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Socioeconomic Determinants of Livestock Production Technology Adoption in Northern Ghana

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Authors' contributions

All authors worked assiduously towards the preparation of this manuscript. All authors designed the study. Authors DE and RA performed the initial statistical analysis and wrote the first draft of the manuscript. Author IGKA wrote the protocol, managed and refined the analyses of the study. All authors contributed well to the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The Northern region of Ghana hosts the largest number of livestock producers compared to the other regions, but output is still low despite the introduction of improved technologies which have the potential to increase livestock yields when adopted and provide better livelihoods to participating households. Consequently, adoption of improved technologies has been low, slow and uncertain. This study set out to examine factors that influence the adoption of livestock production technologies. One hundred and fifty (150) livestock farmers were randomly sampled from six communities in three districts of the region. The data was analysed using descriptive statistics and a logit regression model. The results showed that the low level of awareness of livestock production technologies have contributed to the low adoption by farmers. The logit regression results disclosed that the likelihood to adopt livestock production technology was significantly explained for 56% by extension contact, intent of producing livestock, number of children, herd size (for some animals species), source of stock, farm record keeping, education and gender. 44% of variation in adoption is therefore caused by other factors. It is recommended that any intervention to increase the

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adoption of livestock production technology should focus on creating greater awareness and also consider the specific policy variables that influence adoption.

Keywords: Northern Ghana; logit model; adoption; livestock production technologies.

1. INTRODUCTION

Livestock production (including poultry, sheep, goats, cattle) is an important livelihood activity of the people of Northern Ghana. As a major source of animal protein livestock contributes to balanced human nutrition and by so doing enhances the achievement of food security. For most rural livelihoods, livestock acts as an insurance against sudden financial crises by virtue of its ability to be sold for cash income. In addition to helping maintain soil fertility and structure through provision of manure, livestock also provides draught power enabling bullock-owning households to expand the scale of production. Most people in the rural areas in Northern Ghana rely on livestock production for supply of food as well as other economic objectives.

Despite the important functions of livestock in Northern Ghana outlined above, relatively little attention is devoted to developing livestock production in the region. This means that farmers that depend directly on livestock production for livelihood are affected. Nationwide, there is deficit (livestock) production which only forces the country to depend on imports of meat, chicken, eggs, etc. to fill the demand gap in the country. The overall effect is the rapid folding up of many commercial livestock farms and a consequent collapse of the poultry industry. Recent production reports indicate that even though domestic meat production increased by 132 percent over a 5-year period (i.e. between 2003 and 2008), this only accounted for 30 percent of the total domestic demand (Ministry of Food and Agriculture report, 2011). As a result, 70 percent of the quantity demanded has to be met through imports from international markets. Available statistics on the performance of the livestock sub-sector signals that Ghana's meat situation is in deficit amounting to over 95,000 Mt annually (Ministry of Food and Agriculture report, 2010). The situation is partly attributed to constraints faced by the livestock industry in Ghana. The sector suffers from low productivity due to limited use of improved production technologies, poor livestock housing, feed management and post-production problems. The constraints have been outlined in the second Food and Agricultural Sector Development Programme (FASDEP II) document of Ghana's Ministry of Food and Agriculture (MoFA). One prescription for mitigating the problems of the sector is the use of improved livestock production technologies.

Technology adoption, as defined by Bortamuly and Goswami [1] is the implementation of knowledge acquired about a specific innovation. According to the author, technology adoption is the product of extension. In every process of development, adoption of innovations is essentially necessitated. Globally, technology adoption is seen as sure channel to increase productivity, enhance household income, reduce rural poverty and ensure food security [2-7]. Smallholder farmers in Ghana (and northern region livestock farmers in particular) are faced with challenges of food shortages during some months of the year, where many households are hardly hit with food poverty. One of the strategies designed by government to minimize food poverty and food insecurity is the introduction of improved technologies to increase production and productivity. Since a lot of the farmers in the region are engaged in small scale livestock production, a number of improved livestock production technologies (LPTs) have been made available for field application including artificial insemination, cross-breeding and urea treatment of straw (mostly for cattle and small ruminants), block licking (for small ruminants), vaccination (for all livestock) and shade drying of pigeon pea. However, the adoption and utilization of such technologies are yet to gain widespread acceptance, especially among small scale livestock farmers in the region still tied to their obsolete traditional technologies. The low level of technology adoption in the livestock sector impedes progress and limits the sector's contribution to food self-sufficiency and/or food security. It is believed that technology adoption comes with intensification and intensification may lead to productivity increases. Unlike crop production in developing countries which is subject to the vagaries of climatic disturbances, livestock farmers have some degree of control over their activities and this could lead to income stabilization, poverty reduction and improved food security. Smallholder farmers are often faced with array of challenges that may hinder their inclinations to adopt improved technologies. Consequently, productivity levels of livestock farmers in the region fall far below the potential output, thereby posing a number of critical questions to researchers and policy makers. In Ghana, technology development and dissemination has usually favored the crop sub-sector compared to the livestock sub-sector. The relative neglect of the livestock sector may partly account for its low contribution to agricultural gross domestic product (6.1%) as compared to the crop sub-sector (66.2%) (Ministry of Food and Agriculture report, 2011). This is clearly evidenced by the bulk of empirical studies on adoption of agricultural technologies having been focussed on the crop sub-sector and the emphasis have been on crops like maize, wheat, rice, few leguminous crops [8,9] but with little attention devoted to livestock. As far as the Ghanaian context is concerned and to the best of our knowledge, there is little empirical work on adoption of livestock production technologies. Meanwhile, improved technology use and management options are the only viable alternatives to accelerate productivity growth of the livestock sector. Increasing productivity requires the use of modern productivity-enhancing technologies. The truth is that most Ghanaian smallholder farmers are used to their traditional ways of production, resulting in low productivity and profits. Awareness creation is an important element in the adoption of improved technologies. However, in most developing countries, after technologies are introduced, less effort is devoted to get clients well informed of the existence and proper utilization of such technologies. Meanwhile, farmers as rational beings need to be convinced through education, demonstration or otherwise on the potential benefits and dis-benefits of an innovation. As farmers may have both visible and unseen constraints, coupled with institutional and infrastructural challenges, more efforts are often required on the part of technology developers, dissemination agents and policy makers to get technology recipients better educated on the pros and cons of any given technology, but this is often not done.

Severe shortage of feed and fodder has stifled productivity and expansion of livestock in the country. In most instances, cereal crop residues are the main sources of feed for livestock. The nutrient composition of such feeds is very poor, since crude protein and other vital nutrients are deficient. To overcome such deficiencies, animal nutrition and crop breeding research have generated a number of promising new technologies that have the potential to boost production and improve the nutritional quality of feeds and fodder. Again, high yielding crops with superior qualities to generate nutritious feed (such as in rice, wheat, sorghum and millets) have been produced through research. For example, studies have shown that a 1% increase in digestibility of sorghum or millet straw is able to increase bovine milk yield by 5–6% [10]. Moreover, several vaccines are available for preventive and curative disease management and infrastructural expansion for disease control. Postharvest technologies help producers to realize better gains from technological changes in the primary production sector. Low-cost processing technologies have been developed for both small and large scale producers. Yet, adoption of these livestock production technologies has been low and slow in Northern Ghana. In most rural settings, the level of awareness of improved technologies is often very low. Several critical factors might contribute to the limited use or non-use of such existing technologies; what are these factors? Finding answers to these questions remained the focus of this study. The objective therefore, was to determine the awareness level and evaluate the socio-economic factors influencing the adoption of livestock production technologies in northern Ghana. Knowledge of factors affecting technology adoption are needed by government in its extension service delivery programme and other stakeholders for moulding policies that are geared towards effecting change in attitudes, which may likely have desirable impact on livelihoods.

1.1 Empirical Literature on Determinants of Technology Adoption

Research has indicated that demographic factors (age, education and religion), economic factors (occupation, income) and farm-specific variables (firm size, type of enterprise) are important determinants of technology adoption. Way back in the 1960s, among other authors [11] established that economic factors are the major driving forces influencing technology adoption. Although economic forces are important, they may not necessarily be the major driving forces of adoption. Under different conditions and contexts, other intrinsic as well as extrinsic factors such as management and implementation problems may present critical challenges and impede adoption of innovations. On the other hand, other studies have identified socio-demographic factors that influence adoption of improved technologies. For example, a number of studies have predicted age to have negative effect on adoption [12] and that younger farmers have higher probabilities to adopt technology than older farmers; [13-15]. [16] explained that young people are often less risk-averse to adopting innovations than the aged. Older people often adhere to traditional techniques of farming, leading to low levels of adoption. Similarly Onuekwus and Okezie [17] also stated that the age of a farmer has positive influence on adoption of rabbit technologies. In Burkina Faso, [18] found age to positively influence the adoption of improved sorghum varieties. Apart from age of farmer's, education has been identified as a critical determinant of technology adoption. Education is considered to enhance the general mentality and therefore to positively influence the attitude of an individual towards innovations. Bortamuly and Goswami [1] argue that while education may foster technology adoption, it may also cause people to switchover to some other activities instead of adopting expensive technologies [19,20].

Gender disparity is important in livestock production and must, together with other factors be taken into account. [21] noted that for mainly traditional and historical reasons, men continue to dominate livestock production and especially the more valuable species. The dominance of men over women shows up in terms of stock ownership, decision-making and control of livestock production systems. However, empirical study of the determinants of improved maize technology adoption in Ghana by [8] did not establish any significant relationship between gender and adoption. In Papua New Guinea, similar conclusions were made by [22] with reference to gender heterogeneity in adoption.

In other studies, farmer's income has been found to influence the level of adoption. Kinnucan, Hatch [23] indicate that high income farmers are better adopters of improved technologies than low income farmers because the high income farmers possess additional financial risk-taking attitudes. The characteristics or attributes of the technology, the adopters or clientele, the change agents (extension worker, professional etc.) and the socio-economic, biological and physical environment in which the technology takes place [24] all play part in technology adoption. [25] showed that a farmer's choice to adopt a given technology is dictated by the needs, cost of technology and potential benefits envisaged. Just and Zilberman [26] in their study on stochastic structure, farm size and technology adoption in developing country agriculture established a relationship between economic size and technology adoption, with a possible quadratic effect of size on adoption. They found out that large businesses were more likely to adopt new technologies faster than smaller firms. According to their discussions, larger firms usually consider the overall benefit from the technology in making adoption decisions. For example, a farmer with large stock of livestock, with different species may not have a problem with buying salt lick due to a wide range of animals that stand to benefit from this product, but the same might not hold true for a small farmer with limited range of livestock.

2. MATERIALS AND METHODS

2.1 Study Area

The Northern region of Ghana, which occupies an area of about 70,383 square kilometres, lies between longitude 1.0ºE and 3.0ºW, latitude 9.0º and 11.0ºN of the equator and is the largest region in terms of land area. The region is drained by the Black and White Volta and their tributaries (Rivers Nasia, Daka etc). Ecologically, the study area is located in the Guinea Savannah zone with an annual average rainfall of 1050 mm. Typically, the rainy season starts in April and ends in October. The rainfall pattern is monomial with temperatures varying between 14ºC (59ºF) at night and 40ºC (104ºF) during the day. The 2010 census produced a population of 2,479,461. The major occupation of the people in the region is farming and mixed farming is predominantly practiced, with most farmers blending crops and livestock in their farming activities. Crops such as rice, maize, millet, sorghum and groundnut dominate in their production. The ecological zone favours animal rearing due to grass and forage availability. Animals are reared both on subsistence and commercial levels in the study area. The dominant livestock reared in the study area are sheep, cattle, goat, guinea fowl, chicken and donkeys. (http://www.ghanadistricts.com/region/?r=6: accessed on 15/08/2014).

2.2 Data

The study generated both qualitative and quantitative data through field household survey.

The instrument used for data collection is a questionnaire and was administered in March 2014. The questionnaire captured both closed and open-ended questions that sourced information on various household and demographic characteristics such as sex, age, farmers educational level, household livestock history and records, technology awareness and use as well as socio-economic factors that influence adoption of livestock production technologies, extension access, income from livestock, among others.

2.3 Sampling and Data Collection Methods

The study used multistage sampling technique. In the first stage we randomly selected three districts, which include Savelugu/Nanton district, Tolon district and Tamale Metropolis. In the second stage, two (2) communities were randomly selected from each District or Metropolis and in the third stage 25 households were randomly selected each from the 6 communities. A total of 150 households were interviewed, with 50 households selected from each District or Metropolis. Information was collected through personal interview schedules. Three of the questionnaires had several missing information and were therefore excluded from the analysis. Data based on 147 questionnaires were used in the analysis.

2.4 Method of Data Analysis

Principally, technology adoption has been studied in the framework of discrete choice modelling. A farmer's decision towards the adoption of technology is expected to be influenced by several factors, including resource availability and/or affordability, socio-economic characteristics, expectations, among others. According to Feder, Just [27,28], if a technology is adopted then it means that at least a component of it is being used by the client. In livestock production, the decision to adopt or continue to use a technology is discrete. Such discrete decisions are often studied using random utility models. In such models, a farmer N faces a choice among J alternative actions, in this case adoption or non-adoption. The farmer would obtain a utility or profit from each alternative action chosen. The utility (u) that the farmer derives from choosing alternative J is given by u_{nj} : $j = 1, 2, ..., J$. The farmer chooses the particular alternative J that provides the maximum utility or benefits. Stated differently, the utility maximizing farmer will adopt a technology if and only if at least the benefit (be it economic, financial, managerial, easiness of work, etc.) to be derived from adoption is greater than the costs of adopting the technology. In this way, the farmer's adoption behaviour can be simplified as:

choose alternative

$$i \text{ if and only if } u_{ni} > u_{nj} \text{ for } j \neq i$$

The utility obtained from each alternative choice is latent and only the decision variable is observed. Thus, among the farmer's latent decisions we can only measure whether the technology is adopted or not. The rational (utility maximizing) farmer would choose the option that yields the highest satisfaction. Implicitly, it is assumed that a farmer who uses the technology obtains a higher utility than one who fails to adopt. The probability that the farmer adopts the technology depends on the relative level of satisfaction that can be derived from it compared to other alternatives.

The binary logistic regression model was used to assess the factors that determine the adoption of LPT. The logistic regression model starts by considering Z as the set of unobserved continuous variable. The larger are the values of Z , the greater is the probability that a livestock production technology would be adopted. The relationship between Z and the probability of adopting LPT is given by the function:

$$P_i (y_i = 1) = \frac{e^{Z_i}}{1 + e^{Z_i}} = \frac{1}{1 + e^{-Z_i}} \quad (1)$$

From equation (1), the latent variable can be derived by

$$Z_i = \log\left(\frac{P_i}{1 - P_i}\right) \quad (2)$$

P_i is the probability that the i^{th} farmer adopts LPT.

Z_i is the value of the unobserved continuous variable for the i^{th} farmer. The latent variable, Z is linearly related to the observed explanatory variables by

$$Z_i = b_0 + b_1x_{1j} + b_2x_{2j} + ...+ b_kx_{kj} + \varepsilon_i \quad (3)$$

$x_{k,i}$ is the k[th] predictor of the i[th] farmer, b_k is the k[th] coefficient and k denotes the number of explanatory variables.

Z is a binary variable such that

$$Z = \begin{cases} 1 \text{ if the farmer adopts LPT} \\ 0 \text{ if otherwise} \end{cases}$$

From equation (1) and substituting equation (3), the probability of adoption now becomes

$$P_i = \frac{1}{1 + e^{-(b_0 + b_1x_{i1} + b_2x_{i2} + ...+ b_kx_{ik})}} \quad (4)$$

Econometrically, the relationship between the latent variable and explanatory variables is given by equation (5) below

$$Z_i = \beta_0 + \sum_{k=1}^{14} \beta_k X_{k,i} + \varepsilon_i \quad ;i=1, 2,.........., n \quad (5)$$

β_0 is the intercept, β_{1-14} denotes parameters to be estimated, ε_i = random disturbance term, X_1 to X_{14} are defined as follows:

2.5 Adoption of Livestock Production Technology (Y)

The dependent variable for the logit regression model is binary, representing farmers' decision to adopt livestock production technologies or not. [27] defined adoption as the degree of use of a new technology in the long run when a farmer has full information about the new technology and its potential benefits. The dependent variable takes a value of "1" for farmers who adopt livestock production technology and "0" for non-adopters. A farmer is said to adopt the technology if at least one aspect of the technology package is selected for use on the farm.

2.6 Extension Visit (X_1)

This variable indicates whether a farmer solicited any information from an extension agents or not. It is a continuous variable since it measures the frequency of extension contacts or visits. Farmers who are in frequent contacts with extension agents are expected to have relatively more information about new technologies in general and also training on technology packages. This is expected to help farmers to adopt improved technologies, in this case LPT. Based on this argument, it was hypothesized that extension visit would positively influence LPT adoption. Arguably, adoption of LPT is not necessarily determined by number of extension visits, since farmer's decision to adopt LPT may to a large extent depend on the quality of information provided by the extension agent, risk attitudes of the recipient farmers, among others.

2.7 Intent of Keeping Livestock (X_2)

Smallholder farmers typically have peculiar intentions or motives for keeping livestock. In the study it was discovered that one important reason why farmers keep livestock has to do with payment of school fees and hospital bills. The reason is that livestock, particularly small ruminants (sheep and goats) are fast growing and multiply rapidly and can also be readily sold for cash income. Rural farmers often ascribe more attention to children's education; hence they always look for ways to finance their children's education. Again, sicknesses are the greatest enemies of the farming households. Once they fall sick, all other activities come to a standstill, hence the intentions to insure themselves against such uncertain events by engaging in small ruminant production, since the mainstream (formal) insurance system is deficient in rural and developing Africa. This variable is a dummy and assumes a value of "1" if the farmer's intention of keeping livestock is to pay bills and "0" if kept for any other reason. It was postulated that farmers who have the responsibilities to pay school fees and hospital bills should be better adopters of improved technologies in livestock production than farmers who are not. The sign of the coefficient of this variable is positive.

2.8 Species (X_3)

This refers to number of the different types of livestock on the farm. In the study area, each farmer keeps at least one of four different types of livestock, including cattle, sheep, goats and poultry. It is expected that the number of species should affect the decision to adopt LPT. Farmers who keep only one type of animal, e.g. goat only or livestock only, etc. are said to have one type of species. Those whose keep goat and sheep, or cattle and goats, etc. are said to control two types of species and so on. This is an indirect measure of diversification in livestock. The more the number of species controlled on a farm, the more diversified is the farmer. Diversification may also be a kind of risk-coping strategy and we expect more diversified farmers to adopt technologies compared to specialized farmers. Thus, a priori, we expect a positive relationship between decision to adopt LPT and species.

2.9 Number of Children (X_4)

In most rural farming households, children are an important source of labour for agricultural production. In the ancient days, families with large sizes were cultivating large acreages of land. In modern societies, the trend might not necessarily follow the same logic, however. Particularly in cattle production the use of Fulani men to tend large stocks of cattle actually makes little demand of children as sources of family labour for livestock production. Again, the possession of large stocks of livestock can measure the wealth of the farmer. When more children make a demand on the family budget, then the likelihood of adoption may be low. The variable X_4 was used as a proxy for family labour availability. It is a continuous variable, measuring the number of children in the farming household that provide labour in livestock production. On a priori grounds, we expect the sign of the coefficient to be negative or positive. On the one hand, we expect that when more children provide labour for livestock work, the farming household should not be bothered with labour issues as often it is for adopting new technologies. Some improved technologies require additional labour outlay which may serve as impediment to adoption. On the other hand, if the farming household has many children, then we envisage a negative adoption when the technological package requires additional financial outlay but where the children also lay greater financial burden on the farming household.

2.10 Income (X_5)

Measured as the total financial returns from the sale of livestock and livestock products (including eggs, skin, feathers, etc.) for the year, income was hypothesized to directly influence farmers' attitudes towards adoption. Generally, farmers with higher incomes are more able to bear the additional costs that may accompany new technology adoption. On the other hand, we can argue that farmers with high income may ever have adopted technological package that has improved their income levels and once they are familiar with the multiplier effects of improved technologies, they may be better adopters of new technology than their low income counterparts. Hence, it was assumed that as farmer's income from livestock increases, the rate of adoption of improved technologies will also increase. The expected sign for the income coefficient is thus positive provided that the marginal utility obtained from LPT adoption still remains positive.

2.11 Herd Size (X_6)

Research has indicated that adoption of improved technology is influenced by the size of firm. In livestock production, herd size is used as a measure of firm size. In Table 1, we give an overview of the type and number of animals distributed over the respondents in the survey. Herd size is a continuous variable and measured as the total number of a particular livestock species kept by a household. The main hypothesis was that, provided that farmers are in the first stage of the production function, then those with fewer animals would show a greater desire to increase herd size to fulfil household cash needs or other economic gains while farmers with larger herd sizes would be reluctant in their adoption decisions, perhaps because they may be experiencing diminishing marginal returns or are already in the third stage of the production function, in which case there are negative marginal products. This said however, the definite direction of herd size on adoption may also depend on the specific species of animal kept by the farmer. On the other hand, if the farmers are also growing crops which generate better income than livestock, then one would expect adoption of LPT to be low, since it is then more profitable to expand the crop enterprise than the livestock venture. Despite the counter arguments, a priori, we still expect the sign for the coefficient of this variable to be positive across all species, ceteris paribus.

2.12 Source of Stock (X_7)

This variable refers to various ways in which the farmer acquires livestock breeds for production. It is a dummy variable, assuming a "1" if acquired through purchase and "0" if obtained through inheritance or gift. Farmers who acquire their livestock breeds through purchases may do everything possible to increase the production by adopting improved methods while those who acquire through gifts or inheritance may be less motivated to adopt new technologies even when such technologies are inexpensive. The expected sign of this variable is therefore positive.

2.13 Gender (X_8)

In Northern Ghana, the gender of an individual often defines the roles that one can play in the family. Gender influences the number and types of livestock kept by the household, and this can also influence the decision to adopt a technological package. Usually, men are more desirous to control more livestock than women, hence will be more willing to embrace new techniques that are able to increase their herd sizes. The gender variable is dichotomous, assuming a value of 1 if male and 0 if female.

2.14 Experience (X_9)

Experience is measured as the number of years a farmer has been engaged in livestock production. A farmer with more experience in farming will be reluctant in adopting improved technologies than an inexperienced farmer. Hence, this variable is assumed to have a negative influence on the dependent variable.

2.15 Age of the Farmer (X_{10})

This is a continuous variable and is measured in years. Aged farmers will tend to ignore improved methods and still continue to use rudimentary technologies they know already while young farmers, being adventurous, may tend to try new and improved technologies to increase production. The expected sign for the age coefficient is negative.

2.16 Farmer's Education (X_{11})

Education is measured as the years of schooling in the formal educational system that the respondent received. Farmers with more years of formal education are expected to have better information and knowledge about improved technologies than those who do not have formal education. As the farmer gets more formal education, the probability of adopting technology increases, therefore, it was expected that farmers with more years of formal education will adopt more of improved technologies. The expected sign for the coefficient of this variable is therefore positive.

Table 1. Distribution of respondents by type and category of livestock produced

Species	Number of animals	Frequency	Percent	Average herd size
Cattle	1-5	29	44%	
	6-10	13	20%	
	11-15	7	11%	
	16-20	8	12%	11
	21-25	4	6%	
	26-30	2	3%	
	>31	3	5%	
Sheep	1-10	58	50%	
	11-20	38	32%	
	21-30	14	12%	14
	31-40	5	4%	
	41-50	1	1%	
	51 or more	1	1%	
Goat	1-10	76	57%	
	11-20	47	35%	
	21-30	9	7%	11
	31-40	2	1%	
Poultry	1-10	17	16%	
	11-20	31	29%	
	21-30	23	21%	
	31-40	20	19%	27
	41 -50	6	6%	
	51 or more	11	10%	

2.17 Complexity of Technology (X_{12})

Farmers will adopt technologies that they can easily practice without (much) assistance. Technologies are seen as complex by farmers if they find it difficult to readily practice the technology on their own. Complicated technologies may have a negative effect on adoption. The coefficient of this variable is therefore expected to be negative.

2.18 Current Market Price of Livestock (X_{13})

This refers to the market price received by the respondent for a unit of livestock at the time of interview. Farmers who received high market prices may suggest to farmers that they will have returns on investment made in the production of their livestock. This may be an incentive to adopt improved technologies to increase production than when market prices are low. Price is measured in Ghana Cedis and is expected to be positively signed.

2.19 Farm Management (X_{14})

Farmers who keep records are more informed about their assets and liabilities. Such farmers are better able to take management decisions, which may better inform the farmer's decision to adopt technology to improve farm productivity or better not to adopt the technology. With good records, farmers have facts about the performance of each technological package and are able to deduce whether a new technology would be beneficial or otherwise. The expected sign of the coefficient can therefore be positive or negative.

3. RESULTS AND DISCUSSION

3.1 Demographic Characteristics and Households Composition

The average household size was 12 members. The large household size could be attributed to the spread of polygamous marriages and the extended family system practiced in the study area. Moreover, the large household size indicates availability of labour for both farming and livestock production activities, since most of these members participate in farming activities. For children who attend school, they still help parents and guardians in the farm or livestock enterprise after close of school. Table 2 presents the distribution of education across the various age categories. The results show that there were more respondents with no education (54.42%) than those with some form of education. The aged (60 years and above) were mostly not educated, but majority of farmers with primary education fall in the 20–39 years category. Thus, the study area has most farmers having no or primary education (approximately 85%), which can have significant influence on awareness and adoption of technology.

Approximately 5% of farmers who aged between 20 and 39 had tertiary education. The result shows that most of the respondents fall within the active working age category (between 20 and 59). From the results one could argue that the illiteracy rate is relatively high and this can affect the adoption of improved livestock production technologies. In terms of gender participation, we found that 89% of the farmers were males and only 11% were females, indicating that males dominate livestock production in the study area. The few females who participate in livestock production concentrate on small ruminants (sheep & goats) and poultry production. The low participation of women in livestock production can be attributed to key socio-cultural barriers. In most families, female livestock owners still hold allegiance to their husbands by virtue of men's position as household heads.

Education and experience in farming are critical determinants of technology adoption; hence we attempted to find which educational category had more experience, as this would be an indication of the extent of LPT adoption in the study area. Table 3 provides the summary of the distribution of education with experience. The results indicate that farmers without any form of formal education (80.77%) had more than 30 years of experience in livestock farming, while the few highly educated farmers were relatively inexperienced in the livestock enterprise. Since majority of the farmers have no education and those without education have more experience in livestock farming than the few educated farmers, technology adoption in the study area can be very difficult, ceteris paribus.

3.2 Respondents Sources of Stock for Production

The source from which farmers obtain the production stock is an important determinant of technology adoption. Livestock farmers in the study area obtain their production stock from three principal sources, namely: Gifts, purchases and inheritance. Across all types of livestock, majority of respondents get stocks from purchases only (47.26%) while only few obtain the stocks from all three sources (9.59%). Table 4 further highlights the distribution of respondents by source of production stock. The observation that purchases is the dominant source of stock for livestock production indicates farmers' willingness to adopt improved technology, since technology adoption usually comes with additional financial commitment. If farmers already purchase stocks, the likelihood that they may embrace new innovations can be quite remarkable.

3.3 Farmers' Awareness of Livestock Production Technologies

Overall, the level of awareness of LPTs was very low among farmers in the study area. Out of the total respondents interviewed, on the average only 24% of respondents were aware all possible improved LPT while 76% were not aware. Across individual technological packages such as breeding or housing technologies, awareness varied between 18 and 28%. But for individual LPTs awareness could be as high as 69%, indicating that farmers have selective awareness. Health related livestock production technologies had the highest level of awareness while breeding technologies were the least known. The low level of awareness could be due to respondents not participating in associations and infrequent visits of extension agents. According to the respondents, the few extension agents who visit them are often more interested in sharing knowledge that pertains to crop technologies than LPTs. Farmers' awareness can be created and enhanced through the encouragement and formation of farmer group(s) or participation in farmer groups and also regular follow-up and feedback sessions of extension agents with farmers. Table 5 displays the frequency of awareness of some selected livestock production technologies under breeding, health, feeding/nutrition and housing. With respect to individual technologies, vaccination had the greatest level of awareness (69%) while other improved livestock housing was the least known (1%). Despite relatively good level of awareness of individual technologies, the general level of awareness on LPTs is very low and tailor-made extension services on information relating to the existing LPTs is needed to raise the awareness level.

The level of awareness also varied according to the number of animal species controlled by the respondents. In Table 6, we present the distribution of respondents awareness of LPT based on the number of animal species reared by the farmer. Only 8 farmers specialized in rearing a single species of animal, while 53 farmers reared exactly three species of livestock animals. It is observed from the results that awareness level is generally higher across all technological packages with farmers who control 3 or 4 types of animal species, indicating that diversified farms are often better aware of improved LPTs than specialized farms.

Table 2. Percentage distribution of education by age category of livestock farmers

Education	Age category			
	20-39	40-59	60 and above	Total
None	27.42	72.22	84.62	54.42
Primary	45.16	22.22	7.69	30.61
Secondary	20.97	1.39	7.69	10.2
Tertiary	4.84	-	-	2.04
JHS/middle	1.61	4.17	-	2.72
Total	100	100	100	100

Table 3. Percentage distribution of education by the farming experience of livestock farmers

Education	Years of farming/livestock production (experience)				
	<10	≥10 but<20	≥20 but<30	≥30	Total
none	37.93	54.72	80.77	80	54.42
primary	44.83	28.3	15.38	-	30.61
secondary	13.79	11.32	3.85	-	10.2
tertiary	1.72	3.77	-	-	2.04
JHS/middle	1.72	1.89	-	20	2.72
Total	100	100	100	100	100

Table 4. Distribution of livestock farmers by source of production stock

Source of stock	Frequency	Valid percent
Purchases only	69	47.26
Gifts only	3	2.05
Inheritance only	9	6.16
Purchases and Inheritance only	45	30.82
Purchases and Gifts only	5	3.42
inheritance and gifts only	1	0.68
Purchases, Inheritance and Gifts	14	9.59
Total	146	100

Table 5. Percentage distribution of farmers' level of awareness on selected LPT

Breeding technology						
	CB	CS	SE	AI	OC	Mean
Aware	52%	7%	21%	6%	5%	18%
Not aware	48%	93%	79%	94%	95%	82%
Health technology						
	VA	DP	DW	SP	DR	
Aware	69%	19%	43%	9%	2%	28%
Not aware	31%	81%	57%	91%	98%	72%
Feeding/Nutrition technology						
	CSF	SBL	SDP	UTS	OSP	
Aware	61%	27%	23%	7%	1%	24%
Not aware	39%	73%	77%	93%	99%	76%
Housing technology						
	IS	SI	ES	KL	IH	
Aware	25%	52%	43%	12%	1%	26%
Not aware	75%	48%	57%	88%	99%	74%
Average awareness over all technologies						**24%**

CB – crossbreeding, CS – castration, SE – selection, AI – artificial insemination, OC – outcrossing, VA – vaccination, DP – dipping, DW – deworming, SP – spraying, DR – drenching, CSF – concentrate/supplemental feeding, SBL – salt/block licking, SDP – shade drying of pigeon pea, UTS – urea treatment of straw, OSP – overplanting of Stylosanthes in pasture, IS – intensive system, SI – semi-intensive system, ES – extensive system, KL – kraaling, IH – other improved housing system

3.4 Livestock Production Technology Adopted by Farmers

Awareness of a particular technology is not the same as adoption. Adoption studies indicate that not all farmers that become aware of a given technology go on to use it. For that matter, we measured the adoption of LPT in the study area. Our results show that majority of the farmers in the study area did not adopt any of the LPTs enumerated in Table 4. Only 66 respondents (approximately 45%) adopted one or more of the technologies and these were categorized into low adopters, partial adopters and high adopters. The categorisation is based on the number of technologies adopted. Out of the total number of farmers who adopted, 56% used 1 to 3 technologies and are classified as low adopters, 35% of the adopters used 4 to 6 technologies and are regarded as partial adopters. Only 9% of the adopting farmers used 7 to 10 technologies (high adopters), see Table 7. Again, adoption within a specified number of species is generally low among farmers, especially with farmers who keep lower number of species. For example, for farmers who keep a single species of livestock, none is a high adopter, but for farmers who keep all the four species, 4% are high adopters. From the results, the overall LPT adoption by farmers is low. The low adoption rate can be attributed to a number of factors. First of all, our preceding analysis indicates that farmers in the study area have low level of education. Moreover, the farmers with low level of education also have more experience in livestock farming. Therefore, the low level of education coupled with relatively more experience in livestock farming may be the principal constraints to adoption. Secondly, the awareness level among the respondents was also low and with lack of training in the proper use of the technology, it is not too surprising that adoption is also low.

The source of awareness on improved livestock technologies include extension visit, researchers from Animal Research Institute, NGOs, Veterinary officers, among others. Extension contact dominated the sources of information on technology as 32% of respondents indicated access to information through extension agents. This was followed by indigenes, Animal Research Institute and NGOs representing 30%, 17% and 15% respectively. Veterinary officers were also mentioned as source of information (6%) and others. Extension recorded the highest source of information. The result is expected since extension services in Ghana is mostly provided by the government and is the main and official source of information for farmers through Ministry of Food and Agriculture. There is therefore a need to focus on extension in creating farmers awareness on information relating to livestock production.

3.5 Factors Influencing the Adoption of Livestock Production Technology

The logit estimates of the factors influencing adoption of LPT are presented in Table 8. The socio-economic variables captured in the model include contact with extension services, intent of keeping livestock, number of livestock species kept on farm, number of children of farmers, income, herd size (cattle, sheep, goat and poultry), source of stock (purchase) and complexity of the technology, current market price of livestock, farmers' experience, age, gender, educational level and farm records. In the model, coefficients of ten out of the seventeen explanatory variables were found to be statistically significant. The results revealed that extension visit, intent, children, complexity, education and goat herd size have negative effect on adoption, whereas source of stock, farm records and cattle herd size have significant positive influence on adoption of LPT. The positive coefficient of the gender variable implies that men are better adopters of technology than women, which meets our apriori expectation and also confirms empirical findings. Education was found to significantly reduce farmers' adoption of technologies. Thus, farmers with more education are less likely to adopt improved LPT than less educated farmers, which agrees with findings by [29] who found adoption to be negatively related to the level of education. The results however contradicts the work of [30] who found education as unimportant in explaining adoption. The reasons for the difference in the findings could be attributed to the different technologies presented. Some technologies require certain enhanced knowledge to be able to understand and adopt, e.g. artificial insemination. Other technologies, however, might not require higher level of education to understand, e.g. technologies that relate to housing of animals.

The significant Wald Chi-square statistic of 65.56 indicates that the explanatory variables jointly influence the farmers' decision to adopt improved LPT. The McFadden Pseudo R-squared of 0.5569 indicates that about 56% of the variation in the probability of adoption is explained by the factors considered in the model. The remaining 44% of variation are explained by other factors. The marginal effects of the explanatory variables are presented in Table 6 below. Extension contact was the most influential determinant of the decision to adopt improved LPT.

Extension contact was found to be significant at 1% but had an inverse effect on adoption of LPT. In many parts of the country, publicly founded agricultural extension services are the only official sources of information about improved agricultural technologies that farmers have access. The negative sign of the coefficient implies an inverse relationship with technology adoption, such that the more contact a farmer has with the extension agent, the lower the probability of adoption. When frequency of extension visit increases by 1 the probability of technology adoption in livestock production decreases by 1.35%. This result was not as expected because farmers are previewed to information mostly by their contact with extension agents and thus should have a positive correlation with technology adoption. The result contravenes our apriori expectation as well as the work done by [29], who found frequent contacts with extension agents to enhance adoption. On the other hand the results of the extension variable are in agreement with the work by [31] which established that extension visit is inversely related to the adoption of soil and water conservation technologies. According to [8], the adoption of new technology is normally influenced by farmers contact with extension services, since extension agents provide inputs and technical advice. One possible explanation for the inverse relationship observed in the study may relate to the fact that, even though livestock farmers have contact with the extension agents, these only provide information that relates more to crop production rather than livestock, as it is a common practice among extension agents in Ghana. Therefore, as farmers become more knowledgeable about crops, they tend to do more of crop farming than livestock production. As farmers divert from livestock to crop farming, it is expected that the probability of adopting new technologies relating to livestock production will decrease.

The intention for keeping livestock variable was found to be significant motivation that influenced LPT adoption. Fundamentally, farmers engage in livestock production to pay school fees and hospital bills. The variable was found to be statistically significant and influenced LPT adoption negatively. The negative coefficient suggests that farmers that were motivated to produce livestock purposely to pay school fees and hospital bills are less interested in adopting improved technologies in livestock production than farmers who are not. Thus, when a farmer who did not intend producing to pay school fees and hospital now decides to do so, the probability of adopting LPT would decrease by 0.44% and this is very significant at 1% level of significance. A plausible explanation for this observation is that fees and bills lay a lot of financial burden on such households and any technology that may require little financial input may incur their displeasure, leading to their non-adoption.

Table 6. Percentage distribution of LPT awareness of farmers by number of livestock species

Species = 1 (n=8)					Species = 2 (n=40)				
Breeding technology									
CB	CS	SE	AI	OC	CB	CS	SE	AI	OC
50%	-	13%	-	-	40%	5%	20%	10%	3%
Health technology									
VA	DP	DW	SP	DR	VA	DP	DW	SP	DR
63%	13%	38%	13%	-	75%	23%	50%	8%	-
Feeding/Nutrition technology									
CSF	SBL	SDP	UTS	OSP	CSF	SBL	SDP	UTS	OSP
75%	13%	13%	13%	-	63%	33%	28%	5%	-
Housing technology									
IS	SI	ES	KL	IH	IS	SI	ES	KL	IH
38%	25%	25%	-	-	25%	55%	43%	10%	-
Species = 3 (n=53)					**Species = 4 (n=46)**				
Breeding technology									
CB	CS	SE	AI	OC	CB	CS	SE	AI	OC
49%	2%	19%	8%	2%	67%	15%	24%	2%	11%
Health technology									
VA	DP	DW	SP	DR	VA	DP	DW	SP	DR
53%	17%	42%	13%	4%	85%	20%	39%	4%	2%
Feeding/Nutrition technology									
CSF	SBL	SDP	UTS	OSP	CSF	SBL	SDP	UTS	OSP
51%	21%	23%	9%	2%	70%	30%	22%	7%	-
Housing technology									
IS	SI	ES	KL	IH	IS	SI	ES	KL	IH
21%	42%	38%	6%	-	28%	65%	52%	22%	2%

Table 7. Percentage distribution of respondents by number of LPT technologies adopted and number of animal species kept on farm

Number of species on farm	Number of technologies adopted			
	1–3	4–6	7–10	Total
1	25%	13%	-	38%
2	23%	10%	5%	38%
3	25%	9%	4%	38%
4	26%	28%	4%	59%
Overall adoption across all species	56%	35%	9%	100%

In Table 9 below, the results of probability of adoption of the variables that significantly influence adoption are presented. The number of children of the farming household was used as a proxy for family labour availability. The results proved to be significant even though it was inversely related to the probability of adoption. The negatively signed coefficient shows that families with more family labour available tend to adopt less of technology while families with smaller family labour available tend to adopt more of technology. The number of children has a significant probability of decreasing technology adoption by 0.15% when family labour increases by one person. This was expected because the importance of family labour cannot be under-estimated as hiring of labour is costly for households with small family labour force. It is also possible that in the adoption of new improved methods more labour will be required. For example in the housing of livestock more labour is required as it needs continual cleaning and maintenance.

Income was used as proxy for current capital returns from livestock production and hypothesized to directly influence farmers' attitudes. The variable was statistically significant (P<0.05) with a positive coefficient indicating that current capital has a major effect on the decision to increase production. By implication any commercially oriented approach to livestock production will require substantial initial cash to purchase more animals and also for accessing improved technologies. This result conforms to our a priori expectation. [23] observed that farmers with high income are better users of improved technologies because such farmers are better positioned to take financial risks than low income farmers.

Herd size was hypothesised to be inversely related to the decision to adopt livestock production technologies and expand production because the probability of a positive response increases for farmers with smaller herd size and vice versa. At P<0.1 cattle herd size coefficient was significant and positively signed, thus defeating our apriori expectation. On the other hand, goat herd size was very significant and negatively influenced adoption at 5% level of significance, which confirms our expectations. The contrasting findings of herd size among different species of animals indicate that technology adoption also depends on the species of animal under consideration. While goat farmers with fewer animals showed a greater zeal to increase herd size, cattle farmers with larger herd sizes were more interested in adoption of improved LPTs. The cattle herd size has a probability of increasing technology adoption probability by 0.06% when herd size increases by additional stock. This is arguably plausible because in the study area, cattle stocks are known to be an important household asset and thus help in coping with risk.

Table 8. Logit regression results of factors influencing adoption of LPT

Variable	Coefficient	Std. err.
Extension contact	- 5.89***	1.91
Intent of keeping livestock	- 2.64***	1.14
Species	0.51	0.86
Number of children	- 0.66***	0.24
Cattle herd size	0.25*	0.15
Sheep herd size	- 0.02	0.06
Goat herd size	- 0.27**	0.11
Poultry herd size	- 0.03	0.03
Source of stock	6.09**	2.54
Education level	- 1.52***	0.56
Farm records	5.67***	1.76
Complexity of technology	- 1.60	0.99
Experience	- 0.02	0.08
Age	0.32	0.92
Income	0.00	0.00
Current market price	1.17	0.98
Sex	4.25**	1.81
Constant	20.68	6.77

Wald chi^2 (14) = 65.56, prob> chi^2 = 0.000, pseudo R^2 = 0.5569, log likelihood = -26.0852
**** significant at 1%, ** significant at 5%, * significant at 10%*

Table 9. Marginal effects of the explanatory variables on adoption

Variable	dy/dx	Std. err.
Extension contact	-1.35***	0.41
Intent of keeping livestock	0.44***	0.14
Cattle herd size	0.06*	0.03
Goat herd size	- 0.06**	0.03
Number of children of the farmer	- 0.15**	0.05
Farm records	0.55***	0.13
Complexity of technology	0.35*	0.20
Source of stock	0.75***	0.13
Education level	- 0.34***	0.12
Sex	0.68***	0.14

Average probability of adoption = 0.64

The direct effect of cattle herd size on adoption is reasonable, looking at the fact that cattle stocks are the prestige of most livestock farmers in the region. The larger the number of cattle a farmer possesses, the wealthier that farmer is considered to be and earns the respect of society. On the other hand, the inverse relationship between goat herd size and adoption could also be anticipated since the survey showed that farmers with fewer numbers of goats were more willing to increase their stock population than those with larger farms, who were more concerned about feeding difficulties.

The source from which farmers obtained the breeding stock produced a positively signed coefficient, indicating a positive influence on adoption. Farmers who purchased their breeding stocks had larger probability to adopt LPT (0.75%). Farmers who purchase breeding stocks may do everything possible to increase the population by adopting improved methods while those who obtain them through gifts and inheritances may be less motivated to adopt new technologies even when such technologies are not expensive.

Farm records had a positive coefficient, implying a direct correlation between technology adoption in livestock production and records keeping. This was consistent with our apriori expectation because farmers who keep records are more informed for taking management decisions, in this case, technology adoption to help improve farm productivity. Record keeping has a probability of increasing technology adoption by 0.55% in livestock production for farmers who keep records. [32] noted that farmers' who often pay attention to records keeping of their farm business have superiority in management decisions and are also better positioned to acquire credits to boost their businesses.

4. CONCLUSION

Improved livestock production technology adoption is a potential avenue for increased income and food security among smallholder farmers. The study revealed that on the average, about 76% of the respondents were unaware of all possible improved LPTs, which primarily could be attributed to the inadequate or lack of information to farmers in the study area. Farmers' access to information was low as extension agents only visit farmers during cropping season which meant less attention to the livestock sector. Other sources of information were NGOs, indigenes, Animal Research Institute, veterinary officers and self-knowledge, but their visits are mostly on yearly bases, thus limiting farmers' access to timely information. Extension contact, intent of keeping livestock, education, sex, number of children of the farmer, herd size (cattle and goats), source of stock and farm records were found to be significant factors of adoption of LPT in the study area. Based on the findings the following conclusions are made:

- ❖ Farmers' awareness and use of livestock production technology is very low in the study area.
- ❖ Factors such as, intent of keeping livestock (to pay school fees and hospital bills), expectation of future prospect of the farm, income from livestock, source of stock and farm records were found to be significant variables and had a probability of increasing the adoption of livestock production technologies in Northern region of Ghana.

5. RECOMMENDATIONS

- ❖ Since most of the respondents were unaware of livestock production technologies due to lack/inadequate information, extension agents must increase the frequency of extension visits to farmers. This could increase the level of awareness and consequently their farmers' knowledge on improved farming methods. The extension agents must be knowledgeable on improved livestock production technologies so they can transmit same to farmers engaged in livestock production.

- ❖ Any intervention to increase the adoption of improved livestock production technology in the study area among other things should consider the specific factors such as herd size, extension contact, income, source of stock and expectation of the farmers that influence adoption.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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