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FACTORS AFFECTING ADOPTION OF IRRIGATION AS A STRATEGY TOWARDS ENHANCING FOOD PRODUCTION AMONG FARMERS IN KEE WARD, MAKUENI COUNTY, KENYA

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Abstract

The ASAL areas today face the challenge of feeding its population, and thus face malnutrition and hardly go without food aid during drought seasons. The adoption of irrigation holds the key to food security. This research was intended to investigate the factors affecting the adoption of irrigation as a strategy to enhance food production among farmers in Kee Ward, Makueni County. The research had variables that made the specific objectives, which included the level of income of the household head, the level of education of the household head, and the availability of training and extension services to the farmers. The research design adopted was descriptive in nature, and the sampling technique was a two-stage sampling technique, which involved purposive sampling for the 28 farmers who have adopted irrigation and random

sampling of another 28 farmers who have not adopted irrigation. A sample of 56 respondents was therefore selected from the target population of Kee Ward's 4,298 farmers. The population consisted of all the farmers within Kee ward, which included both commercial and subsistence farmers. A self-reporting questionnaire was used to collect data. This included both structured and unstructured questions in order to capture the data appropriately. Data was then analyzed both quantitatively and qualitatively through descriptive and inferential statistical analysis techniques including a multiple regression model according to the objectives of the study. The study found out that those who had adopted irrigation had a bigger source of income compared to those who had not adopted, that most of those who had adopted irrigation had done tertiary educated unlike those who had not adopted who majority had done up to form 4, and that agricultural training seminars were hardly organized in Kee ward, and that Kee ward had very few agricultural extension officers. The study recommended that the county and national governments should subsidize irrigation inputs, advance cheap credit facilities to farmers in ASALs, and subsidize education at all levels (including tertiary levels). The study also recommends the county government to employ adequate agricultural extension officers especially in ASALs, also have demonstration plots in every ward and also arrange for free farm clinics in ASALs for the farmers to learn.

Keywords: Adoption, agricultural extension officer, agricultural sector, irrigation, innovation

INTRODUCTION

For many years, the agricultural sector in Kenya has been the backbone of the Kenya's economy. This sector contributes about 25% of the Gross Domestic Product (GDP), and a further 27% through manufacturing, distribution and service businesses. It also contributes to 65% of total export earnings making it the largest contributor to the economy in Kenya. It also accounts for about 80% of national employment, mainly in the rural areas. About half of the country's entire agricultural production is subsistence and is non-marketed, and mainly is produced by small-scale farmers in the rural areas (Agriculture in Kenya, 2017).

About 84% of Kenya is ASAL (Arid and Semi-Arid Lands), which means they are not conducive for rain-fed farming (The Presidency, Ministry of Devolution and Planning, 2015). This implies that man has to modify his land and environment to suit his agricultural activities. Such modification has to come through irrigation among other methods to supplement rain fed farming. In many countries, the scarcity of water has been a serious constraint to production of food and a major cause of poverty and hunger. Improved management of water is a major key

to securing food production so as to lighten today's nutritional suffering and also feed an extra 3 billion people by the year 2030 (Purcell, 2014), hence irrigation is a crucial functional level strategy to realize food security for all. In Kenya the total area of land under irrigation is about 80,000 hectares. Small-scale irrigation by both Public and private farmers is still less than 50,000 hectares. This is reasonably small compared to the country's probable potential of more than 300,000 hectares.

Makueni has a total area of 7,440Km^2 with a cultivable land of area 554,000ha, which is about 74% of its total area. In 1999, it had a total population of 767,000 people and the population density per square kilometer was 103. Agriculture, including livestock, is a major economic activity with crop production contributing only 9% of the total agricultural income. However, it has an irrigated area of 1,866 ha which represents only 0.3% of the cultivable area (MoA, Central Bureau of Statistics, 1999). This implies that rain-fed agriculture is predominant in Makueni. Irrigation in Makueni County Government is under the county's Ministry of Water, Irrigation and Environmental Services, whose main objectives include general provision of water, irrigation and construction of dams, borehole drilling and water harvesting (Republic of Kenya, 2015).

Kee Ward is situated in the North Western end of Makueni County in Kaiti Constituency. It comprises of Ikalyoni, Makongo, Kitandi, Kivani, Kyamwalye, Mutulani, Nguluni and Kasunguni Sub–locations, which all have a total population of 21,025 people and covers an area of 81.6km^2. However, Kee Ward is largely an ASAL and does not majorly support rain-fed agricultural farming since its rain per annum is between 400mm to 800mm (ADS eastern, 2017) According to Purcell (2014), large-scale irrigation projects are often unsustainable, but a variety of affordable small-scale techniques can increase the production of food. Kee ward being an ASAL does not require large-scale irrigation projects since it has no permanent rivers to sustain the projects. However, Kee ward has several permanent earth dams which include Mbooni dam in Kyamwalye, Kwa Kasyoki dam in Makongo, Kivaku dam in Ikalyoni, Kivani dam in Kivani, Kitandi dam in Kitandi, Kwa Kakui dam in Watema and Kwa Kalii in Nguluni sublocations (KWAO, 2017).

Several intervener organizations, both non-governmental and the CDF have initiated and funded irrigation projects for farmers. Due to the challenges experienced by farmers in ASAL areas which include unreliable rainfall, changing weather patterns (Sombroek et al., 1982), the intervener organizations have in the past years initiated a conducive environment for Kee Ward residents to practice small-scale irrigation by building sand dams and earth dams. These organizations include Kaiti CDF project, and non-profit making organizations i.e. Africa Harvest and Utooni Development organization.

Kee ward has seven permanent earth dams with at least one permanent earth dam in each sub-location. Of the 326 targeted farmers served by the earth dams, only 13 farmers (3.99%) have adopted irrigation from them. In spite of the efforts made by the Makueni County Government and NGO organizations to make Kee more food secure through irrigation, the strategy only seems to be embraced by few farmers, and most of the few farmers have adopted the manual irrigation system using buckets or watering cans (Types of Irrigation, 2012). Since Kee ward has a total farming population of 4,298 farm families, only 28 farmers practice irrigation (KWAO, 2017). This represents only 0.65% of the farming population. Adoption of irrigation as a strategy in farming has been a thorny issue in the country, especially among small-scale farmers. Failure to adopt irrigation as the strategy to improve food security has adverse implications to Kenya's population and economy.

Purpose of the Study

The main purpose of this study was to investigate the factors affecting adoption of irrigation as a strategy towards enhancing food production among farmers in Kee ward, Makueni county, Kenya.

THEORETICAL REVIEW

The theoretical review has been drawn from the three theories: diffusion of innovation theory, technology acceptance theory and resource based theory.

Diffusion of Innovation Theory

Diffusion is the process by which communication of an innovation is done through certain channels over time among the members of a societal system (Rogers and Shoemaker, 1971), and an innovation could be an idea, a practice, or an object perceived to be new by an individual or other unit of adoption (Rogers, 2003). Therefore, diffusion of innovation refers to the process that happens as individuals adopt a new idea, a product, a practice, a philosophy, among others. The theory of diffusion of innovation asserts that every market has group(s) of customers who differ in their preparedness and willingness to adopt a new product. The innovation product therefore spreads (diffuses) through a market in successive, overlapping waves and not in one straight course. Rogers (Rogers, 1962) in mapping out this process of diffusion emphasized that in most cases not many people are initially open to the new idea and will therefore adopt its use. As 'spread the word' is done by these early innovators more and more people become open to the innovation hence leading to the progress of a critical mass. As

time progresses, the innovation diffuse among the population until it reaches a point of saturation.

According to Rogers (1962), the rate of adoption of an innovation or technology simply refers to the number of members of a society who start using the new innovation or technology during a specific period of time. Since it is a relative measure, the rate of adoption of one group is usually compared to the rate of adoption of another group, usually of the whole society. The attributes of an innovation that affect the rate of adoption include the ease at which the innovation can be adopted into daily life, the advantage created by adopting the innovation, the expense associated with trying out the innovation, and finally, the ability of other members within the society to see those who have already adopted the innovation.

According to Rogers (1962), an adopter category is a categorization of people within a social system which is based on innovativeness. In his book called Diffusion of Innovations, Rogers named five categories of adopters in order to normalize the usage of adopter groups in diffusion research, who are innovators, early adopters, early majority, late majority and laggards. In addition to the opinion leaders and gatekeepers who are in a particular society, there are change agents who may come from without the community. The change agents bring innovations to any new community – firstly through the gatekeepers, then secondly through the opinion leaders, and then to all individuals into the community (Rogers, 1962).

Since decisions are neither collective nor authoritative, each member of the society faces his/her own decision in regard to innovation, and this follows a 5-step process as given by Rogers, which are firstly the Knowledge stage, secondly the persuasion stage, thirdly the decision stage, fourthly the implementation stage and finally the confirmation stage (Rogers, 2003)

This theory was important to this research in that adoption of irrigation technology is an innovation and successively follow the adoption processes of an innovation, and define the adopter categories i.e. innovators, early adopters, early majority, late majority and laggards.

Technology Acceptance Theory (TAM)

TAM was initially projected by Davis (1989) is an Information Systems theory that models how users embrace and use a technology. According to Suvarna and Godavari (2012), technology has pervaded all aspects of human life, including health, agriculture, business, education, entertainment etc. No matter which field technology is applied, it should have positive impact on work in such a way as to improve production.

Unless accepted and adopted, technology can be of little value (Oye et al, 2012). Therefore it is vital to understand technology acceptance because according to Suvama and

Godavari (2012), increase in the supply of information is the most significant benefits related with access to the latest technologies. According to Louho, et al. (2006), technology acceptance is just about how individuals embrace and adopt a technology for utilization. The acceptance to use a technology can be explained as the provable readiness within a user group to use information technology for the tasks it is intended to support. So, acceptance of technology is a function of the involvement of the user in the use of technology. For the success or failure of any technology, its acceptance is critical. Dillon and Morris (2001) argue that the acceptance of technology is a psychological process that can be conceptualized as an outcome variable that users go through when deciding about the technology.

Davis (1989) drew out the two key determinants of TAM which are firstly, perceived utility, which is the level to which an individual believes that the utilization of a system can advance his performance; and secondly, perceived ease of use, which is the level to which an individual believes that the utilization of an information system will be free of effort.

Therefore, from the model, the perceived ease of use of irrigation, and its perceived usefulness will lead to a behavioral intention or attitude, and change the behavior or attitude towards the irrigation technology, hence leading to whether or not to adopt it.

Resource Based Theory

The resource based theory looks into the reasons why organizations in the same industry vary in their performance over given time. This theory asserts that the difference in the performance is attributed to the differences in the firm's internal capabilities that yield to competitive advantage for the organizations. According to Wheelen and Hunger (2012), a capability refers to a firm's capacity to make use of its resources. It consists of business processes and routines that direct the dealings among resources to turn inputs into outputs. Through a firm's continued use of resources, the capabilities of the firm become stronger and very difficult for the competitors to comprehend and imitate. Therefore as a source of competitive advantage, Hitt, et al, (2005) argues that a capability should neither be so simple to imitate, nor so complex that it defies internal steering and control. When capabilities and resources are the firm's source of competitive advantage over its rivals, then this is said to be the core competency for the firm. It is an important internal activity that a firm performs better than other internal activities which are equally or less competitive. (Thompson and Strickland, 2003). Also, Hitt, et al, (2005) argues that the theory holds that there are four main attributes of resources that lead to competitive advantage, i.e. being rare, non-substitutable, valuable, and costly to imitate.

This theory, which only focuses inside the firm, holds that resources are the firm's major determinants of performance, and they may contribute to the firm's sustainable competitive

advantage. According to Pearce and Robinson (2005), organizations differ in essential ways because each firm has a sole package of resources, which mainly are tangible, intangible and organizational assets. The firm's tangible assets are the material and monetary means the organization uses to offer value to its consumers.

METHODOLOGY

Research Design

To enable the researcher look at the factors affecting adoption of irrigation as a strategy to enhance food security, descriptive research design was adopted. This entailed data collection so as to answer the questions in the subject under study, allowing the respondents to give information on adoption of irrigation, hence getting accurate results. This research design incorporated both qualitative and quantitative data, making it the best design for this study.

Target Population

The target population of this study was all the farmers within Kee Ward, who number about 4,298 farmers (KWAO, 2017), which included both the 62 commercial farmers and 4,236 subsistence farmers.

Data Collection Instruments

Questionnaires were used to collect data, where the questionnaires contained both open-ended questions and closed ended questions since describe they are easy to administer, permit a greater degree of response and are easy to analyze because they are in direct usable form (Mugenda and Mugenda, 2003). Also, the questionnaire was the most appropriate instrument due to its capacity to collect a large amount of data in a reasonably quick period of time (Kothari, 2004).

An introduction letter from the school of post-graduate studies Machakos University was obtained and presented to the National Council for Science and Technology through the Ministry of Education, Science and Technology offices at Makueni County to obtain permission to collect data in Kee ward, Makueni County. A pilot test was also done to test the validity and reliability of the data collection tool.

Sampling Procedure

From the target population, the study applied a two stage sampling procedure to select the respondents of the study. Firstly, since the number of all the farmers who have adopted irrigation in Kee ward is 28, purposive sampling technique was applied because they had the

desired characteristics for the research exercise. According to Saleemi (2011), the researcher exercises his ruling in the choice of the items which are sampled and then includes them in the sample which he thinks are most typical of the population with regard to the characteristics under investigation. The 28 farmers who had adopted irrigation therefore formed part of the sample. Secondly, the study randomly sampled out a total of other 28 farmers from all the Kee sub-locations who had not adopted irrigation to counter-match the number of farmers who had adopted irrigation. According to Saleemi (2011), every item of the population is given a fair chance of being included in the sample in the simple random sampling. The study therefore had a sampling frame of 56 farmers who became the respondents in the research exercise, as detailed in table 1.

Table 1: Target Population and Sample size of Farmers in Kee Ward

Sub-location	**Subsistence who have adopted irrigation**	**Commercial who have adopted irrigation**	**Total famers adopted irrigation**	**Sample of farmers who have not adopted irrigation**	**Total Sample Population**
Makongo	0	2	2	4	**6**
Ikalyoni	0	0	0	4	**4**
Kivani	0	2	2	4	**6**
Kyamwalye	0	6	6	3	**9**
Kitandi	1	8	9	3	**12**
Nguluni	0	1	1	4	**5**
Kasunguni	3	3	6	3	**9**
Mutulani	1	1	2	3	**5**
Total	**5**	**23**	**28**	**28**	**56**

Data Processing and Analysis

The processing of data involved editing, coding, data entry, verification, tabulation and computing results from the questionnaires. To determine the relationship between the variables, both descriptive and inferential statistics were used for analysis. The descriptive statistics included frequencies, percentages, mean, and standard deviation and mean scores. The processed data was then presented in pie charts, line graphs, bar graphs and tables. A multiple regression model was adopted to examine and analyze the relationship between the dependent variable with the independent variables.

The general multiple regression model adopted was:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon$

Where:

Y = the dependent variable which is a function of k independent variables X_1, X_2, ….. X_n

ε = the random-error term which is added to make the model probabilistic rather than deterministic

β_0 = the Y-intercept

β_1, β_2, … β_n = the coefficient which determines the contribution of the independent variable X_1.

X_1, X_2 ….X_n = the independent variables.

Source: McClare and Sucich, (2009)

ANALYSIS AND FINDINGS

Model Summary

The study analyzed the variations in adoption of irrigation due to the farmers level of income, level of education and training and agricultural extension services, and the results were as in the table 2 below.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std error of the estimate
1	0.965[a]	0.931	0.911	4.729

The adjusted R squared in Table 2 is the coefficient of determination which shows the variation in the dependent variable with respect to changes in the independent variables. From the findings, the value of the adjusted R square was 0.931. This means that there was a variation of 93.1% on the independent variables at 95% confidence interval. The remaining 6.9% mean that there are other factors which affect adoption of irrigation, and these factors are not discussed in this study. R, which is the correlation coefficient, shows the relationship between the three independent variables under study. The findings as in table 1 show a correlation coefficient of 0.965, implying that there is a very strong positive correlation relationship between the three independent variables under study.

Regression Equation and the Predictor Relationship

The multiple regression model adopted was analyzed mathematically using SPSS software and then mathematically expressed as in Table 3. The model adopted determines the importance of

each of the independent variables in regard to adoption of irrigation as a strategy to enhance food production in Kee ward, Makueni County.

Table 3: Regression Coefficients

Model	Unstandardized coefficient		Standardized Coefficients	t	Sig.
	β	Std error	Beta		
Constant	33.422	13.594	-	2.460	0.43
Level of farmer's income	-3.340	0.773	0.527	-4.320	0.003
level of farmer's education	0.094	0.021	0.558	4.569	0.003
Training and agricultural extension services)	-0.96	0.067	-0.257	-1.112	0.065

The established multiple linear regression equation is as shown.

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon$

$Y = 33.422 – 3.34\beta_1 + 0.094\beta_2 – 0.96\beta_3$

Since the study was on the dependence and independence relationship between the study variables, the multiple regression model adopted was used to determine the significance of each of the variables with respect to their effects on adoption of irrigation in Kee ward, Makueni County. From Table 3, the constant of 33.422 shows that if the independent variables were zero rated, the rate of adoption of irrigation would be 33.422.

Level of Income and Adoption of Irrigation

The farmers' level of income is statistically significant as shown by $\beta_1 = -3.340$, which is the coefficient of the level of income of the lead farmer in the family. It implies that one unit change in the level of farmers' income would result in 3.34 decrease in adoption of irrigation.

Level of Education and Adoption of Irrigation

The level of education is statistically significant as shown by $\beta_2 = 0.094$, which is the coefficient of the level of education of the lead farmer in the family. It implies that one unit change in the level of farmers' education results in 0.094 increase in adoption of irrigation. This means that the level of the farmer's education has a positive impact on adoption of irrigation.

Training and Extension services and Adoption of Irrigation

Training of farmers and agricultural extension services is statistically significant as shown by $\beta_3 = -0.96$ which is the coefficient of training and extension services. It implies that one unit change in the level of farmers' training and agricultural extension services would result in 0.96 decrease in adoption of irrigation.

Analysis of Variance (ANOVA)

The Probability value (p-value) in a statistical hypothesis test is the probability of getting a test value which is as extreme as or more extreme than the observed value if the null hypothesis (H0) is true. A comparison of the p-value is made with the actual significance level of the test, and if it is smaller, then the result is significant, and the smaller the p-value the more convincing it is to reject the H0. From the ANOVA findings in the table 4, the p-value is 0.001 (less than 0.05). This implies that there is a correlation between the independent variables and the dependent variable.

Table 4: ANOVA

	Sum of Squares	df	Mean Squares	F	Sig.
Regression	2105.435	2	1052.717	47.067	0.001[b]
Residual	156.565	7	22.366	-	-
Total	2262	9	-	-	-

The ANOVA analysis was intended to investigate whether the variation in the independent variable (level of farmer's education) explain the observed variance in the study of the outcome (Adoption of Irrigation). From the results, the independent variables significantly explain the dependent variable (F=47.067, p=0.001).

CONCLUSIONS

The objective of the study was to examine the factors affecting adoption of irrigation as a strategy to enhance food security in Kee ward, Makueni County. The findings of the study have significant importance to Kenya's agricultural sector especially in establishing food secure ASALs. The level of income had significant relationship with adoption of irrigation (regression coefficient of the level of income $\beta_1 = -3.34$) implying that the more the income, the more they will adopt irrigation, hence an increase in food production. The study therefore concludes that farmer's level of income is strongly related to adoption of irrigation.

The study revealed that the farmers' level of education is also significantly related to the adoption of irrigation. The level of education had a significant positive relationship with the adoption of irrigation (regression coefficient $\beta_2 = 0.094$) implying that more educated farmers are more likely to adopt irrigation than less educated farmers. This study therefore concludes that the level of the farmers' education is positively significant in adoption of irrigation. Finally, the study also found out that training and extension services is significantly related to the adoption of irrigation. Training and extension services had a significant relationship with the adoption of

irrigation (regression coefficient β_3 = -0.96) implying that the farmers who had access to on-the farm-training, seminars and extension services will likely adopt irrigation than those who did not. The study therefore concludes that the access to training and agricultural extension services is related to the adoption of irrigation

RECOMMENDATIONS

The area of food security in Kenya's ASALs is an essential area in both the country and the world at large. Therefore, this requires urgent intervention to make urgent contribution to the poor. There are many other variables which contribute to adoption of irrigation and food security. The study therefore recommends that both the County governments and National government should subsidize irrigation inputs and also advance cheap credit facilities to all farmers in ASAL areas in order to initiate the efforts in irrigation by low income earning farmers to food production and security within the county and country. The study also recommends the national government to finance education at all levels up to tertiary levels, just as it has done to primary education. The study further recommends the employment of more agricultural extension officers, and the training of small scale farmers, especially in ASAL areas be done as a priority. This can be done by the county government, the central government and Non-Governmental organizations who should draft training programmes to sensitize farmers on irrigation, even using the available resources.

The study also recommends the building of more permanent earth dams and sand dams. Both the county government and the national governments should invest more in water management by allocating more financial resources in the ASALs than in the agriculturally rich areas. This will completely wipe away the dependence of rain-fed agriculture for food reliance since most farmers will embrace irrigation to supplement rain-fed farming. In this the war against food insecurity in ASALs will be greatly won.

LIMITATIONS OF THE STUDY

The study was limited to a small-scale area (only one ward) and so the study scope was not comprehensive since the following hindrances barred the ability of extending to further areas and be able to make a conclusive impact.

Firstly, scarcity of financial resources was a challenge since the researcher was the sole financier of the study. The financial resources were needed for travelling, stationery, photocopy and typing services. The researcher therefore sourced for extra funds from relatives and friends for the exercise. Secondly, inadequate availability of some of the materials for doing the literature review. The researcher therefore had to spend most of his evenings in the library in

search of literature material. Lastly, the research area was in the interior of Ukambani's rural and remote areas with transport challenges. The researcher therefore had to create enough time for the research exercise, and also hire boda bodas for easy and fast travelling. Lastly, some of the respondents were semi-illiterate and therefore needed translation and interpretation of some of the items in the data collection tool.

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