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SOCIAL FACTORS AFFECTING ADOPTION OF ZERO-GRAZING DAIRY FARMING TECHNOLOGY AMONG SMALLHOLDER FARMERS IN BONDO SUBCOUNTY, KENYA

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ABSTRAT: *Adoption of zero-grazing technology in Bondo Sub-County has remained low at 4-8 percent despite its introduction in the area in 1990s. No in-depth analysis has ever been conducted in Bondo Sub-County on the factors responsible for low adoption of this technology. Knowledge gaps exist on practices of successful zero-grazing dairy farming that if addressed may result to an increase in milk production. The purpose of this study was to analyze social factors influencing adoption and performance of zero-grazing dairy farming among smallholder farmers. A study was conducted on a sampled population of 279 from a target population of 4253 smallholder farmers. This consisted of adopters and non-adopters of the technology. Sampling techniques were used to select households. The results showed that age, gender and farm experience significantly influenced adoption of dairy farming technology. The study concluded that age, gender and farm experience influence adoption of technology in the area.*

KEY WORD: *Dairy farming, zero-grazing, adoption, bi-probit model.*

INTRODUCTION

In Kenya, agriculture is the mainstay of the economy directly contributing 35 per cent of the Gross Domestic Product (GDP) annually and another 25 per cent indirectly. The sector accounts for 65 per cent of Kenya's total exports and provides more than 70 per cent of informal employment in the rural areas and 18 per cent of formal employment (Republic of Kenya, 2013). Agriculture in itself is also a market for industrial goods such as machinery, equipment and fertilizers used in the farming process. It promotes and creates various off-farm activities such as transportation, research programmes that look

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for better and improved methods to be applied in farming and livestock activities. Agriculture ensures a constant food supply and food security for the population. It also saves the country funds that would have rather been used in importing food from other countries this in turn has a positive effect on the country's balance of payments and there is surplus money to invest in other areas of the economy such as social overheads, roads and hospitals (MOA, 2014). Above all, agriculture contributes towards rural-urban balancing, through the creation of employment in the rural areas thus discourages rural to urban migration and this helps in the better distribution of incomes and balanced use of social amenities. Through all this multiplier effects, agriculture is perceived as an engine of economic growth and development.

Investment in technologies such as zero-grazing dairy farming, agricultural mechanization, irrigation, and greenhouses, with computer-controlled technology, provides ideal conditions for high quality crops. Kenya has also adopted genetic engineering that has allowed new plants to be bred that resist drought and diseases while giving higher yield. Introduction of agricultural value-chain approach also has a prospect of improved future agricultural productivity.

Over the years, agricultural production in Kenya has been facing challenges that have contributed to reduced productivity. Alila and Alila (2006) noted that the performance of Agriculture slackened dramatically over the post-independence years from an average of 4.7 percent in the first decade to only below 2 percent in the 90s. This decline culminated in a negative economic growth rate of -2.4 percent in 2000. In the year 2010 agriculture grew by 6.3 percent as opposed to contractions of 4.1 percent and 2.6 percent experienced in 2008 and 2009 respectively (KNBS, 2011). Today, however, the challenges in agricultural production are much more complex and much more immediate. Global issues such as climate change and food insecurity need to be addressed simultaneously. This means that agricultural innovations must necessarily emerge out of complex decision making process that weigh immediate concerns of feeding the world's expanding population. Kenya's agriculture is mainly rain-fed and is entirely dependent on the bimodal rainfall in most parts of the country. A larger proportion of the country, accounting for more than 80 percent is semi-arid with annual rainfall average of 400 mm. Drought are frequent and crops fail in one out of every three seasons (MOA, 2013). Kenya's agriculture is predominantly small-scale farming mainly in the high potential areas, production is carried out on farms averaging 0.2-3ha, mostly on commercial basis. This small-scale production accounts for 75 percent of the total agricultural output and 70 percent of marketed agricultural produce.

In general, the adoption of improved agricultural technologies is said to be a vital pathway out of poverty for many farmers in developing countries (Bandiera and Rasul

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2006; Mishra & Park, 2005). However, adoption does not happen immediately as a lot of factors need to be considered. To support the adoption of zero grazing at the national level, the Republic of Kenya has put in place policies, which advocate for intensification of agricultural production aimed at increasing output and productivity (Bebe *et al.,* 2002). In addition, at the international level, in recent years, developing countries including Kenya have received increased attention on adoption of agricultural technologies (Makokha *et al.,* 2007). Adoption of new technologies is viewed as the key to agricultural development (Adesina and Zinnah, 1993).

Bondo Sub-county is one of the many regions in Kenya that experience food insecurity due to low agricultural production that has been attributed to the harsh environmental conditions, but at the same time, low uptake of agricultural innovations. For the last 10 years, various agricultural innovations have been introduced in the area through agricultural extension but with minimum success. These includes, new seed varieties, inorganic fertilizers, zero grazing livestock production method, agricultural mechanization, modern irrigation techniques and agribusiness value chain strategy. This notwithstanding, Bondo Sub-county continues to experience chronic food shortages with over 50 percent of food being bought from markets outside the Sub-county. Milk deficit is a common occurrence in the Sub-county since many farmers are still using traditional livestock keeping methods that have low returns. Dairy farming is an important livelihood strategy for smallholder farmers in Kenya. This is especially so for those in rural areas as it provide food security and livelihoods for rural households. It is therefore important for smallholder farmers to invest in reliable dairy technology to ensure that they have a constant flow of milk to provide for deficit market demand. These among other factors have triggered this study to interrogate what underlies the low uptake of agricultural innovations that intended to improve food production in Bondo Sub-county that is suffering from chronic food shortage conditions.

LITERATURE REVIEW

Factors Influencing Adoption of Agricultural Technology

There are several factors that determine whether a farmer will or will not adopt a certain technology. Studies have shown that farmers' decision to adopt or not to depend on their needs, cost incurred and benefit accruing from the adoption of the technology (Karki, 2004). The decision of a farmer to adopt a technology will also depend on the characteristics of an innovation (Kinnucan *et al.,* 1990). These characteristics do not take into account whether the proposed technology is better than one it intends to replace. What matters is whether farmers see the new technology to have an advantage over the one it is replacing and to what extent they stand to benefit from the new technology.

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Farmers consider a range of characteristics such as household (education, age, and family size), farm characteristics, technology characteristics, wealth (economic status), contact with extension agents, farmers knowledge of specific technologies, price, access to credit and the position of a farmer in farmer in farmers organization to determine the adoption of new technologies (Legesse, 1992; Teressa, 1997; Walday, 1999). Oladele (2005) also mentioned a range of economic, social, physical, and technical aspects of farming that influences the adoption of agricultural production technologies.

The adoption of the technologies promoted could also be determined by the profitability from the agro pastoralists' point of view (Giger *et al.*, 1999). This goes to suggest that farmers will abandon or discontinue the use of a technology if they feel that it is not beneficial either in the short or long run. The irony lies in the fact that the economic impact of the adoption of a technology cannot be known in advance with certainty (Karki, 2004).

Level of Awareness of Zero Grazing Dairy Farming Technology

Awareness is described as having knowledge or cognizance; aware of the difference between two or more versions (The free dictionary). Over the last decade, milk productivity growth has been positive. The increase in productivity may be attributed to a number of factors such as improved animal husbandry practices and veterinary care, better quality feeds, and adoption of more intensive grazing systems and improved cow breeds (Wambugu, *et al.,* 2011). Farmer awareness is promoted by presence of extension officers in Kenya. Dairy producers aim to increase productivity at the lowest possible cost. Farmers seek to ensure that the safety and quality of their raw milk will satisfy the highest expectations of the food industry and consumers. In addition, on-farm practices should ensure that milk is produced by healthy cattle under sustainable economic, social and environmental conditions. This can be achieved by observing the best practices in the industry. Good dairy farming practices entail the following as stated by FAO (2009): Animal health; milking hygiene; nutrition (feed and water); animal welfare; environment and socio-economic management. Farmers should take into consideration applying these principles & practices to the whole farm system within a philosophy of continuous improvement, starting with the livestock in scope (SAI).

Farmer awareness is particularly important in production; Farmers should use good quality forage and improved pasture which may provide sufficient nutrients for maintenance and production of approximately 5.0 kg/day of milk (Trail and Gregory, 1981). Concentrates are fed to supply energy and protein for increased milk production. In addition to the limited availability, the high cost of concentrates and the declining

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milk to concentrate price ratio makes it difficult to feed adequate concentrates regularly resulting in low productivity. The declining milk price to concentrate price ratio from 1985 through 1993 caused the decline in viability of dairying. It has been shown that unless the milk to concentrate price ratio is greater than one, the economics of feeding concentrates may be doubtful (Walshe *et al.,* 1991). The declining milk price to concentrate price ratio maybe used as a guide to choose feeds and the optimum quantity of concentrate to be fed in a given situation.

Farmers should have knowledge of these practices and how to apply them so as to be deemed aware. Therefore being aware entails knowing this potential production changing practices and whether they apply them or not is another issue. Awareness of the market dynamics by the farmer will also affect the amount of milk that reaches the market.

The decision on use of technologies is dependent on how farmers perceive of technology. According to Price (1996), perception acts as filter through which new observations are interpreted. According to Van de Ban and Hawkin (1988), perception is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. Decision making model of Norton and Mumford (1983, cited by Heong, *et al*., 1994) shows that, on the basis of perception of the problem, farmer's choice of action (decision) will depend on his evaluation of this and other outcomes, in terms of his own personal perspectives. Allport (1965) cited that perception involves understanding and awareness of a meaning or recognition of the objects. In this research, the objects are technologies. According to Koppel (1978), the predominant role of technology is facilitating major improvement in agricultural productivity. Therefore it is important to know how farmers perceive technologies for better understanding of their choice in decision to adopt or not. Technology is one of the resources for agricultural production. According to Ingold (2002), definitions of technology differ widely, depending on whether the intent is to embrace the totality of human works, in all societies and during all epochs. Rogers (1983) reported that technology is a design for instrumental action that reduced the uncertainty in the cause and effect relationships involved in achieving a desired outcome.

Technology specific characteristics

Social Factors

There are a number of factors that influence the extent of adoption of agricultural technology by individual or a group of farmers. These are social, economic and institutional factors. Social-cultural factors are complex and focus on knowledge,

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beliefs, arts, morals, laws and customs and any other capacities and habits acquired by man as a member of a society. These factors are important because a member of the society needs to know them in order to participate in various activities (Tylor, 2006; Mwangi, 2015). Normally, in any society, the social issues are actions taken by individuals and have close interconnectedness with other people. The cultural aspect of a society is concerned with questions of shared social meanings, that is, the various ways we make sense of the world. In so far as culture is a common whole way of life, its boundaries are largely locked into those of nationality and ethnicity (Barker, 2008; Eboje 2012; Clarke and Akinbode, 1968). Cultures are not pure, authentic and locally bound. They are the synergic and hybridized products of interaction across space (Bhabha, 1994). Culture is the people's way of life.

Traditionally, women have a lesser role than men in the decision making process that affect and control their own lives and those of their homesteads and entitlements (Flintan, 2003; Muir, 2006). According to Papadopoulus (2010) culture has negative attributes to adoption of agricultural innovations. The social structure in developing nations has been found to be a powerful determinant of individual's access to technological innovation, often, structural rigidities must be overcome before the communication of innovations can have much effect (Bordenave, 1976). For example, farmers who own larger farms than most others, who enjoy a higher socioeconomic status, and who have more ample mass communication opportunities, are most innovative in adopting new agricultural technologies. Perhaps a farmer's failure to adopt innovations is due more to lack of opportunities, rather than to an in-built traditional resistance to change. Farmers with more land, more money, and more knowledge can more easily obtain credit, further information, and other inputs to adopt technical innovations. Since they adopt innovations relatively earlier, they gain more of the benefits of innovations, such as high profits that accrue especially to innovators. The majority of poorer farmers in developing nations lack resources and either cannot adopt innovation or else must adopt relatively later. Most farmers in developing nations simply are not free to implement their own innovation decisions.

Development agencies tend to provide assistance especially to their innovative, wealthy, educated, and information-seeking clients. Following this progressive diffusion strategy leads to less equitable development. For example, more progressive farmers are eager for new ideas, and have the economic means to adopt; they can also more easily obtain credit if they need. Because they have large-sized farms, the direct effect of their adoption on total agricultural production is also greater. Rural development workers follow this progressive client strategy because they cannot reach all of their clients, so they concentrate on their most responsive clients, with whom they are most homophilous. In other words, individuals who have greater resources usually benefit more from the

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innovations introduced by development agencies than those individuals who have fewer resources, thus widening the socio-economic benefit gap (Shingi and Mody, 1976). Human capital of the farmer is assumed to have a significant influence on farmer's decision to adopt new technologies. Most adoption studies have attempted to measure human capital through a number of social factors such as farmer's education, age, gender, and household size (Fernandez-Cornejo, *et al*., 2007, Keelan *et al*., 2014)

Education: Education level of the farmer has been assumed to have a positive influence on farmer's decision to adopt new technology (Namara, *et al.*, 2013).For instance, a study by Okunlola *et al.,* (2011) on adoption of new technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizers found that the level of education had a positive and significant influence on adoption of technology. This is because higher education influences respondent's attitudes and thoughts making them more open, rational and able to analyse the benefits of new technology (Waller, *et al.* 1998). This eases the introduction of a new innovation which ultimately affects the adoption process (Adebiyi & Okunloa, 2010). Other studies that have reported a positive relationship between education and adoption as cited by Uematsu and Mishra (2010) include, Putler and Zilberman (1988) on adoption of microcomputers in agriculture, Mishra *et al.,* (2009) on use of internet, Rahm and Huffman (1984) on reduced tillage, and Traore, et al., (1998) on on-farm adoption of conservation tillage.

Other the hand, some authors have reported insignificant or negative effects of education on the rate of technology adoption (Grieshop *et al.*, 1988, Samiee *et al.*, 2009, and Afrizon, 2011). Studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops. Since the above empirical evidence have shown mixed results on the influence of education and adoption of new technology, more study needs to be done in order to come up with a more consistent result.

Age: Age is also assumed to be a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Kariyasa and Dewi, 2011). On the contrary, age has been found to have a negative relationship with adoption of technology. This relationship is explained by Mauceri *et al.*, (2005), and Adesina and Zinnah (1993) that as farmers grow older, there is an increase in risk aversion and a decreased interest in long term investment in the farm. On the other hand, younger farmers are typically less risk-averse and are more willing to try new technologies. For instance, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their stock of human capital but declined with age for those farmers closer to retirement.

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Gender: Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana-Wabbi, 2002). In analyzing the impact of gender on technology adoption, Morris and Doss (1999) had found no significant association between gender and probability to adopt improved maize in Ghana. They concluded that technology adoption decisions depend primarily on access resources, rather than on gender and if adoption of improved maize depends on access to land, labour, or other resources, and if in particular context men tend to have better access to these resources than women, then in that context the technologies will not benefit men and women equally. On the other hand gender may have a significant influence on some technologies. Gender affects technology adoption since the head of the household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms .For instance, a study by Obisesan (2014) on adoption of technology found that gender had a significant and positive influence on adoption of improved cassava production in Nigeria. This result concurred with that of Lavison (2013) which indicated male farmers were more likely to adopt organic fertilizer unlike their female counterparts.

Household size is simply used as a measure of labour availability. It determines adoption process in that, a larger household have the capacity to relax the labour constraints required during introduction of new technology (Bonabana-Wabbi, 2002; Mignouna *et al.*, 2011).

Land Tenure System: Land reform experts claim that the main obstacle to increased agricultural output is shortage of land and population pressure (FAO, 2003 FAO, 2006; 2007). However, it is not the shortage of land alone, which affects the output of agriculture; it is the structure of land tenure, the lack of proper land ownership as well as lack of improved agricultural technology and changing climatic conditions. This is predominantly the major problem particularly in most of sub-Saharan Africa countries including Kenya. According to FAO, land tenure is the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. Land tenure is set of rules invented by societies to regulate behavior. Rules of tenure define how property rights to land are to be allocated within societies. They define how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints. In simple terms, land tenure systems determine who can use land as a resource and for how long, and under what conditions. The size of land ownerned will determine the kindly of technology to be adopted. Example zero-grazing dairy farming technology needs enough land for the establishment of fooder along with enough space for the construction of a standard zero-grazing unit.

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Family size: Family size includes the number of usual resident members in a household. Usual resident members are defined as those who have lived in the household for at least 6 months during previous 12 months. It may include fostered children, grandparents and other relatives who have joined the household with the intention to live permanently or for an extended period of time. It is another factor that affects adoption of agricultural technology because it increases the availability of labour on the farm.

METHODOLOGY

Description of study site

The study was done in Bondo Sub-county, Siaya - Kenya. Bondo is one of the six Sub-counties that make Siaya county. The Sub-county has a total area of 1328 km^2 of which 577.2 km^{2}is land surface, while 751km^2 is covered by water. It borders Siaya Sub-county and Busia County to the North-West, Kisumu to the East and Rarieda Sub-county to the East and, Homabay Sub-county across the Lake on the South-East and South, to the West lies the Republic of Uganda (see Appendix I). Bondo Sub-county lies between 0'26' to 0' 90' South of the Equator and from longitude 33' 58'E and 34' 35'W. There are three administrative divisions namely Usigu, Maranda and Nyangoma, and twenty six sub-locations. The Sub-county has six electoral wards and one constituency known as Bondo.

The sub County has an area of 31,800 ha, measuring 480 km^2 of arable land. The altitude ranges 1140-1400metres above the sea level with temperature ranges of 15-33 ^{o}c. The area receives annual rainfall of 800-1600mm p.a. The population is about 144,780 with an average farm size being about 3.5 acres. Agro-ecological zone are LM2-LM3 and LM4 being dominant. Dominant soil types in West and South Sakwa, Usigu- are ferrasols. North Sakwa and Central Imbo have luvisols with low- moderate fertility. Yala Swamp in Usigu division has gleysols, which are water logging, fertile and variable. Major food crops includes: Maize, Sorghum and Beans. Major cash crops are Cotton and Horticulture grown along the Lake Victoria. Major Livestock are Zebu cattle, goats, sheep and local poultry. Fishing is also a major livelihood activity contributing about 50 to the Livelihood needs

Research Design

The study adopted descriptive survey research design. The design was found suitable for this study since it provided insights and understanding of the factors influencing adoption of zero-grazing dairy farming technology among smallholder farmers in Bondo Sub-

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county. Descriptive research also includes fact finding and making enquiries of different kinds of information, such as information on age, sex, marital status, education, occupation and many others. Another reason why descriptive survey was used is because it described the state affairs as it exists at a particular time. The main characteristic of this method is that the researcher had no control over the variables and could only report what had happened or what is happening. The data in this research were derived from both observational situation and through questionnaire.

THEORETICAL FRAMEWORK

De Souza Filho (1997:82) suggests that farmers are influenced by various economic and non-economic factors to make decisions regarding the adoption of agricultural technologies. Farmers will hesitate to adopt a technology if income increase is expected to be low and if costs of the technology outweigh the benefits. Other common exploratory variables include farm size, risk and uncertainty, human capital, labour availability, credit and supply constraints. According to El-Osta and Morehart (2000), farmers have been able to succeed financially through increased productivity and lower per unit costs as a result of the contribution that technological advances make to the dairy industry. These advances have been categorized as capital-intense such as genetically superior dairy cows and management-intense practices such as improved nutrition and feeding commonly known as zero-grazing.

However, these are not applicable to those smallholder farmers that are already constrained financially and do not have the appropriate breeds. These limitations have been observed among smallholder farmers in their quest to increase farm productivity (Zvomuya, 2007). Research and technology directed at addressing constraints such as feeding, appropriate breeds selection, animal health and other constraints that if addressed will lead to improved productivity. This has been done through a number of projects initiated by Ministry of Agriculture, Research organizations such as Kenya Agricultural and Livestock Research Organization (KALRO) which has invested in ensuring that smallholder farmers are given assistance in improving their farm practices. Byerlee and Polanco (1986) suggest that although transferring technology as a package allows interactions among components and emphasizes the large difference in yields between traditional and improved methods, it comes at a cost as farmers are constrained by capital and have to consider the risks associated with it.

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Sample size and sampling procedure

The target population was dichotomous in nature, as such it comprised of the farmers who practice zero grazing and farmers who do not. The list containing farmers who practice zero-grazing and those who do not was obtained from the sub-county livestock office. This formed the sampling frame. It consisted of 4253 small-scale livestock farmers with less than 10 acres of land situated in Bondo sub-county.The sample size was determined using formula given by Nassiuma (2000) for household, as given in equation one.

$$n = \frac{Z^2 pqN}{e^2(N-1) + (Z^2 pq)} \quad \text{..........1}$$

Where N = sample size, p= population proportion with the characteristic of interest, $q = (1-p)$, N = Size of the population, e = margin of error, Z= critical value at the desired confidence interval. This formula is applicable for sample size where target population is below 10,000

Bondo sub-county was purposively selected from the six sub-counties in Siaya County. Bondo sub-County was selected because it is one of the sub-Counties in Kenya where National Dairy Development project was initiated. In the six wards of Bondo sub-County proportionate sampling technique was used to determine the number of small-scale farmers that were sampled. In each ward Simple Random Sampling technique was used to select the first respondent, then systematic sampling technique was used to select the rest of the respondents. Out of 4253 small-scale farmers 294 were randomly selected using simple random sampling technique. However, 17 farmers were not considered in the final data analysis because of poor response, which includes many unanswered questions. Structured questionnaires were administered during primary data collection. The study had a sampling frame of 277 small scale dairy farmers drawn from the six wards of Bondo sub-county.

Data analysis

Descriptive analysis

To describe the features of generated data descriptive statistics were provided. The statistics were continuous and categorical variables. Descriptive analysis is a method that provides statistics used to describe the basic features of the data in a study. The statistical measures were summarized by central tendency (mean, mode, median),dispersion and variance. Different descriptive statistics were used depending on whether the outcome variable is continuous or categorical. They provide simple summaries of the

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characteristics of the sample such as measures of central tendency, dispersion, and variability. They often provide guidance for more advanced quantitative analyses. However, they have limitation of not showing the relationship among the variables and the influence that each variable may have on the response. In this study, measures of central tendency such as the mean values and measures of dispersion such as the minimum and maximum (range) and standard errors were produced for continuous variables. For categorical variables descriptive statistics (the percentages) were used to describe and summary the social- economic variables that were used in the various models.

Logit Model

Logit model was used in analysing factors influencing adoption of zero-grazing technology. The logit model predicts the outcome of dairy technology. The dependent variable was Prob (Adoption = 1| X) where X is the set of independent variables $p(Q_i=1)$

$$P_i = \frac{1}{(1+e^{-z})} = \frac{e^z}{(1+e^{-z})} \quad \text{.....14}$$

Z=xβx+u.....15

The probability of not adopting the locally produced adapted technology is:

$$1 - P_i = \frac{1}{(1+e^z)} \quad \text{.....16}$$

From equation 3.17, the odds ratio is specified as

$$\frac{P_i}{(1-P_i)} = e^{x\beta+u} \quad \text{.....17}$$

Model specification

The empirical model of the effect of the explanatory variables on adoption of zero grazing technology among smallholder farmers was specified in linear relationship as:

$$Y_{i1} = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 +$$

$$\beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14} + \beta_{15}X_{15} + \beta_{16}X_{16} + \beta_{17}X_{17} + \varepsilon$$

.....3.13

Where Y_{i1} is the adoption of zero grazing technology, β_0 is the intercept, $\beta_{i's}$ are the coefficients of the equation, X_1 is the age, $X_2$the gender, X_3 the education level, X_4 the family size, X_5 the farm experience, X_6 the farm size, X_7 cost of technology, X_8 farm

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income, X_9 off farm income, X_{10} cost of labor, X_{11} training, X_{12} the extension, X_{13} frequency of visit, X_{14} the land tenure, X_{15} the credit access, X_{16} the distance to the market, X_{17} the group membership and ε the error term.

Table 1: Measurements of Variables Expected signs

Variable	**Type**	**Description**	**Expected sign**
Dependent			
Adoption of Zero grazing tech	Dummy	Adoption of zero grazing technology (1=adopter; 0=otherwise)	
Performance amount of mild produce	Continuous	Amount of milk produced in litres	
Independent			
Social			
Age	Continuous	Age of the farm household head	+
Gender	Dummy	Gender of the household head	+/-
Education level	Categorical	Highest academic attained by household head	+
Family size	Continuous	Total number of household members	+/-
Experience	Continuous	Experience in farming	+
Farm size	Continuous	Farm size in acres	+

Source: Researcher, 2019

RESULTS

Descriptive Statistics

The descriptive characteristics of respondents were grouped as continuous and categorical variables. Descriptive statistics were used to summarize the social characteristics of the farmers in the study area. Summary statistics was also done to show the sample characteristics and to remove outliers.

Level of Adoption

The findings of the study showed that majority of the respondents were non adopters of zero grazing technology and they were 132 males and 73 females as shown in table 2. Only 17 females have adopted the technology while adopters are 57 in number.

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Household respondent		Adopters		Total
		No	yes	
	Female	73	17	90
	Male	132	57	189
Total		205	74	279

Source: Authors' compilation, 2019
Table 1: Influence of gender on Adoption of Zero Grazing Technology in Bondo sub-county

Percentage wise it is shown that 205 (73.5 percent) farmers have not adopted the technology while 74 (26.5 percent) have adopted zero grazing technology. This shows that there is low level of adoption of zero grazing in the study area.

Age Distribution of Household Head

Figure 1 below shows that age distribution of the sampled respondents. The maximum age is 79 and the lowest age is 19 years. It is further shown that the average age is 49.44 years which is the most active age terms of farm activities. Similar findings were found by Staal *et al.*, (2001) who showed that the average age respondents participating in cattle farming is 48 years.

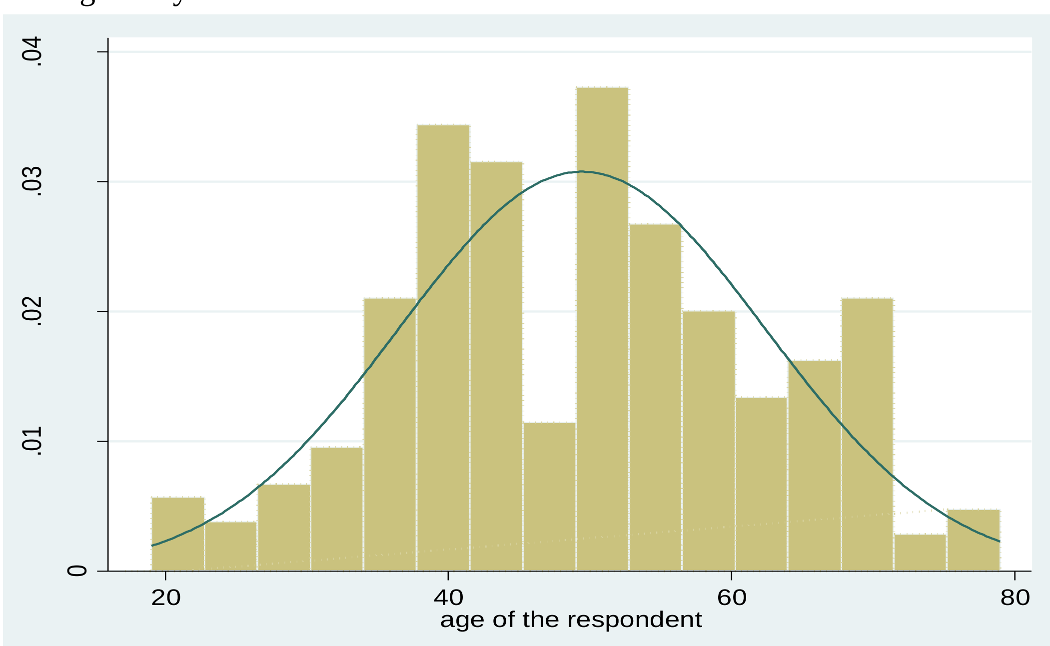

Figure 1: Age Distribution of the Respondents
Source: Authors' compilation, 2019

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Frequency of Gender of the Household Head
Majority of household head were male headed and this accounted for 67.7 percent while 32.3 percent of the households are female headed.

	Frequency	Percent	Cumulative Percent
Female	90	32.3	32.3
Male	189	67.7	100.0
Total	**279**	**100.0**	

Source: Authors' compilation, 2019
Table 2: Gender of the Household head

Gender distribution is an indication that men dominated household (table 3). Male farmers are likely to have more access to inputs, capital and information through farmers' networks and contact with extension agents than female farmers (Dey, 1981). In the recent studies on animal health choices found gender to play little or no role among smallholder farmers in Kenya (Tambi *et al*., 1999; Heffernan and Misturelli, 2000; Randolph and Ndung'u, 2000). These findings suggest that household strategies should be designed to target male since they are the majority. Efforts should also be put in place to encourage more women to modern dairy farming.

Summary of Categorical Variables

The categorical variables were gender of the household head, education level, land tenure system, access to technology, access extension services, frequency of extension visits, breed of cows kept, group membership, access to credit services, access to extension services. The highest academic levels of the respondents are shown in table 4 below. It is shown that the 4.3 percent of the respondents had no formal schooling. On the other hand, 31.9 percent of the respondents were found to have schooled up to secondary education. This is an indication that majority of the respondents had their highest academic level at secondary level. Only 26.9 percent of the respondents had accessed to education up to a tertiary level and others (this could be adult education, masters level and doctoral level degree).

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Table 4: Highest Level of Education of the Respondent

Education level	Frequency	Percent	Valid Percent	Cumulative Percent
No formal	12	4.3	4.3	4.3
Primary	94	33.7	33.7	38.0
Secondary	89	31.9	31.9	69.9
Tertiary	75	26.9	26.9	96.8
Others	9	3.2	3.2	100.0

Source: Authors compilation, 2019

Education is an important component in adoption of zero grazing technologies. Low level of education may be an impediment in adoption of zero grazing technology. Low education level may limit adoption of technologies since they may not be willing to try new innovations. Schultz, (1990) and Adesina and Zinnah (1993) argued that quality education represents human capital, as it is thought to be largely responsible for improving access to new technology and general economic welfare of an individual.

Diagnostic Tests

The following diagnostic tests were done before testing the study hypotheses; Multicollinerity and Normality test.

Test for Multicollinearity

Two or more independent variables might be correlated with each other. This situation is referred as collinearity. There is an extreme situation, called multicollinearity, where collinearity exists between three or more variables even if no pair of variables has a particularly high correlation. This means that there is redundancy between predictor variables. Presence of multicollinearity, regression model becomes unstable. In this multicollinearity was tested by computing a score called variance inflation factor (VIF), which measures how much the variance of a regression coefficient is inflated due to multicollinearity in the model. The smallest possible value of VIF is one (absence of multicollinearity). As a rule of thumb, a VIF value that exceeds 5 or 10 indicates a problematic amount of collinearity (James *et al.*, 2014). The results in table 5 shows that all the variables under this study had VIF less than 5. Therefore, there was no multicollinearity.

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Table 5: Test of Multicollinearity Using Variance Inflation Factor (VIF)

Variable	**VIF**	**1/VIF**
Education level	1.43	0.698748
Land Tenure	1.19	0.841687
Age	1.17	0.856916
Family Size	1.17	0.858086
Gender	1.07	0.930615
Experience	1.06	0.939301
Mean VIF	**1.18**	

Source: Researcher, 2019

Tests for Normality

The test results indicate whether you should reject or fail to reject the null hypothesis that come from a normally distributed population. Normality test can be done and produce a normal probability plot in the same analysis. The normality test and probability plot are usually the best tools for judging normality, especially for smaller samples. In this study, Shapiro-Wilk normality test was used. This test assesses normality by calculating the Shapiro-Wilk of Shapiro-Francia ‘W’ statistic between the data and the normal scores of the data. If null hypothesis H_0: Data is Normally Distributed. And according the results

presented below (table 6), the variables were normally distributed. Therefore, the study proceeded to test for hypothesis using z-statistic.

Table 6: Results for Normality Using Shapiro-Wilk Test

Variable	**Obs**	**W**	**V**	**z**	**Prob>z**
Age	279	0.99248	1.502	0.952	0.17051
Gender	279	0.99504	0.991	-0.022	0.50874
Education	279	0.99191	1.617	1.124	0.13047
Family Size	279	0.98692	2.614	2.248	0.0123
Land Tenure	279	0.96459	7.074	1.576	0.057
Experience	279	0.43686	112.512	1.048	0.1478

*W and V are Shapiro-Wilk and Shapiro-Francia Test Statistic for normality respectively.
Z is the test statistic for standard normal distribution.
Source: Researcher, 2019

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Regression Results and Test of Hypotheses

The coefficient of age as shown in table 7. was positive and significant (0.10198) implying that when age of the farmer increases by one unit, the chances of adoption of zero-grazing technology is likely to increase by 0.102 units. This means that older farmers have more experience of dairy farming activities and are more likely to adopt and practice new technologies. The coefficient of gender was negative (-0.1454) and insignificant (p – value 0.834 > 0.05). The coefficient of education was positive and significant (p – value 0.021 < 0.05). The coefficient of education was 0.9102 meaning that when education level of the farmer increases by one unit the likelihood of adoption of zero-grazing technology increases by 0.912 units.

Family size recorded a negative and insignificant coefficient (p- value 0.214 > 0.05). Farming experience had positive and significant coefficient at 10% level of significance. The coefficient of experience was 0.03887 showing the when experience increases by one unit, the chances of adoption of zero-grazing technology is likely to increase by 0.09 units. Farm size also recorded a negative and insignificant coffecient (p- value 0.924 > 0.05).

Table 7: Logit Regression Results

Number of obs = 279
LR ch2(19) = 232.0700
Prob > Chi2 = 0.0000
F (19,260) = 3.8400
Pseudo-R^2=71.90

Variables	**Coefficient**	**Std .Err**	**z**	**P > |z|**
Age	0.1019	0.0455	2.24	0.025
Gender	-0.1454	0.6926	-0.21	0.834
Education	0.9102	0.3937	2.31	0.021
Family size	-0.1861	0.1497	-1.24	0.214
Experience	0.3886	0.0221	1.76	0.079
Land tenure	-0.3178	0.3634	-0.87	0.382
Constant	4.6928	4.7062	1.00	0.319

Source: Researcher, 2019

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From the results and according to the hypoyhesis; The social factors such as age of the house hold head, gender, education level, family size and experience do not significantly influence adoption of zero-gazing dairy farming technology in Bondo sub-county was therefore rejected and concluded that social factors do affect the adoption of zero grazing dairy technology in Bondo Sub-County (table 8).

Table 8: Bi Probit Regression Results

Adoption	**Coefficient**	**Std. Err**	**z**	**p > |z|**
Age	0.0534	0.0227	2.35	0.019
Gender	-0.1625	0.3481	-0.47	0.641
Education	0.376	0.1894	1.98	0.047
Family size	-0.1153	0.0775	-1.49	0.137
Experience	0.0225	0.0115	1.95	0.051
Land tenure	-0.1438	0.1861	-0.7	0.44
Group	-0.8377	0.4036	-2.08	0.038

Source: Authors' compilation, 2019

In this research, the probability to adopt zero grazing technology to the probability not to adopt can be explained using odd ratios. The logistics regression results were presented in table 9. This model applies in a case where the dependent variable (adoption). A case where a farmer has adopted zero grazing technology was assigned code 1 while farmer who has not adopted zero grazing technology was designated code 0. This is as per Hosmer and Lemeshow, 2000 and Cavane, (2011).

The logistic model analyzes the dichotomous variable coded as 1 = farmers who practice zero grazing and 0 = farmers who do not (Hosmer and Lemeshow, 2000 and Cavane, 2011). The results indicate that the number of observation for this study was 279 respondents and design of 278 degree of freedom with f – statistic of F (19,260) = 3.84. The reported prob > chi2 = 0.0000 implying that the model was fit to estimate the parameters. The estimated regression equation on the factors affecting the adoption of zero grazing technologies in Bondo Sub county shows that the age odds ratio to adopt zero grazing technology was found to be 1.1073 and is statistically significant. This indicates that age of the farmer influences the adoption of zero grazing in Bondo Sub-County. This implies that as the more the older farmers are the more chances to adopt zero grazing. This could stem from the fact that older people could have saved capital which enable them to invest in advanced technologies such as zero grazing, which young people could not afford due to a likelihood of having no savings. These findings conform the study done by Nalunkuuma et al (2013) their study found that the odds ratio of age of household head was 1.03, which implied that older household heads are 1.03 times more

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likely to adopt zero grazing. The study was also consistent with the findings of Murage and IIatsia (2011) and Kafle and Shah (2012) who found that age and technology adoption had a significant relationship.

Table 9: Logistic Regression

Number of observation = 279

Population size = 279

Design df = 278

F (19,260) = 3.84

Number of strata

Prob >chi2 = 0.0000

Adoption	**Odds Ratio**	**Std .Err**	**z**	**P > |z|**
Age	1.1073	0.0416	2.710	0.007
Gender	0.8646	0.5358	-0.230	0.815
Education	2.4849	1.0966	2.060	0.040
Family size	0.8302	0.1100	-1.400	0.161
Experience	1.0396	0.1511	2.670	0.008
Land tenure	0.7277	0.2542	-0.910	0.364
Constant	109.1672	441.6405	1.16	0.247

Source: Authors' compilation, 2019

The table 4.13 also showed that education level had a higher odds ratio of 2.485 and significant influence on adoption of zero grazing farming. These findings are consistent with the findings of Fita *et al.*, (2012), Karamjit et al (2009), Murage and IIatsia (2011), Musaba (2010). Educated household heads acquire, understand, and disseminate new technologies within a shorter time compared to less educated household heads (Ebojei et al 2012, Kafle and Shah 2012). Furthermore, education whether self or in children enables people realize the importance and benefits of adopting new technologies (Musaba, 2010). The odds ratio implies that farmers who have more years of schooling are 1.10 (Nalunkuuma et al., 2013) times more likely to adopt zero grazing than those with less years of schooling.

In contrary, factors such as gender, farm size and land tenure had insignificant (p-values greater than 0.05 significance level) chance of adoption of zero grazing.

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DISCUSSION

The result shows that between 70-81 percent of the zero-grazing farmers were aware of various zero-grazing technological components and the benefits of adopting the technology. This implies that farmers engage in zero-grazing dairy farming only if they are aware of ZG technological components requirements and the potential benefits. This is because by being aware of the benefits of zero grazing, they will strive to learn about the importance of putting in place the standard technological components. This include: feed quality, breed quality of cows for zero-grazing as well as animal health and disease management/control for the purpose of producing high and quality milk. Consequently, the results indicate that adopters had a significantly higher awareness index of zero grazing technology compared to non-adopters.

The findings imply that awareness of zero grazing technological components is paramount to adoption of a technology. This finding is consistent with FAO (2009) and Wambugu *et al.*, (2011) that level of awareness of zero grazing components such as improved animal husbandry practices and veterinary care, better quality feeds, and adoption of more intensive grazing systems and improved cow breeds is critical for improved productivity.

The study sought to determine if social factors such as gender education level and family size had significant effect on adoption of zero-grazing dairy farming technology. Regression results in table 4.11 shows that age has positive and significant effect on adoption of zero-grazing dairy farming technology. This contradicts Quddus (2010), Quddus (2012), Feder *et al.,* (2001) and Kipkemei (2014) who found that age was negatively related to technology adoption. This means older farmers are likely to have more sources of income compared with their younger counterparts (Clinch and Vaidya, 1993).

This is probably because age is related to experience and therefore older farmers are likely to be more experienced and able to discern the importance of improved technology more as compared to the less experienced young farmers (Murage and IIatsia, 2011; Ellis and Freeman, 2004; Enos and Park, 1988). For instance, studies on agricultural technology adoption by Gbetibouo (2009) and Adesina and Forson (1995) observe that there is no consensus in the literature as to the exact effect of age in the adoption of farming technologies because the age effect is generally location or technology specific and hence, an empirical question. On one hand, age may have a negative effect on the decision to adopt new farming technologies simply because older farmers may be more risk-averse and therefore, less likely to be flexible than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt because older

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farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers (Ndambiri *et al.*, nd; Ahmed 2004; Ajewole, 2010; Akudugu *et al.*, 2012 and Alexander *et al.*, 2005).

Studies have shown that age of the farmer is related to adoption decisions. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk due to their longer planning horizons (Bultena and Hoiberg, 1983; Gould et al., 1989; Polson and Spencer, 1991). Therefore, following earlier empirical findings, the maintained hypothesis that age is negatively related to adoption is violated by the results of the current study.

These results agree with the findings of Kafle and Shah (2012) and Shields *et al*., (2012) who observed a positive and significant relationship between age and technology adoption. Similarly, Tambi *et al*., (1999) reported a positive and significant relationship between demand for improved technology and producers within the age group 25 to 50 years compared to those who were less than 25 years in Kenya.

The coefficient of gender was negative and significant showing that adoption of zero-grazing dairy technology is affected by gender in the study area. Male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw and Admassie, 2004). Moreover, Tenge and Hella (2004) argue that having a female head of household may have negative effects on the adoption, because women may have limited access to information, land, and other resources due to traditional social barriers. A study by Nhemachena and Hassan (2007) finds contrary results, arguing that female-headed households are more likely to take up adoption of new technologies. The authors conclude that women are more likely to adopt because they are responsible for much of the agricultural work in the region and therefore have greater experience and access to information on various management and farming practices. Thus, the adoptions of new technologies or adaptation methods appear to be rather context specific.

In the case of Nigerian, Jatto (2012) found that majority of the farmers had tertiary education meaning that they are highly educated. It is expected that the level of education will contribute significantly to decision making of a farmer. Obinne, (1991); Alabi and Aruna (2006) and Ndahitsa, (2008) documents that that level of education determines the quality of skills of farmers, their allocative abilities and how well informed they are to the innovations and technologies around them. Oladipo and Adekunle (2010) notes that individuals with higher educational attainment are usually being faster adopters of innovation. Kabunga (2014) found that education is positive and highly significant,

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implying that household heads with more years of formal education are more likely to adopt improved dairy cows in the case of Uganda.

Farm experience was measured in the number of years since a respondent started dairy farming on his own farm. Experience of the farmers is likely to have a range of influences on adoption. Experience expected to improve farmers' involvement in zero-grazing dairy production. Farmers with higher experience appear to have often full information and better knowledge and are able to evaluate the advantage of the technology. Hence it was hypothesized to affect adoption positively (Chilot *et al*., 1996). This finding supports prior study by (Challa & Tilahun 2014; Adebiyi and Okunlola 2010; Adebayo, 1997; Cavane, 2011).

CONCLUSION

Agricultural technology development is an essential strategy for increasing agricultural productivity, achieving food self-sufficiency and alleviating poverty and food insecurity among smallholder farmers in Kenya. In Bondo sub-county - Kenya, a number of agricultural technologies have been introduced yet the rate of adoption remained very low.

There is a need to promote agricultural technologies by designing a strategy based on farmer's problems and need. The study established that the level of awareness of zero grazing dairy farming technology was higher. Despite the higher level of awareness of the technology adoption rate was low. This may be attributed to the influence of social factors.

The results indicate that age, farm experience and education level of household head had a positive and significant influence on adoption of zero grazing dairy farming technology in Bondo sub-county. Gende had a negative and significant influence on adoption of zero-grazing dairy technology.

Therefore, the hypothesis that social factors that include age of the house hold head, gender, education level and experience do not significantly influence adoption of zero-gazing dairy farming technology in Bondo sub-county was therefore rejected and concluded that social factors do affect the adoption of zero grazing dairy technology in Bondo Sub-County.

Implication and Recommendations

To solve the problems of low adoption of zero grazing dairy farming technology, decision makers should pursue a range of policies and strategies to boost the adoption rate hence increased dairy production and farm productivity. The study made the following recommendation that can increase level of adoption of zero grazing dairy farming technology in the study area.

Based on the social factor such as age, the government and other stakeholders should synthesize the young generation to engage in modern agricultural practices such adoption of zero grazing dairy technology for instance availing avodable credit faciities. Education and training widens farmers' sphere and ability to receive and process information on dairy technologies hence increasing the likelihood of adoption. The government and county government should enhance farmers' education through adult literacy, demonstration centres and extension education so as to improve up-take of dairy technologies.

Awareness of the potential benefits from zero-grazing dairy farming is an important factor in influencing rate of adoption of zero grazing technology in Bondo sub-county. Both National and county governments should take the lead in giving information on the benefits of adopting zero-grazing dairy farming technology because the adoption rate of this technology remains very low in the area.

Future research

The current study did not consider awareness of the benefits of practicing zero-grazing dairy technology. Therefore, future study can be done to consider the level of awareness of the benefits of practicing zero-grazing dairy technology. covered sub county level.

The current study covered Bondo sub-county . Future study can be done to cover larger geographical area such as County level and also in other areas that practice zero-grazing dairy technology in Kenya.

The current study did not cover the rate of adoption among the surveyed households in Bondo sub-county. There is need to carry out longitudinal panel survey to measure the rate and impact of adoption.

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