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What Influences Farmers' Choice of Indigenous Adaptation Strategies for Agrobiodiversity Loss in Northern Ghana?

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Heavy dependence on the natural environment for agricultural production in northern Ghana adversely affects the availability of agrobiodiversity and in turn household livelihoods. Farmers have over the years developed strategies for adapting to reduction in agrobiodiversity but the extent of adoption varies among farmers. This study used the multinomial logit model to determine the factors influencing farmers' choice of indigenous adaptation strategies in response to agrobiodiversity loss in northern Ghana. The analysis is based on a sample of 310 farmers drawn from 31 communities in northern Ghana. The factors that positively influence the choice include household head's sex, farming experience, radio ownership, household size, borrowing credit and awareness of reduction in crop diversity. On the other hand, age, education, farm size, awareness of climate change, farm cash income and existence of market in community, negatively influence choice of strategies. Furthermore, farmer to farmer extension and off-farm income influence adoption either positively or negatively with respect to the adoption option in question. Thus, to encourage adaptation and conservation mechanisms, policies should strengthen farmer based organizations and promote education on the sustainable use of the natural environment. Government policies must also enhance access to off-farm income generating activities.

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1. INTRODUCTION

The United Nations Convention on Biological Diversity (UNCBD) [1] defines biodiversity as the variability among living organisms from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of within species, between species and of ecosystems. According to Brookfield and Paddoch [2], agrobiodiversity refers to the many ways by which farmers use the natural diversity of the environment for production, including choice of crops, as well as land and water management. The importance Agrobiodiversity cannot be overemphasized since it forms the basis of food supplies and raw materials for the manufacture of other products.

Agrobiodiversity is a component of biodiversity and its loss refers to the reduction of the components of biodiversity in and around agricultural land or farms, including absence of previously existing crops or crop varieties, and the reduction in crop yield (Thrupp [3]; Pascual and Perrings [4]). The concern about losses in agrobiodiversity has led many environmentalists, governments, and non-governmental organizations to assess ways of promoting biodiversity conservation (Jackson et al. [5]; Munzara [6]). This has resulted in the implementation of conservation measures against agrobiodiversity loss in northern Ghana.

The climate of northern Ghana is tropical with two seasons, a rainy season and a dry season. The rainy season extends from May to October, followed by the dry season which runs from October to April. The area falls within the Guinea and Sudan Savanna ecological zones. The savanna woodlands benefit the local climate and form a natural barrier to the desiccating harmattan winds, helping to maintain a favourable micro-climate for agricultural production in the southern parts of Ghana (Ministry of Lands, Forestry and Mines (MLFM) [7]). Agrobiodiversity in northern Ghana is however being threatened by bushfires, expansion of agricultural production, over-grazing as well as logging and charcoal production (MLFM [7]). Due to these and other climatic factors (e.g. high temperature, drought, and flooding), farmers are experiencing reduction in yields of staple food crops in the area as reported during the field survey.

Given the losses in agrobiodiversity in the area, adaptation has become necessary. Several agricultural adaptation practices and technologies have been outlined in literature (Thrupp [3]; Gyasi and Enu-Kwesi [8]; Gbetibouo [9]; Ngigi [10]; Deressa et al. [11]). The choice of any adaptation practice is mostly coupled with cultural diversity and local knowledge that support livelihoods of agricultural communities (Thrupp [3]). According to Stanturf et al. [12], low soil organic matter levels, intensification of land use for agricultural production and bushfires in the area have led to diminishing agrobiodiversity levels and have also resulted in some shortfalls in productivity. This paper therefore identifies the factors that influence farmers' choice of indigenous adaptation strategies as well as inform stakeholders about the issues that require more attention in addressing agrobiodiversity loss. The research findings reported in this paper would contribute to the development and shaping of policies to encourage enabling factors of agrobiodiversity conservation. The paper would also complement existing literature about the availability and applicability of indigenous adaptation strategies that promote agrobiodiversity conservation.

The rest of the paper is organized as follows: the literature review is provided in section two; section three describes the methodology used in the research, section three presents the results and discussion, and finally the conclusion and recommendations are presented in section four. This paper is a follow up to Armah et al. [13]. The scope of this paper is limited to northern Ghana which comprises the Northern, Upper West and Upper East regions.

2. LITERATURE REVIEW

Wolff [14] defines agrobiodiversity as a component of biodiversity that contributes to nutrition, livelihoods and the maintenance of habitats, in the context of agriculture. Agrobiodiversity can be grouped into (a) varietal/genetic diversity, (b) crops, animals and other species diversity and (c) farming systems/other agroecosystem diversity (Upreti and Upreti [15]). Agrobiodiversity contributes to the sustainability of agricultural production systems and is capable of enhancing livelihoods of resource poor farmers by ensuring food security and diversification of income sources. The economic, social and cultural value of biodiversity is still being discovered, but unfortunately, the ecosystems which host these bio-materials are continuously and systematically being destroyed rapidly (Munzara [6]).Agrobiodiversity loss refers to the reduction of the components of biodiversity in and around agricultural land or farms, including absence of previously existing crops or crop varieties and reduction in crop yield (Thrupp [3]; Pascual and Perrings [4]). It is, therefore, imperative to generate practical measures that will reduce the effects of agrobiodiversity loss. This can be done through the farmers' use of sustainable agricultural practices and other adaptation and coping strategies.

Adaptation involves the development and enhancement of strategies that in addition to coping with such events also reduce and take advantage of their effects. Levina and Tirpak [16] define a strategy as a broad plan of action that is implemented through policies and measures. According to UNDP [17], adaptation requires strategies for both short-term and long-term planning, and need a variety of responses as well as extensive resources to prevent future damages. Adaptation also needs to balance tradeoffs with sustainable development and poverty reduction efforts as well as disaster risk reduction (*ibid*). Several indigenous agricultural adaptation strategies have been discussed in literature (Gyasi and Enu-Kwesi [8]; Gbetibouo [9]; Ngigi [10]; Deressa et al. [11]). These indigenous strategies refer to the practices that have been developed through farmers' own knowledge as well as those practices that are passed on from one generation to another. Such indigenous practices include mulching, mixed cropping, crop rotation, application of manure, and land fallowing. Other indigenous strategies used to cope with agrobiodiversity loss are farmer-to-farmer extension and engaging in off-farm employment. In this paper, indigenous strategies have been grouped into land and crop management practices, livestock related activities, off-farm income generating activities, and production and marketing activities. According to Gbetibouo [9], a range of household or farmer characteristics, institutional factors, and other factors that describe local conditions influence farmers' adaptation choices. The characteristics of the household or farmer include sex, age, level of education, household size, years of farming experience, farm cash income as well as off-farm income. The institutional factors that influence adaptation include formal agricultural extension services, farmer-to-farmer extension, access to tractor services, access to electricity, access to markets and access to credit. Other factors such as access to climate information, rainfall, temperature, soil fertility among others have also been identified to influence adoption of agricultural technologies (Gbetibouo [9]; Deressa et al. [11]). However, these factors have different effects on adoption.

3. METHODOLOGY

3.1 Analytical Framework

The economic theory of adoption is based on the assumption that the potential adopter makes a choice based on the maximization of expected utility subject to prices, policies, personal characteristics, and natural resource assets (Caswell et al. [18]). As noted above, adoption of technologies by farmers depends on socio-economic characteristics of the farmers, factors that are subject to the type of intervention, and other infrastructural or institutional factors. There are many methods used to determine choice of options and these include the conditional logit model, multinomial logit model, nested logit model, repeated nested logit model, and the Copula based discrete choice model among others. The multinomial logit approach is used when the individual choices are discrete and consist of a set of alternatives, (van Dijk and Fok [19]; Paudel et al. [20]).

The multinomial logit model, an example of unordered choice models, can be motivated by a random utility model with the assumption that respondents maximize their utility in their decision making (Arovuori and Kola [21]; Greene [22]). An individual would therefore choose an alternative that they perceive to give the highest level of satisfaction among the other alternatives available. Unlike the binary logit models, the multinomial logit model allows analysis of decisions when more than two alternatives are involved, and makes possible the determination of choice probabilities for different categories (Madalla [23]).

To describe the multinomial logit model, let *Y* denote a random decision variable with values {1,2,…*J*} for a positive integer *J* and *x* a set of explanatory variables (Deressa et al. [11]). In this study the *Y* represents the alternative strategies for agrobiodiversity loss adaptation. The set of explanatory variables comprise the characteristics of the individual or household making the choice, characteristics of the alternative choices as well as other institutional characteristics.

Following Gbetibouo [9] and Deressa et al. [11], the multinomial logit model analyzes how the elements of x would affect the response probabilities $P(Y = j \mid X)$, *j=1, 2,…J*). Furthermore, the probability that a farmer *i* will choose an adaptation alternative j among the set of adaptation options could be defined as:

$$P(Y = 1 \mid X) = P(U_{ij} > U_{ik} \mid X) \quad (1)$$

Where U_{ij} and U_{ik} are the perceived utilities by farmer i of adaptation options j and k respectively with X_i being the vector of explanatory variables. Since the probabilities must sum to unity, $P(Y = j \mid X)$ would be determined once the probabilities for j=2,…J are known. The response probabilities of the multinomial logit model are;

$$P\left(Y = j \mid X\right) = \exp\left(X\beta_j\right) / \left[1 + \sum_{h=1}^{J}\left(X\beta_h\right), j = 1, \ldots J\right] \quad (2)$$

The parameter estimates of the multinomial logit model provide only the direction of the effect of the independent variables on the dependent variable; they do not represent actual magnitude of change or probabilities (Deressa et al. [11]).

The indigenous adaptation practices were categorized into the following four adaptation strategy options which represent the dependent variable.

a) Land and Crop management practices (which is used as the base strategy in the analysis)

    - Raising mounds and ridges
    - Mulching
    - Fallowing of land
    - Use of crop residues and manure application
    - Prevention of bushfires
    - Mixed cropping or farming
    - Crop rotation
    - Crop diversification
    - Timing of planting (i.e. to coincide with the onset of rains)
    - Regular weeding or pest control

b) Livestock related activities (i.e. production and sale of livestock)
c) Engagement in off-farm income generation activities

    - e.g., charcoal burning; pito brewing; petty trading; rice, shea (*Vitellaria paradoxa*) butter and dawadawa (*Parkia biglobosa*) processing; etc.

d) Production and Marketing strategies (i.e. combination of any two of the afore-mentioned strategies).

Since there is no apparent ordering of these alternatives, farmers' adaptation strategy is explained by estimating a multinomial logit model.

3.2 Choice and Measurement of Explanatory Variables

Literature reveals that the assessment and adoption of a strategy depends on the characteristics of the strategy and the perception of the adopter (Cooper and Zmud [24]; Damanpour [25]; Rogers [26]; Scott [27]; Caswell et al. [18]). The explanatory variables considered in this paper (as shown in Table 1) are grouped into;

i. Individual or household characteristics
ii. Characteristics to the subject of agrobiodiversity (e.g. awareness of agrobiodiversity)
iii. Institutional or infrastructural characteristics

Table 1. Explanatory Variables and Measurements[1]

Farmer characteristics/ Variables	Measurement	Mean
Sex of household head	Dummy; 1=female and 0=male	N/A[2]
Age of household head	Years	51.6
Educational level of household head	Dummy; 1=at least basic education and 0=otherwise	N/A
Experience in farming	Years	30.0
Household size	Number of persons	11.0
Ownership of radio set	Dummy; 1=Yes and 0=No	N/A
Farm cash income (crops or livestock)	Ghana Cedis	346.1
Off-farm income	Ghana Cedis	222.4
Farm size	Hectares	3.2
Subject Characteristics/variables	**Measurement**	**Mean**
Crop diversity reduction[3]	Dummy; 1=Yes and 0=No	N/A
Awareness of climate change	Dummy; 1=Yes and 0=No	N/A
Institutional variables	**Measurement**	**Mean**
Borrowing funds	Dummy; 1=Yes and 0=No	N/A
Access to farmer-to-farmer extension services	Dummy; 1=Yes and 2=No	N/A
Existence of market in community	Dummy; 1=Yes and 2=No	N/A

3.3 Data and Sampling Procedure

A multi-stage sampling technique was applied to select respondents for the study. Northern Ghana was purposively sampled because of the high incidence of agrobiodiversity loss. Two districts each were randomly selected from the Upper East and Upper West regions while four districts were randomly selected from the Northern region due to its relative size. In each of the districts, except the Kasena-Nankana East district where three communities were selected, four communities were randomly selected with ten households also randomly selected from each community. However, in some of the communities eight out of the ten selected households responded to the questionnaire. In all, the analysis in this paper is based on data from a sample of 310 farmers drawn from 31 communities in northern Ghana.

The data for this study was obtained through questionnaire administration to respondents at the producer and community levels. The producer level questionnaire sought for information including farmers' assets, household composition and income sources, access to infrastructure and credit, characteristics of respondents' farms and awareness about agrobiodiversity loss on their farms. The community focus group discussions involved community leaders (including assembly members, where available), opinion leaders, youth leaders, and other distinguished farmers. It covered demographic characteristics of the community, types of indigenous practices commonly used in the community for coping with agrobiodiversity loss, as well as their awareness of agrobiodiversity loss.

[1] Farmer characteristic variables relates to demographic variables and farm size, while subject characteristic variables relates to issues about agrobiodiversity.
[2] N/A refers to "not applicable"
[3]Reduction in crop yield and/or replacement of indigenous crop varieties with exotic ones (this leads to monotypic cropping patterns).

4. RESULTS

4.1 Adaptation Strategies

The indigenous mechanisms for coping with agrobiodiversity loss have been categorized into Land Management strategy; Crop Management strategy; Livestock related strategy; Off-farm activities; and Production and Marketing strategy. The results showed that 87.7% of the respondents used land management strategy, 84.9% used crop management strategy, 64.0% use livestock related strategy, and 31.0% used off-farm activities as means of adapting to agrobiodiversity loss. However, since land management and crop management strategies directly complement each other, they have been combined as Land & Crop management strategy. Table 2 presents a summary of the various practices that comprise each of the strategies and the percentage of producers who use them.

4.2 Factors Influencing Choice of Adaptation Strategies

The STATA software was used to estimate the multinomial logit model. Since the parameter estimates of the multinomial logit model provide only the direction of the effect of the independent variable on the dependent variable, the marginal effects are discussed in this paper. The Hausman test for independence of irrelevant alternatives (IIA) assumption failed to reject the null hypothesis that the strategies are independent of other alternatives and thus established the validity of the multinomial logit model for this study (Table 3).

The regression result for the multinomial logit model is presented in Table 4. In this study, land and crop management strategy was used as the base strategy because it is the most common adaptation strategy in the study area. The coefficient on sex is significant and positive, showing that female respondents were more likely to engage in off-farm income generating activities to adapt to agrobiodiversity loss. Older farmers were less likely to engage in off-farm income generating activities to adapt to agrobiodiversity loss. As the marginal effects show, an increase in the number of years of education of a household head is likely to reduce the likelihood of choice of off-farm income generating activities. Experienced farmers have a higher tendency of choosing off-farm activities as an option to adapt to agrobiodiversity loss on their farms. Ownership of radio is likely to increase the probability of adopting production and marketing strategies as well as off-farm activities. Large farm size has the tendency of reducing adoption of off-farm income generation activities. Borrowing of funds is likely to enhance the probability of adopting off-farm activities.

Farmers' awareness of climate change lowers the tendency of adopting off-farm income activities. On the contrary, awareness of reduction in the yield of certain crop varieties enhances the adoption of off-farm activities.

Table 2. Classification of Practices into Indigenous Adaptation Strategies

Land Management Strategy	**Percentage (%)**	**Crop Management Strategy**	**Percentage (%)**	**Livestock Related Strategy**	**Off-farm Activities**	**Production & Marketing Strategy**
Raising mounds and ridging	14.8	Mixed cropping or farming	33.9	Production and sale of livestock	Petty trading	Combination of any two of the three strategies;
Mulching	16.8	Crop rotation	17.4	N/A	Dress making	i.e.
Land Rotation (i.e. fallowing)	20.6	Timing of planting	20.0		Security watch	i). Land & Crop
Manuring (use of crop residues and/or animal manure)	34.2	Regular weeding or pest control	2.6		Shea butter and dawadawa processing	management strategy; ii). Livestock related strategy; and iii). Off-farm activities
Avoiding bushfires	1.3	Crop diversification	11.0		Pito (alcoholic beverage) brewing	N/A
N/A	N/A	N/A	N/A		Handicraft making Charcoal production	
Total %	**87.7%**	**N/A**	**84.9%**	**64%**	**31%**	**N/A**

Source: Field survey (2011)

Table 3. Hausman tests of IIA assumption

Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives				
(Storing estimation results as _HAUSMAN)				
Omitted	**chi2**	**df**	**P>chi2**	**evidence**
1	0.000	10	1.000	for H_o
2	3.769	3	0.287	for H_o
3	0.000	1	1.000	for H_o
4	0.000	13	1.000	for H_o
**** Small-Hsiao tests of IIA assumption				
Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives.				

Source: Authors' field data (2011)

Table 4. Marginal Effects of the Factors that Influence Adoption of Indigenous Strategies to Adapt to Agrobiodiversity Loss[4]

Variable	Livestock related strategy	Off-farm activities	Production & Marketing strategies
Sex	-0.0051	0.0002***	-0.0973
	(0.885)	(0.000)	(0.105)
Age	-0.0007	-0.00001***	0.0011
	(0.534)	(0.000)	(0.573)
Education	-0.0147	-0.00003***	-0.0284
	(0.525)	(0.000)	(0.567)
Farming experience	-0.0002	6.72E-6***	-0.0014
	(0.859)	(0.000)	(0.569)
Radio ownership	0.0266	0.0002***	0.1646 ***
	(0.399)	(0.000)	(0.001)
Household size	-0.0024	0.00002***	0.0056
	(0.374)	(0.000)	(0.212)
Farm cash income	-9.85E-7	-9.0E-8***	0.00003
	(0.918)	(0.000)	(0.436)
Off-farm income	-0.0454***	6.37E-8***	0.0322***
	(0.000)	(0.032)	(0.000)
Farm size	-0.0026	-8.48E-6***	0.0210
	(0.607)	(0.000)	(0.126)
Borrowing credit	0.0527	0.0001***	0.0945
	(0.151)	(0.000)	(0.409)
Awareness of climate change	0.0079	-0.00004***	0.0444
	(0.818)	(0.000)	(0.470)
Awareness of crop reduction	-0.0007	0.0002***	0.0395
	(0.980)	(0.000)	(0.387)
Farmer to farmer extension	-0.0176	-0.0002***	0.1163**
	(0.531)	(0.000)	(0.020)
Market	0.0050	-0.0002***	0.0520
	(0.842)	(0.000)	(0.317)
Observation	310		
Wald chi2(42)	4550.15		
Prob >chi^2	0.0000	Note: ***significant at 1%; ** significant at 5%	
Pseudo R^2	0.2961		

Source: Field survey (2011)

[4]*The base strategy is Land and Crop Management*

Farmer to farmer extension services reduces the likelihood of adopting off-farm income generating activities whereas it increases the probability of adopting production and marketing strategy. Access to markets was observed to reduce the likelihood of engaging in off-farm income generating activities. Also, farm cash income is negatively associated with the likelihood of engaging in off-farm activities for agrobiodiversity loss adaptation.

As expected, the results show that farmers who also engage in off-farm employment will be more willing to utilize that option to adapt to agrobiodiversity loss. They also have a higher tendency of adopting production and marketing strategies. Off-farm income however limits the adoption of livestock related activities as compared to adopting land and crop management practices.

5. DISCUSSION

The land and crop management strategy includes about ten practices. About thirty four percent of the respondents practice the use of manure which comprises incorporation of crop residues back into the soil as well as the use of animal manure such as cow dung. Manure improves soil structure and encourages soil microbial activity for retention of moisture and nutrients to increase fertility. Some of the respondents also practice mulching. The materials used as mulch are mainly plant materials, and these cover and protect the soil surface to conserve soil moisture as well as reduce the effects of erosion. The plant materials when degraded add to the nutrient content of the soil.

More than half (i.e. 64%) of the respondents sampled engage in livestock production as a means of adapting to agrobiodiversity loss. Livestock production and sale provide work throughout the year and acts as a source of income for farmers. It also helps in supplementing the food needs of household member. Also, manure from livestock can help maintain soil fertility and increase crop productivity.

About 31% of the respondents also engaged in off-farm income generating activities as a means of coping with agrobiodiversity loss. Income obtained from off-farm activities could be used to support the livelihood of households in terms of food purchases and meeting of other needs. Charcoal production and sale was one of the off-farm activities that some farmers engage in as a coping mechanism. Charcoal production involves harvesting fuel wood either from woodlots or felling of trees and burning them to obtain charcoal. Even though farmers earn income from the sale of charcoal, the process of charcoal production is a potential threat to conservation of agrobiodiversity.

Although bushfires threaten the survival of crops, contribute to land degradation as well as reduce the suitability of soils for crop support, only a few of the respondents adopt bushfire control practices. A fifth of the respondents use other land management practices such as land rotation, which helps in breaking crop pest and disease cycles, and raising of mounds and ridging which loosen the soil and enhances water holding capacity for development of roots.

About thirty four percent of the farmers practice mixed cropping or farming as a means of adapting to agrobiodiversity loss. Growing different types of crops on a farm enhances their survival by acting as an insurance against crop failure that could be caused by crop pests and diseases. Furthermore, on farms where crop production is integrated with livestock production, crop wastes may be used to feed livestock while animal wastes may serve as manure. The livestock could also provide power in agricultural production as a means of traction on farms and carting of agricultural produce from farms. Rainfall in northern Ghana is low and variable both spatially and seasonally, and imposes a delicate balance between the onset, duration and amount of rain and the timing of agricultural activities (Yengoh et al. [28]). Timing of planting to correspond to the onset of rains is widely used in the area.

Women were found to engage in most off-farm income generating activities such as pito brewing, and dress making to obtain additional income.[5] Traditionally, women in northern Ghana do not own land and are discouraged from growing certain types of crops (e.g. cash crops and main cereal crops). Nonetheless, women have the responsibility of catering for the needs of their children and other household necessities, and this compels them to engage in other income generating activities. Older farmers are more likely to engage in farm activities (Deressa *et al*. [11]), rather than carry out off-farm activities which are often undertaken outside their community of residence.

Though the results show that an increase in the number of years of education reduced the probability of engaging in off-farm income generating activities in favour of crop and land management, an educated person may diversify income sources by engaging in other income generating activities in addition to agriculture. Experienced farmers have high skills in farming techniques and increased likelihood of using portfolio diversification as well as spread risk among activities (Nhemachena and Hassan, [29]).Some radio stations in the study area broadcast agricultural programmes to educate farmers on better farming practices which in turn promote agrobiodiversity conservation on farms. Radio ownership is also an indicator for wealth, which tends to enhance farmers' adaptation (Deressa *et al.* [11]).

The observation that larger households were more likely to adopt off-farm activities is contrary to the expectation that household members would complement labour requirements on farms, and would engage in activities like raising mounds, ridging, application of manure and weeding which are all labour intensive activities. However, lack of employment opportunities, high population and poor living conditions have resulted in the migration of labour out of the area to engage in off-farm income generating activities.

The result for farm size is consistent with that of Gbetibouo [9] which asserts that large-scale farmers are more likely to adopt agrobiodiversity adaptation strategies because they have more capital and resources (e.g., Gbetibouo [9]). The report from the focus group discussions also proved that farmers who borrow money either use it to meet instantaneous consumption needs or invest in other off-farm activities due to risk of reduced productivity on their farms. As stated earlier, climate change has the tendency of reducing the availability of agrobiodiversity on farms through events of drought and floods.

Even though awareness of reductions in crop yield enhances adoption of off-farm activities, the probability of adoption (as shown in Table 4) is small. This is because farmers may also adapt to reductions in crop yield by engaging in diversification measures involving crop rotation, mixed farming as well as application of manure to increase crop yield. Obtaining extension services about farming practices that have been tried and approved by other farmers will induce farmers' implementation of such practices to increase agrobiodiversity levels on their farms. Knowledgeable farmers within communities gather information from multiple sources and are a good source of effective farmer to farmer extension services (Deressa et al. [11]).

[5] *Pito is a local alcoholic brew made from Sorghum*

Farmers' access to market is a channel for enhancing the sale of agricultural produce; this would therefore induce farmers to adopt better agricultural practices to increase yield of output both for sale and for consumption. It was reported through the community focus group discussions that market places in the area are centres for social interaction among farmers who, apart from buying and/or selling, also engage in information sharing about better farming practices. Farm households that earn more income from their farming activities are likely to increase agricultural production in order to increase output. Gbetibouo [9] states that wealthier households are more willing to adapt by adopting such crop management practices (e.g. changing planting dates).

Farmers' engagement in off-farm employment may serve as a proxy for the amount of time available for farming activities (Gbetibouo [9]. Therefore, households with more off-farm income may be likely to continue with those activities, and due to the resulting wealth effect, they may also have the likelihood of adopting other additional strategies to adapt to agrobiodiversity loss.

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

In this study, multinomial logit model was used to determine the factors that influence farmers' choice of adaptation strategies to agrobiodiversity loss. The analysis used data obtained from a survey of smallholder farmers as well as community focus group discussions in northern Ghana. The factors reported to influence adaptation positively include respondents' sex, farming experience, radio ownership, household size borrowing credit and awareness of crop reduction. Also, age, education, farm size, awareness of climate change, farm cash income and existence of market in community, negatively influence choice of strategies with respect to land and crop management practices (i.e. the base strategy). Furthermore, farmer to farmer extension and off-farm income influence adoption either positively or negatively with respect to the adoption option in question.

In northern Ghana, apart from helping with farm work, women mostly engage in other forms of employment (e.g. charcoal production, pito brewing and handicraft production) to generate more money for their households. Women's livelihoods are dependent on natural resources. Therefore, policies should encourage education on the sustainable use of resources in the context of cultural practices and societal norms. Since farmer to farmer extension services were observed to enhance adoption of land and crop management strategies, government policies must promote the use of farmers' indigenous knowledge for the conservation of agrobiodiversity.

Government, Non-Governmental Organizations (NGOs) and other stakeholders must develop and promote educative radio programmes to create awareness on the benefits of conservation as well as educate farmers on better farming practices. Furthermore, off-farm income generating activities such as handicraft production and others that create demand for rural products must be promoted since they may enhance income as well as rural development. Government must also develop markets to enhance sale of agricultural products, thereby increasing farmers' income and serving as a means to Agrobiodiversity loss adaptation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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