

# **Perceptions and Determinants of Adoption of Indigenous Strategies for Adaptation to Climate Change: Evidence from Smallholder Livestock Farmers, North-West Ghana**

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## **Abstract**

Given the challenges that climate variability and change brings to bear, farmers adopt certain measures in order to adapt to their environment. Some of these measures include planting certain tree species for livestock feeding and the creation of a fencing material to kraal livestock by planting shady trees. This provides a local climate for the wellbeing of insect fauna which helps to build soil properties such as decomposition of organic materials, maintaining soil moisture content, etc. This paper used both qualitative responses in the form of Focus Group Discussions in eight communities to obtain farmers' indigenous perceptions of climate change, and quantitative methods, multinomial logit model, to analyse the factors that influence the adoption of indigenous adaptation strategies to climate change among livestock farmers in North-West Ghana. A semi-structure questionnaire was administered to 200 randomly selected livestock farmers in two districts of Upper West region. Four categories of indigenous adaptation strategies were identified. These are Feed, health, house and breed related strategies. The health related strategy was used as a based category. The results from the Focus Group Discussions revealed that farmers have used the occurrence of thunder and lightning, fruiting time of certain tree species, germination of certain grass species during certain periods of the year, appearance of certain insect and bird species, nature of the moon and appearance of rainbow to locally estimate the change in climate. Further empirical results showed that the factors that statistically and significantly influenced the decision by smallholder livestock farmers to adopt indigenous adaptation strategies were noticed climate variability, number of extension contacts, time to market, access to credit, flock size, household size and number of livestock types diversified. Based on these findings, policies that will enhance farmers' knowledge on climate variability should be encouraged. Also, farmers should be encouraged to intensify the diversification of the livestock species they rear.

**Keywords:** indigenous adaptation strategies, adoption, climate change, multinomial logit, North-West Ghana

## **1.0 Introduction**

Climate change has a heavy impact on resources that are highly sensitive, and agriculture is one sector (Barnett *et al*, 2007). There is global consensus about the adverse effects of climate

change on agriculture and food production (Gatiso, 2015). The contribution of livestock to the economy of Ghana cannot be over emphasized-as its contribution to the agricultural GDP was 7.5% (MOFA 2013). Findings like Rotter and vandeGeijn, (1999), Houghton *et al.*, (2001), Seo and Mendelsohn, (2006), Nardon *et al.*, (2010) and Upadhyay *et al.*, (2016) reported negative impact of climate change on livestock especially in semi-arid areas like North-West Ghana.

Due to the impacts of climate change, there is growing interest in farmer perceptions and local knowledge about climate change. For these reason, they adopt conservation practices that preserve the environment and the species and breeds of livestock that are reared by livestock keepers. Farmers after perceiving changing climate, are not able to afford the cost of introduced adaptation strategies, and therefore rely on the traditional measures as ways of adapting to the adverse effects of climate change and variability.

The measures adopted, indigenous in nature, cuts across livestock production sectors such as feeding, health, breeding and housing strategies. An indigenous adaptation strategy is a type of strategy developed and used by local farmers to adapt to perturbations of climate change (Kihila, 2017), while the introduced strategy is the improvement being made to farmers' indigenous strategies by development partners and introduce to farmers to adopt (Tabbo and Amadou, 2017). Adoptions of these adaptation strategies are therefore influenced by local perceptions about the existence of climate change and a host of factors, and Nhemachena and Hassan (2008), Hassan and Nhemachena (2008), Deressa *et al.* (2010), Baffoe Asare *et al.* (2013), Ngombe *et al.* (2014) and Ghimire *et al.* (2015) has elaborated several factors that affect adoption decisions. However, most of these factors have been skewed towards crop farmers without considering its relationship with livestock farmers. Motivated by this research gap, this study, having identified the livestock indigenous strategies, examines the indigenous perceptions of climate change and the factors that are responsible for the adoption of the strategies.

## **2.0 Methodology**

### **2.1: Focus Group Discussions**

The purpose of the Focus Group Discussions (FGDs) was to obtain information on local perceptions and knowledge on climate change and identify livestock related climate change and variability adaptation strategies. Prior to the start of the FGDs, a team comprising a facilitator, a note taker and an observer was trained on how to obtain information during the FGDs. There was also a meeting with key people in the communities to inform them the purpose of the research. Community mobilisation was conducted through which the team invited 10 livestock farmers each of the male and female category. Meetings were conducted for each group of male and female participants in eight (8) communities.

### **2.2 Theoretical Framework**

The theoretical framework behind this study is the utility theory. This is important because, it gives an accurate understanding of the probabilities. It also motivates and makes distinctions among the alternative model specifications. Finally, it provides the theoretical basis for calculation of changes in consumer surplus from changes in the attributes of the alternatives. This theoretical framework which is based on the random utility model as specified by Green (2003) is specified as follows:

$$U = X\beta + \varepsilon \tag{1}$$

Where U denotes a farmer's decision to adopt an adaptive strategy.

X=Explanatoryvariable

$\beta$  = Parameter to be estimated

$\varepsilon$  = the error term

Assuming  $Y_a$  and  $Y_b$  are a smallholder livestock farmers' utility of two choices, which can be represented as  $U^a$  and  $U^b$ . For example,  $U^a$  could be the utility derived from Feed Related Strategies while  $U^b$  could represent the utility derived from Health Related Strategies. The choice by the farmer between the two strategies indicates which one provides a higher utility; the farmer's utility is however latent. Hence the observed indicator is equal to one (1) if  $U^a > U^b$  and zero (0) if  $U^a \leq U^b$ .

A common formulation is the linear random utility model, specified as:

$$U^a = X' \beta_a + \ell_a \quad (2)$$

$$U^b = X' \beta_b + \ell_b \quad (3)$$

Factors involving choices are obtained by using the multinomial models. There are several types of such models but for ease of computation, this study adopted the multinomial logit model.

Following from (Greene, 2003) a smallholder livestock farmer choosing for example an indigenous feed related strategy is modeled to be a function of three main characteristics: socioeconomic, institutional and environmental characteristics as shown in equation (1).

That is, the probability that an  $i^{th}$  smallholder livestock farmer chooses a  $j^{th}$  climate change adaptation strategy is given as:

$$Prob(Y_i=1) = \frac{e^{\beta_j X_i}}{\sum_{k=1}^3 e^{\beta_k X_i}}, \quad j=0,1,\dots,3 \quad (1)$$

Where  $\beta_j$  is a vector of coefficients;  $X_{i_s}$  are the exogenous variables,

Assuming  $\beta_0 = 0$ , equation (4) will be normalized to remove indeterminacy and the probability estimated as follows:

$$Prob(Y_i = 1|X_1) = \frac{e^{\beta_j X_i}}{1 + \sum_{k=0}^3 e^{\beta_k X_i}}, \quad j=0,2,\dots,J, \beta_0 = 0. \quad (5)$$

Estimating Equation (5) using maximum likelihood method yields the log-odds ratio presented in

Equation (6):

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = X_i(\beta_j - \beta_k) = X_i\beta_j, \quad \text{if } k = 0. \quad (6)$$

Where:  $P_{ij}$  = Maximum utility that the  $i^{th}$  smallholder livestock farmer gains in choosing the  $j^{th}$  adaptation strategy over the  $k^{th}$  adaptation strategy;

The choice of any adaptation strategy to climate change is therefore the log-odds in relation to the base alternative, non-adopters. According to Green (2003), the coefficients of the multinomial logit are difficult to interpret and associating  $\beta_j$  with the  $j^{th}$  outcome is tempting and misleading. Instead, the marginal effects are usually derived to explain the effects of the exogenous variables on the endogenous variable in terms of probabilities as presented in Equation (7).

$$\frac{\partial P_j}{\partial X_i} = P_j \left[ \beta_j - \sum_{K=0}^J P_k \beta_j \right] = P_j (\beta_j - \bar{\beta}) \quad (7)$$

The marginal effects measure the expected change in the likelihood of choice of a particular climate related strategy with respect to a unit change in an exogenous variable (Green, 2003).

## 2.2 The Empirical Model

Probit and logit models are the most common models used by researchers (Hausman and Wise, 1978; Wu and Babcock, 1998) to identify and quantify the effects of factors that influence the adoption of agricultural technologies; this is due to the nature of the dependent variable. The dependent variable can take on two or more variables. If it takes two variables, then binary logit or probit models are appropriate. The multinomial logit (MNL) or multinomial probit (MNP) is the preferred model to use over the binary logit or probit models if the dependent variable takes on more than two variables.

We considered the multinomial logit because there is high probability of farmers adopting more than two strategies in the study area. The multinomial logit model is chosen for this study over MNP because it is widely used in studies involving multiple choices; it is also easier to compute (Hassan and Nhemachena, 2008; Karki and Bauer, 2004).

The multivariate analysis involved the use of the multinomial logit model to analyse the predictors of climate change perceptions (Teyeet *al.*, 2015). The multinomial logit model was used to determine the factors that influenced the adoption of climate related technologies introduced by research (Etwireet *al.*, 2013). Deressaet *al.* (2010) adopted the MNL model to analyze the factors affecting the choice of coping strategies in response to climate extreme events in the Nile basin of Ethiopia. According to them, the advantage of MNL is that it permits the

analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories.

Kurukulasuriya and Mendelsohn (2006) employed the multinomial logit model to see if crop choice by farmers is climate sensitive. Similarly Seo and Mendelsohn (2006) used the multinomial logit model to analyze how livestock species choice is climate sensitive.

In this study therefore, the dependent variable are the adaptation strategies identified, which are unordered to justified the use of ordered logit and probit, and so, the use of the multinomial logit is justified. The strategies adopted by smallholder livestock farmers in adapting to climate change and variability are broadly categorized into five (5) main groups namely, Feed Related Strategies (FRS), Health Related Strategies (HRS), Housing Related Strategies (HRS) and Breed Related Strategies (BRS). The fifth category, worth considering is the category of livestock farmers who did not adopt any adaptation strategy usually referred to as Non-adopters (NoA). Each of these strategies was identified by reviewing literature, conducting focus group discussion and key informant interview at the community level. Each farmer was then asked to list the adaptation strategies they use in their farming activities to ensure effective livestock improvement in the face of climate change. A farmer may be using more than one strategy at a time. Descriptive statistics represented in the form of bar charts was used to show the percentage of farmers using each strategy.

The empirical model specification is therefore specified as:

$$Y_{ij} = \beta_0 + \beta_1 CV + \beta_2 ExtCts + \beta_3 TMkt + \beta_4 Crdt + \beta_5 FrmSZ + \beta_6 LvskD + \beta_7 HSZ + \beta_8 EDUC + \varepsilon \quad (2)$$

Where  $i$  = smallholder livestock farmer and  $j$ = adaptation strategies

Descriptive statistics represented in the form of pie chart was used to show the degree of farmers who used each strategy.

### 2.3 Sources of Data and Sampling Procedure

Data used in this study was collected through primary and secondary sources. Primary data was collected through focus group discussions (FGDs) and individual farmer interviews. Prior to this, a reconnaissance survey was conducted in some selected communities. This provided a platform where farmers were engaged to collect information about their farm activities. The visited communities, Metor, Naburnye, Orbilli and Kasalgre in the Lawra district and Zedung, Wallanteng, Zimoupare and Segru in the Nandom district, were among the selected communities in which Climate Change, Agriculture and Food Security (CCAFS) projects are undertaken.

A multi-stage sampling technique was applied in sampling respondents for this study. Upper West region was purposively selected and again, two (2) districts, Lawra and Nandom, were purposively selected, because an intervention project dubbed “Adaptation at Scale in Semi-Arid (ASSAR) project was being implemented in these districts. Each district was then stratified into

four strata. The basis of using stratified sampling was to group the CCAFS communities, from which the sample communities will be chosen, so that one community will be randomly selected from each group. Simple random sampling technique was used to select one community from each stratum making a total of eight (8) communities. Again, simple random sampling technique was used to disproportionately select 25 smallholder livestock farmers from each community, making a total of two hundred (200) livestock farmers. Structured questionnaires were administered to each of these 200 smallholder livestock farmers.

### 3.0 Results and Discussions

The four main strategies that were identified during the research work include feeding, health, breeding and housing strategies. Under the indigenous feeding strategies, because of climate change, feed has become very scarce, so farmers adapt to the changing climate by giving small quantities of feed to their animals when feeding their livestock. They then start to add small quantities of the feed as the livestock finish eating. This method is adopted to prevent feed wastage.

To store feed, sheds are usually constructed in front of the farmers' house so that lots of feed are collected during the ending part of the wet season and stored on the sheds for dry season feeding.

On indigenous health strategies, farmers treat wounds of animals by applying a solution of sooth on the affected area of the animal. Some farmers even use the sooth, by drenching, to prevent diarrhoea among livestock.

On breeding strategies, the farmers find it very easy to adopt and manage the indigenous (West African Dwarf goat/sheep and the West African Short Horn type of cattle) because of their adaptability to West African climate. As a result of feed scarcity in recent times, one of the indigenous breeding methods apply by farmers adapt to climate change is by reducing the number of their flock to levels that can easily be managed. They do so by selling off some of them. Table 3.1 entails details of the broad and sub-strategies.

**Table 3.1: Identified Indigenous Strategies**

Type of Strategy	Description of Strategy/sub-strategies
Indigenous Feeding	<ul style="list-style-type: none"> <li>➤ Adjustment of the quantity of feed given to animals</li> <li>➤ Use of agricultural by-products such as yam and cassava peels, groundnut haulms, soyabean haulms, leaves of fic tree as livestock feed (Konlanet <i>al.</i>, 2014).</li> <li>➤ Use of fruits from FaidherbiaAlbida (goat biscuit tree)</li> <li>➤ Storing of feed on top of locally constructed sheds for dry season feeding</li> </ul>
Indigenous Health	<p>It is the use and application of traditional medicine for the treatment and vaccination of animals</p> <ul style="list-style-type: none"> <li>➤ Wounds of livestock can be treated by using barks of certain tree species (Khan <i>et al.</i>, 2013).</li> </ul>

	<ul style="list-style-type: none"> <li>➤ Wounds are also treated by applying a solution of “duulang”. Duulang is a local name given to accumulated smoke (sooth). The sooth is usually harvested from the walls of the kitchen. Since the source of energy for cooking is usually from firewood, smoke can easily gather on the kitchen walls.</li> <li>➤ Certain types of leaves of trees (locally called bagna) when pounded into a paste and mix with water can be used to drench livestock to control diarrhoea.</li> <li>➤ Leaves of “gorgor”, a type of tree, is use as a dewormer to deworm livestock.</li> </ul>
Indigenous Breeding	<ul style="list-style-type: none"> <li>➤ The indigenous ones were best identified as local breeds and the introduced as improved (Fulani type) breeds</li> <li>➤ Keeping of sizeable number for easy management</li> </ul>
Indigenous Housing	<p>An indigenous house/pen has a:</p> <ul style="list-style-type: none"> <li>➤ A pen without a yard,</li> <li>➤ with no window or opening to allow for ventilation</li> <li>➤ Small entrance</li> </ul>

**Source: Field Survey (2016)**

Other efforts being made to adopt include the prevention of bush burning/fire and the performance of traditional prayer for rains to come. Traditional prayer is in the form of consulting the gods and asking the gods for good rains and bumper harvest.

### **3.1: Indigenous Perceptions of Climate Change**

#### **3.1.1: Local Knowledge on Climate Change**

Participants of the Focus Group Discussion (FGD) were asked about their knowledge of climate change and variability. The confirmations that climate change and variability do exist was based on shift in rainfall onsets and durations, change in timings and irregular fruiting of certain tree species, stronger winds in recent years than some 20 years ago, drought and sunshine intensity. They postulated that, about some 20-30 years ago, the rains used to start in February/March and end in October/November, but now it starts in May/June and ends in September/October.

Seasonal variability of rainfall in recent years shows that, the rains now stop early. Though, located in a semi-arid environment, the study area used to observe substantial rainfall in November, but for more than fifteen (15) years now, it has not been raining in the month of November. Also there are lots of stronger winds now due to rampant deforestation and less afforestation activities. This exposes the environment to stronger winds. The strong winds which used to occur at the beginning of the rainy season (March) now occur burly two to three months (August) into the rainy season.

In addition, averagely, drought used to last for at most two (2) weeks, but now, it is very common to stay with drought for as long as two (2) months. It has also revealed that sunshine intensity and temperature are on the increase.

Irregular fruiting of trees nowadays is also a sign of the change in climate. Common among the trees include mangoes and ackee apple (*Blighiasapida*). The ackee apple is locally called by the people of the study area as “Achiapoo”. This tree used to fruit in March but now fruits in October, a vast change in fruiting time. The name, “Achiapoo” could have locally derived from Ackee apple.

**Picture 1: Fruits of Achiapoo Tree**



**Source: Field Survey (2016)**

Depletion of soil fertility and loss of biodiversity is another confirmation that the climate has change. We used not to apply fertilizer to our crops, but in the past 30 years, it is not uncommon to have a low harvest if you do not apply fertilizer.

Another important observation of climate change is the onset of harmattan. Harmattan is the hot, dry and dusty wind that blows from Northeastern part of West African Sahara, causing cracks on human body and usually very cold (9°C) in the early hours of the morning and steadily rises to 30°C during the day. The study revealed that some 20-30 years ago, the harmattan period used to be from January to February, but it now sets in from late October or November to end of February or early March.

### **3.1.2: Local Knowledge or Perceptions that Indicates or give a Forecast of Future Climate**

This analysis was based on six indicators during a Focus Group Discussion sessions. These include thunder and lightning, germination of certain grass species, appearance of certain insect and bird species, nature of the moon and appearance of rainbow.

The first local knowledge about the existence of climate change is the occurrence of thunder and lightning. In the past, thunder and lightning was used to indicate that millet was about to mature. This observation is still been used by crop-livestock farmers in the study area. Also, when thunder and lightning occurs it is spiritually aligned to harming/striking someone having done something bad, and which is culturally unacceptable in the society. It also revealed that thunder and lightning could be used to determine whether the rains will cut short or stay longer.

Secondly, the germination of “kerekere grass” indicates that there will be good harvest that year respectively. Germination of Makumpagsule, Gemiea, Miea and bolo grasses in the past shows high rainfall. The grass germinates with the onset of the first rainfall. On the other hand, the appearance of the grass species, “duorongduorong” shows that the dry season is imminent.



Furthermore, the Appearance of grasshoppers at the beginning of rains is an indication of good rainfall. Also, birds' type locally known as Chipele, Zier and Pempele appearing prior to the onset of rains indicates that, the rains will start early and there will be more rains during the season. White birds that follow cattle signify imminent of rainy season. A type of bird called "Dachir" if seen at the beginning of the rainy season shows that there will be bumper harvest of maize.

In addition, the appearance of insect type called "Zulu" signifies onset of early rainfall and the rains will extent further. This method is still been used by the people. The appearance of other insect species that signifies rainfall includes Pachi, fiifi and ants from termitarium. However, the appearance of butterfly-like insects' type called "Walpempole" and "Tantulu" shows that there will be low rainfall. Also, when an insect type called "Brugmanyili" is seen, it shows that the dry season is imminent. The appearance of rainbow is also an indication of no rainfall and also signals that the wet season is coming to an end.

Though not scientifically proven, it has been observed that, in the moon, there are two objects, when observed critically especially at night, that indicate the dry and rainy season, one is to the east and the other to the west. The eastern one (dry season) pushes the western one (rainy season) away and sets in as dry season. The opposite is true when rainy season sets in.

Finally, if the moon appears sharply and quickly at night, it shows good rainfall and that it is likely to rain, but if it comes slowly in a curvature movement, it shows low rainfall and that it is most likely not to rain.

### **3.2: Factors Influencing Adoption of Indigenous Strategies for Climate Change Adaptation**

There were four dependent and eight independent variables that were considered in this multinomial logit model. These independent variables were considered for the model after multicollinearity test was conducted using the Variance Inflation Factor (VIF) approach. This allowed us to drop some variables such as gender of the farmer, noticed decrease in rainfall amounts, etc. Thus, variables that did not fall below the tolerance value of less than 0.4 and more than the VIF value of 2.5, as proposed by Allison (1999) were retained. Therefore multicollinearity did not pose any problem to the model. The Wald chi square ratio was 70.35, with the overall model been significant at 1%. The Hausman test of Independence of Irrelevant Alternatives (IIA) was conducted and the result showed that the IIA was not violated, justifying the suitability of the multinomial logit model for the data set. Since the coefficients only provide the magnitude of the change in the dependent variable due to a unit change in the independent variable, the marginal effects which was considered for discussion, provides both magnitude and direction of change. The marginal effects of the model are shown in Table 3.2. The health related strategies were used as the base outcome. That is any other adaptation strategy was used to compare with the health related strategy.

Noticed climate variability, number of extension contacts, time to market and access to credit by smallholder livestock farmer were the factors that influence the decision to adopt feed related strategies. Also, only flock size and household size positively and negative influence respectively, the decision to adopt breed related strategies, and finally noticed climate variability,

time to market and number of livestock type diversified were the factors that influenced the used of house related strategies.

**Table 3.2: Marginal Effects (ME) of Factors Influencing Indigenous Adaptation Strategies**

Independent Variables	Feed Related Strategies ME	P-value	Breed Related Strategies ME	P-value	House Related Strategies ME	P-value
Noticed climate variability	0.0744** (0.9811)	0.007	0.0221 (0.4703)	0.122	0.0987** (1.1354)	0.008
Number of extension contacts	-0.0402*** (-0.4334)	0.000	-0.0075 (-0.1112)	0.637	0.0062 (-0.0161)	0.742
Time to market	-0.0346*** (-0.3990)	0.000	0.0089 (-0.0381)	0.672	-0.0257*** (-0.3098)	0.000
Access to credit	-0.0991** (-1.3196)	0.002	-0.0687 (-0.6179)	0.365	0.0464 (0.1751)	0.742
Farm/Flock size	-0.0039 (0.0136)	0.959	0.0291* (0.2078)	0.062	0.0038 (0.0820)	0.666
Number of livestock type diversified	-0.0055 (-0.0594)	0.659	-0.0331 (0.1711)	0.938	-0.0334* (-0.2998)	0.081
Household size	-0.0083 (-1.0736)	0.271	-0.3787*** (-2.2437)	0.000	-0.0124 (-1.1055)	0.309
Years of education	-0.0068 (-0.0767)	0.221	-0.0014 (-0.0231)	0.689	-0.0007 (-0.0216)	0.920

Base outcome: Health Related Strategies

Number of observations: 200

Pseudo R<sup>2</sup>: 0.138

Log Pseudo Likelihood: -258.71

Wald Chi<sup>2</sup>: 70.35

Prob> Chi<sup>2</sup>: 0.002

\*\*\*, \*\* and \* denotes statistical significance at 1%, 5% and 10% respectively

Source: Field Survey, 2016

\*Figures in parenthesis are the co-efficients of the explanatory variables

The probability of adopting the indigenous feed related strategies as against the indigenous health related strategies as climate change adaptation strategy increases by about 7.4% if a smallholder livestock farmer with past livestock rearing experience noticed climate variability. One way that our environment can be conserve is by an interplay of climate variability, pasture productivity and livestock feeding. Climate variability can lead to poor pasture production which is used as browse plants for livestock feeding. The effect of this could have led to farmers adopting adjustment measures when feeding livestock. If there is inadequate or lack of feed for livestock feeding, productivity would be affected since a significant number of livestock would

die of hunger. This is contrary to findings that a smallholder farmer is about 17% less likely to adopt soil and plant health strategies if temperatures are unpredictable (Etwireet *et al.*, 2013). Unpredictability of temperatures could influence farmers to notice climate variability.

Number of extension contacts received by a livestock farmer significantly and negatively reduces the decision to adopt feed related strategies by about 4%. The opportunity cost of spending time with an Agricultural Extension Agent (AEA) to be trained to adopt an introduced feed related strategies could be used by farmers to practice what they already know regarding feeding of their livestock such as the adjustment of the quantities of feed given to animals, planting of tree species for (lean season) livestock feeding, etc. The findings is different from Etwireet *et al.* (2013), Hassan and Nhemachena (2008) who opined that if farmers get access to extension service, their possibility of adopting improved breeds and varieties, mixed mono crop-livestock systems under dryland and irrigation as an adaptation response to climate change would increase.

Average time to market reduces the probability of adopting the feed and house related strategies as an adaptation option to climate change by about 3.5% and 2.6% respectively. Average time to market influences the decision to adopt introduced strategies. In most cases, inputs such as medications for treating livestock diseases, prepared ration or concentrate feeds are found at input market centers. If the market centers are too far to farmers' reach, they would not get access to these inputs that will help them to increase their productivity. This finding is in line with Hassan and Nhemachena (2008) who found distance to market to be significant and negatively influence the decision to adopt mixed-mono and multiple crop-livestock systems under irrigation as an adaptation strategy, but goes contrary to Barley *et al.* (2017) who found access to market to be significant and positively affects farmer input use intensity.

Access to credit reduces the probability of adopting the feed related strategy as an adaptation option to climate change by about 9.9% respectively. This can be attributed to the fact that minority (20%) of the farmers have access to credit. This is contrary to Hassan and Nhemachena (2008) as they opined that access is credit significantly and positively influence farmers' decision to adopt mixed mono crop-livestock systems under dryland as an adaptation option to climate change.

The results of this study also show that smallholder livestock farmers in the region with an average farm/flock size of eight (8) goats for example, have a 2.9% chance of choosing the indigenous breed related strategies as against the indigenous health related strategies. Majority (92%) of the farmers adopted the local breeds and the application of indigenous practices such as the "duulang"- an accumulated smoke (sooth) in the treatment of diarrhoea and wounds could have been the reason of the low average livestock numbers as compared to the national average of 12 (GSS, 2014). This is not a good practice as far as conservation and sustainable livestock production is concern. The findings is in line with Etwireet *et al.*, (2013), Barley *et al.*, (2017), Hassan and Nhemachena (2008) who found that farm size has a significant and positive influence on the decision to adopt a recommended agricultural practice such as planting different fodder trees, integrating crop with livestock production and mixed mono crop-livestock system under dryland respectively as an adaptation option to climate change and variability by smallholder farmers in northern Ghana.

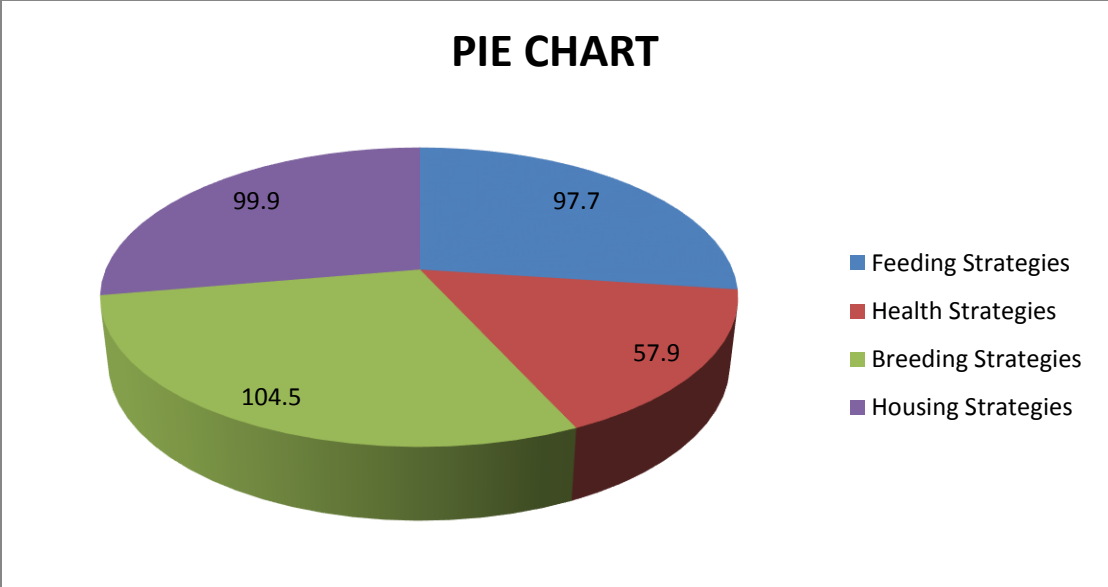
The probability of choosing the indigenous breed related strategy as against the indigenous health related strategy as a climate change adaptation option reduces by about 38% as household size of the farmer increases. Increase in household size means that, the needs of household members would increase especially as school fees of those who attends school would have to be paid, payment of hospital bills and what have you. Therefore, it makes it very difficult for livestock owners who are mostly the heads to expand their production by adopting more breed related strategies such as the introduced ones. The finding agrees with Hassan and Nhemachena (2008) who found household size to be significant but reduces the probability of adoption of mixed mono crop-livestock system cultivated/reared under dryland. However, our findings did not conform with Barley *et al.*, (2017) who found that household size has a significant and positive effect on the adoption of integrated crop and livestock species as an adaptation strategy to climate change.

The likelihood of choice of the indigenous house related strategy against the indigenous health related strategy increases by about 9.9% if a smallholder livestock in the region, with past livestock keeping experience, noticed climate variability. Climate variability can lead to erratic rainfall pattern with high rainfall within a short period of weeks. This could lead to cold-stress and humid related diseases among livestock when left to sleep in the open. When this happens, farmers would prefer to provide shelter for their animals rather than providing treatment, hence the high (88%) level of adoption of the indigenous housing strategies.

The number of livestock type diversified reduces the probability of choice of the indigenous house related strategy as an adaptation option by about 3.3% as against the indigenous health related strategies. In the study area, majority of the livestock owners rear more than one species (cattle, sheep, goats, pigs, local fowls and guinea fowls) of livestock. However, there is usually one room/pen available to accommodate these species, and this does not help to improve and expand production. Decrease in production is a measure of hampering sustainability of livestock types. The semi-extensive system of livestock production in the study area lowers the adoption of improved housing strategies.

In a nutshell, the examination of the environmental and socio-economic factors resulted in the level/degree of adoption of the strategies as illustrated in figure 3.1 below.

**Figure 3.1: Pie Chart Illustrating the Degree of Adoption of the Indigenous Strategies**



**4.0 Conclusion and Policy Recommendations**

The study identified farmers’ perceptions on climate change and indigenous adaptation strategies used by smallholder livestock farmers in rural farming districts of North-West Ghana. Farm households in the study area have noticed that the climate is changing due to decreasing rainfall amounts and increasing temperatures. They noticed this locally, based on the occurrence of thunder and lightning, fruiting time of certain tree species, germination of certain grass species during certain periods of the year, appearance of certain insect and bird species, nature of the moon and appearance of rainbow. Due to this, measures of indigenous nature are being adopted to adapt to the state of the climate, some of which are; planting of certain tree species for livestock feeding, the use of agricultural by-products as feed for animals, use of herbs in the treatment and vaccination of animals, use of accumulated smoke to treat control diarrhoea in livestock, use of indigenous breeds which are perceived to be resistant to the climate of the area and use of indigenous housing which is usually small and not spacious for free movement of animals.

The study further revealed that, the degrees of adoption of the strategies are determined by certain household, institutional and environmental factors. Therefore, the multinomial logit regression results showed that noticed climate variability, number of extension contacts, time to market, access to credit, flock/farm size, number of livestock diversified and household size are the determinants of indigenous strategies for adaptation to climate change.

Intervention projects must be tailored at improving local innovations/indigenous knowledge of farmers in the study area. In this way, local people will feel pride in themselves as their innovations are being recognized. This will encourage them to improve upon their current practices. Also farmers should be encouraged to adopt rainwater harvesting techniques both at farms and homesteads in order to have some water all year round for livestock watering. Finally but not the least, more extension agents with background in livestock extension can be recruited to educate farmers on better and improved farm management practices.

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