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RESEARCH ARTICLE

EFFECT OF DECISION MAKING STAGE ON ADOPTION OF HYDROPONIC TECHNOLOGY IN DAIRY FARMING PROJECTS IN KENYA

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ABSTRACT

Introduction: This study examined the influence of decision making stage on adoption of hydroponic technology in the implementation of dairy farming projects in Kajiado County, Kenya. The focus of this study was on how the use of hydroponic technology for fodder production enhanced dairy farmers' productivity and income levels.

Material and Methods: A sample of 110 respondents was selected using simple random sampling technique (Isinya, Loitokitok and Ngong) divisions in Kajiado County. Participants were dairy farmers practising zero grazing. Semi-structured questionnaires were used to collect primary data. Correlation analysis and Regression analysis using Ordinary Least Squares were used to analyse data.

Results: The findings of this study show that decison making stage had no influence on adoption of hydroponic technology in the implementation of dairy farming projects in Kajiado County.

Conclusion: The study concludes that capacity development for dairy farmers and design of suitable public policies on hydroponic technology can enhance hydroponic technology adoption.

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INTRODUCTION

The agricultural sector in developing countries is faced with challenges due to market liberalization and structural adjustments. To seize new market opportunities, farmers need to innovate to become more efficient producers and effective entrepreneurs. Innovative farmers need new technologies and information on how to access and manage innovation, as well as better support services for the delivery of inputs, knowledge and better infrastructure for delivering produce to the market (Schreiber, 2002). Livestock domestication in Africa has been undertaken for thousands of years. The dairy industry has grown gradually in Africa, however, traditional systems have dominated milk production for several years and still supply considerable amounts of milk today accounting to above 90% of dairy ruminant population in Sub-Saharan Africa (Olaloku and Debre, 1992). However, some of the major pressing challenges to dairy farming include, feed scarcity which is often cited as the primary constraint to livestock productivity in crop-livestock mixed farming systems (Legese *et al*., 2008). Successful dairying in the future will depend on high levels of milk production, culling for low production, controlling feed costs, and using good replacements (Staal and Pratt, 2001).

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Hydroponics Technology also known as soilless culture, has been used for thousands of years, dating back to the hanging gardens of Babylon and the floating gardens of the Aztecs in Mexico (Resh,1997). The first modern use of Hydroponics Technology was in the early 1930's by William Gericke from the University of California. Gericke used a water culture method to grow plants such as tomatoes, beets, carrots, potatoes, fruits, flowers, and more. Currently, the hydroponic systems are used all over the world including areas with non-arable soil such as Mexico and the Middle East (Resh,1997). In France, the Government has sponsored research to facilitate performance of numerous experiments with hydroponic cultivation. Hydroponic methods consistently outperform soil cultivation with faster growth, higher yields and better quality produce.

Holland, is recognized as world leaders in commercial hydroponics, they produce some of the best hydroponic crops, Hydroponically grown Dutch flowers are sold in auctions then flown worldwide to meet the global demand (Netherlands Department of Environment, Food and Rural Affairs, NDEFRA). The Dutch hydroponic industry is well supported by the government on research, training and information. The industry enjoys efficient commercial infrastructure which include provision of production inputs, transport, cluster-based production and marketing systems (NDEFRA).

The Conversion of greenhouses to hydroponic systems was necessitated by widespread soil depletion, a build-up of soil disease, salinisation, high water tables and favourable economic returns (Hanger, 1993). In Canada commercial hydroponic production has been embraced and the total area has expanded from as little as 100ha in 1987 to 1,574ha (3,886 acres) in 2001. Hydroponics is the most popular method of growing vegetables in Canada because it is a less labour intensive way to manage larger areas of production, and an efficient way to control inputs and manage facilitates for pest and diseases. It eliminates the need for soil fumigants and can increase yields of popular vegetables by up to 100%. (Department of Agriculture and Agri-food, Canada website, 2001). Empirical studies on hydroponic technology have mostly been done in the developed and emerging countries, have dwelt on aspects of hydroponics, that are characteristics and trends in global industries,new crops, new hydroponic technology, new pest and disease control, the nutritional, costs and acceptability by farmers (Dung *et al.,* 2010; Hinton, 2007; Tudor *et al.,* 2003). In Kenya, Hydroponic Technology is a recently introduced fodder growing technology and it is fast rising in the country, with majority of the over 2 million livestock farmers yet to try it. The major challenge facing the hydroponic technology in Kenya is the fact that most Kenyans have not yet embraced the use of technology in growth of livestock feeds. To most livestock farmers there is not enough sensitization on the importance of adoption of hydroponic technology and access to the material for growth of livestock feeds. This can be majorly attributed to lack of enough extention officers to disseminate information to farmers. The growing of fodder using Hydroponic Technology is a new concept to the world. Although hydroponic Technology has been in use for over 50 years to supply a wide range of livestock fodder types for different purposes in varying living environments (Agrotek, 2002). Hydroponically grown fodder is considered as a sprouted forage, which provide a variety of highly nutritive food with important mineral and vitamin contents to livestock and birds (Harris, 1973).

Hydroponic technology can play a major role in dairy production. This is because fodder production can be done anywhere as long as traditional constraints are abated by improvements in technology (Mosnier and Wiek, 2010). The adoption of this technique can easily enable production of fresh forage from oats, barley, wheat and other grains. Therefore, with this technique in fodder production, dairy feeds quality, nutrition, dairy animal health, meat and milk production can improve tremendously. Hydroponic technology can be a major economical and income generation determinant among dairy farmers (Medola, 2007), what farmers gain from adoption of hydroponic technology has a direct influence on the poor households by raising their income while indirectly raising employment and wage rates on landless labourers. The benefits that a dairy farmer derives from the adoption of hydroponic technology play a role in the dairy farmer's decision to adopt the technology. Various factors motivate dairy farmers to participate in dairy farming, more so that it contributes to household welfare (Urassa and Raphael, 2002). Therefore, if the hydroponic technology introduced will increase the levels of income, farmers will be more than willing to take it up. This is based on the assumption that wealthy dairy farmers have more access to resources and are willing to invest more because they are able to manage the risk that they would be under if the technology is adopted (Doss, 2003).

Cooperatives Society are significant economic and social actors in hydroponic technology advancements. Dairy farmers benefit from cooperative equipments and loans and also, learn about hydroponic technology. It also facilitate the dairy farmer with capital and inputs in terms of subsidies to enable them adopt hydroponic technology, the cooperative society out-reach programmes meet personal as well as community goals of the dairy farmers. The high cost of manufacturing feeds, shortage of raw materials, import levies, pressure on available pasture land for grazing and increasing demand for crop land are some of the challenges contributing to hydroponic technology adoption in the world. The grazing land has been taken up by homesteads on an increasing scale at the expense of dairy farming. Kajiado has lately become a hub for real estate constructions; this can be attributed to the nearness of the county to Machakos County, Makueni County and Nairobi County. This study sought to add onto the available literature, detailing the extent to which decision making stage influence adoption of hydroponic technology in the implementation of dairy farming projectsin kajiado County, Kenya.

This study focused on selected dairy farmers in the three administrative divisions in Kajiado County, namely: Isinya, Loitokitok and Ngong the divisions were selected because they are where zero grazing dairy farming is rampantly in practice. Kajiado County is semi-arid, very dry with no continually flowing rivers. The ever rising cost of commercial feeds and the small parcels of land has hindered most farmers from dairy farming. However, use of hydroponic technology for fodder production can enhance dairy farming productivity and hence improve farmers income levels. There is little understanding of factors which determine adoption of hydroponic technology, despite the fooder shotatge in Kajiado County, hence the need for this study.

Theory

The theoretical approach used to guide the study was drawn from selected components of Diffusion of Innovation Theory (DOI) approach and Actor Network TheoryThe literature on Diffusion of Innovation Theory and Actor Network Theory suggest that the adoption behavior of farmers is explained by farmer and household characteristics. According to Rogers (2003), the decision to adopt is a process that does not happen spontaneously, but happens over time. A farmer will try out different technologies to identify what works well on their farms with the available resources before making the decision to incorporate a particular technology into practice. Rogers (2003) asserts that an innovation-decision process is "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation", the innovation-decision process involves five steps that an individual should go through before adopting technology; knowledge, persuasion, decision, implementation, and confirmation. According to Straub (2009) historically, adoption was understood in terms of behavioural change. This implies that adoption happens over time and only when an innovation has been accepted will it be used and integrated into the farmer's system. Hydroponic technology adoption is farmer driven and is done by dairy farmer's choice. The adoptiond decision depends on various factors such as socio-economic characteristics, perceptions, policy and technology features (Bhattarai, 2009). Benefits seems to be at the core of the farmers decision to adopt hydroponic technology. For

example Lwelamira *et al.,* (2010) suggsts that wellfare is a key factor. The effect of farm size on adoption could be positive, negative or neutral. For instance, McNamara *et al.,* 1991); Abara and Singh, (1993); Feder (1985); Fernandez-Cornejo, (1996) and Kasenge (1998) found farm size to be positively related to adoption. On the other hand, Yaron (1992); and Harper (1990) found negative relationship between adoption and farm size. Interestingly, Mugisa-Mutetikka (1999) found that the relationship between farm size and adoption is a neutral one. Abara and Singh (1993) argue thatt farmers with small farms consider fixed costs to be a hinderance to the aoption. However, a Proper design and mangement of hydroponic systems can be environmentally acceptable alternatives to field-grown fodder (Timmons *et al*., 2002). Inspite of the important role hydroponic technology can create, growers worldwide need to develop water-efficient, sustainable growing systems which can facilitate supply of high quality, safe products (Okemwa, 2015).

MATERIAL AND METHODS

Research Design

The study adopted a descriptive survey research design owing to its easy in facilitating collection of a large amount of data for the study. Selection of variables as possible indictors to examine the extent to which decision making stage influence adoption of hydroponic technology in the implementation of dairy farming projects was based on the adoption-diffusion theory (Rogers, 2013) and past empirical work. Descriptive research design is a scientific method which involves observing and describing the behavior of a subject without influencing it in any way (Shuttleworth, 2008). A descriptive research design determines and reports the way things are (Mugenda and Mugenda, 2003). The research design has enough provision for protection against bias and maximized reliability (Kothari, 2004). This design was employed to obtain most recent and relevant information about the subject of this study (Mbonyane and Ladzani, 2011). The design focused on the determinants of hydroponics technology adoption in implementation of dairy farming projects in Kajiado County.

Sample

Accordin to Kombo and Tromp (2006) Population is a group of individuals, objects, or items from which samples are taken for measurement. The target population for this study was 368 zero grazing dairy farmers registered with Ministry of Agriculture, Livestock and Fisheries in Kajiado County. They were distributed in various administrative divisions of : Isinya, Loitokitok and Ngong.The three administrative divisions were selected because these were the areas in Kajiado county where zero grazing dairy farming is practiced. The study grouped the population into clusters comprising of the three (3) administrative divisions. From each Cluster a sample frame (obtained from the Ministry of Agriculture) was developed to select 110 respondents using simple random sampling.

Table 1. Sample Size determination and Sampling Design

Categories	Target Population (zero grazers)	Percentage (30%)	Sample size
Ngong	128	30%	38
Loitokitok	97	30%	29
Isinya	143	30%	43
Total	368	30%	110

According to Mugenda and Mugenda (2003) if well chosen, samples of between 10% and 30% of a population can often give good reliability. The sample size determination and sampling strategy is presented Table 1.

Data collection tools

The main data collection tools were questionnaires. A pre-test was conducted to enhance the reliability of the instruments. This ensured that the data collection instruments captured the required data. Based on responses and comments provided by respondents in the pre-test exercise, a final survey questionnaire was prepared. The results were correlated in order to test for stability over time.The procedure for extracting an estimate of reliability was obtained from the administration of split half reliability method.The method involves splitting instrument into two halves (odd and even items) then calculating the Pearson's correlation coefficient(r) between the responses (scores) of the two halves. The scores for all odd and even numbered items for each of the 24 respondents in the pilot study was computed separately. The correlation obtained represented the reliability coefficient of half of the instrument. Hence a correction was made to obtain reliability of the entire instrument. Coefficient of 0.7 is a commonly accepted rule of thumb that indicates acceptable reliability (Mugenda, 2008). A composite Cronbach Alpha of 0.82 was established for all the questions indicating that the questionnaire was reliable as its reliability values exceeded the prescribed threshold (0.7) of acceptable reliability (Mugenda, 2008). The study ensured validity of the data by addressing face and content issues. A pilot study of 24 zero grazing dairy farmers drawn from two administrative division, Namanga and Mashuru were selected randomly to ensure they bear the same characteristics as per other administrative divisions in the study area. According to Orodho (2004) validity is the degree to which a test that measures how well the results obtained from analysis represents the study under research. The Construct ,Content and face validity was tested by analysing the data collection instrument to check on appropriateness,usefulness and meaningfulness of the specific inferences reseacher makes based on data collected, to ensure that the data obtained from analysis represent the phenomena under study. To validate the research instruments, the research sought the opinion of the supervisors after the pilot and the proposed adjustments were captured.

Data collection Tools

A questionnaire was developed to obtain information. Data was collected from the three (3) administrative divisions, namely: Isinya, Loitokitok and Ngong, from each Cluster a sample frame had been developed. The questionnaire was divided into five sections with section A meant to get information about personal charateristics and the knowledge of dairy farmers including the education levels, experience, age, gender and innovation knowledge. Section B was intended to gather information on influence of persuasion, section C was to get data on decision making stage whereas section D was to get information on confirmation stage on hydroponic technology adoption and Section E was to determine implementation of dairy farming projects.

Measurement

Measurement on the data collection instrument was a likert type scale. The decision making stage was the independent variable with dimensions (Cost of Technology, Access to

credit, Environmental Changes, land and Labour) as the indicators while the implementation of dairy farming projects was the dependent variable with (Technology adoption) as the indicators. The independent Variables indicators (Cost of Technology, Access to credit, Environmental Changes, land, Labour) and the dependent variable indicator (Technology adoption) formed the.

Data Analysis

Data obtained from the field was coded, and analysed using SPSS and Stata software. Data was analysed using, correlation and a multiple regression models. The objectve of the analysis was to identify the relationship which existed between the study variables (Aldrich, and Cunningham, 2016). An analyical model used in the study is presented below;

The analytical model used in this study to determine the relationship between the dependent and independent variables is presented in a regression model as follows;

$Y= \alpha + \beta_1X_1+\beta_2X_2+\beta_3X_3+ \beta_4X_4+ \varepsilon$

Where:

Y = Technology adoption
α = Constant term
β_1 = is the co-efficient of cost of technology
β_2 = is the co-efficient of access to credit
β_3 = is the coefficient of environmental changes
β_4 = is the coefficient of land
β_5 = is the coefficient of labour
X_1= values of cost of technology
X_2= values of access to credit
X_3= values of environmental changes
X_4= values of land
X_5= values of labour
ε = Error term

RESULTS AND DISCUSSION

The findings are presented firstly, based on descriptive statistics, followed by referential statistics. The data on gender shows that the majority 62%, 54 were male while female were 38%, 33.

The respondents age shows that the age category of 40-49 had the highest number of respondents (27%, 24) the age bracket between 30 - 39 years (23%, 20) then (20%, 17) in age bracket 20 to 29 years (15%,) where 50 - 59 years (9%, 8). The mean age of the respondents was 44 years with the youngest respondent being 20 years and the oldest being 72 years. The highest level of education of the dairy farmers was as follows; 43%, 37 of the respondents had college level education, while 32%, 28 had university level education. secondary ducational level education18%, 16 while primary educational level 7%,6. The sources of information on Hydroponic Technology shows that the respondents recieved information from various sources. The co-operative / group (32%,28), through Neighbours/friends and relatives, (23%,20), Radio/TV, (17%, 15), Government/ extension officers (13%,11) and other sources 9%,8.

Correlation and Regression Analysis

Correlation and regression analysis was used to examine the extent to which decision making stage influenced adoption of hydroponic technology in the implementation of dairy farming projects. The correlation matrix is presented in Table 2. The results depicted by the correlation matrix Table 2. Shows that technology cost moderately reduces rate of technology adoption. Also, land devoted to hydroponic technology and employees employed for hydroponic technology has negative relationship with the technologyadoption. While this result is disturbing, it may also imply that hydroponic technology does not require huge parcell of land nor more employees but a small one parcel of land and a few employees for implementation. Other factors were not significantly correlated with technology adoption. The results in Table 3. , show that environmental changes reduce the technologyadoption. Also, a negative but coefficient is found between land devoted for hydroponic technology and technologyadoption, suggesting that this technology may be appropriately used in small parcels of land and not bigger ones. Despite the Joint F statistics (3.07) being significant at 5%, the R-squared value is very small (0.182). This implies that only 18% of the variations in technology cost, environmental changes and land devoted for hydroponic technology explains the technologyadoption with a whole 82% unexplained. The R-Squared suggests that there could have been some omitted variables from the equation.

Table 2. Correlation Matrix of Decision Making Stage

Variable	Technology adoption	Technology cost	Environmental Change	Land For Ht	Employees For Ht
Technology adoption	1.000				
Technology cost	-0.314***	1.000			
Environmental Change	-0.0637	0.571 ***	1.000		
Land For ht	-0.357***	0.259*	0.067	1.000	
Employees For ht	-0.728***	0.192	0.145	0.1180	1.000

N.B:***, **, * Indicate significance at the 1, 5 and 10 per cent levels, respectively. Source: Research Findings 2016

Table 2. Econometric Regression Results of Decision Making Stage

Variable	Robust Coefficient	t-statistic	Probability
Constant	19.84	15.32	0.000
Technology cost	-0.71	-0.62	0.537
Environmental changes	-2.69	-2.30	0.027
Land for ht	-4.07	-2.21	0.033
Adjusted R-Squared	0.182		
F-statistic and Probability	3.07 (0.039)		

Source: Research Findings 2016

DISCUSSION AND CONCLUSION

The hypothesis that there is no significant relationship between the extent to which decision making stage influence adoption of hydroponic technology in the implementation dairy farming projects was not supported. The decision making stage aspects such as land, employees, environmental changes and technology cost, has negative relationship with the technologyadoption. The land devoted to hydroponic technology, employees, environmental changes and technology cost does not influence implementation of dairy farming projects. However, Hydroponic technology does not require huge parcell of land nor more employees but a small parcel of land and a few employees for implementation. While male are more likely to adapt new technology on farming this attribute was due to the inability of most women to own land for farming which predominantly belonged to males.This is in accordance with a previous study conducted by Whitehead (1985) who advanced that traditionally, most women do not own land for farming. In his study, Whitehead (1985) further argued that historically, women's access to land in most African cultures was based on status within the family and involved right of use, not ownership (Whitehead, 1985).

Aliber and Walker (2006) also advanced that although married women had user rights over their husbands' land, the husbands in most cases have more exclusive rights over the land's disposal (Aliber and Walker, 2006). Paxton (2010); Roberts (2004); Velandia (2010); and Walton (2010) which revealed that age influenced adoption decisions. According to an earlier study conducted by Waller (1998); Caswell (2001), education was found to affect technology adoption as well as increased farm productivity levels. In their study, they revealed that education created a psychologically favourable mental attitude for the effective and efficient acceptance of new technologies.
The dairy cooperative/groups were ranked the best source of information on hydroponic technology followed by neighbours/friends and relatives. The farmers contacted the co-operative/groups on a daily basis when delivering milk and hence were able to seek and/or obtain information easily. The co-operative also facilitated meetings between the farmers and other agencies such as the government extension and private manufacturers by organizing field days. Neighbours were in close proximity and gave practically reliable information based on their experiences.

The farmers were able to gauge the performance of their dairy cows. While the government/ extension officers provided field visits and personal attention to dairy farmers with various messages, the frequency of farm visits was very low and mostly the dairy farmers did not take them serious.Findings in this regard are in accordance with Awotide (2012) in the study about technology adoption which he contended that access to information about improved farming practices and agricultural technologies was essential to increase the extent of adoption. The majority of the farmers had been trained on hydoponic technology. Some of the limitations to this study were; the study was a cross sectional hence, the applicability of the findings could be limited. Secondly, the study focused on fodder production yet the technology can be used for production of other vegetable plants. Thirdly, the sample size was small and this could also affect the generalisation of the findings. The study recommends that for successful implementation of dairy farming in Kajiado County dairy farmers should be trained regularly on hydroponic technology and Government policies. In addition, prospects for hydroponics technology adoption can improve if governments design public policies that support subsidies for such production systems. Apart from economic benefits, hydroponics adoption facilitates water conservation, cogeneration of energy, income-producing employment and improving the quality of life.

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