Research Journal of Agriculture and Environmental Management. Vol. 5(3), pp. 065-074, April, 2016
Available online at http://www.apexjournal.org
ISSN 2315 - 8719© 2016 Apex Journal International

Full Length Research

Factors influencing spatial and temporal trends in Lushoto's agro biodiversity

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Accepted 21 March, 2016; Published 29 April, 2016

Agro biodiversity is a fundamental feature of biodiversity that helps to sustain the processes that support food security. This paper explores trends and various factors that influence variations in agrobiodiversity in Lushoto District, Tanzania. Four villages namely Boheloi, Mbuzii, Yamba and Migambo were purposively selected from different altitudes. Both primary and secondary data collection methods comprising of household interviews, literature reviews, field observations and Participatory Rural Appraisals (PRAs) were applied in this study. Five percent of farming households in each village was sampled randomly for household interviews. The data obtained were analyzed using both descriptive statistics and multinomial logit model. Findings from this study indicate that over the past 30 years, indigenous agrobiodiversity in Lushoto District is gradually decreasing as most of the landraces have been replaced with modern crop varieties. This appears to have been principally influenced by both personal and socio-economic characteristics of the respondents. Notable among such characteristics are education, off-farm income and marital status. The signals of climate change that were mentioned in the area were unpredictable rainfall patterns, recurrent droughts and increasing temperatures which had been so much evident during the last 30 years. As an adaptation strategy to the changing climate, farmers are choosing crop varieties that are well-suited to the prevailing conditions. This practice had thus resulted in the loss of some indigenous key crop varies such as the local maize, beans, Irish and sweet potatoes varieties. Thus there is a need for concerted efforts to ensure the effective management of agrobiodiversity in the area. This could help the farmers better adapt to climate change and safeguard indigenous species.

Key words: Agrobiodiversity, trends, Lushoto, Tanzania, Logit model.

INTRODUCTION

Agrobiodiversity includes the variety of species, genetic resources and the various ways in which farmers can exploit biological diversity to produce food and manage ecosystems (Frison et al., 2011). This phenomenon constitutes the foundations of more resilient farm systems essential to cope with both the predicted and observed impacts of climate change (Frison *et al.,* 2011). Several factors influence spatial and temporal trends in agrobiodiversity in various parts of the world. However, the effects of these factors may vary from region to region, farm to farm and even from one farmer to another (Singh, 2012). Furthermore, some of these factors may be more dominating in certain areas. For instance, in Lushoto district in Tanzania, climate change related factors led to the introduction of agroforestry management practices in the past decade leading to significant variations in agrobiodiversity in the area (Lyamchai et al., 2011). Farmers also enhance agrobiodiversity through intercropping, crop rotation, multiple sowing dates and adjustment of ecosystem management practices to increase resilience to climate change (Tengo and Belfrage, 2004). This makes agrobiodiversity an important coping strategy against climate change, especially in most rural communities (Kotschi, 2008).

Loss of agrobiodiversity does not only affect fuel, fiber and food production, but also a range of ecosystem

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services, habitats for wild species and human health (Jackson et al., 2005). Moreover, declines in agrobiodiversity have caused significant economic losses, threatening food productivity and security leading to broader social costs (Thrupp, 2000). This has driven environmentalists, governments and Non-Governmental Organizations (NGOs) to assess ways of promoting biodiversity conservation (Munzara, 2012). The benefits derived from adopting agrobiodiversity include increased resilience to climate change, attainment of food security, livelihood enhancement as well as regulation and support of ecosystem services. In fact, biodiversity including agrobiodiversity constitutes about 11% of world Gross Domestic Product (GDP) thus agrobiodiversity loss generates quite high economic costs (USAID, 2004). Most climate change-based research have focused on impacts and adaptation in arid and semi-arid areas (Armah et al, 2012; Lyimo and Kangalawe, 2010; Mary and Majule, 2009). In spite of evidence that Lushoto district is a humid region with a rich diversity of agricultural produce at varying altitudes (Das and Laub, 2005), not much is known about trends in agrobiodiversity and factors influencing spatial and temporal trends in agrobiodiversity in the area.

We selected Lushoto district as our case study area because it is within the humid agro-ecological zones that are nearly neglected in most climate change studies but which we think are important areas that can contribute in providing a detailed information on the climate impacts scenarios. Furthermore, Aggarwal et al (2010) noted that studies on strategies adopted by farming households contribute to better policy choices especially when factors influencing these strategies are identified. It is therefore imperative to gain insight on spatial and temporal variations in agrobiodiversity and the factors driving these variations this time from the humid agroecological zone thus to contribute to the existing efforts on adaptation to climate change worldwide. The primary objective of this study was to determine the spatial and temporal variations of agrobiodiversity and the factors influencing the observed variations. Specifically we intended to identify spatial and temporal variations of agrobiodiversity in Lushoto for the past 30 years and examine the major driving forces of the observed variations in agrobiodiversity in the area.

METHODOLOGY

Description of study area

The study was conducted from February to April, 2015 in four villages within Lushoto district, Tanzania. Lushoto district is situated in the northern part of Tanga Region, Tanzania (Figure 1).

The study villages were selected villages largely considering their altitudinal differences (Table 1) and their participation in agrobiodiversity activities. The study villages were: Boheloi, Mbuzii, Yamba and Migambo.

The District covers an area of 3,500 km^2 and accounts for about 12.8% of Tanga Region (National Bureau of Statistics, 2013). The Western Usambara Mountains dominate the landscape of Lushoto district which lies between 300 - 2100 m above sea level (asl). The highlands cover about 75% (2625 km^2) of the total district area, with altitude ranging from 1000 – over 2500 m asl whilst the lowlands cover about 25% (875 km^2) of the total District area between altitudes of 300 – 600 m asl (Lushoto District Profile, 2005). Lushoto district is in the humid-warm agro-ecological zone with annual precipitation between 600 mm in the plains up to 2,000 mm in the escarpment and on the plateau (Lyamchai, 1998). Rainfall is in bimodal pattern with short rains from October to December and long rains from March to June. Average annual temperatures range from 17 to 27°C (Neerinckx et al., 2008).

Notably, the area is within the rainforest vegetation category and natural forest reserves (*Magamba*) and plantation forests (*Shume-Nywelo*) are dominant landscapes (Wickama and Nyanga, 2009). The district is famous for the cultivation of tea, coffee, cardamom, vegetables, fruits, spices, maize, beans, bananas, cassava, yams, sweet and Irish potatoes and a number of other temperate fruits (Regional Commissioners Office 1993; Lyamchai, 1998).Soils in Lushoto are generally lactosols (Wickama and Nyanga, 2009). This land use pattern makes the West Usambaras one of the most intensely farmed areas of Tanzania (Pfeiffer, 1990).

Data collection and interpretation

We applied both qualitative and quantitative research methods including household interviews (HHs), focus group discussions (FGDs), Key informant interviews (KIIs) direct observations, life histories transect visits and literature reviews. Each FGD comprised of 12 participants with at least three females to obtain the views of women in the villages (Koda, 2000). A checklist of questions aimed at capturing the insights of village representatives and participants on their perceptions about cropping patterns, climate change, community adaptation initiatives and factors influencing trends in agrobiodiversity were asked. The facilitator of the FGDs ensured that every participant was actively involved in the discussion to avoid instances whereby some participants dominate the discussion while others fear to voice their opinions in front of their superiors (Koda, 2000). Important to note is that, individuals who participated in the FGDs were not included in the household questionnaire interviews. This enabled us to obtain a wider coverage of respondents in the study area. Key informants selected for this study were prominent local leaders and agricultural extension officers, Village

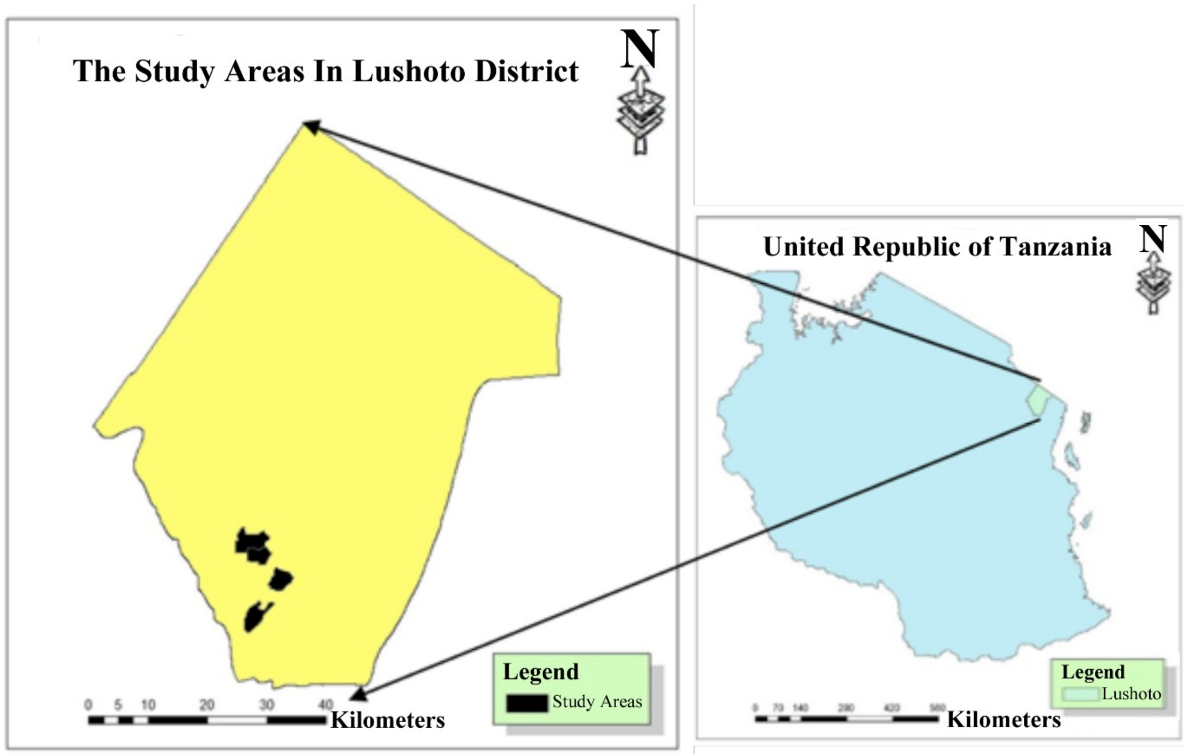

Figure 1. Map of study area.

Executive Officers (VEOs), members of the Village Environmental Committees (VECs) and elderly residents in the various villages (Lyimo and Kangalawe, 2010). Five key informant interviews were conducted in each selected village. The key informants were identified with the help of village administrative leaders in each of the selected villages. Checklists of questions were used to guide the interviews with the selected respondents. The key informant interviews addressed climate patterns in the area and its effect on trends in agrobiodiversity.

A multistage sampling technique was used in selecting100 interviewed household respondents. In each village, five percent of farming households were randomly selected for the study as suggested by Boyd et al. (1981); De Weerdt (2003); and Fatuase and Ajibefun (2013). Quantitative data were analyzed using Statistical Package for Social Sciences (SPSS) version 20, STATA version 12 and Excel 2014 edition. Qualitative and secondary information obtained through the focus group discussions, key informant interviews and written literature were triangulated in line with the themes and objectives of this study. Information obtained from FGDs was used to support findings from the questionnaire interviews and also to further explain statistical results obtained. Verbal information were reported without distorting the intended theme and supplemented with secondary data (Given, 2008). Data were triangulated to reduce bias or any distortions of the researcher's picture of certain information of reality being investigated in order to provide accurate and credible report (Cohen *et al.,* 2006). After reviewing literature, ten personal characteristics were selected and used as independent variables in a multinomial logit regression model. This model was used to determine the effect of these variables on farmers' adoption of agrobiodiversity. The logit model is specified as:

$$P_i = F\left(Z_i\right) = F\left(\propto + \beta X_i\right) = \frac{1}{1+e^{-Z_i}} = \frac{1}{1+e^{-(\propto + \beta X_i)}}$$

(Equation 1)

In this notation, *e* represents the natural logarithms, which is approximately equal to 2.718. *Pi* is the probability that an individual would make a certain choice (which in this case is the choice between adopting agrobiodiversity or not), given *Xi,* where *Xi* is set of independent variables, β*i* are the coefficients of the explanatory variables and α the constant term. The dependent variable is the logarithm of the odds that a farmer will adopt agrobiodiversity by growing three or more crops and integrating with livestock or not.

Literature discloses that the assessment and adoption of a strategy depends on the characteristics of the

Table 1. Characterization of the four selected study villages in Lushoto district.

Village	Boheloi	Mbuzii	Yamba	Migambo
Ward	Gare	Mbuzii	Gare	Kwai
Area (Ha)	500	750	-	-
Altitude (m asl)	1000-1500	1000-1500	2000-2500	>2500
Temperature (°C)	15-20	15-20	15	< 15

(-) Area of village not available

strategy and the perception of the adopter (Scott 2012). Also, when factors influence the adoption of some farming practices, it can be reflected in agrobiodiversity trends. Viewed through a broad cross-disciplinary lens, there is agreement that the adoption of agricultural innovation depends on a range of personal, social, cultural and economic factors, as well as on the characteristics of the innovation itself (Pannell et al., 2006). Prokopy et al. (2008) also shows that education, income, farm size, access to information, positive environmental attitudes, environmental awareness and utilization of social networks are positively, associated with the adoption of best management practices. Furthermore, Gbetibouo (2009) cited factors such as lack of secure property rights, lack of savings, lack of technical skills and off-farm employment as additional barriers to adoption of climate change adaptation strategies. The following explanations were used to justify the independent variables for the logistic regression:

i. Gender of the respondent (Gender): A dummy variable (1=male, 0=female) included in the model to determine the influence of gender on adoption of agrobiodiversity. Women farmers tend to adopt innovations at a relatively lower rate than men due to seemingly limited access to information and resources (Doss and Morries 2001). Therefore a positive influence is hypothesized for male respondents.

ii. Age of respondent (AGE): A continuous variable indicating the age of the respondent in years. Respondents' age may have either negative or positive effect on adoption decisions. Older farmers may continue to grow the crop varieties that they are conversant with and may be conservative to new technologies and interested in following traditional methods they are used to. Furthermore, they have also gathered enough experience with varying climatic conditions, various species and varietal combinations during certain periods of the year which may cause them to either adopt an innovation or not (Quayum et al., 2012). Younger farmers on the other hand, are more likely to adopt new farming strategies or innovations (Akubuilo, 1982).

iii. Experience (EXP): A continuous variable expressed in years of farming and is expected to have a positive effect on adoption of agrobiodiversity. Longer farming experience leads to increased tree planting and productivity as well as the probability of soil conservation and changing of crop varieties (Deressa et al., 2009).

iv. Extension Service (EXT): A dummy variable which takes 1 if the respondents' receive extension services from colleague farmers as well as farmer-based institutions and organizations and 0 if otherwise. Adoption of agrobiodiversity can be influenced by educating farmers on improved varieties, cropping techniques, optimal input use, market conditions, storage and nutrition (Raghu et al., 2014). Farmers with access to extension services are believed to have new, and updated information to enable them improve production and also increase farm income (Deressa et al., 2009; Armah et al., 2012).Hence for the decision to adopt agrobiodiversity, access to extension services was expected to have a positive sign or coefficient.

v. Household Size (HHs): A continuous variable which referred to the number of members of the household. This explanatory variable was included because it affects the labor supply at household level. Households with more people to feed are more likely to adopt strategies which they expect to increase yield and household income (Tham-Agyekum et al., 2014).

vi. Yield (Y): A continuous variable which referred to the number of bags "gunia" of staple crops such as maize, beans, cassava and potatoes harvested by the farmer the previous year. Farming households with higher yield are more likely to practice agrobiodiversity because they obtain enough food to feed their households. Datt and Ravallion (1996) purported that, since the needs of the rapidly growing population could not be met by expanding the area under cultivation, developing and employing yield increasing agricultural technologies is imperative. Ibrahim et al. (2012) also reported about the direct effect of the adoption of a strategy on the farmer's income resulting from higher yields and more profitable prices.

vii. Marital Status (MAR): A dummy variable which takes 1 if the respondent is married and 0 if otherwise Married farmers are likely to be under pressure to produce more for family consumption and for sale. Similarly, the availability of family labour could also be an incentive for married farmers to cultivate more crops and use agricultural information (Prara, 2010).

viii. Annual Farm Income (INC): A continuous variable which referred to farmers' annual income earned from the sale of farm produce in the previous year. Annual farm income was provided by farmers in Tanzanian Shillings (TSH) and the amounts were later converted to the

United States Dollar (USD) using the conversion rate of 1TSH = 0.00050 USD (http://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=TZS accessed July, 2015). This explanatory variable was included in the model because farming households which earn more from a strategy are more likely adopt it. According to Besley and Case (1993), the adoption of agricultural innovations has long been considered a solution to heighten agricultural income and diversification. This enables farmers to provide household needs and further diversify to non-farm livelihood strategies.

ix. Off-farm Income (OFF-FARM): It is a continuous variable representing farmers' annual income earned from off-farm income-generating activities in the previous year. Annual off-farm income was also given by farmers in Tanzanian Shillings and converted to USD (Section viii). Participation in off-farm activities can solve liquidity problems while intending to purchase chemical fertilizer and improved seeds. Due to this, a positive coefficient was hypothesized in the final estimation result both for agrobiodiversity adoption decision.

x. Education: A dummy variable which takes 1 if the respondent had obtained any formal education and 0 if otherwise. The desire to produce more could lead to agricultural information seeking and use. Education enables the individuals to know how to seek for and apply information in day-to-day problem solving. This is because as the individual gained the ability to read, he is able to extend the scope of his experience through the print media (Opara, 2010). In view of this, formal education was estimated to have a positive effect on adoption of agrobiodiversity.

The summary of the descriptions, measurements and a priori expectations of the independent explanatory variables are presented in Table 2.

RESULTS AND DISCUSSION

Household characteristics of interviewed respondents

Household status which refers to whether a respondent is the head of a household or not and the gender of the interviewed respondents were considered important variables to measure because they are likely to help explain gender roles in household decision-making and the practice of agrobiodiversity. A study by Phiri (2011), explained that the gender of the household head significantly enhances the prospects of shifting crop-planting dates and that women are more likely to shift planting of crops when weather varies. The interviewed farmers comprised of 37% female of which 20% were household heads (Table 3).

Sixty-three percent of the interviewed respondents were males and all were household heads. This finding is in agreement with previous studies which stated that more men engage in farming activities than women (Jibowo, 1992). It appears that, although women were farming in Lushoto district, the activity is principally a male-dominated activity as it is a labor intensive venture.

Agrobiodiversity trends in the studied villages

The respondents said that although not a mandated cultural practice, most farmers who inherited farmlands in most cases they continued to cultivate the same crops inherited from their predecessors. Lushoto has been well-known for the cultivation of crops such as tea, coffee, cardamom, maize, beans, bananas, cassava, potatoes, vegetables and temperate fruits since 1961 (Tanga Regional Development Report, 1993). Notably, 40% of the interviewed respondents in Boheloi village said that they engaged in beans and maize cultivation from 2005-2014 (Figure 2). Also during the same period, all the farmers interviewed in Yamba village cultivated maize and beans. The analyses further suggest that farmers in Migambo village currently grow maize and beans (Figure 2). It was discovered that cassava is one of the major food crops in Lushoto District, mainly grown for subsistence and mainly not for sale. Quantities of cassava marketed in the district are relatively limited (Tanga Regional Development Report, 1993).

Farmers reported during the FGDs and KIIs that, the production of apples, pears and plums in the area had continued to increase steadily from 2005-2015 (Figure 2). The discussants added that in the last two decades, growing of timber trees such as *Gravillea robusta*, *Pinus spp*, *Cupressus* and *Eucalyptus spp*, *Acacia melanoxylon* have started especially in Yamba and Migambo as a result of agroforestry campaigns, increased prices and demand for timber products. They added that these trees served as windbreaks which in turn helped to reduce erosion in steep sloping areas. It was also observed during the reconnaissance survey in the villages that farmers used such trees for construction of buildings, fences, bridges as well as firewood and briquettes for cooking.

Lushoto has been well-known for the cultivation of crops such as tea, coffee, cardamom, maize, beans, bananas, cassava, potatoes, vegetables and temperate fruits since 1961 (Tanga Regional Development Report, 1993). Notably, 40% of the interviewed respondents in Boheloi village said that they engaged in beans and maize cultivation from 2005-2014 (Figure 2). Also during the same period, the farmers interviewed in Yamba and Migambo villages cultivated maize and beans (Figure 2). The discussants also reported that, 30 years ago, farmers in Boheloi village cultivated fruit tree crops such as pears, apples and plums. However, they added that, lately due to falling yield attributed to increasing temperatures in the area, fewer fruits were obtained during the harvest season thus contributing to farmers'

Table 2. Variable description for Logit model.

Variable	Description	Measurement	Apriori expectation
X_1	Gender (GEN)	Dummy (male=1, female=0)	+
X_2	Age of respondent (AGE)	Years	+/-
X_3	Experience in farming (EXP)	Years	+
X_4	Access to extension service (EXT)	Dummy (yes=1, no= 0)	+
X_5	Household size (HH)	Number of persons	+
X_6	Yield for previous year (YIELD)	Number of bags of key staples	+
X_7	Annual Farm Income (FM)	USD	+
X_8	Off-farm Income (OFF-FM)	USD	+/-
X_9	Marital Status (MAR)	Dummy (Married=1, Otherwise= 0)	+
X_{10}	Education (EDUC)	Categorical	+

Table 3. Gender and household status of respondents.

Gender	Household head		Total (%)
	Yes (%)	No (%)	
Female	20	17	37
Male	63		63
Total	83	17	100

lack of motivation to grow fruit trees. This situation had caused them to concentrate more on the production of crops such as vegetables, maize, beans, banana and cassava.

The interviewed farmers in Mbuzii village also reported that the number of farmers engaged in coffee production in their area had gradually declined from 30% in 1985-1994 to 10% and subsequently 0% from 2005 to 2014 (Figure 2). This could be due to the relatively warmer temperatures recorded in the villages at lower altitudes (Table 1). Noteworthy, the analyses of the household interviews in Yamba village revealed that there was an increase in the number of farmers growing cassava, vegetables and banana although there was no significant increase in the number of coffee farmers. This was attributed to the gradual increase in temperature in the area. The farmers interviewed in all the four selected villages reported that in the last 30 years, areas under forest lands have gradually decreased and this might be due to expansion of farmlands as well as unsustainable farm and forest management practices. Like many poor communities, woodlands in Tanga Region are increasingly being exploited for charcoal, fuel, furniture, building and construction materials. Afforestation programmes have therefore been introduced in order to safeguard the environment against further depletion or degradation. Social, Environmental and Climate Assessment Procedures (SECAP) and International Union for Conservation of Nature, East Europe Committee (IUCN/EEC) are undertaking afforestation programmes in Lushoto and Muheza to control soil erosion (Tanga Regional Development Report, 1993). The interviewees said that they practiced agrobiodiversity because the soil nutrients had gradually been depleted and agrobiodiversity had a potential to restore soil fertility. They added that some crops had to be changed as the seasons change in order to sustain crop production.

Key crop varieties lost / terminated in the study areas

The discussants in Boheloi village reported that they had abandoned or lost some traditional maize varieties because of low market demands and poor yield. Majority (87%) of the interviewed respondents explained that they had stopped cultivating some key crops which included both local and improved varieties of coffee, cassava and sweet potatoes (Table 4). Climatic changes, decreasing yield, changing diets and loss of soil fertility were highlighted as the main causes for the loss of these crops. It is interesting to notice that, there were some farmers who had not abandoned any crop varieties as they had specialized in specific crops and sustained market demand for those crops. According to them, they mainly cultivated maize, beans, banana and Irish potatoes. Some of the interviewees and discussants in Mbuzii village explained that although they had not changed most of the crops over the years, they had

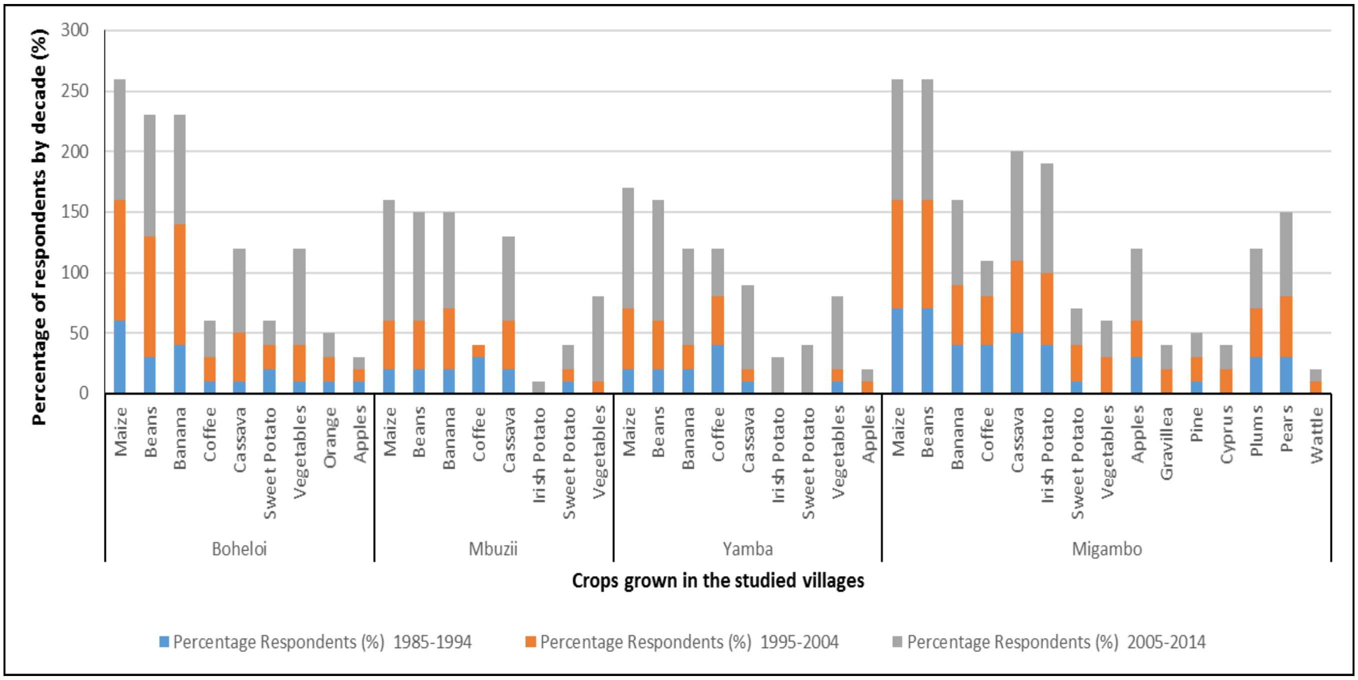

Figure 2. Crop variations in the four villages from 1985-2014.

switched local varieties for new ones mainly because of low yield recorded for the local varieties.

The respondents also raised concerns that tree crops found in Mbuzii and Boheloi villages have decreased and are gradually disappearing with time. This could possibly explain studies by Lyamchai et al. (2011) reporting that famers in Lushoto have resorted to the planting of trees and tree crops through several agroforestry campaigns and programmes to increase soil moisture. It was said during the FGD that compared to Yamba and Migambo villages, Boheloi and Mbuzii villages had relatively fewer tree crops.

Key crop varieties introduced in the study area

The interviewees reported that farmers in Yamba village have also replaced most indigenous crop varieties with improved ones (Table 5).

They added that market demands and prices for local Irish potato varieties have fallen drastically because the improved varieties yielded higher tubers. Further discussions with the respondents indicated that 72% of farmers who cultivated local crop varieties had introduced some new crop varieties which include improved and high-yielding varieties of tomatoes, fresh beans, cabbage, onions, Irish and sweet potatoes. This could contribute to efforts to enhance food security as these crops are often used in preparing most household meals.

Timber trees such as *Gravillea robusta*, *Pinus spp*, *Cupressus* and *Eucalyptus spp* were reported to have also been introduced in the areas. The reasons that were put forward for such trends include climate change, decreasing crop yield, changing diet and loss of soil fertility. These results support a study by Lyamchai et al. (2011) who reported that due to climate change, 78% of farmers in Lushoto have three or more crops on their farms. This could be a strategy to mitigate the risk of total crop failure. During the FGDs and KIIs, the farmers said that the re-use of harvested seeds resulted in low yields. They further explained that the introduction of timber trees on their farms was due to capacity building trainings and awareness campaigns for agroforestry practices coupled with the ready market and growing demand for timber products.

Factors influencing agrobiodiversity trends in the study area

The results indicate that the 10 personal and socio-economic variables (age, household size, gender, marital status, access to extension service, level of education, experience in farming, crop yield, annual farm income and off-farm income) used to predict respondents practice of agrobiodiversity yielded a Pseudo R^2 estimation of 0.2084 from the model (Table 6). This implies that only 21% of farming households' decision to adopt agrobiodiversity can be explained by the variables included in the model. The log likelihood of -104.745 and LRChi^2 of 55.14 for adoption was significant at 1% level, showing that the logit regression model was well fitted.

As a result the ten variables, when taken together were found to effectively predict farmers' practice of

Table 4. Lost crops reported by respondents in the selected villages in Lushoto.

Scientific name	English name	Local name (Village [a])
Zea mays	Maize	Kilima (all)
		Situka (B)
Phaseolus vulgaris	Common beans	Maharage (all)
	Coffee	Kahawa (B, Y)
Solanum tuberosum	Irish potato	Viazi (M, Y, Mg)
		Malanta (B)
		Viazi (B, Y, Mg)
Ipomoea batatas	Sweet Potato	Viazi vitam (B)
Solanum lycopersicum	Tomato	Nyanya (B, M, Y)

[a] B, Boheloi, M, Mbuzii, Y, Yamba, Mg, Migambo; [b] l, lost/abandoned

Table 5. Crops introduced by respondents in the selected villages in Lushoto.

Scientific name	English name	Local name (Village [a])
Zea mays	Maize	kifan kishoka (M)
		Kifaru (B, M)
		Decalb (B, M)
		Pioneer (Y, Mg)
	Yellow maize	Yellow maize
Phaseolus vulgaris	Common beans	Maharage (all)
Solanum tuberosum	Irish potato	Viazi (B, Y, Mg)
		Viazi Obama (Y, Mg)
		Asante (Y, Mg)
Solanum lycopersicum	Tomato	Nyanya (B, M, Y)
Capsicum annuum	Green pepper	Pili pili hoho (B,M)
Pinus spp	Pine	Pine (Y, Mg)
Gravillea robusta	Silky oak	Gravillea (Y, Mg)
Brassica oleracea	Cabbage	Kabeji (B)
Phaseolus vulgaris	Fresh beans	(B, M)
Allium cepa	Onions	Vitunguu (B)
Cocos nucifera	Coconut	(B)

[a] B, Boheloi, M, Mbuzii, Y, Yamba, Mg, Migambo; [b] n, new variety introduced in the last decade.

agrobiodiversity in Lushoto District. Age of household head, marital status, and access to extension services, crop yield obtained in the previous year, years of experience in farming, annual off-farm income and gender of the interviewed respondents had positive relationship with adoption of agrobiodiversity. These characteristics having positive coefficients were more likely to increase the probability of a farmer to practice agrobiodiversity. Noteworthy, all the variables met *a priori* expectation with the exception of annual farm income and household size which had an inverse relationship with adoption of agrobiodiversity. This means that these variables are less likely to increase the probability of a farmer to practice agrobiodiversity.

Of the ten factors, education, annual farm income, annual off-farm income and marital status were statistically significant at one percent probability. This implies that the estimated logit model and its associated error components are statistically significant at the 1% probability. Access to basic formal education had a potential to influence the adoption of a strategy because farmers are equipped with reading and writing skills

Table 6. Empirical Logistic estimation for effect of selected characteristics on adoption of agrobiodiversity.

Likelihood Chi^2ratio			(LR chi2) (10) = 55.14				
			Prob. > chi^2 = 0				
Log likelihood = -104.74456			Pseudo R^2 = 0.2084				
Variable	**Co-efficient**	**dy/dx**	**Std. Err.**	**P>z**	**[95% C.I]**		**X**
EDUC	-2.09187***	-.3223312	0.07073	0	-0.46096	-0.1837	0.85
AGE	0.03378	.0074159	0.00479	0.121	-0.00197	0.016801	47.475
HH size	-0.08497	-.0186546	0.01456	0.2	-0.04719	0.009878	7.125
MAR	2.555258***	.5473069	0.13688	0	0.279029	0.815585	0.95
EXT	1.573131***	.3672096	0.1057	0.001	0.160033	0.574386	0.775
FM INC	-0.00072***	-.0001577	0.00006	0.005	-0.00027	-4.8E-05	431.469
YIELD	0.008079	.0017736	0.01101	0.872	-0.01981	0.023359	4.28562
EXP	0.010896	.0023921	0.00454	0.598	-0.0065	0.011287	20.8
OFF FM	2.04464***	.46158	0.08239	0	0.300108	0.623052	0.7
GENDER	0.669849	.150186	0.10154	0.139	-0.04883	0.349201	0.625
Constant	-3.93923						

***, indicates significance level at 1%; Dependent variable is adoption of agrobiodiversity; $LRChi^{2,}$ log likelihood chi square; Column (1)-the estimated parameters of the Logit regression model; Column (2) - the expected values of the dependent variable conditional on being uncensored; Column (3) - the change in intensity of adoption with respect to a unit change of the independent variable; Column (4) - marginal effects for the unconditional expected value of the dependent variable.

expected to enable them read, write and understand information. This might make them more receptive to innovations compared to their counterparts who have no formal education. These findings suggest that there is need to introduce intensive adult education programmes as extension packages for rural farmers. Agbamu (1993) stated that farmers' knowledge of innovations contributed to adoption of effective strategies. The results presented in Table 3 shows that although not significant at 1%, gender had a positive relationship with farmers' adoption to agrobiodiversity as the demographic data of the respondents showed that more men engaged in farming (Table 3). A study by Ayoade and Akintode (2012) also revealed that the rate of adoption of and innovation by women is relatively low. Women agriculturalists are often associated with traditional subsistence and low-yield food crops, poverty, lack of influence and the inability to adopt crop and husbandry innovations (Youssef, 1995).

Although significant, a negative relationship between annual on-farm income and farmers' adoption of agrobiodiversity could be an indication that farm income is less likely to influence the practicing of agrobiodiversity. This could be attributed to the relatively lower on-farm income earned by the interviewed farmers who were mainly small holder farmers. Higher on-farm incomes could probably be a motivation for farmers to adopt agrobiodiversity. Empirical evidence on the linkage between farm and off-farm sectors are limited because most literature on the effect of on-farm and off-farm income on the farm sector are inconclusive. Off-farm income tends to provide farmers with liquid capital for purchasing productivity-enhancing inputs such as improved seed and fertilizers (Giiro, 2013). Furthermore by including off-farm income-generating activities in the household output portfolio (in addition to the traditional farm products), many farm households, especially small-scale farmers, are able to enhance diversification. The advantages of such diversification in the scope of household-level economies are quite substantial.

These results suggest that off-farm livelihood activities are more likely to enhance on-farm diversification, especially for small scale farmers (Fernandez-Cornejo et al., 2007). Marital status also indicated a positive relationship on the adoption of agrobiodiversity. This is probably because couples are more likely to share ideas and information about farming as well as improved varieties and strategies. The results may also imply that spouses and children of farmers are also more likely to contribute to farming by providing labor and other resources such as land and financial capital to further increase scale of production. Another study elsewhere has reported that marriage serves as a means of generating family labor and since women and children are able to participate in crop production, processing and marketing, farming practices and use of technologies are related to marital status (Atiboke et al., 2012). Marital status could be associated with household size which is also likely to influence agrobiodiversity positively. Owokunle (1983) also, agrees that majority of land development scheme participants in Kwara state of Nigeria received assistance from their wives and children to operate their farms.

During the interviews, major challenges mentioned by farmers were crop pests and diseases which affected crop yield and hence farm income. Furthermore, factors such as limited land size and insufficient capital are possible barriers which could prevent farmers from realizing higher income from agrobiodiversity. This could also imply that, farmers who rely solely on farm income may not have enough income to purchase farm inputs and so may be unable to expand in the subsequent years. The respondents therefore suggested that donor support through subsidies, credits, farm inputs and loans should be extended to small scale farmers in rural parts of Tanzania so as to sustain the practice of agrobiodiversity in the area. Arguably, the sustainability of this option is questionable as Hadgu (2009), reported that the provision of credits to farmers led to introduction of new varieties and hence losses in landraces and a consequent decrease in agrobiodiversity.

Conclusion

The introduction of modern or improved crop varieties in the last three decades have largely contributed to the gradual loss traditional landraces and general agrobiodiversity loss in Lushoto district. This has been more evident in the lowland areas of Lushoto district especially in Boheloi and Mbuzii villages that are found in altitudes between 1000 and 1500 meters above sea level. Other factors like changing and unpredictable weather patterns in the area, market prices of produce, environmental conditions and household food preferences have contributed to the current trends in agrobiodiversity status of Lushoto district. As an adaptation strategy to the climate change in the study areas, farmers reported that crop varieties that are well-suited to the prevailing climatic and environmental conditions are often preferred by farmers. This has significantly reduced the number of farmers cultivating crops such as the local maize (*Zea mais*), beans (*Phaseolus vulgaris*), Irish potatoes (*Solanum tuberosum*) and sweet potatoes (*Ipomoea batatas*). The multinomial logit model used for the estimations indicated that at P>0.01 access to extension services, farmers' marital status, on-farm and off-farm income could influence adoption of agrobiodiversity and hence the trends in in Lushoto. There is therefore the urgent need to conserve and manage landraces that are threatened to extinction through intensified extension education and participatory intervention programmes.

ACKNOWLEDGEMENTS

This research was supported by START and IDRC through the African Climate Change Fellowship Programme (ACCFP) Phase III. The Masters Program of Rosalyne Naa Norkor Baddoo was sponsored by TRECCAFRICA. We also wish to extend our appreciation to staff of the Lushoto District Agricultural Office, Institute of Resource Assessment in University of Dar Es Salaam and Sokoine University of Agriculture. We appreciate their support in creating a congenial atmosphere and providing valuable advice to make this research successful.

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