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Assessment of the Impact of Sustainable Land Use Practices on Food Security in West Usambara Mountains, Tanzania

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Abstract

This paper assessed the impact(s) of practicing sustainable land management (SLM) technology on food security in West Usambara Mountains. Primary data were collected through household questionnaires, focus group discussions, key informants interviews and personal observations while secondary data were collected from relevant local authority reports and records. A total of 160 households were interviewed. Research results suggest that, the area is still experiencing soil erosion problem reported by 61.9% of the respondents although at reduced scale. Multiple linear regression model to establish the contributing factors revealed that age of household head, farmland ownership and household income have significant and positive impact on improving household dietary diversity and hence improves food security while non adopters of SLM showed declined dietary diversity. The study conclude that in order to increase food security keeping soil health in place through practicing SLM is a necessary condition.The study concludes that, to increase your food security keep your soil in place by practicing SLM.

Keywords: Food security; Household dietary diversity; Multiple linear regression; Sustainable Land Management Technologies; West Usambara Mountains.

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1. Introduction

On average, one out of every three people on earth is in some way or the other affected by land degradation. Latest estimates indicate that nearly 2 billion hectares of land worldwide are already seriously degraded, some irreversibly [1]. To rescue the situation, the adoptions of sustainable land management (SLM) technologies seem to be the best way. In Tanzania, soil erosion is one of the major threats to agricultural production [2]. Factors such as population growth, deforestation and poor farming techniques have been pointed out as the major causes. Estimate put 300,000 to 400,000 hectares of forest that are cleared every year to meet the demand for farming land, timber, poles and firewood while the generation and replacement is only 25,000 hectares per year [3]. The West Usambara highlands are among the areas mostly affected by soil erosion in Tanzania; here, soil erosion is resulting in an annual loss of fertile topsoil of about 100 tonnes/ ha and consequently reducing crop yields [2,4].

There are many efforts towards careful management of natural resources in the West Usambara Mountains such as; Soil Erosion Control and Agro-forestry Project (SECAP) introduced through German support in 1981 for a period of 20 years (1981-2000) [3], Tanzania Forest Research Institute (TAFORI) established in 1981 [5], African Highlands Initiative (AHI) [2] and Traditional Irrigation and Environmental Development Project (TIPDO) established in1989 [6]. Although many efforts have been done with regard to management of land in West Usamabra Mountains, [2] reported that, attention to participation, adoption to these conservation practices is still so low.

However there are no studies done on assessing the impact on offered sustainable land practices on the on food security. Based on that fact, this study fills the gap by sharing robust empirical evidence on sustainable land management technology practices in West Usambara Mountains, and to investigate how they have improved livelihood, more particularly on food security. As suggested by [7] that the variable is the best proxy for assessing livelihood outcomes. Furthermore, the same variable was used to measure the livelihood outcomes on hydrology and land use in Republic of South Africa [7].

Knowing the impacts of practicing sustainable land management (SLM) to farmers, will enable the sustainability of land management practices in Usambara Mountains. Findings will build the strong base to farmers whether offered land management practice are worthwhile undertaking or not with regards to their food security. In addition, study findings will contribute in policy reforms especially on the land conservation practices. However, the study holds on hypothesis that: The use of offered SLM technologies will not contribute significantly to household’s food security.

1.1. Conceptual framework linking technology adoption and livelihoods

The conceptual framework was adopted and modified from [8]. It based on the assumption that, after technologies have been developed from research institutions, NGOs and projects are then disseminated to farmers. Thereafter, farmers will adopt technologies and agree to be contract farmers if they respond to their needs. But also, farmers who will think otherwise will reject the technologies by not showing interest for becoming contract farmers. After some time of testing, the contract farmers will gain experiences with technologies and have more solid basis for accepting or rejecting them (Figure 1).

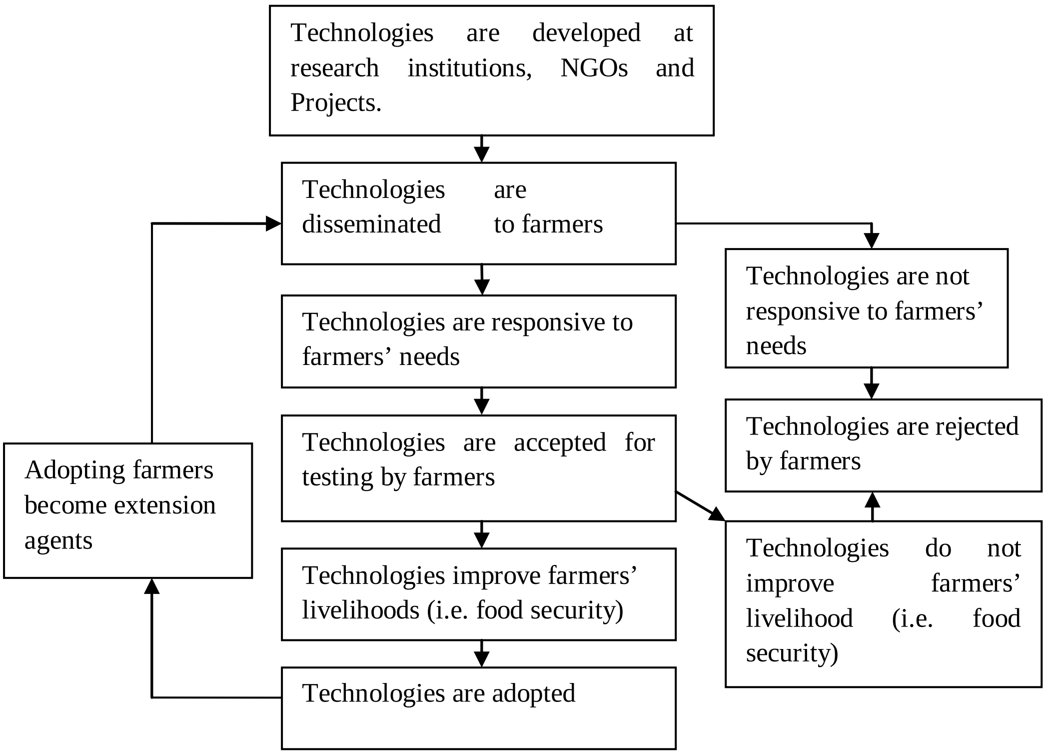

Fig. 1. conceptual framework linking technology adoption and livelihoods

Source: Modified from [8]

1.2. Materials and methods

The West Usambara Mountain ranges in North East Tanzania, forms part of the Eastern Arc Mountains. With elevation ranging from 900 – 2250 meters above the sea level they occupy about 80 % of Lushoto District in Tanga Region. More than 80 % of the population of Lushoto District, estimated at 526,278 reside in the West Usambara Mountains making it the most densely populated that is 100 person/km^2 in the country [3].

The target population for the study was farmers who cultivate crops, vegetables and fruits. A sampling frame is a list that identifies the target population [9]. The sampling frame for this study was obtained from administrative leaders in the selected study sites. However, purposive sampling was used to select five wards namely; soni and mbuzii (low landscape areas) and lukozi, malindi and shume (high landscape areas) in-order to get all scenarios of SLM practices in both locations (Figure 2). Furthermore, Stratified sampling technique with a calculated sample size fraction or F-coefficient of 0.0126 was employed to get household samples from each ward that is Lukozi (31), Malindi (47), Shume (30), Mbuzii (18) and Soni (34). Thereafter, simple random sampling was conducted for one to one household interview that made a total of 160 interviewed households.

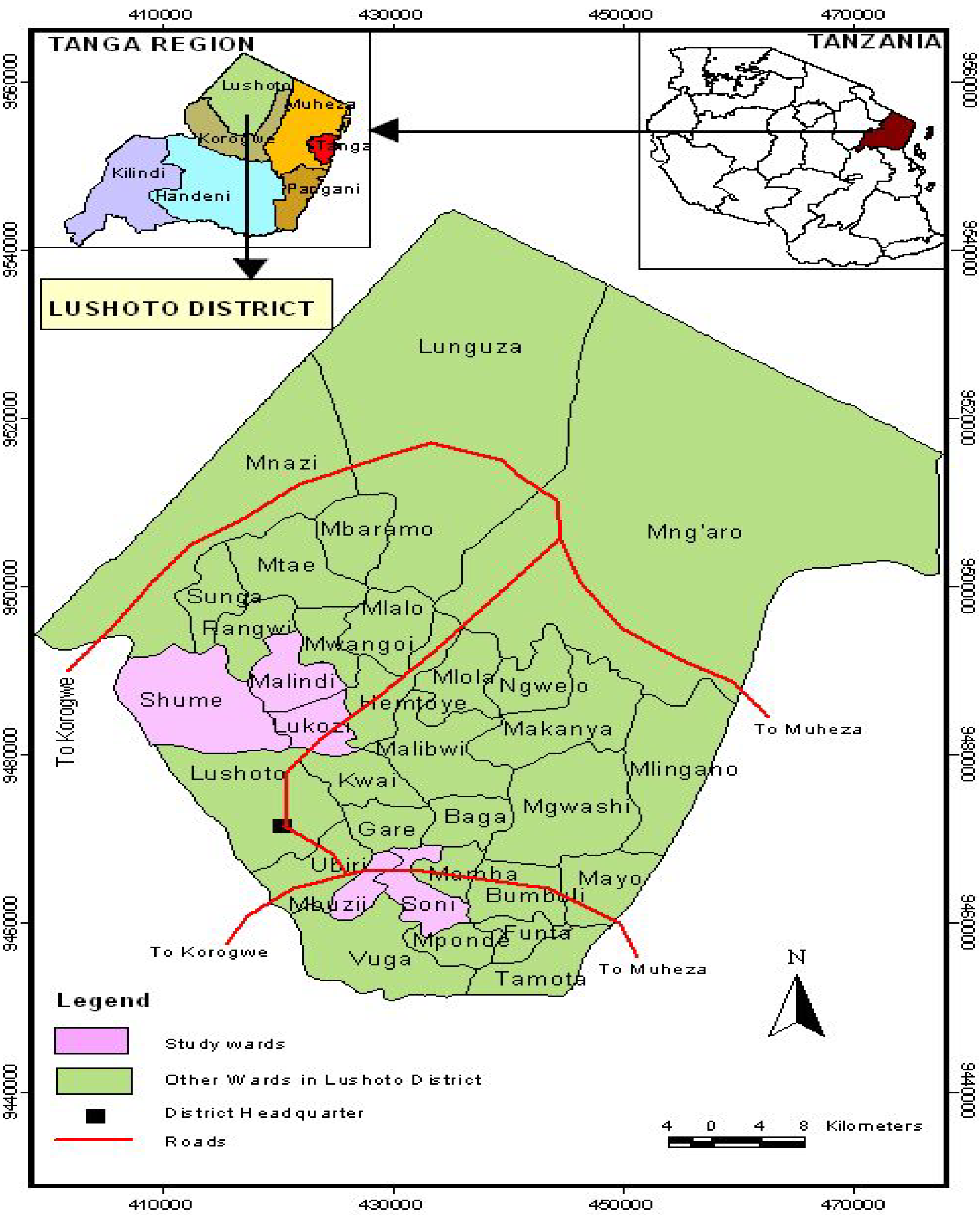

Fig. 2. Map showing the study wards

However, field data collection involved two stages. The first stage was focus group discussion with the key informants of Lushoto such as district agricultural and livestock development officer, three extension officers and group of 20 selected farmers of which 8 were female, with the aim of gathering information on sustainable land management practices in Lushoto and selection of wards for data collection. Second stage, was the use of questionnaire whereby both close ended and open ended questions were asked. In-addition, descriptive statistics, multiple linear regression (as specified in equation one), household dietary diversity and independent T-test statistics were used to analyze the data. The household dietary diversity was used due to the favourable climatic condition of the study area i.e. same piece of land can be used three to four cycles of production within a year and hence availability of variety food groups.

$$Y = a_0 + a_1 adSLM + a_2(HHincome) + a_3 landown + a_4 hhsize + a_5 educave + a_6 agehead + \hat{e}$$
(1)

Whereby; **Y** is the dietary diversity measure (simple count of food groups), as a variable for household food security. According to [10] suggested that to better reflect a quality diet, the number of different food groups consumed is calculated, rather than the number of different foods consumed. Knowing that households consume, for example, an average of four different food groups implies that their diets offer some diversity in both macro- and micronutrients. This is a more meaningful indicator than knowing that households consume four different foods, which might all be cereals.

2. Results

2.1 Characteristics of farmland and nature of land degradation

The characteristics of farmland position are among the factors that affect land use type and nature of land degradation in a particular area. In connection to this, the slope of farmland characteristics of the sample household heads was considered. The research findings show that 52.8% of the respondent cultivate in the middle slope, 23.6% upper slope, 12% valley bottom, 10.7% plateau flat and only 0.9% river bank (Figure 3). This suggests that, land management should not be an option since more than half of the habitats are on sloping farming areas.

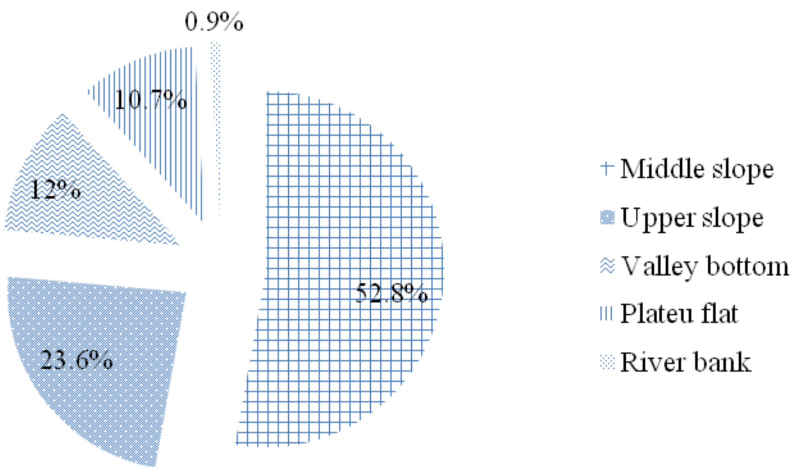

Fig. 3. Nature of farmland arrangements use in Lushoto District

Out of 160 research sample, about 61.9% of the respondents indicated that soil erosion is still a problem to their farmlands. In view to this, 50.0% and 58.1% of the respondents confirmed both decreasing of soil fertility and yield status to their farmland, respectively. Worth noting here, sustainable land management is still a problem and an urgent help is needed to resolve the problem of these farmers. Despite the above facts, only 25.6% of the respondents see soil erosion is of very much concern. Worth noting here is the fact that there is still low understating of farmers on soil erosion. This further suggests that, extension officers have to play more of their roles on land management education to farmers.

Fig. 4. Various view of farming activities in Lushoto District

2.2 Sustainable land management technology practices and household's food security

The response variable that predicts the presence or absence of characteristics or outcomes based on the value of a set of predictors or independent variables were farmland ownership, education of the household, age of the household head, total number of members in the household, household average income per year, and sustainable land management adopters versus non-adopters as these were assumed to be potential determinants of household food security. Farmland ownership, household head age, household average income per year, and sustainable land management non-adopters were found significantly predictor variables for household dietary diversity (Table 1).

It was earlier noted that, non-adopter has nothing to do with any negative connotations. Sustainable land management adopter versus non-adopter was the first considered as independent variable. It was expected that adopter to have significant positive influence on household dietary diversity due to its impact in raising level of farmers' produces, and the reverse for non-adopters. Consistent with this expectation, multiple linear regression showed sustainable land management non-adopter had a predictive power in explaining household dietary diversity. Farmers who have not adopted sustainable land management (non-adopters) have much higher chances for reducing their household dietary diversity. It indicates that a unit increase of non-adopters leads to a decrease of household dietary diversity by a factor of 0.887. This result is statistically highly significant ($p<0.001$) (Table 1).

Table 1: Multiple linear regression for household dietary diversity

Assumed independent variables	Standardized coefficient beta	t	Sig	95% confidence interval for B	
				Lower boundary	Upper boundary
Constant		17.427	.000	5.809	7.294
Dummy sustainable land management non-adopter ***	-.887	-26.311	.000	-4.014	-3.453
Household head age **	.061	2.368	.019	.002	.019
Household Head Education level	-.004	-.167	.867	-.386	.326
	.065	2.165	.032	.000	.000
Average income per year from farming activities **	.050	1.662	.099	-.007	.079
Total number of members in the household					
	.058	2.285	.024	.039	.542
Farmer land ownership **					

Note: *** indicates significant at 1%, ** indicates significant at 5%

Household head is an important person for decision making in the household**,** the age of head of household was assumed to have a positive relationship with food security. That is, as the age of the household head increase, increases the farming experiences and land holding (increases owned farmlands). This gives higher chances for the farmer to test different adoption technologies offered. Consistent with this expectation, multiple linear regression showed that age of the household head have a predictive power in explaining household dietary diversity. Households with higher household head age have many chances for increasing dietary diversity. It suggests that, a unit increase of household head age increases dietary diversity by a factor of 0.061. This result is statistically significant ($p<0.05$) (Table 1). The finding of positive association between household head age and household dietary diversity is consistent with initial assumption and it is also similar to findings by [11] observed that age of head of respondent in developing countries associate positively with household dietary diversity.

Average household income per year was assumed to have positive relationship with household dietary diversity.

That is, as the income rises, it increases more chances for household to secure more food and hence household dietary diversity. Consistent with this expectation, multiple linear regression showed that average household income per year have a predictive power in explaining household dietary diversity. It indicates that, a unit increase of household average income per year increases household dietary diversity by a factor of 0.065. This result is statistically highly significant ($p<0.01$) (Table 1). The result of positive association household average income and dietary diversity is consistent with initial assumption and it is also similar to the findings in Pakistan by [12] who observed that household income associate positively with the household food security.

Farmland ownership was assumed to have positive relationship with household food security. That is, the bigger the size of farm household possess the more likely to produce differently crop types hence increases household dietary diversity. Consistent with this expectation, multiple linear regression showed that farmland ownership have a predictive power in explaining household dietary diversity. It suggests that, a unit (acre) increase of farmland household ownership increases household dietary diversity by a factor of 0.058. This finding is statistically significant ($p<0.05$) (Table 1). Similar findings in Kenya observed by [13] found that an increase in farm size holdings reduces vulnerability to food insecurity. This is possibly because farmers who have large farm sizes tend to have different plots with different crop varieties of which some tends to be diseases resistant crops and other drought resistant crops, hence ensured harvests that lead to food secured.

2.3 Analysis of variance for the modal acceptability

On assessing the analysis of variance (ANOVA), the regression sum of square found much greater than the residual sum of square, which indicates that more than half of the variation in household dietary diversity was explained by the model. The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance as shown in Table 2. The goodness-of-fit statistics (R and R^2) were also used, the multiple correlation coefficients (R) was found to be large (0.95), it indicating a strong relationship. In addition, the coefficient of determination (R^2) was found large (0.900), worth noting here, about 90% of the variation in household dietary diversity was explained by the model. This means that, the variables added are the good predictor of the dependent variable.

2.4 Collinearity statistics and collinearity diagnostics for regressor variables

On assessing multicollinearity, the tolerance (i.e. is the percentage of the variance in a given predictor that cannot be explained by the other predictors) was found to be 55.2% to 96.0%. Thus the small tolerance shows that only 4% to 44.8% of the variance in a given predictor can be explained by the other predictors. However, when the tolerances are close to 0, there is high multicollinearity and the standard error of the regression coefficients will be inflated. A variance inflation factor (VIF) greater than 2 is usually considered problematic, and the largest VIF was found 1.811 as shown Table 2.

Thus, the collinearity diagnostics confirmed that there were no problems with multicollinearity. Since several eigenvalues are not close to 0, suggesting that predictors (education level, age, household size, income, land ownership and non-adopters) were not intercorrelated and hence the entire bundle of predictors predicts well the response variable. In addition, the condition indices were computed as the square roots of the ratios of the largest eigenvalue to each successive eigenvalue. Values greater than 15 indicate a possible problem with collinearity; greater than 30, a serious problem. However, neither of the values were above 30 nor 15. This means, no problem with collinearity (Table 3).

Table 2: Collinearity Statistics[a] for assessing multicollinearity in regressor variables

Regressor variables	Tolerance	VIF
(Constant)		
Household Head Education level	.960	1.041
Household head age	.958	1.044
Total number of members in the household	.680	1.470
Average income per year from farming activities	.693	1.442
Farmer land ownership	.973	1.027
Dummy sustainable land management non-adopter	.552	1.811

a. Dependent Variable: Number of food groups eaten last week

Table 3: Collinearity diagnostics[a] to confirm multicollinearity in regressor variables

Dimension	*Eigenvalue*	*Condition Index*
1	5.592	1.000
2	.843	2.576
3	.250	4.733
4	.143	6.254
5	.082	8.253
6	.075	8.651
7	.015	14.093

a. Dependent Variable: Number of food groups eaten last week

2.5 Option(s) for Improvement of Sustainable Land Management Practices.

Respondents were asked on how spread and practised are SLM to their community, research findings show that, the majority 68 (42.5%) said that they are spread and practised but not that much that is some more efforts are needed, 49 (30.6%) said they are poorly spread and practised, 22 (13.8%) said they are not spread and practised at all while only 21(13.1%) said that they are very well spread and practised (evenly distributed). Worth noting here is, about half of the respondents suggest there are low practices of SLM and there is a needed strategic effort for making it being practised in study area. In addition, concerning land management practices, research findings show that, the majority 93 (45.8%) do not use any of the sustainable land practices, 70 (34.5%) use diversified cropping systems (strip cropping and mixed intercropping), 26 (12.8%) use cropping system and soil erosion control structures (contour farming, terracing and grass barriers) and only 14 (6.9%) use integrated agro-forestry practices (combining trees and shrubs with crops and/or livestock).

Furthermore, access to information/skills on land management practices, research findings found that, 25 (15.6%) get through individual one to one (only one extension agent and the farmer), 86 (53.8%) through village meeting, 17(10.6%) through using mass media (e.g. radio, flyers, TV, magazines, books, journals, etc.), 28 (17.5%) from other farmers and only 4 (2.5%) get through farm field (Demonstrations plots) as shown in figure 4. Worth noting here, the farm field (Demonstrations plots) is of great importance to impact not only skills but also motivational spirit on adopting a practice offered, as it offers opportunities for sustainable learning venue to farmers (be it individual farmer or farmer-groups/association) to observe the proper soil management, crop growth and yield impact and hence impact strong basis for practice. Surprisingly, it is the one given very low priority (figure 5).

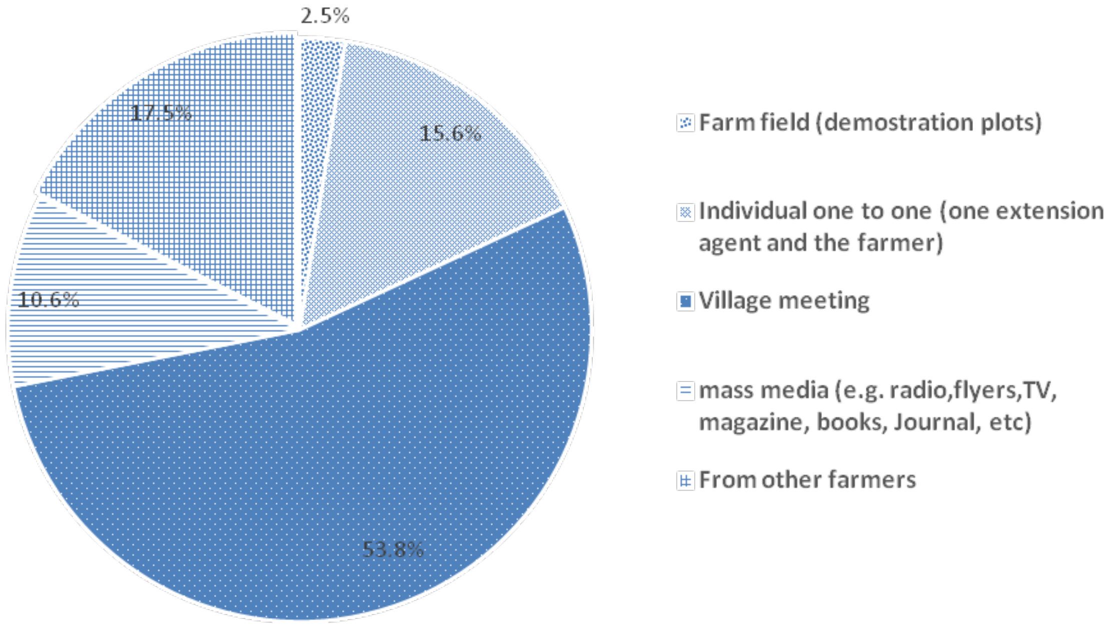

Fig 5: Sustainable land management practices/skills dissemination to farmers in Lushoto District

However, about 144 (90.0%) do not practise crop rotation in their farmland(s) as the mechanism for soil to gain its fertility. A focus group discussion revealed that, an increased population has made this happening. Its further suggests that, it's among other sources for soil losing its fertility and hence low production. Since farmers do cultivate three to four times a year, with very little replacement of organic manure due to shortage of grazing land. The majority 143 (89.4%) are practising zero grazing with few livestock that cannot sustain enough supply of manure to their farmland(s).

Furthermore, about 123 (76.9%) are faced by serious problem of high prices of fertilizer. Worth noting here, there is still a high need for managing soil fertility in the district. Focus group discussion revealed that, despite 15.6% get information of SLM practices through individual one to one (one extension agent and the farmer) but many of these extension officers have lower skills and in mostly cases they are not available. However, limited availability of extension officers with poor regular follow-ups, fewer motivational actions, few farmer groups/associations, limited and poor demonstration plots were pointed out as the core sources for the low practices of sustainable land management. In addition, about 143 (89.4%) are not member in any farmer group/association and only 17 (10.6%) are members in famer group/associations, this further hardens fast skills dissemination to farmers.

However, as an options for improvements, these findings have useful implications; first, to increase the number of extension officers with respect to proper provision of education to them. Second, there should be a deliberate strategic efforts to construct demonstration plots as they build a strong basis for adoption (seeing is believing). Third, there should be a reformation either from the previous or formation of new farmer-groups /associations, as they will give them vital power to address their concerns but also it's easy to get a help/assistance in group than individually. Fourth, there should be a low labour intensive method(s) designed for land conservations. This will be useful for adoption by those households with fewer people and hence increase land conservation for sustainable land uses.

3. Conclusion

In this study we have investigated sustainable land management technology practices on household food security in West Usambara Mountains. By using multiple linear regression that assessed household dietary diversity and independent T-test statistics that showed enough evidence ($p<0.001$) to reject null hypothesis (H_o) which states that; adoption of SLM technologies will not contribute significantly to household's food security in favor of the alternative. Therefore, the study conclude that in order to increase food security keeping soil health in place through practicing SLM is a necessary condition. In addition, the study covered lushoto district as among the most affected mountainous place in Tanzania. However, we recommend further studies to other affected mountainous places like Uluguru Mountains and others, so as to get the big picture for generalization.

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