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Influence of Rain Water Harvesting Technologies on Household Food Security among Small-Scale Farmers in Kyuso Sub-County, Kitui County, Kenya

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Abstract: *This study was done in Kyuso Sub-County which is located in Kitui County, Kenya. The Sub-County suffers from food insecurity which is linked to declining agricultural productivity. The government of Kenya, through the Ministry of Agriculture, and other development partners have, continuously promoted on-farm rain water harvesting technologies. Despite these efforts food insecurity has been rampant in the Sub-County. The purpose of this study was to determine the influence of rain water harvesting technologies on household food security among small-scale farmers in Kyuso Sub-County. Rain water harvesting technologies examined were road side run-off, zai pits and water pans. The study was carried out in Kamuongo Division of Kyuso Sub-County using the descriptive survey design. Structured interview schedule was used as the main tool of inquiry to gather data from selected households within the division. Questionnaires were administered to a sample 140 farmers through face-to-face interviews. The multiple linear regression model was used to analyze data. The results revealed that, at 5% level, rain water harvesting technologies did not significantly influence house hold food security in Kyuso Sub-County.*

Key words: *Kyuso Sub-County, household food security, dryland farming, rain water harvesting, road side run-off*

I. Introduction

Crop production in dryland areas must be improved to help meet the requirements of the growing world population. A major contribution to this improvement will be the capture and use of a greater portion of the limited and highly variable precipitation in dryland areas. Dryland farming technologies including on-farm rain water harvesting and management can increase water use efficiency, thus increasing yields and reducing the likelihood of crop failure (Food and Agriculture Organization [FAO], 2008).

Agriculture remains the largest employment sector in most developing countries.

The majority of the population in sub-Saharan Africa make their living from rain-fed agriculture. In Kenya 85 % of her population derive their livelihood from rain-fed subsistence agriculture (Rockström, 2000).More than three-quarters of Kenya's land is arid or semi-arid with 3.2 million food insecure affected marginal farmers and agro pastoralists living in the arid and semi arid Sub-Counties of eastern Kenya (Food and Agriculture Organization [FAO], 2009). Jan (2007) contends that even after decades of modern agricultural research, the small-scale farmer in most parts of Kenya is still poor. He adds that the small scale farmer still operates a largely traditional technology to meet subsistence needs. If agricultural research is to help the small-scale farmer, there must be a selective emphasis on technology appropriate for the typical small-farm situation of scarce financial resources and poor access to information (Jan, 2007).

Kenya's agriculture in arid and semi-arid areas is predominantly small-scale. Production is carried out on farms averaging 0.2–3 ha and without irrigation. Farms are generally small, and in most cases are suffering from a degradation of resources and the environment. The small-scale farmers in the study Sub-County can be described as being resource-poor and subsistence-based. Since these dryland comprise 84 % of Kenya's land mass (GOK, 2010) there is huge potential for increasing productivity for these farmers with adoption of modern farming practices including irrigation and dryland farming technologies.

Land resource is a major input in agricultural production whether in dry or humid areas. The major purpose of dryland farming technologies is to conserve soil, water and nutrients for the purposes of crop production (Gichuki, 2000). The objectives of soil management are to maximise the limited water supply, maximise plant nutrient supply, minimise erosion, and maintain or improve soil fertility and soil physical conditions (Mati, 2006). Water management forms a critical component of agricultural production. Under water harvesting, a deliberate effort is made to transfer runoff water from a catchment to the desired area or storage structure (Mati, 2006).

The food supply situation in Kenya has been a cause for concern. According to the Ministry of Agriculture (2009), over 10 million people suffer from chronic food insecurity and poor nutrition. It is estimated that at any one time, about two million people in the country require food assistance (Ministry of Agriculture [MOA], 2009). The long rains season in Kenya (March-May), which normally accounts for 80 % of total annual food production, has been failing over the years leading to severe drought, and widespread crop failures in the arid and semi arid areas of Eastern and North Eastern counties of Kenya (Kaloi, Tayebwa, & Bashaasha, 2005). Kyuso Sub-County lies in Kitui County in the drylands classified as arid and semiarid lands and receives low and unreliable rainfall of between 250 and 780 mm per year (Government of Kenya [GOK], 2009). The Sub-County suffers from food insecurity which is linked to declining agricultural productivity and general poverty. Drought as a natural cause is the main problem. Kyuso Sub-County has been under relief emergency operation from 2004 to date, with varying proportions of the population, as a result of either crop failure or low crop production. They are unable to sustain their households from one season to the next (Kenya Food Security Steering Group [KFSSG], 2011).

The Ministry of Agriculture has made efforts to promote rain water harvesting technologies in Kyuso Sub-County (MOA, 2011). These technologies include zai pits, road run-off and water pans (Mati, 2006). Often farmers face acute food shortage due to failure to harvest in consecutive seasons during which period most farmers rely on relief food for sustenance. Whereas food aid has played a key role in saving lives in the Sub-County during times of extreme drought and famine, it has had a negative impact of creating a dependence syndrome among farmers (GOK, 2009). Dependency syndrome is known to limit creativity and hence maintain the status quo of food insecurity. Investments in dryland farming techniques in semi-arid regions lead to immediate and perceptible yield increases and contribute to reducing rural poverty (Reij & Steeds, 2003).

In the arid and semiarid areas rain water harvesting technologies are key to achieving food security. Frequent droughts have been identified as a major problem inflicting small scale farmers in Kyuso Sub-County. Though the Ministry of Agriculture and other stakeholders have over the years been sensitizing and training small-scale farmers on various on-farm rain water harvesting technologies, Kyuso Sub-County has remained food insecure. Many small scale farmers in the Sub-County depend on food aid for their survival. Lack of proper rain water harvesting structures could be some of the major causes of food insecurity in the Sub-County.

The objective of the study was to investigate the influence of rain water harvesting technologies on household food security of small-scale farmers in Kyuso Sub-County. From the objective of the study, the following null hypothesis was derived and was the basis for the investigation: There is no significant influence of rain water harvesting on household food security among small-scale farmers in Kyuso Sub-County.

II. Rain Water Harvesting

In arid and semi-arid areas dryland farming is inevitable. Dryland farming is the practice of growing profitable crops without irrigation in areas which receive annual rainfall of 500 mm or even less (Creswell & Martin 1998). In these areas lack of soil moisture limits crop production to part of the year. The low water supply may be caused by low rainfall, high runoff water losses or high evaporation. In dryland farming emphasis is on rain water harvesting and conservation of soil water for crop production. According to Biamah and Nhlabathi (2003) rainfall water use efficiency could be improved through runoff water harvesting and conservation for crop production

In semi arid Kenya, rainfall is bimodal and characterized as low, erratic and poorly distributed. The short and long rainy seasons receive about 55% and 45% of the total annual rainfall respectively. The short rains (October to December) are more reliable, evenly distributed and adequate for crop production. The long rains (March to May) are associated with most crop failures due to the poor distribution, unreliability and inadequacy for crop production (GOK, 2010).

Rainwater harvesting can be traced back to the 9th and 10th Century (Global Research Development Center [GRDC], 2008). People in South and Southeast Asia collected rainwater from roofs and from simple dams constructed from brush. Rainwater has long been used in the Loess Plateau regions in China where between 1970 and 1974, about 40,000 well storage tanks of various forms were constructed (GRDC, 2008). A thin clay layer was generally laid on the bottom of the ponds to minimize seepage losses and trees were planted at the edges of the ponds to help minimize evaporation.

Rain water harvesting could be defined as a water-management technique for growing crops in arid and semi-arid areas where rainfall is inadequate for rainfed production and irrigation water is lacking. Farmers in Yemen tend to use water-harvesting techniques where rainfall is not sufficient. Their approaches include: runoff agriculture, where runoff is concentrated on a smaller area, generally used for arable or perennial crops; and runoff storage, generally in small reservoirs, used to supplement rainfall – often in horticulture or for livestock or domestic use (FAO, 2008).

Interest in rain water harvesting is growing in Kenya, as more people are beginning to realize that surface runoff is a resource as important as the rain, and that it can be used for sustainable crop production and/or livestock watering. Consequently, there has been a major development in a diverse range of technologies in water harvesting and conservation (Mati, 2006). Rain water harvesting systems are also applicable over a wide range of conditions in areas where average annual rainfall is insufficient to meet the crop water requirement, with seasonal rainfall being as low as 100 to 350 mm (Mutisya, Zejiao & Juma, 2010). Farmers observe the flow of surface water through their own watersheds, and based on experimentation on trial and error basis, sophisticated runoff farming systems are developed. Some of the innovative ways according to Mati (2006) include the tapping of sheet flow from roads, diversion of sheet flow from rocky areas adjacent to the farmland, or diversion of surface runoff from footpaths.

Hai (1998) described rain water harvesting techniques as consisting of micro-catchment and external-catchment systems. Micro-catchment systems are basins, pits, bunds and all other water harvesting systems that get their runoff from small areas. A portion of upslope land is allocated for runoff collection, which is harvested and directed to a cultivated area down slope. There are many types of micro-catchment techniques practiced in Kenya, such as zai pits, semi-circular bunds, negarims and earth bunds. Semi-circular earth bunds are found in arid and semi-arid areas for both rangeland rehabilitation and for annual crops on gently sloping lands (Thomas, 1997). For the establishment of fruit trees in arid and semi-arid regions, with seasonal rainfall as low as 150 mm, Negarim micro-catchments are often used. Negarims are regular square earth bunds turned 45 degrees from the contour to concentrate surface runoff at the lowest corner of the square (Hai, 1998). Similarly, large trapezoidal bunds, 120 m between upstream wings and 40 m at the base, have been tried in arid areas in Kenya, like Turkana, for sorghum, tree and grass growing (Thomas, 1997). In Kyuso zai pits and negarim techniques are taking root (MOA, 2011).

Road runoff water harvesting systems vary from simple diversion structures directing surface water into crop fields, to deep trenches with check-dams in order to enable both flood and subsurface irrigation. Where surface conditions permit, storage in pans can be quite cost-effective, as has been demonstrated by farmers of Lare in the Nakuru Sub-County of Kenya. In a project where over 1,000 pans were dug to trap road runoff, the area was transformed from a food-aid recipient to a net exporter of food through this technology (Mati, 2006).

III. Materials and Methods

This study was conducted in Kyuso Sub-County located in the Kitui County of Kenya. The Sub-County covers an area of 2,509 km^2 with a population of 64,224 people and 12,378 households (Kenya National Bureau of Statistics [KNBS], 2010). It is one of the arid and Semi-arid Sub-Countys in Kenya receiving average annual rainfall ranging from 250-780mm.

The study adopted a descriptive survey design. This design was appropriate because it enabled the description and exploration of the rain water harvesting technologies used by farmers in the selected study areas and determined the household food security in the Sub-County (Kathuri & Pals, 1993). The variables under the study were not manipulated. According to Mugenda and Mugenda (2003) this research design seeks to obtain information that discloses existing phenomena by asking individuals about the rain water harvesting technologies, their level of implementation, status of crop production and the existing household food security.

According to the Kenya National Bureau of Statistics (2010) Kyuso Sub-County has 12,378 households. This constituted the target population. The accessible population consisted all the 2,629 households in Kamuongo Division of Kyuso Sub-County, the study area (KNBS, 2010). The average farm holding is about 2ha. Mixed farming is practised. Farmers keep goats, sheep and cattle and also plant crops such as maize, sorghum, pearl millet cowpeas and green grams. Horticultural crop production is practised along seasonal river valleys. The horticultural crops grown are mangoes, pawpaws, tomatoes, kales and onions (MOA, 2011).

A sample of 12 to 15 individual farmers were selected purposively from each location in the study area for the initial focus group discussion (FGD) planned for the study. The criteria for their selection were gender, age, education, and marital status. One sublocation was selected randomly from each location to be a site for FGD.

Kyuso Sub-County has 4 divisions. One division, Kamuongo, was selected purposively because the Ministry of Agriculture had in the past promoted rain water harvesting technologies in the division. There are 12,378 households in the Sub-County. In social science research, the following formulae can be used to determine the sample size

$$n = \frac{z^2pq}{d^2}$$

Where: n = the desired sample size (if the target population is greater than 10,000)

z =the standard normal deviate at the required confidence level .

p = the proportion in the target population estimated to have the characteristic being measured.

q=1-p

d = the level of significance set.

Where, $0<p, x<1$. according to Mutai (2000) confidence level 95 %, the level of accuracy of 10% z =1.96 from normal distribution may be used when very strong evidence is not required, if there is no estimate available of the proportion in the target population to have the characteristic of interest,50% should be used (Mugenda & Mugenda, 2003).

Since the target population is more than 10,000 the formulae applies,

$$n = \frac{(1.96)^2 (.50)(.50)}{(.05)^2}$$

$$= 384$$

With a large sample, the researcher is confident that if another sample is taken of the same size, findings from the two samples would be similar to a high degree (Mugenda & Mugenda, 2003).

A sample size of 140 was selected. This sample size was adequate as Kathuri and Pals (1993) and Denscombe (2007) recommend a minimum of 100 subjects as ideal for a survey research in social sciences. The extra 40 was necessary to take care of none response and attrition. This extra number of farmers also assisted in giving meaningful representation in the study area.

Out of the four administrative divisions of Kyuso Sub-County, Kamuongo was purposively selected. This is because dryland farming technologies have been promoted in the division over time (MOA, 2011). It was thus a representative of the population. Divisional and locational extension officers were used to draw a list of all the household heads in the study area.

Proportionate random sampling was used to determine the number of respondents for a given location while systematic random sampling was then used to obtain the actual respondents from the location. For each location the target population was divided by the proportionate sample size to obtain the sampling interval for the location. The starting point was blindly selected using table of random numbers (Mugenda & Mugenda, 2003). Respondents were picked from that determined starting point and following the sampling interval. This formula was applied to all the three locations until the sample size of 140 was obtained. The specific sample sizes for the selected locations are as shown in table 1.

Table 1: Proportionate Sample Size and Number of Households per Location in Kamuongo Division

Location	Number of households	Proportion	Household Heads
Kamuongo	719	0.27	38
Itivanzou	882	0.34	47
Tyaakamuthale	1028	0.39	55
Total	**2629**	**1.00**	**140**

Source: Kenya National Bureau of Statistics (2010)

Two instruments were be used to collect data in the study area. A focus group discussion guide was used to collect data about the soil and water conservation technologies practised by the small scale farmers in Kamuongo Division. It was also used to collect data on the status of food crop production as a result of these technologies, extent of household food insecurity among the small scale farmers and the soil and water conservation technologies that influence the small scale farmers' food security in the study area.

A structured interview schedule was used to collect data from household heads involved in the study. A structured interview schedule was chosen because of the ease of administration and scoring of the instruments besides being readily analyzed (Cohen, Manion, & Morrison, 2007). It was also useful in that the type of response to items facilitates consistency across the respondents (Denscombe, 2007). This type of instrument is useful in that it allows participation by illiterate people and allows clarification of any ambiguity in addition to minimizing discrimination of the less articulate (Kvale & Brinkmann, 2009). The instrument collected data on the dryland farming technologies practised by small-scale farmers in Kyuso Sub-County. It was also used to collect information on the crops grown and the food situation status. Challenges faced by farmers as they implement the soil and water conservation technologies were explored.

The instrument was subjected to peer examination in the Department of Agricultural Education and Extension and colleagues in the Ministry of Agriculture. Secondly academic experts looked at its contents and determined its ability to measure what it was intended to measure. In addition appropriate sampling procedures were be used to eliminate or reduce validity threat due to selectivity. A built in theoretical framework in the proposal was used to assess compliance to construct validity. For focus group discussion instrument validity was ensured by having colleagues and experts discuss it and ensured that all aspects of interest were covered. The researcher himself who had thorough understanding of the subject moderated the discussions. In order to follow deliberations and to avoid losing track the researcher was assisted by another person in recording proceedings.

The structured questionnaire instrument was pilot-tested in Kyuso Division, Gai Sublocation which has similar subject, climatic and agroecological characteristics as the study location. Twenty households were surveyed during the pilot test. The piloting of the instrument helped to assess its appropriateness and aided in further refinement based on its reliability coefficient. The reliability of the instrument was estimated after the pilot study using the Cronbach's alpha procedure. A reliability coefficient of 0.795 was obtained which is above

0.7 adopted as the minimum threshold as recommend by Boermansab and Kattenbergb (2011). The tool was therefore good and was used for data collections.

Data collection included Focus Group Discussion with key informants and self administered questionnaire instrument to the 140 sampled household heads. Data and summaries from the Focus Group Discussions were analyzed using descriptive statistics namely percentages and frequencies to capture categories and patterns of interest.

Data from the questionnaire was transcribed, coded and synthesized by study objective. Data entry in the computer then followed after which analysis of quantitative data was done, using the statistical package for social sciences (SPSS).

The objective was analyzed using descriptive statistics namely percentages and frequencies and multiple linear regression was used to determine the relationship between the independent and the dependent variables. Multiple linear regression inferential statistic was the most suited for analyzing data in this study because it attempts to determine whether a group of independent variables, rain water harvesting technologies in this case, together predict a given depended variable (household food security in this study). The hypothesis was to be either rejected or accepted at 5% ($\alpha = 0.05$) level of significance.

IV. Results and Discussions

Water harvesting is an important option for agricultural production in drylands. Water harvesting, which includes runoff farming and runoff storage can be less costly than irrigation and can be developed locally depending on rainfall and land conditions. Table 2 documents the water harvesting technologies practiced in the study area.

Table 2: Rain Water Harvesting Technologies n=140

Rainwater harvesting technology	Count	Percent (%)
Zai pits	33	23.6
Road side run - off water	19	13.6
Water pans	1	.7

Table 2 shows that the most popular method of rain water harvesting is the zai pits where 23.6% of the farmers in the study area practice it. This is followed by road side run-off water harvesting accounting for 13.6%. A negligible number, 0.7% use water pans as a method of water harvesting.

Hypothesis of the study was to test if rain water harvesting measures had any influence on household food security among small-scale farmers in the study area. The following null hypothesis was stated: There is no significant influence of rain water harvesting on household food security among small-scale farmers in Kyuso Sub-County.

The hypothesis was tested using multiple linear regression by running the model in the SPSS. The independent variables were rain water harvesting technologies while the dependent variable was household food security measured by grain cereal and grain legume production from one acre of land. The hypothesis was tested at confidence interval α=0.05. Since p was .858 which is greater than 0.05 we fail to reject the hypothesis $H_{01.}$ Rain water harvesting alone do not necessarily positively influence household food security. This finding is contrary to expectations but agrees with Kaluli, Nganga, Home, Gathenya, Muriuki and Kihurani (2012). While investigating the effect of rainwater harvesting and drip irrigation on soil moisture and crop performance in arid and semi-arid area of Kaiti water shed in Makueni County Kaluli, et al (2012) found that water harvesting technologies (zai pits and contour ridges) did not significantly increase soil moisture when compared to the control. The pits and contour ridges failed to collect and store rain water and provide adequate moisture to crops even after the rain had stopped. Because rainfall was insufficient during most of the study period, there was hardly any surface runoff even from the control and drip irrigated plots. Although Mati (2006) found that contour ridges and zai pits increased the yield of maize in semi–arid climate, in this study such increase did not significantly influence household food security at 5% level of significance.

V. Conclusion and Recommendations

Rain water harvesting technologies practiced by small-scale farmers in Kuyso sub-county were road side run-off, Zai pits and water pans. The most popular method of water harvesting is the zai pits where 23.6% of the farmers in the study area practice it. This is followed by road side run-off water harvesting accounting for 13.6%. A negligible number, 0.7% use water pans as a method of water harvesting. The influence of rain water harvesting on household food security among small scale farmers in Kyuso Sub-County was found to be insignificant at 5% level of sign

Conclusion

The findings of this study led to the conclusions that rain water harvesting technologies require certain critical amount of rainfall below which they would not significantly increase soil moisture to facilitate improved crop production. Frequent and prolonged rainfall failures and poor agronomic practices are some of the important factors that deny farmers the full benefits of rain water harvesting technologies.

Recommendations

(i).Ministries and Departments of Agriculture and other development partners are advised to come up with policies that require not only promotion of water harvesting practices but also empower their extension staff to train farmers on good agronomic practices.

(ii). Governments could also develop policies that promote irrigation so that during seasons of inadequate rainfall supplementary irrigation could be done in order to bring crops to maturity and thus prevent possible crop failure.

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