag{1}$$

The second step was the computation of Kendall's *W* statistic using the formula shown in Equation 2.

$$W = \frac{12S}{m^2(n^3 - n) - mT} \tag{2}$$

where *n* represents the number of objects; *m* is the number of variables and *T* is a correction factor for tied ranks which was calculated as shown in Equation 3.

$$T == \sum_{k=1}^{g} (t_k^3 - t_k) \tag{3}$$

where t_k is the number of tied ranks in each (*k*) of *g* groups of ties. The sum was computed from the overall groups of ties found in all *m* variables of the data worksheet. *T* equalled zero when there were no tied values. Kendall's *W* is used as an estimate of the variance of the row sums of ranks R_i divided by the maximum possible value the variance can take; this occurs when all variables are in total agreement. Hence, 0 ≤ *W*≤ 1 whereas (1 represents perfect concordance). Friedman's Chi-square statistic (Equation 4) was used to test the significance of Kendall's *W*.

$$\chi^2 = m(n-1)W \tag{4}$$

The overall aim of the analysis was to identify variables that agree in the estimation of the common property of the objects in terms of preferences, profitability and acceptability of NIGAs by farmers. The Spearman correlation among all judges from Kendall's *W* using the formula presented in Equation 5 was calculated:

$$\bar{R}_s = \frac{kW - 1}{k - 1} \tag{5}$$

where $\overline{R}_S$ denotes the average Spearman correlation and k the number of judges or rankers. The Spearman's rank coefficient can be denoted by r_S and symbolically presented as in Equation 6.

$$r_S = \frac{1-\left(\partial\sum d_i^2\right)}{\left(n\left(n^2-1\right)\right)} \quad (6)$$

where d_i represents the difference in the ranks given to the values of the variable for each item of the particular data. This formula is applied in cases when there are no tied ranks. However, in case of fewer numbers of tied ranks, this approximation of Spearman's rank correlation coefficient provides sufficiently good approximations. If there are no repeated data values, a perfect Spearman correlation of +1 or -1 occurs when each of the variables is a perfect monotone function of the other. Intuitively, the Spearman correlation between two variables will be high when observations have a similar (or identical for a correlation of 1) rank (that is, relative position label of the observations within the variable: 1st, 2nd, 3rd, etc.) between the two variables, and low when observations have a dissimilar (or fully opposed for a correlation of -1) rank between the two variables. Spearman's and Kendall's *W* can be formulated as special cases of a more general correlation coefficient.

The analysis of farmers' perceptions of the role of NIGAs in biodiversity conservation was complemented by the application of some forms of standard scaling techniques. These techniques are broadly debated in the literature with the mainstream of the debate subscribing to the summative construction of Likert scale (Likert, 1932) dubbed by Krosnick et al. (2018) and Cooper et al. (2015) as the "Likert's method of summated ratings." The method uses a standard scaling procedure or method that attributes numerical values to responses (Pollard et al., 2007) and requires that the scoring, scaling, and the response format for items are consistent. For example, if a Likert scaling technique is used then all items will confirm to a Likertr scale (e.g. 5 points with "disagree" and "agree" response stems) as well as the use an additive scoring method (Krosnick et al., 2018).

However, the "Likert's method of summated ratings" is also criticized for the problem of inconsistency between the scoring method (additive) and the scaling method (Pollard and Johnston, 2001; Pollard et al., 2007), as well as the lack of a simple scale of reference to assure consistency across disciplines (Perscaroli et al., 2020). Instead, a method for selecting items which is broad enough to sample the full range and not restricted to just one source or domain (Pollard et al., 2007) and a simple-to-use rating tool that can be used for benchmarking responses in questionnaires (Pescaroli et al., 2020) are recommended, especially where the target groups, for cultural, social, or political reasons may be improper for in-depth analyses (e.g. scales of up to 7 or 10). The output of the tool is a replicable scale from 0 to 3 presented in a tabular form that includes category labels with qualitative attributes and descriptive equivalents which are used in the formulation of model answers (Pescaroli et al., 2020). The advantage of the Likert scale based response model is that it can be applied in a wide variety of disciplines (ibid).

The "Likert's method of summated ratings" is also criticized for misrepresenting and losing information due to the closed-form scaling and the ordinal nature of this measure (Goeb et al., 2007; Li, 2013). According to Goeb et al. (2007), perception or attitude data are often evaluated with techniques designed for cardinal measurements, despite the problem of attitude which suggests an ordinal interpretation of Likert scales. To overcome these problems, Goeb et al. (2007) present the interpretation of scales for perception or attitude measuring and suggest data analysis techniques under the proper ordinal understanding. Likewise, Li (2013) proposes a novel fuzzy Likert scale which was developed based on the fuzzy sets theory. According to Li (2013), the main strength of the fuzzy Likert approach is that it allows partial agreement of a scale point enabling the capture of lost information and regulation of distorted information. The fuzzy sets theory offers scholars with a better "language that is half-verbal-conceptual and half-mathematical-analytical" (Ragin, 2000). It allows the conversion of a discrete ordinal variable into a continuous variable while maintaining the sematic meaning and capturing the interval details of ordinal variables in an open response format (*ibid*). This is advantageous because it helps to moderate the problem of information misinterpretation and attenuation in the conventional "Likert's method of summated ratings."

In Myanmar, Oo and Usami (2020) applied the characteristics defining the concept of perception (that is, relative advantages, compatibility, complexity, trialability, and observability) to measure farmers' perception of GAPs in rice production. They included different statements for measuring these characteristics. Specifically, they used a Likert-scale five-point continum starting from 1 (strongly disagree) to 5 (strongly agree) and categorised respondents into two groups using a cut-off point of 4 (that is "did not perceive" if the score was less than 4 and "perceived" if the score was equal to or greater than 4). They then calculated the Cronbach's alpha to examine the reliability of data collected on farmers' perception of GAPs in rice production. They found that the different components of GPAs in rice production were perceived as relatively difficult to apply by farmers.

Although it is considered a good index for stability, the Cronbach's alpha has some disadvantages: it is affected by duration (time) and dimensionality of adoption (Al-Osail et al., 2015). As the time increases, reliability will increase (Streiner, 2003; Tavakol and Dennick, 2011). Therefore, the index measures stability but not the internal consistency (which decscribes the extent to which all the items in a test measure the same concept or constructs). Hence, the Cronbach's alpha is not sufficient for measuring reliability (Agbo, 2014; Al-Osail et al., 2015). Adding other indices of internal consistency such as the Kendall's coefficient of concordance (Kendall and Babington, 1939), Spearman's rank correlation and R^2 coefficient is recommended because it gives more accurate and reliable results (ibid). As non-parametric methods, the Kendall's *W* and Spearman's rank-order are generally suggested for non-normal data.

The Kendall's coefficient of concordance and Spearman's rank correlation coefficient are non-parametric statistics. The Kendall's coefficient of concordance is a normalisation of the statistic of the Friedman test (Legendre, 2005; Voshaar et al., 2021). It has a close relationship with the Milton Friedman's two-way analysis of variance without replication by ranks (Kraemer, 1976; Legendre, 2005). They both address hypotheses concerning the same data table and they use the same χ^2 statistic for testing. The Spearman's rank correlation coefficient assesses how well the relationship between variables can be described using a monotonic function. It is important to note that the Spearman correlation between two variables is actually equal to the Pearson correlation between the rank values of those two variables. The Pearson's correlation assesses linear relationships, but the Spearman correlation assesses monotonic relationships (whether linear or not). It should be noted here that in most situations, the interpretations of the variant of Kendall's *W* (that is, the Kendall's tau) and Spearman's rank correlation coefficient are very similar and thus, invariably lead to the same inferences. However, the former is more preferable to the Spearman's rank correlation coefficient and Pearson's correlation for a number of reasons. Firstly, it is insensitive to errors and its *p*-values are more accurate with small sample sizes whereas, the Spearman's correlation is much more sensitive to error and discrepancies in data and it has usually larger values than the Kendall's *W* (Chok, 2010). Secondly, the distribution of Kendall's tau has generally better statistical properties (Kraemer, 1976; Legendre, 2005). Thirdly, the interpretation of Kendall's tau results, in terms of the probabilities of observing the agreeable (concordant) and non-agreeable (discordant) pairs is very direct (LeDonne et al., 2011). It is worth noting here the difference between the Kendall's *W* and Kendall's tau. The former is calculated for more than two variables, while the latter (Kendall's tau) is calculated for two variables as any other correlation coefficient.

The Pearson correlation is the most frequently used coefficient for normal distributed data but it has a disadvantage of being sensitive to outliers (Abdullah, 1990; Balakrishnan and Lai, 2009). The Kendall's *W* is even less sensitive to outliers and is often preferred due to its simplicity and ease of interpretation (ibid). Originally, the Kendall's correlation coefficient was proposed to be tested with the exact permutation test (Kendall, 1938). This non-parametric approach can help to compare the ability of the correlation coefficients to reflect a given monotone association, aside from the possible differences caused by discrepancies in the statistical testing procedures.

As compared with Spearman's and Kendall's correlation, the Pearson's correlation approach escalates the possibility of outliers, and results in increasingly poorer performance of the correlation (Chok, 2010). This is more evident for large sample sizes where the probability of obtaining datasets with the outliers is higher. Thus, if the data contains outliers, the Kendall's *W* and Spearman's rank-order correlation coefficient are considered more appropriate (Chok, 2010). The Pearson correlation coefficient is appropriate only for interval data while the Spearman's and Kendall's correlation coefficients could be used for either ordinal or interval data (McKillup, 2005). The available literature also suggests the Spearman's correlation to be more appropriate for data that involves several types of variables (Hubert, 2009; Armstrong, 2019). For data that have at least one ordinal variable, the Kendall's *W* is more appropriate (Hubert, 2009). Other scholars (Schober et al., 2018), suggest Spearman's correlation coefficients for the same scenarios. The Pearson correlation is a natural parameter of association for a bivariate normal distribution (it assumes zero value if and only if the two variables are independent). Thus, a statistical test based on the Pearson's correlation coefficient is likely to be the most powerful for this type of data than similar tests on the other correlation coefficients (Armstrong, 2019). However, for non-normal data, the sensitivity of the Pearson correlation coefficient has led to recommendations of other correlation coefficients (ibid). The standard procedure for testing significance of the estimates for the Pearson's correlation coefficient is sensitive to the deviations of bivariate normality (Chok, 2010). Due to the proximity of Spearman's to Pearson's correlation coefficient in bivariate normal data, and the appropriateness of Spearman's statistical test for any type of interval data the Spearman's correlation coefficient is more preferable than the Pearson's correlation and Cronbach's alpha (McKillup, 2005; Chok, 2010).

In the present study, the Likert-scale analysis, Kendall's coefficient of concordance, *W*, and the Spearman correlation were used to assess agreement among respondents (judges or rankers) regarding their perceptions of the importance of NIGAs in Uluguru Mountains. The analysis was complemented by the use of Spearman's rho and Kendall's tau statistics to test the null hypothesis that the NIGAs adopted by smallholder farmers in the study area are interrelated or associated. The focus of this study is on mountain areas which makes the study more imperative recognising that mountain ecosystems are generally fragile and very sensitive to anthropogenic changes and indirect alterations in the environment (Houet et al., 2010; Wang et al., 2018; Mengist et al., 2020). Just as important, the occurrence of climate change and anthropogenic factors alter the potential for provision of mountain ecosystem services and goods which calls for a special attention to achieve sustainable land management and utilisation in these areas (Chaudhary et al., 2017; Mengist et al., 2020).

The conceptual framework for the study

As indicated in the conceptual framework (Figure 1), farmer's decision to adopt NIGAs is influenced by both internal and external factors, coupled with the farmer's perception of expected outcomes as conceptualized by the expected utility maximization theory. The internal factors include the personal as well as farming and economic characteristics. Farmers' perceptions of NIGAs are associated with farmers' characteristics, such as the age of the farmer, gender, marital status, education, size of household and farming experience (Bagheri et al., 2008; Benmeke and Ajayi, 2008; Pinthukas, 2015; Abdul-Gafar et al., 2016; Sasima et al., 2016; Mugula and Mkuna, 2016). Farming characteristics, such as size farmland area, farmland location (if located far or close to homestead), and availability of active labour have a positive influence on farmers' perception (Meseret 2014; Pongvinyoo et al., 2014; Sasima et al., 2016; Maswadi and Suharyani, 2018). Famer's perception of NIGAs is therefore influenced by many factors, including the household's economic characteristics, such as, access to credits and the value of assets owned by the farmer (Ndambiri et al., 2013). In Colombia, for example, the adoption decision of agroforestry practices was influenced by the access and use of credit and location, among others (Jara-Rojas et al., 2020).

The external factors influencing farmers' perception of NIGAs include the existing transforming structures and processes, such as, the public and private institutions supporting and promoting the adoption of NIGAs, laws, policies, culture, access to extension services, access to information, and training (Abdul-Gafar et al., 2016; Arslan et al., 2020). The expected outcomes are then mirrored from the actual outcomes which includes increased income, improved food security, improved wellbeing, reduced vulnerability, reduced land degradation and enhanced ecosystem resilience, as well as improved biodiversity conservation and more sustainable use of natural resource base.

The literature on the influence of both internal and external factors on the perception and adoption of NIGAs and GAPs by smallholder farmers is enormous. For example, in the Oyo State of Nigeria, Banmeke and Ajayi (2008) assessed farmers' perception of the agricultural information resource centre at Ago-Are as a source of information for improving agricultural productivity. They found a significant relationship between the type of information sought and respondents' perception of the resource centre and they recommended organizing frequent training for farmers. Their recommendation accentuates the role of transforming structures and processes in influencing perception and adoption of NIGAs to enhance livelihoods and biodiversity conservation. They furthermore view this as providing a basis for discussing targeted agricultural and policy interventions in the sub Saharan Africa (SSA) region, including the mountain areas. Elsewhere, in Haraz catchment area of Mazandaran province in Iran, Bagheri et al. (2008) investigated the perception of paddy farmers towards sustainable agricultural technologies. They found that education level of household head (personal household characteristics), contact with agricultural experts and extension participation (transforming structures and processes) were the best predictors of farmers' perceptions.

Arslan et al. (2020) who present a synthesis of micro-economic

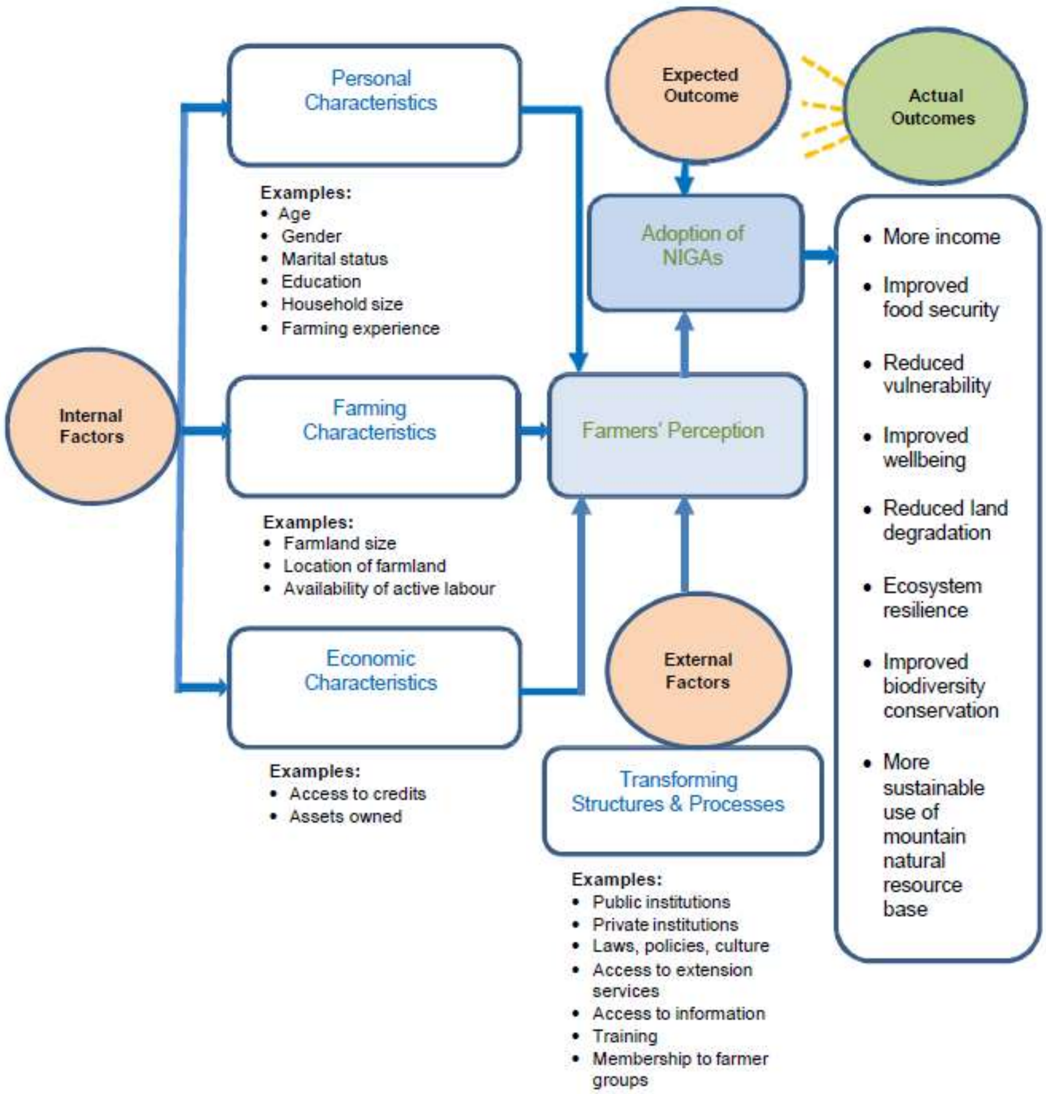

Figure 1. Conceptual framework for the study.

literature on the analysis of drivers of agricultural technology adoption in Africa using a meta-data set built from the results of different recently published papers identify eleven determinants that were positively influencing the perception and adoption of technology in the continent. Four of these were related to transforming structures and processes (access to extension, access to information, farmer group participation, and access to credit); five related to economic characteristics (land size, livestock assets, off-farm income, overall income and wealth index); one was the exposure to high temperatures (a location specific factor); and the final one was secured land tenure (a mixture of farm characteristics, transforming structures and processes).

The study area

The study was conducted in Uluguru Mountains covering fourteen hamlets (Table 1) in the wards of Mlimani and Luhungo (Morogoro Municipality), and Mzumbe (Mvomero district) in Morogoro, Tanzania. The mountains run approximately north-south with altitudes of up to 2,630 m above sea level at their highest point (EAMCSEF website, undated) and their range contains a nature reserve which constitutes the Uluguru North, Uluguru Soutn and Bunduki Forest Reserves. About fifty villages border the Uruguru Forestry Reserve with population of over 151,000 found within the mountain area (ibid). The vegetation of the area is extremely variable (Figure 2) ranging from drier lowland coastal forest to transitional rainforests, sub-montane, montane and upper montane forest types, as well as the afromontane grasslands on the Lukwangule plateau. All these ecosystems are rich in endemic species making them of high conservation priority. However, land degradation in the area is rampant due to existence of unsustainable anthropologic activities (Yanda and Munishi, 2007; William, 2010; Harrison and Mdee, 2017; Massawe et al., 2020).

Table 1. Location of the study sites.

Village/Hamlet	Ward	Division	District	Altitude (masl)	Position	
					Eastings	Northings
Tangeni/Kikoya	Mzumbe	Mlali	Mvomero	656	345874	9234196
Tangeni/Chalinze	Mzumbe	Mlali	Mvomero	860	347046	9233084
Tangeni/Simbo	Mzumbe	Mlali	Mvomero	737	346759	9232891
Tangeni/Mng'hongo	Mzumbe	Mlali	Mvomero	737	346466	9233799
Tangeni/Mihubulu	Mzumbe	Mlali	Mvomero	883	347563	9234125
Kilala	Luhungo	Morogoro	Morogoro	731	349501	9236858
Mundu	Luhungo	Morogoro	Morogoro	847	350263	9236314
Mambani	Luhungo	Morogoro	Morogoro	975	350490	9237492
Kivaza	Luhungo	Morogoro	Morogoro	722	348904	9236453
Mbete	Mlimani	Morogoro	Morogoro	808	353746	9241263
Ruvuma	Mlimani	Morogoro	Morogoro	1041	352694	9240058
Choma	Mlimani	Morogoro	Morogoro	1212	354139	9239703
Kisosa	Mlimani	Morogoro	Morogoro	1341	353599	9239560
Tulo	Mlimani	Morogoro	Morogoro	1192	352716	9239617

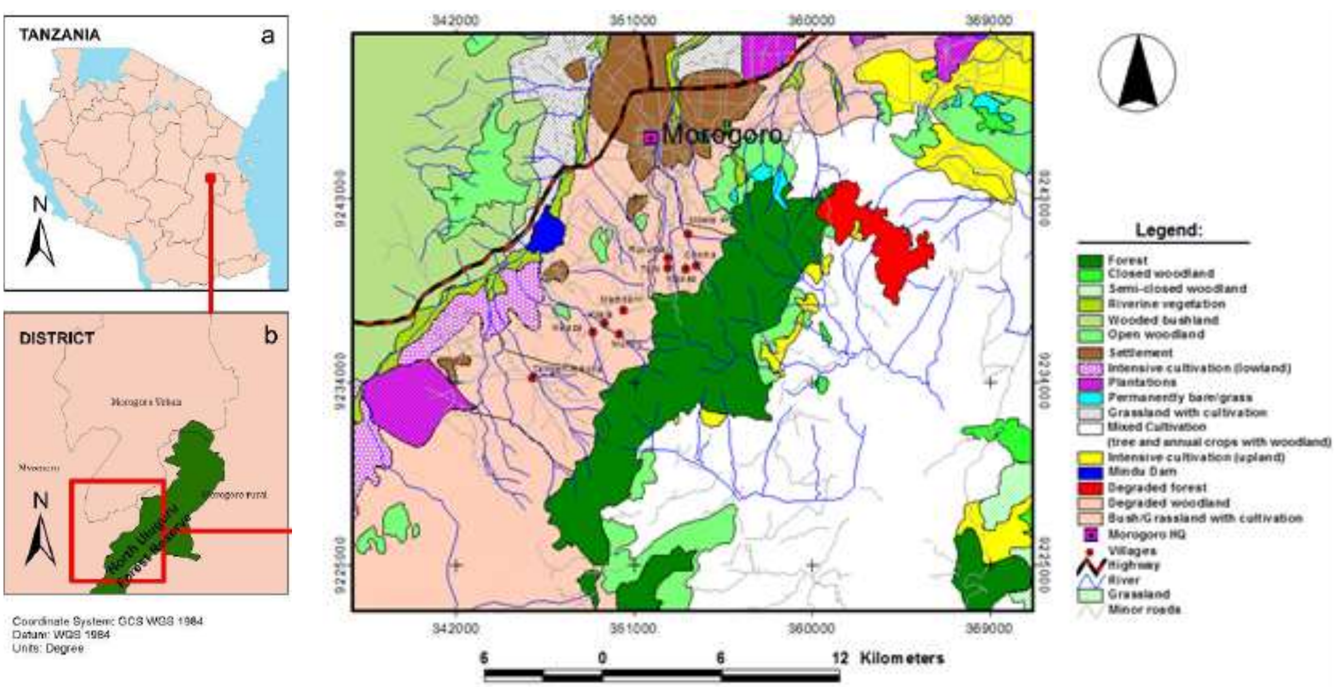

Figure 2. Map showing the location of the study area and major land uses.

The mountains also serve as a water catchment and water source for populations living downstream in Morogoro rural and Municipal districts as well as other residents in the Dar es Salaam City and the Ruvu/Wami River Catchments. Thus, the study area was purposefully selected based on, not only its importance as a water catchment, but also as a biodiversity hotspot encountered by the challenge of increasing human activities that threaten biodiversity and environmental integrity at large.

Sampling and data collection

The study used the multi-stage sampling procedure to select the study villages and sample households. In the first stage, fourteen hamlets were selected purposely based on their participation in the previous NIGA projects. In the second stage, households were stratified into strata according to the wealth ranks assigned by UMPWSP and more recent government initiatives in the study area

Table 2. Distribution of sample sizes by sample hamlets.

Hamlets	Households	Sample size*	%
Tangeni village (5 hamlets)	1,030	66	32.8
Kilala	85	12	6.0
Mundu	145	15	7.5
Mambani	152	21	10.4
Kivaza	167	21	10.4
Mbete	22	9	4.5
Ruvuma	72	15	7.5
Choma	210	21	10.4
Kisosa	84	12	6.0
Tulo	42	9	4.5
Total	2,009	201	100

*The total sample size used in the final analysis (after data cleaning and removal of outliers) was 154 households.

(WCST, 2010). The third stage entailed the selection of sample households from each stratum using the proportionate probability sampling procedure. The distribution of sample households by study sites is shown in Table 2.

The study used both primary and secondary data. Prior to commencement of fieldwork, the researchers hired six enumerators to assist them during data collection. These were trained on how to administer questionnaires and use other research tools, such as checklists and guidelines. They were also reminded about the research ethics they should comply with. The actual fieldwork started with a reconnaissance survey to get an overview and understanding of the study area and applicability of the questionnaire. During the reconnaissance survey the household questionnaire was pre-test to a small sample before the actual fieldwork to check for its relevance to the study area and objectives. This was followed by the main survey which used different research tools and techniques, including structured questionnaires, interviews with key informants (selected based on their involvement in NIGA initiatives) and Focus Group Discussions (FGDs).

The FGDs were attended by at least 10 participants per village representing different socioeconomic groups that existed in the area, including the rich, poor, youth and women, men, abled and disabled people. In addition, direct observation served as a complementary tool. In selecting the key informants for interview the snowball technique was used. The technique is particularly suitable when the population of interest is hard to reach and compiling a list of the population poses difficulties for the researcher (Etikan et al., 2016). It begins with a convenience number of initial subject which serves as “seeds,” through which wave 1 subject is identified; wave 1 subject, in turn, identifies wave 2 subjects; and the number of interviewees consequently expands wave by wave-like a snowball growing in size as it rolls down a hill (Heckathorn, 2015).

Data processing and analysis

the different NIGAs which were introduced in the study area were identified using the household questionnaire, FGDs, KIIs, direct observation approaches, review of government and project documents, as well as office records from relevant government and non-government organizations. During the questionnaire survey, the respondents were asked to rank the identified NIGAs according to their potential in enhancing livelihoods and biodiversity conservation. The rankings were coded as: lowest rank (1), low rank (2), moderately low rank (3), moderately high rank (4), high rank (5), and highest rank (6). The codes were then used in the computation of the Kendall’s coefficient of concordance, *W*. To identify the best NIGAs, the visualisation (percentage chart) and the Friedman test were used as appropriate analytical tools because the rankings involved mainly ordinal variables. The Friedman was used to test the null hypothesis that the respondents or farmers in the study area did not agree among themselves about NIGAs that are potential as livelihood and biodiversity conservation strategies [that is, the null hypothesis (H_0) that the Kendall’s *W* was less than 0.4] versus [the alternative hypothesis (H_1) that the Kendall’s *W* was not less than 0.4]. In this case, the coefficient (*W*) values of 0.4 and above were used to ascertain if the rankings of respondents agreed with each other. Additionally, we calculated the Spearman correlation among all judges or rankers from the Kendall’s *W* and complemented our analysis by employing the Spearman’s rho and Kendall’s tau statistics.

Specifically, we used the reduced household reliance on, and frequency of, using timber products from the Uluguru Forest Reserve (UFR) as a proxy for biodiversity conservation. We asked farmers to indicate the extent to which they agree or disagree with the assertion that agroforestry reduced dependence on and frequency of using firewood, building poles and timber products from UFR. In particular, we designed three Likert questions, one for each of these three forest products, to study the perception and attitude of respondents on the extent to which agroforestry has enhanced biodiversity conservation. During the coding, it was realised that none of the respondents reported to be neutral, we therefore recoded our five scale Likert data into the following four response alternatives: strongly disagree (1), Disagree (2), Agree (3), and strongly agree (4). It is important to note that the use of 4-point Likert alternatives is not new in the literature. Behnke and Kelly (2011) for example, used the 4-point Likert alternatives to investigate the influence of Latino parent involvement in the programmes to help Latino youth thrive at school. Elsewhere, Robinson and Shepard (2011) also used the same technique to investigate outreach, applied research, and management needs for the Wisconsin’s great lakes freshwater estuaries.

For comparison reason, we generated two scenarios for Likert analysis by treating the three questions as both Likert-type and Likert scale questions (Clason and Dormody, 1994; Boone and

Table 3. Likert grading criteria for reduced reliance on products from forest reserve and enhanced biodiversity conservation.

Grading	Criteria				
	Composite (sum)	**Mean**	**Median**	**Quartiles**	**Cumulative (%)**
Low or poor	≤7	≤2.6	1 and 2	1 and 2	≤60%
Moderate	7 - 10	2.6 - 3.6	3	3	60 - 80
High	≥10	≥3.6	3 and 4	3 and 4	≥50%

Source: Modified from Rubaish (2010).

Boone, 2012). The main idea was to find out if the results from the two scenarios were different or the same. The Likert-type items can be described as single questions which apply some facets of the novel Likert response alternatives but the researcher does not combine the responses from the item into a composite scale (Clason and Dormody, 1994).

In the second scenario we combined the responses from the three questions (the Likert scale questions) to create a perception or attitude measurement scale. According to Boone and Boone (2012), the Likert scale data are generated by computing a composite score (sum or mean) from the Likert-type items. The mean for central tendency and standard deviations for variability are the most recommended statistics. Since Likert scales produce ordinal data one may also use the Inter-Quartile Range (IQR) of each item (Garth, 2008). Alternative procedures would entail the use of Pearson's r, *t*-test, ANOVA and regression analysis (ibid). The arithmetic mean measures the distribution of agreement scores that are collected on an ordinal scale (Goeb et al., 2007; Rubaish, 2010). The median, the number found exactly in the middle of the distribution, is a measure of central tendency which shows what the "average" respondent might think, or the "likeliest" response whereas the IQR is a measure of spread which shows whether the responses are clustered together or scattered across the range of possible responses (Maheta and Patel NR/SPSS Inc., 1996; Garth, 2008).

However, the median, quartiles, and cumulative percentage measures are preferred to the mean when distributions are skewed Rubaish (2010). Therefore, the mean would not be an appropriate measure in cases where distributions are skewed; instead one would use cumulative percentage. The latter, cumulative percentage is preferred because it is a straightforward, easy to comprehend, and apply method (Rubaish, 2010). In our study, we used five grading criteria to interpret the results of analysis (Table 3), namely composite (sum and mean), media, quartiles, and cumulative percentages of scores 3 and 4 (that is, the sum of "agree" and "strongly agree" responses, respectively).

RESULTS AND DISCUSSION

Ranking of NIGAs and results of Kendall's *W* test

The summary of ranking of NIGAs according to their potential to enhance livelihoods and biodiversity conservation is as shown in Figure 3. The proportions of households that practiced NIGAs are shown in Table 4 for each NIGA. When the "highest" and "high" ranks are summed together, agroforestry was ranked as the most important NIGA in enhancing livelihoods and biodiversity conservation (with cumulative percentage of more than 60%), followed by beekeeping (50%), terraces (about 35%), and contour farming (about 30%).

As the recent study by Yamane and Ito (2020) indicates, the common agroforestry systems in the study area include the homegardens (where several crops are grown mainly for commercial purposes, including banana and an array of tree varieties, such as the jackfruit, mango, cinnamon, cardamom, breadfruit, coco palm and eucalyptus), and the hillside agroforestry systems (where food crops like maize and cassava, mixed with yams and common beans, dominate). Besides the direct use values of agroforestry products, such as firewood, building poles, fodder, fruits and timbers (Van Donge, 1992; Tiisekwa, 2002; Ruheza et al., 2012; Mkonda and He, 2017), agroforestry also provides several ecosystem services range from its contribution to control of soil erosion, conservation of soil fertility through nutrient recycling and enhancement of biodiversity conservation). Thus, it was important to understand the perceptions and attitudes of respondents in this study regarding the role of different NIGAs in enhancing livelihoods and biodiversity conservation and level of agreement in their perception and attitude.

The results of analysis of the Kendall's *W* test, Friedman test and the estimate of coefficient of concordance are presented in Table 5. The point estimate of the coefficient of concordance was 0.40 which was about the same value as the average over all possible Spearman correlation. This test statistic suggests that the farmers agreed with each others to a reasonable though not super high extent ($\chi^2(4)$ = 241.527, p = 0.000). In fact, the asymptotic p – value of 0.000 strongly suggests that the coefficient of concordance was not zero, meaning that there was some agreement among judges in terms of how they ranked the NIGAs. Accordingly, the null hypothesis that the Kendall's *W* was zero (that is, there was perfect disagreement among the judges or respondents) is rejected. However, the fact that the Kendall's *W* was not equal to 1 (that is, the judges/respondents did not perfectly agree amongst themselves) does not imply that they did not rank the NIGAs in the same order but each NIGA faired well at the

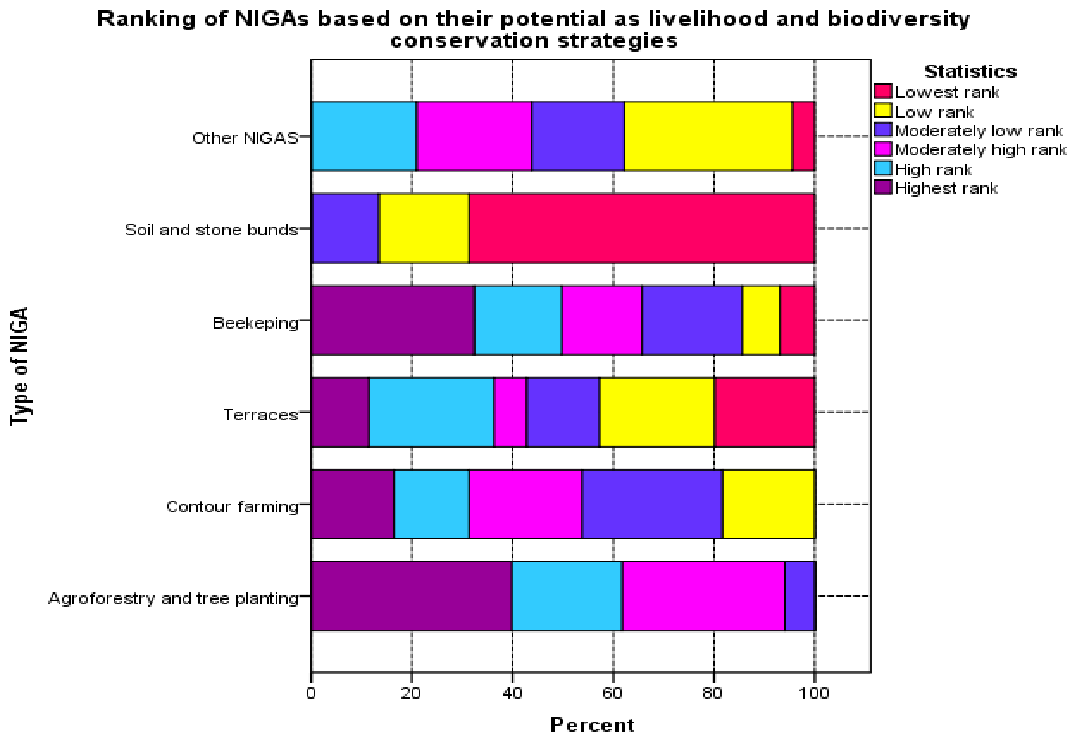

Figure 3. A bar chart showing the results of NIGA ranking based on their importance as livelihoods and biodiversity conservation strategies.

hands of some judges or rankers (respondents) and poorly at the hands of others (Meheta and Patel/SPSS Inc., 1996). Under perfect disagreement, each NIGA would fare the same overall and would thereby produce identical values for equal total rankings for all NIGAs, consequently, the Kendall's *W* would be equal to zero. It should also be noted that, the test-statistic, Chi-square (χ^2) is synonymous to variance over the mean ranks: it is zero when the mean ranks are exactly equal and becomes larger as they lie further apart. The asymptotic significance (our *p* – value) is less than 0.05 confirming that the rankings were statistically significantly different for all the five categories of NIGA. Agroforestry and terraces/contour farming were rated most favourably with mean ranks of 4.11 and 3.22, respectively, followed by soil/stone bunds and other NIGAs, such as natural fallow, use of composite manure, crop rotation, and others rarely adopted NIGAs combined together (both categories with a mean rank of 2.57). Unexpectedly, beekeeping in this case was ranked the fifth with a mean rank of 2.52.

The present results of Kendall's tau and Spearman rank correlations are presented in Table 6. We used these statistics to evaluate the extent to which the five categories of NIGAs were interrelated or associated. The data contained five NIGA categories (adoption of agroforestry, terraces/contour farming, beekeeping and other NIGAs) which were ordinal variables making it reasonable to use either of the two rank correlations. We used both test statistics and they yielded similar correlation coefficients.

The results of statistical tests using the Kendall's tau and Spearman's rho indicate that the *p* - values of correlations between the adoption of agroforestry/tree planting and soil/stone bunds were statistically significant ($r_s = 0.212$, $p = 0.009$). The adoption of agroforestry was also positively associated with adoption of beekeeping ($r_s = 0.189$, $p = 0.019$), and other NIGAs ($r_s = 0.212$, $p = 0.009$). The adoption of terraces and contour farming was positively interrelated with soil/stone bunds ($r_s = 0.273$, $p = 0.001$). The *p* - value of correlation between the adoption of soil/stone bunds and beekeeping was statistically significant ($r_s = 0.356$, $p = 0.000$). It was also statistically significant between the adoption of soil/stone bunds and other NIGAs ($r_s = 0.512$, $p = 0.000$). Consequently, we failed to reject the null hypothesis that the NIGAs adopted by smallholder farmers in the study area are interrelated.

These results are interesting and have important implication for policy making and promotion of NIGAs in mountain areas. From the test statistics presented in Table 6, it is reasonable to argue that the association between adoption of soil/stone bunds and other NIGAs

Table 4. Proportion of households who practised NIGAs by type of NIGA.

Type of NIGA/response	Frequency	%	Cumulative (%)
Agroforestry			
No = 0	43	27.9	27.9
Yes = 1	111	72.1	100.0
Total	154	100.0	
Terraces/contour farming			
No = 0	98	63.6	63.6
Yes = 1	56	36.4	100.0
Total	154	100.0	
Soil/Stone bunds			
No = 0	138	89.6	89.6
Yes = 1	16	10.4	100.0
Total	154	100.0	
Beekeeping			
No = 0	141	91.6	91.6
Yes = 1	13	8.4	100.0
Total	154	100.0	
Other NIGAs*			
No = 0	138	89.6	89.6
Yes = 1	16	10.4	100.0
Total	154	100.0	

*Other NIGAs include the remainder of NIGAs which were rarely practised by farmers in the study area, such as natural fallow, the use of composite manure, and crop rotation.

(such as natural fallow, use of composite manure, and crop rotation) was the strongest amongst all associations. This implies that farmers who adopt soil/stone bunds in mountain areas are also more likely to invest in other NIGAs. More interesting is the finding that farmers who adopted agroforestry were also willing to invest in soil and stone bunds, beekeeping and other NIGAs. We therefore affirm that, if well informed by the perception of target farmers, appropriately packaged and supported by transforming structures and processes, NIGAs have the potential to enhance livelihoods and biodiversity conservation in mountain areas. Similar arguments are given by Rajendran et al. (2016) who underscore the need for provision of adequate farmer training by non-governmental organizations and rural institutions to complement change agents, such as, public extension officers.

Perceptions of farmers about the role of agroforestry in biodiversity conservation

The results of analysis of the respondents' perceptions about the potential of agroforestry as effective biodiversity conservation strategy using Likert-type and Likert scale data were compared. Figure 4, Tables 7 and 8 present the results of the analysis for the Likert-type data. The cumulative scores (sum of scores 3 and 4) for reduced reliance on firewood and building poles were 76 and 61%, respectively (Figure 4 and Table 7). The mean (average) scores were 3.1 and 2.6 for reduced reliance on firewood and building poles (Tables 7 and 8). These results suggest that communities in the study area have moderately reduced reliance on firewood and building poles from UFR. However, there was no evidence to statistically conclude that the communities have reduced reliance on wood products because the cumulative score and mean score for wood products were 44.2 and 2.2% respectively, which according to the grading criteria presented in Table 3, these scores fall under the "low" or "poor" category).

The analysis of Likert scale data resulted in conclusions similar to that of Likert-type data (Tables 9 and 10). The mean Likert scale score was 2.6 and the cumulative mean score was about 7.9 both supporting

Table 5. Results of Kendall's *W* test, Friedman test and average Spearman correlation.

Type of NIGA	Mean rank	Std. deviation	Test statistics
a) Kendall's *W* test			
Agroforestry	4.11	0.450	-
Terraces/contour farming	3.22	0.483	-
Soil/stone bunds	2.57	0.306	-
Beekeeping	2.52	0.279	-
Other NIGAS*	2.57	0.306	-
Kendall's W[a]	-	-	0.400
Chi-Square	-	-	241.527
Df	-	-	4
Asymp. Sig.	-	-	0
b) Friedman test			
Agroforestry	4.11	0.450	-
Terraces/contour farming	3.22	0.483	-
Soil/stone bunds	2.57	0.306	-
Beekeeping	2.52	0.279	-
Other NIGAS*	2.57	0.306	-
Chi-Square	-	-	241.527
Df	-	-	4
Asymp. Sig.	-	-	0
c) Average spearman correlation	-	-	0.405

*Other NIGAs included natural fallow, use of composite manure, crop rotation, and others which were rarely practiced by farmers. [a]Kendall's Coefficient of Concordance.

Table 6. Correlation coefficients (N = 154).

Parameter	Adoption of agroforestry	Adoption of terraces/contour farming	Adoption of soil/stone bunds	Adoption of beekeeping	Adoption of other NIGAs
Kendall's tau b					
Adoption of agroforestry	1.000	-0.101	0.212**	0.189*	0.212**
Adoption of terraces/contour farming	-0.101	1.000	0.273**	0.110	0.008
Adoption of soil/stone bunds	0.212**	0.273**	1.000	0.356**	0.512**
Adoption of beekeeping	0.189*	0.110	0.356**	1.000	0.356**
Adoption of other NIGAs	0.212**	0.008	0.512**	0.356**	1.000
Spearman's rho					
Adoption of agroforestry	1.000	-0.101	0.212**	0.189*	0.212**
Adoption of terraces/contour farming	-0.101	1.000	0.273**	0.110	0.008
Adoption of soil/stone bunds	0.212**	0.273**	1.000	0.356**	0.512**
Adoption of beekeeping	0.189*	0.110	0.356**	1.000	0.356**
Adoption of other NIGAs	0.212**	0.008	0.512**	0.356**	1.000

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

the assertion that communities in the study area moderately reduced their reliance on timber products from the reserve (firewood, building poles and wood considered together) and hence it is sensible to argue

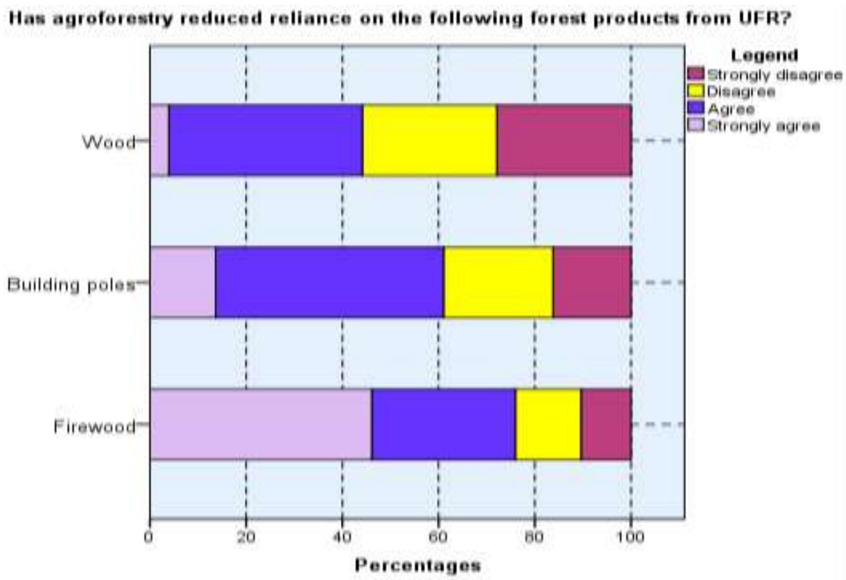

Figure 4. A bar chart summarizing the responses of three Likert-type questions.

Table 7. Summary results of Likert-type analysis for reduced reliance on products from forest reserve.

Responses by products	Frequency	%	Cumulative (%)
Firewood			
Strongly disagree (1)	16	10.4	10.4
Disagree (2)	21	13.6	24.0
Agree (3)	46	29.9	53.9
Strongly agree (4)	71	46.1	100.0
Total	154	100.0	
Cumulative scores 3 & 4			76.0
Minimum score			1
Maximum score			4
Average score			3.12
Building poles			
Strongly disagree (1)	25	16.2	16.2
Disagree (2)	35	22.7	39.0
Agree (3)	73	47.4	86.4
Strongly agree (4)	21	13.6	100.0
Total	154	100.0	
Cumulative scores 3 & 4			61.0
Minimum score			1
Maximum score			4
Average score			2.58
Wood			
Strongly disagree (1)	43	27.9	27.9
Disagree (2)	43	27.9	55.8
Agree (3)	62	40.3	96.1
Strongly agree (4)	6	3.9	100
Total	154	100	

Table 7. Cont'd

Cumulative scores 3 & 4	44.2
Minimum score	1
Maximum score	4
Average score	2.2

Table 8. Summary of results for median Likert-type analysis.

Score	Frequency	Percent	Cumulative %
1	21	13.6	13.6
2	39	25.3	39.0
3	69	44.8	83.8
4	25	16.2	100.0
Total	154	100.0	
Mean			2.6364
Median			3

that biodiversity conservation has reasonably improved in the study area. This implies that agroforestry has performed relatively better than the other NIGAs which were introduced by different programmes and initiatives in the study area.

Unfortunately the results were a bit different for beekeeping. Though it was ranked as the second important NIGA that has the potential to enhance livelihoods, beekeeping was practiced by very few farmers, only 8.4% of all farmers (Table 4). The low adoption of beekeeping was attributed to many factors, including the lack of suitable land at the proximity of farmer's homestead, inadequate access to extension services and lack of capital. Previous studies have also reported different reasons for the low rate of adoption (Vyamana, 2009; Mahonge, 2015). Taking a cultural perspective, Mahonge (2015), for example, attributed the low rate of beekeeping adoption in the study area to the persistence of a norm locally dubbed "*Kazopata*" which is considered to hinder cooperative agreements in the implementation of beekeeping projects. This draws some particular allurements since many programmes and initiatives that promoted beekeeping in the study area have mostly entailed the use of farmer groups as a framework for sharing knowledge, skills and capacity. Yet, farmer groups have mostly existed just notionally rather than materially due to the "*Kazopata*" norm (Mahonge, 2015). According to Mahonge, the norm expressed an inclination of some individuals in the communities to have a covetous character over someone else's ownership, accomplishments and rewards. To showcase this, Mahonge (2015) provides a few cases where farmer groups in the study area were given beehives expecting that the hives would be managed communally but the group members ended up dividing the beehives amongst themselves and practicing beekeeping on an independent basis.

Vyamana (2009) attributed the low rate of beekeeping adoption in Uluguru Mountains to high investment costs. He argued further that beekeeping in this area only benefited a very small number of elite village members who could afford initial investment costs. He added that, as part of the investment in beekeeping, the farmer was required to either make his/her own beehives or purchase beehives from commercial dealers. In essence, Vyamana (2009) viewed beekeeping projects as less inclusive, at least in the context of poor farmers in Uluguru Mountains, who could not only afford to invest in these projects but also to provide their labour for beekeeping and wait for several months before accruing benefits. The reason seems modest and coherent: poor farmers need immediate money to meet their immediate daily subsistence needs first before they consider partaking expensive projects.

Elsewhere within the EAMs, in Udzungwa Mountains, Katani and Ndelolia (2020) attributed the low rate of practicing beekeeping to lack of suitable equipment and inadequate extension services. They indicated that the costs of modern beekeeping equipment were too high to be afforded by smallholder farmers who would wish to practice beekeeping. Consequently, the beekeepers in Udzungwa Mountains opted to use traditional beehives which offered them relatively lower income than when they could use modern beehives. In fact, Katani and Ndelolia (2020) indicated furthermore that productivity could even double if the farmers were able to use modern beehives. In fact, the information we gathered during FGDs and KIIs conducted in the study area indicated

Table 9. Summary of results for mean Likert scale analysis.

Mean score	Frequency	Percent	Cumulative (%)
1.0	11	7.1	7.1
1.3	10	6.5	13.6
1.7	14	9.1	22.7
2.0	17	11	33.8
2.3	7	4.5	38.3
2.7	11	7.1	45.5
3.0	32	20.8	66.2
3.3	27	17.5	83.8
3.7	23	14.9	98.7
4.0	2	1.3	100
Total	154	100	-
Minimum score			1
Maximum score			4
Mean score			2.6342
Std. Dev			0.85793

Table 10. Summary of results for composite Likert scale analysis.

Total score	Frequency	%	Cumulative (%)
3	17	11	7.1
4	13	10	13.6
5	21	14	22.7
6	23	17	33.8
7	8	7	38.3
8	12	11	45.5
9	38	32	66.2
10	37	27	83.8
11	29	23	98.7
12	3	2	100
Total	154	100	-
Minimum cumulative score	-	-	3
Maximum cumulative score	-	-	12
Mean score	-	-	7.9026
Std. Dev.	-	-	2.5738

that, honey production using the traditional (locally made) beehives was as low as merely 5 litres per year, whereas that from a modern beehive would range from 15 to 20 litres per annum.

CONCLUSIONS AND POLICY IMPLICATIONS

This study was conducted in Uluguru Mountains, Tanzania to assess the perceptions of local communities about the role of different NIGAs as livelihood coping and biodiversity conservation strategies. Specifically, the Kendall's Coefficient of Concordance (*W*)/Kendall's tau, the Spearman correlation/Spearman's rho), and the Likert scale methods were used. Our Kendall's, *W* statistic suggested that to some extent, the respondents (judges or rankers) agreed with each other about the rankings of NIGAs though not at a super high extent. Based on this result, the null hypothesis that the respondents or farmers in the study area did not agree among themselves about the NIGAs that are potential as livelihood and biodiversity conservation strategies or the hypothesis that the Kendall's *W* was zero (that is, there was perfect disagreement among the judges or respondents) was rejected in favour of the alternative hypothesis. Based on the Spearman’s rho and Kendall’s tau statistics, we also failed to reject the null hypothesis that the NIGAs adopted by smallholder farmers in the study area were interrelated.

The extent to which the adoption of agroforestry helped to reduce the reliance of communities in the study sites and frequency of using timber products from UFR were also examined. Literally, we assumed that the adoption of agroforestry would help reducing the demand of woody products from the reserve. We therefore used this as an indicator of improved biodiversity conservation and evaluated it using the Likert-type and Likert scale data. The analysis in both cases yielded similar results suggesting that the communities in the study area moderately reduced their reliance on timber products from the UFR. The hypothesis of improved biodiversity conservation was therefore accepted.

Overall, the study findings suggest an important policy implication regarding the necessity for policy makers and development partners to understand the real needs and priorities of target communities prior to the implementation of projects and initiatives that aim at enhancing the livelihood and biodiversity conservation. This is imperative not only for winning the support of beneficiaries but also for designing the right outreach package, out-scaling and diffusion strategies. Therefore, it was concluded that the understanding of specific attitudes and perceptions of target farmers is a prerequisite for developing the relevant transforming structures and processes to promote NIGAs.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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