"FACTORS INFLUENCING REPLICATION AND UTILIZATION OF WATER HARVESTING TECHNOLOGIES FOR FOOD PRODUCTION AMONGST SMALL SCALE FARMERS IN KIENI CONSTITUENCY, NYERI COUNTY, KENYA."

By

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DECLARATION

I declare that this research project report is my original work, and has not been presented for a degree in any other University;

Signature...Date...

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L50/60554/2011

This Research Project Report has been submitted for examination with my approval as University Supervisor;

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DEDICATION

This work is dedicated to my family, my wife Charity, and my children Alex, George, Moses and Kathryn for their love, support and encouragement during my study. Thanks to you all for your endless love and moral support.

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May God bless you all.

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ABBREVIATIONS AND ACRONYMS

ALRMP	Arid Lands Resources Management Programme
ANOVA	Analysis of Variance
ASALS	Arid and Semi-Arid Lands
ASDC	Agricultural Sector Development Strategy.
CAADP	Comprehensive Africa Agriculture Development Program
CIAT	International Centre for Tropical Agriculture
CSA	Climate Smart Agriculture
C.V	Coefficient of Variation
DAO	District Agricultural Officer
ERA	Economic Review of Agriculture
ERS	Economic Recovery Strategy for Wealth and Employment Creation
FAO	Food and Agricultural Organisation of the United Nation
IDPs	Internally Displaced Persons
KARI	Kenya Agricultural Research Institute
LSD	Least Significant Difference
MDG	Millennium Development Goals
MOA	Ministry of Agriculture
NARL	National Agricultural Research Laboratories
NSWCP	National Soil and Water Conservation Programme
PAE	Provincial Agricultural Engineer
PDA	Provincial Director of Agriculture

SH	Stakeholder
SIDA	Swedish International Development Agency
SPSS	Statistical Package for Social Sciences
SRA	Strategy for revitalization of Agriculture
UON	University of Nairobi
USDA	United States Department of Agriculture
WHFSP	Water Harvesting For Food Security Project

ABSTRACT

In 2006 the Water Harvesting for Food Security Project was conceptualized by the Ministry of Agriculture in order to address the problem of over reliance on rain fed agriculture by demonstrating simple water harvesting technologies to small scale farmers throughout the country but especially in the arid and semi arid lands. The farmers were expected to replicate and use the technologies in their own farms in order to help them achieve the envisioned multiplier effects. This study investigated why the replication and utilization of water harvesting technologies by the small scale farmers in Kieni Constituency, Nyeri County was low and came up with measures to improve the situation. The objectives of the research were to determine how socio- economic factors, land sizes and land tenure systems, cost of water harvesting technologies, and sustainable utilization of the harvested water influenced replication and utilization of water harvesting technologies.The study used a descriptive survey design and information was collected using interviews and predetermined questions. One set of questionnaires was administered to household heads and captured data in order to help in finding out the factors influencing replication and utilization of water harvesting technologies and also to get information on the socio-economic status of the households. The second set of questionnaire was administered to extension officers in order to get information on their perception on the factors influencing replication and use of water harvesting technologies and also to validate findings from the households. According to the study, youth were not adequately engaged in farming and their use of water harvesting technologies was low. The older farmers with higher education levels used the technologies more. Use of water harvesting technologies increased with increasing farmers' income and access to credit. Farmers with individual land ownership invested more in water harvesting technologies as are farmers with bigger land holdings. The perception among the farmers that water harvesting technologies are very expensive need to be addressed through training and by introduction of high value crops e.g. capsicum, tomatoes and onions to justify the high costs of construction. This study will contribute to the development of knowledge on the role of water harvesting technologies towards increasing agricultural production and the need to continue investing in these technologies sustainably.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Kenya's arid and semi-arid lands (ASAL) covers about 80% of the total land mass (467,200 Km^2) and holds 34.4% of the population (GOK, 2010).These areas cover regions of low and poorly distributed rainfall which adversely affects agricultural activities. Due to the limited water, small-scale farmers in the ASALs face the difficult task of producing sufficient food even for their own consumption. The increase in population growth and prolonged drought in these areas has considerably strained the food resources available. Food security has therefore become a major concern. In these low rainfall areas water harvesting technologies are key to enhancing food security. Kenya has not invested much in water harvesting and irrigation. However, heavy investment should be placed in formal irrigation if food security is to be realized. The Commission for Africa recommends doubling the area under irrigation by 2015 (Commission for Africa 2005).

The Agricultural sector is the backbone of Kenya's economy and the basis of livelihoods for most Kenyans. Sustainable agricultural growth is critical to raising living standards, generating sustainable economic growth and in building a green economy. Although agriculture is an important economic sector, crop yields in Kenya and in particular yields on small scale farms are far below their potential. In order to enhance agriculture based income, the Agricultural Sector Development Strategy has been adopted by the government to ensure that farmers, producers, processors and marketers of agricultural goods employ the most contemporary methods and technologies (ASDS, 2010).

Water harvesting can play an important role in improving food security and protecting the environment (Maimbo Malesu, 2011). Governments in sub-Saharan Africa have a key role to play in promoting water harvesting, chiefly by providing financial incentives and grants for rural and urban projects. Further, water harvesting will accelerate Climate Smart Agriculture (CSA) and will strengthen the ASDS and ensure consistency between the ASDS and the National Climate Change Response Strategy. Climate Smart Agriculture means agricultural production that increases climate change risk adjusted returns, which further contribute to carbon sequestration. It incorporates agricultural practices that supports livelihoods and food security, enhances resilience to changing climatic risks and reduces greenhouse gas emissions in line with MDG 7 for ensuring environmental sustainability (Farmers Voice, 2010).

There is no panacea for the low productivity and growth rates of African agriculture. Raising agricultural growth rates will require attention to a wide range of issues, as has been emphasized by every recent study (e.g., NEPAD 2003; Commission for Africa 2005; UN Millennium Project 2005b; World Bank and State of the World Report 2011). Huge investments over the long term are needed in rural infrastructure of all kinds, research and development, health and education, and other areas.

The Green Revolution, the dramatic increases in food production in Asia and Latin America was through higher yields, made possible through improved seeds and inputs, especially mineral fertilizers and also through water harvesting and supplementary irrigation. That Revolution is credited with feeding more than 1 billion people in Asia alone. The far lower increases in food production in Africa have been mostly its failure in bringing marginal land into production which further threatens the environment as a result of continuous exploitations of the existing arable land (Africa fertilizer Summit.2006).

The Ministry of Agriculture has been promoting water harvesting technologies amongst small scale farmers since independence. However, this gained momentum since 2006 when the Water Harvesting for Food Security Project (WHFSP) was conceptualized with a view to addressing the problem of over reliance on rain fed agriculture, a situation which has led to frequent famine and over dependence on famine relief constantly in most parts of the country. Apart from improving the nation's food security, the project was expected to improve the livelihoods of the people as envisioned in the Agricultural Sector Development Strategy (ASDS) and vision 2030. This is also in line with Millennium Development Goal (MDG) 1, for eradicating extreme poverty and hunger and also MDG 7 for ensuring environmental sustainability (MOA, 2010 Water Harvesting Guidelines).

The Water Harvesting for Food Security Project (WHFSP) has been running for the last six years with varying success rates in different parts of the country. The initial emphasis was to have the districts in the ASAL areas facilitated with funds to construct water pans that will assist the communities with water for domestic, livestock as well as for supplementary irrigation and also to help in the establishment of tree nurseries so as to increase the area under tree cover from the present 2% to the envisioned 10% as an adaptation mechanism to climate change being experienced in the country and especially in the ASALs. Thereafter, the farmers in those areas were expected to replicate and upscale the water harvesting technologies in their own farms albeit in a smaller scale, in order to achieve the envisioned multiplier effects.

Further, in many sub-Saharan African countries, women do up to 80% of the farm work. These same women receive an estimated 3-5 % support and own just 1% of land. If women were given adequate access to services and facilities such as would be realized by providing water both for domestic and agricultural activities, food production would increase by 20%. Success of these water harvesting initiatives will also empower women to engage in other income generating activities. Benefits from farming that are received by African women are more likely to be invested in family health, education, and welfare (Ngigi, 2003).

The Water Harvesting for Food Security Programme has already been implemented in more than 125 districts in the ASALs and has been able to construct more than 278 community water pans. Most of these sites have tree nurseries that are providing the communities with tree seedling to rehabilitate and conserve the catchments. The funding for the water harvesting programme has continued to increase over the years. During the financial year 2011/12 alone, water harvesting initiatives has been allocated Kshs 1.265 billion; consisting of 1.1 billion for constituency based dam construction covering 170 constituencies. Each constituency was allocated Kshs 6.4 million per constituency, with Kshs 115 million directly from the Ministry of Agriculture (MOA) and Kshs 50 million joint funding by GIZ/MOA for the construction of additional 113 water pans in the whole country. These funds have already been disbursed to the stations implementing the initiatives (Agriculture Secretary Circular, December 2011).

The objectives for the water harvesting projects were outlined by the Ministry of Agriculture as demonstrating and transferring water harvesting and efficient water use technologies to ASAL farmers, increasing food production and productivity levels, introducing and promoting alternative livelihoods for ASAL areas and to conserve the environment by reducing land degradation through introduction of tree nurseries and controlling surface runoff and reduce soil erosion.

The program was further expected to bring in various strategic stakeholders to continue to expand the initiative in surrounding areas using the technologies learnt. Some of the strategic stakeholders expected to be brought on board are the Ministries of Livestock and Fisheries, Kenya Forest Service and National Environment Management Authority (NEMA) to ensure sustainable development.

The various challenges/constraints encountered in the project include inadequate funds against high demands from communities, timeliness in the disbursement of funds since in most cases; funds are disbursed late to the implementing stations. Since these projects are expected to be completed within the financial year, and it also being subjected to performance contracting, the projects are implemented in a hurry and in most cases, site selections are poorly done or not completed at all. . For those completed, most of these water pans don't have water due to poor siting and also due to deficient designs by the ministry of Agriculture's technical staff. There is also inadequate community mobilization which leads to weak community ownership and hence poor sustainability of the project as a result of poor entry point, lukewarm ownership. Most of the projects are done in areas where communities are used to relief from the Government; it is difficult for the community to replicate the technology. There is also the case of poor gender mainstreaming. Women are the major users of water yet they are not adequately represented in the water harvesting committees.

Opportunities which can be utilized to make the project a success include highly qualified technical human resource which can be effectively retrained in areas of water harvesting, vast number of registered groups which can act as entry points to the communities and also large areas of arid and semi- arid land that is needy and suitable for water harvesting. With the gazettement of the Agro forestry rules 2009 which requires each farm to have at least 10% tree cover, there will be a high demand for tree seedlings to plant in the farmlands to meet this target. The climate change challenges have provided an opportunity for the expansion of the project as water harvesting is regarded as one of the effective adaptation mechanisms to this phenomenon.

The Recent resettlement of Internally Displaced Persons (IDPs) mostly in the ASAL areas, for example the Solio Ranch settlement in Kieni Constituency demands that the Government through its Ministry of Agriculture's extension officers promote simple water harvesting technologies if these farmers are going to be self-reliant in food production. Water harvesting ranges from simple-low cost techniques to complex- high cost techniques that involves capturing and storing of rainwater from roof and ground catchments for domestic, agricultural, industrial and environmental management purposes. The potential for water harvesting in providing a viable water supply at specified locations is mainly determined by the amount of rainfall and its seasonal variation, availability of existing catchment surface, cost of harvesting the water, availability of alternative water source and cultural acceptability.

The main objective of Water Harvesting for Food Security Project is to improve agricultural production thus improving farmers' income and food security. This will be accomplished through promotion of production of appropriate food and horticultural crops through efficient use of the harnessed water from the dams and water pans established so that farmers can be able to grow enough food. They will be able to grow high value horticultural crops in established green houses and also be able to diversify to other enterprises like fish farming. Apart from ensuring food security, sales would boost their income and help the communities to alleviate poverty.
This is the way to go if the country is to achieve the desired food security and realize MDG1 "Eradicate extreme poverty and hunger". But are we doing it the right way? If not, what is the best way? This was the purpose of this study.

1.2 Statement of the Problem

Africa has the highest population growth rate, and when accompanied by slow economic growth, high incidences of poverty and hunger have persisted. 75 % of food crops production in Kenya is by small scale farmers. However, only 30 % of the farmers use any supplementary irrigation and use of fertilizer is minimal. The consequence is that most crops rarely grow to maturity and farmers generally obtain low yields. This is the main cause of declining agricultural productivity but also increasing food insecurity and object poverty. (National Soil Fertility Draft Policy paper 2006).
In Solio Ranch settlement scheme for Internally Displaced Persons (IDPs) within Kieni Constituency, farmers were given four (4) acres each for cultivation and were housed in seven satellite villages, on a quarter acre plot each. Four years after, these farmers are still waiting for the government to come and help them open up their land for cultivation. This area is highly water deficient and food insecure but it receives an average 550 mm of erratic rainfall annually but all fall within a considerably short period of time resulting in very high runoff. This water therefore cannot sustain a crop to full maturity despite the fact that the soils are generally fertile and other climatic conditions are favorable for growing a wide range of crops. With the harnessing and storage of the runoff water in water pans, dams and other water harvesting

structures, this water can be used to sustain a crop even during the dry season (Ministry of Agriculture Report, 2011).

After the water harvesting demonstrations conducted by the Ministry of Agriculture staff, the farmers were expected to replicate the technologies in their own farms .This has not been the case. The overall research problem addressed in this study is that despite the efforts to empower farmers by training them and demonstrating to them the various water harvesting techniques and its potential in increasing crop production, the adoption levels by the farmers is still very low. This study sort to find out the factors affecting replication of water harvesting technologies amongst small scale farmers in Kieni Constituency, Nyeri County and has attempted to provide a set of practical suggestions aimed at positively influencing farmers to embrace use of water harvesting technologies to help increase their agricultural production. This will improve the nation's food security, improve the livelihoods of the people and ensure environmental sustainability.

1.3 Purpose of the study

The purpose of this study was to identify the factors that influence replication of water harvesting technologies amongst small scale farmers in Kieni Constituency of Nyeri County. The study tried to investigate the reasons behind low replication levels by the farmers. It investigated how social economic factors, land size and tenure, cost of water harvesting technologies and the level of utilization of harvested water influence replication and utilization of water harvesting technologies by the small scale farmers of Kieni Constituency, Nyeri County.

This study investigated the policies, strategies and impact of government intervention in the promotion of the Water Harvesting Programme for Food Security. This study will further contribute to the development of knowledge on the role of water harvesting technologies towards increasing agricultural production in Kenya and the need to continue investing in these technologies sustainably.

1.4 Research objectives

The study was guided by the following objectives:-

1. To determine how socio- economic factors influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.

2. To establish the extent to which land sizes and land tenure system influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.

3. To determine how the cost of water harvesting technologies, accessibility and availability of credit services influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.

4. To assess how utilization of harvested water will influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.

1.5 Research Questions

The research questions of the study were:-

1. To what extent do the socio- economic factors influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency?
2. How does land sizes and land tenure system influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency?
3. To what extent does the cost of water harvesting technologies, accessibility and availability of credit services influence the replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency?
4. To what extent does utilization of harvested water influence replication of water harvesting technologies by small scale farmers of Kieni Constituency?

1.6 Significance of the Study

The findings generated by this research have been used to make recommendations to the government and other policy makers on appropriate measures necessary to encourage small scale farmers in Kenya to adopt water harvesting technologies so as to increase their agricultural production.

This will lead to decreased poverty, creation of job opportunities and increased income as well as food security from improved crop production. It will make a positive contribution to the economic recovery strategy for wealthy and employment creation in Kenya and also help the country toward realizing its vision 2030.

The growth in agricultural production will help women in particular to achieve economic parity, alleviate poverty and reduce gender inequalities. This will in turn lead to the realization of MDG1for Eradicating Extreme Poverty and hunger; MDG3 for Promoting Gender Equality and Empowering Women and also MDG7 for Ensuring Environmental Sustainability. The study will further contribute to the development of knowledge on the role of water harvesting technologies towards increasing agricultural production in Kenya and the need to continue investing in these technologies sustainably.

The researcher is an employee of the ministry of Agriculture headquarters and participates in the development of policies on water harvesting and irrigation in the ministry. The researcher will be able to ensure that valuable recommendations got from this study are implemented speedily for the benefit of the country.

1.7 Assumptions of the Study

The study assumed that the respondents will give correct and truthful answers when responding to questions put before them, that the sample size chosen was adequate to help in drawing valid conclusions and that the data collection instruments were valid and would measure the desired constructs.

The study also assumed that the various government departments and stakeholders will be willing to provide the required information. The researcher was able to access correct information with ease as he is employed by the Ministry of Agriculture..

1.8 Limitations of the Study

A major limitation during the research was that of budget and time constrains. This mean that the researcher was not able to collect the data from the entire population since this would have involved a lot of travelling and therefore time may not have been available to cover all. The in availability of adequate funds limited the study since the researcher was self-sponsored.

Another limitation was that the respondents may have concealed some information that they felt could be too sensitive to reveal for security reasons. The researcher overcame this challenge by assuring the respondents of confidentiality in using the information given as well as stressing that the information will be for the purpose of the study alone.

There were concentrated efforts to ensure that the questionnaire gets to all sampled farmers and ministry of agriculture extension staff. All duly filled questionnaires were completed and returned but interviews were nevertheless incorporated for purpose of triangulation.

The study only covered Kieni Constituency and the findings may not be easily generalized for the whole country and will therefore only offer valuable guidelines.

1.9 Delimitation of the Study

The study only drew respondents from small scale farmers of Kieni Constituency, Nyeri County. The study targets were small scale farmers engaged in agricultural production in the arid areas of Kieni Constituency, especially horticultural farmers.

1.10 Organization of the study

Chapter one contains background of the study, statement of the problem, purpose of the study, research objectives and research questions and also significance of the study. Chapter two contains literature review, factors influencing replication and use of water harvesting technologies, global water harvesting initiatives, local government initiatives and the conceptual framework. Chapter three explains the research methodology, research design, target population, sampling procedure, research instruments, data analysis, ethical issues and operational definition of variables.

Chapter four deals with data analysis, presentation and interpretation of findings. It provides the overall findings based on primary and secondary data which were gathered. Chapter five presents summary, discussion, conclusions and recommendations of the study findings and gives suggestions for areas that according to the researcher requires further research.

1.11 Definition of significant terms

Agricultural extension The system put in place by the Ministry of Agriculture to pass recommended farming methods and practices to farmers.

Barriers Factors tending to inhibit small scale farmers from investing in water harvesting technologies.

Climate Change Any change in global temperatures and precipitation over time.

Constraints Factors limiting establishment of water harvesting technologies by small Scale farmers by confining them in terms of scale and scope of operation (mainly internal factors).

Food security This is the adequate supply of food stuff for individuals, community and the nation at large for now and the near future.

Negarims These are diamond-shaped basins surrounded by small earth bunds with an infiltration pit in the lower corner of each. Runoff is collected from within the basin and stored in the infiltration pit. The micro catchment conserves both soil and moisture and are appropriate for small scale tree and fruits planting in any area which has a moisture deficit.

Small scale farmers These are families with holdings of less than two hectares.

Stakeholders These are people, communities and institutions with an interest or affected by an issue.

Soil fertility This refers to the percentage of plant nutrients in the soil.

Replication Adoption of water harvesting technologies by small scale farmers after trainings and demonstrations by the Agricultural Extension Officers and other stakeholders.

Trapezoidal Bunds These are earthen trapezoidal embankments with wing walls extending Upslope at an angle of usually 135 degrees used to enclose large areas, up to 1 hectare (ha) to impound large quantities of runoff and crops planted within the enclosed area.

Utilization This refers to sustainable use of water harvested using water harvesting technologies to increase food production.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter explores water harvesting initiatives in the world, Africa and Kenya in particular and how these initiatives have helped these countries to realize food security and to escape from poverty.

It looks at the factors influencing use of water harvesting technologies in general. It also reviews the socio economic factors at play when small scale famers use water harvesting technologies. The literature also reviews how training and the level of education impacts on adoption and replication of water harvesting technologies. Policy, legal and institutional framework are also examined. The conceptual framework is also analysed and discussed. The literature review also indicate whether there exist any gap in knowledge or technology on factors influencing replication and utilization of water harvesting technologies by small scale farmers to increase their agricultural production.

2.2 Factors influencing replication and use of water harvesting technologies

Agriculture continues to be a fundamental instrument for sustainable development, poverty reduction and enhanced food security in developing countries. It is a vital development tool for achieving the Millennium Development Goals (MDG) one of which is to halve the share of people suffering from extreme poverty and hunger by 2015 (World Bank 2008). In Africa, agriculture is a strong option for supporting growth, overcoming poverty and enhancing food security. Agricultural productivity growth is also vital for stimulating all other sectors of the economy. However, agricultural productivity in Africa has continued to decline over the last decades and poverty levels have increased. Crop yields in Kenya and in particular yields on small scale farms are far below their potential. Currently, agricultural productivity growth in sub-Sahara Africa (SSA) lags behind that of other regions of the world and is well below that required to achieve food security and poverty goals. Increasing agricultural productivity can only be done through the introduction and use of improved agricultural technologies such as use of water harvesting technologies to promote supplementary irrigation (ERS, 2005).

Rapid population growth has made Africa to be no longer viewed as a land abundant region, where food supply could be increased by expansion of land used in agriculture. However, large areas in Africa are increasingly becoming marginal for agriculture and arable land has become scarce in many African countries. This makes the need for intensification of land use through use of productivity enhancing technologies such as water harvesting and fertilizer use critical for achieving food security. More land in the marginal areas need to be put under production but this can only be done if water is provided in these areas and efficient water application methods such as drip irrigation used to supply water to crops such as has been achieved in South Asian countries (Byerlee et al,1997).

A major lesson to learn if Kenya is to successfully promote WHFSP is that South Asian countries have generally created a more favorable policy environment for NGOs, public agencies and private sector firms to compete to provide services and products, as well as providing subsidies to encourage farmers to adopt new technologies intended either to conserve water or make its use more productive. Subsidies are often intended to be targeted to specific categories (scheduled castes, poor people), though this targeting is not always effective (Doss, 2006). A related policy in some South Asian countries has been to encourage import of low-cost power pumps with minimal or no duties or controls. In Bangladesh or Sri Lanka a farmer can often choose from diesel, petrol or electric pumps from China, Japan, Korea, and other countries. This combination of government policies to support and encourage manufacturers, importers, retailers, NGOs and making substantial subsidies available to farmers has led to a highly competitive innovative market in micro- water harvesting and management technologies (Doss,2006).

According to Feder et al (1985), high external technologies, lack of infrastructure, research, development and even extension are major obstacles to increase in agricultural infrastructural development in sub-Saharan Africa. The technologies available are limited and the costs are prohibitive. For example, the charges for a D6 crawler tractor excavating a water pan is KSh 3,020 per hour in addition to transporting the crawler tractor using a low loader from the nearest of the only 23 Agricultural Mechanization Services (AMS) stations available in Kenya. This is simply beyond reach of the ordinary farmer. The solution may be to organize farmers in groups so as to pool resources together so as to benefit from economies of scale as they can mobilize the crawler tractor together. Hand digging normally causes major challenges to the farmers due to lack of specialized tools.

In ASAL areas like Kieni Constituency of Nyeri County for example, where crop production is highly deficient, it may be risky to provide incentives such as food for work rations to potential beneficiaries participating in the construction of crop production systems such as water harvesting if sustainability of these projects is to be ensured. It has often been observed that people consider incentives mainly as a job opportunity and may lose any interest in the scheme once the project and the incentives have come to an end. This highlights the potential danger of incentives, rather than genuine motivation, which should be the driving force in all projects if success is to be realized (Boserup, 1965).

Along with checking the sequence of priorities, the planner must also consider alternate sources of water. These must be compared with water harvesting in cost and in the risk involved. The comparison must take into account the water quality required, operational and maintenance considerations as well as the initial cost. Where alternate water is of better quality, is cheaper to develop, easier to obtain or involves less risk, it should be given priority. An example of this is the development of springs or shallow wells for micro-scale irrigation, prior to water harvesting. In all cases, it is essential that the costs are balanced against the potential benefits. As in the case of multipurpose trees in arid/semi-arid areas, for several years the main benefit will be the soil conservation effect and grass for fodder until the trees become productive (Mburu, 2008).

2.3 Socio-Economic factors influencing replication and use of water harvesting technologies

It has been established overtime that the main path to the development of smallholder farming system is through improved technologies, management practices and field husbandry methods that are simple and mostly inexpensive. This path requires considerable ability by farmers for them to make efficient use of family labor and management resources. The ability of farmers to diversify and achieve sustainable small-scale production depends on their socioeconomic characteristics among other things (Langyintuo et al, 2005).

There is no firm economic theory that dictates the choice of which explanatory variables to explain technology adoption behavior of farmers. Nevertheless, adoption of agricultural technologies is influenced by a number of interrelated components within the decision environment in which farmers operate. For instance, feder et al, 1985 identified lack of credit, limited access to information, aversion to risk, inadequate farm size, insufficient human capital, tenure arrangements, absence of adequate farm equipment, chaotic supply of complimentary inputs and inappropriate transportation infrastructure as key constraints to rapid adoption of water harvesting technologies in less developed countries. However, not all factors are equally important in different areas and for farmers with different socio-economic situations.

There are many variables at play when we come to adoption and use of technologies. The household characteristics deemed to influence replication and adoption of water harvesting technologies include household heads characteristics (age, gender and education), household size and dependency ratio. The conventional approach to adoption study considers age to be negatively related to adoption based on the assumption that with age farmers become more conservative and less amenable to change. On the other hand, it is also argued that with age farmers gain more experience and acquaintance with new technologies and hence are expected to have higher ability to use new technologies more efficiently. Education enhances the locative ability of decision makers by enabling them to think critically and use information sources efficiently. However, since water harvesting is a relatively a new technology, education and training are expected to have strong effects on its adoption (Merrey et al, 2006).

The effect of household size on replication and adoption of water harvesting technologies can be ambiguous. It can hinder the adoption in areas where farmers are very poor and the financial resources are used for other family commitments with little left to invest in water harvesting technologies. On the other hand, it can also be an incentive to replicate and adopt the water harvesting technologies as more land will be put under production and yields will significantly increase and help meet the family food consumption needs (Odhiambo et al, 2002).

Other factors may include access to credit, farm size, presence of a high value crop, distance to extension service provider and distance to motor able road. Size of household landholding is considered important as it is positively correlated with replication and adoption of water harvesting technologies as farmers with bigger landholding size are assumed to have the ability to purchase improved technologies and the capacity to bear risk if the technology fails (Feder et al., 1989). Large holdings will also ensure that land is available for construction of the water harvesting structures. Access to cash or credit ensures that the farmer may use the resources to invest in water harvesting structures. The presence of a major cash crop in the house hold is expected to influence replication and adoption of water harvesting structures. This is because in

Kenya, commodities such as tea, coffee, sugar cane and a wide range of horticultural crops have inputs credit schemes for farmers and generally have higher returns to investments for the farmers as compared to other less value crops. Exposure to information reduces subjective uncertainty and therefore, increases the likelihood of adoption of new technologies (Odhiambo, 2002). Various approaches have been used to capture information including: whether or not the farmers attended demonstration tests for new technologies by extension agents and the number of times the farmers have participated in on-farm demonstrations.

The formal banking system is yet to develop credit facilities that suit small scale farming business. A number of micro finance institutions are operating in some areas but they reach only a small proportion of small holder farmers and only provide very short term credit and their effective lending rates are very high (MOA strategic plan 2005 – 2009).

Infrastructure is a main challenge facing the Kieni Constituency farming community. Come rains and most of the roads are impassable making it completely impossible to market farm produce. Most of the roads and access routes have not been murramed apart from a few sections. Additionally, most sections of the roads and routes are continuously damaged by runoff water during the rains. Harnessing of this runoff water will minimize this problem.

2.4 Training on replication and use of water harvesting technologies

Most studies dealing with agricultural production argue that schooling or the level of education of a farmer helps the farmer in the use of production information positively leading to increased adoption and higher yields. Even though education enhances agricultural production in Nepal mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment (Namara et al, 2005). Thus, in a technologically dynamic agricultural system, education improves farmers' locative ability, enabling them to select and embrace improved technologies and optimally allocate existing and new inputs among competing uses. In a related study by Awulachew et al, 2005, they investigated the impact of farmers' contact with agricultural extension services on farm productivity. The study established that the ability of farmers to effectively diversify their farming system is influenced by their contact with agricultural extension officers. The results also showed that access to agricultural extension services, raises adoption of new technologies by about 15 percent. Social participation, family size, experience with farming other crops and the nature of the land (flat/sloped) did not show significant influence on adoption.

To promote use of water harvesting technologies and also promote other appropriate technologies among the farming community in Kenya, extension agents use various methods depending on target group. time of the year and objectives. The most common ones include individual approach where farmers are trained individually, group approach where farmers are trained in a group and also mass media (Ministry of Agriculture and SIDA. 2000)). In the 1980s and 1990s, the Ministry of Agriculture with financial funding from Swedish International Development Agency (SIDA) embarked on one of its most ambitious programme so far, the National Soil and Water Conservation Programme (NSWCP). Farmers were trained to conserve soil and water in their own farms using catchment approach strategy. This involved continuous treatment of farms in a given hydrological area. Initially, farmers were paid to do conservation in their own farms. Later, incentives were given in form of specialized tools to enhance conservation. Trainings for both farmers and staff were a serious component of the NSWCP. This together with the introduction of training and visit extension system by the MOA made the extension agent to be over loaded with responsibilities so that it was not possible to fully concentrate on water harvesting extension messages so much needed by the farmers. The catchment approach supported by SIDA in the 80s and 90s would identify farmers within a given area then make them aware of soil and water challenges and their impact to land productivity. The farmers were then trained on the relevant improvement measures to address the problems (Ministry of Agriculture and SIDA, 2000).

From the year 2001 the extension approach changed such that farmers were expected to identify their problem and then look for extension agent to provide the technical know-how. The farmers were also mobilized by extension agent to form groups where they are trained when they demand for service. The service is provided free (Ministry of Agriculture and SIDA, 2005).

2.5 Global Water Harvesting initiatives

2.5.1 Israel Experience

Examples from Israel, one of the Nations which have invested heavily in areas of water harvesting, has ensured that it does not only grow enough food for its people, but also grow surplus for export. It is suggested that before selecting a specific water harvesting technique, due consideration must be given to the social and cultural aspects prevailing in the area of concern as

they are paramount and will affect the success or failure of the technique implemented. This is particularly important in the arid and semi-arid regions of Africa and may help to explain the failure of so many projects that did not take into account the people's priorities (Backeberg, 2009). In Israel, negarims are the preferred water harvesting technique. Although the first reports of such micro catchments are from southern Tunisia (Pacey and Cullis, 1986) the technique has been developed in the Negev desert of Israel. The word "Negarim" is derived from the Hebrew word for runoff - "Neger". Negarim micro catchments are the most well known form of all water harvesting systems. Israel has the most widespread and best developed Negarim micro catchments, mostly located on research farms in the Negev Desert, where rainfall is as low as 100-150 mm per annum. However the technique, and variations of it, is widely used in other semi-arid and arid areas, especially in North and Sub-Saharan Africa Because it is a well-proven technique, it is often one of the first to be tested by new projects.
In arid and semi-arid Africa, most of the population has experienced basic subsistence regimes which resulted over the centuries in setting priorities for survival. According to Maslow's hierarchy of needs, until all higher priorities have been satisfied, no lower priority activities can be effectively undertaken (Rockström et al, 2005). This may explain the low levels of investments in water harvesting technologies to increase agricultural production. Along with checking the sequence of priorities, the planner must also consider alternate sources of water. These must be compared with water harvesting in cost and in the risk involved. The comparison must take into account the water quality required, operational and maintenance considerations as well as the initial cost. Where alternate water is of better quality, is cheaper to develop, easier to obtain or involves less risk, it should be given priority. An example of this is the development of springs or shallow wells for micro-scale irrigation, prior to water harvesting.

2.5.2 Africa's initiatives

2.5.2.1 Zimbabwe Experience

There was not the same focus on building local capacity to manage as in the more recent project in the Nyamarimbira integrated water supply project, Zimbabwe. It would appear that the initial intervention was supply-driven rather than demand-driven. There was a Board, which held meetings for representatives of all the local committees, of whom 50% were women. Local committees managed some issues, such as reallocation of plots. They also managed initial and annual project fees. However, it seems that the project had no built-in incentives to ensure financial sustainability, and that only project staff had a picture of the future. Rather than building commitment through investment of time, and supporting the Board to manage the process, the intervening agencies retained control. Salaried staff was never accountable to local bodies. The move to an 'integrated approach' and to an apparent ceding of control to the local body in the final stage of the project does not seem to have ensured community ownership. Hence there was no lasting social capital built for the communities involved. The withdrawal of funding was sudden, and not subject to consultation (Kidane et al, 2006). Despite all these, the water harvesting project registered some degree of success. Ndlovu, a local farmer used to harvest only one 50 kg bag of maize from her 1.5 hectare piece of land, which sits on an undulating slope. Thanks to water harvesting, Ndlovu's maize yield has quadrupled and her neighbours have started wondering what she is doing that they are not. "For a long time I was worried about poor harvest because of low rainfall until I heard about water harvesting. The poor rainfall limited me to grow sorghum and millet but that was not for me because I am not able to protect the crops from the birds. I grow maize and have realised good harvests because of implementing water harvesting."

The secret to water harvesting is hard work and a passion for farming, Ndlovu revealed. "I work hard and put to practice the skills I have learnt on pegging and digging the contours in the most suitable location to ensure that they hold the water after the rains." said Ndlovu."I have encouraged other farmers to try water harvesting and some of them wonder if I am using a tractor when they see my harvest yet it is all about learning the technique and applying it correctly."

2.5.2.2 South Africa's experience

In his presentation, Dr Gerhard Backeberg a Water Research Commission Director in South Africa, in his paper presented in Göttingen, Germany, 14 to 16 July 2009 during the 2nd International Seminar on "Land Resources and Land Use asserted that 19 million people in South Africa are rural survivalists with traditional agrarian lifestyles. Of these at least 15 million individuals are living below the poverty line. In contrast farming contributes only 10% of material income for rural livelihoods. Furthermore, land resources in communal areas are largely under-utilised. In some villages in the Eastern Cape and Free State province, levels of food security have increased by means of maize and vegetable production in homestead backyard gardens (Twomlow et al, 2003).

Large areas of croplands surrounding these villages are currently lying fallow and indications are that this land has not been productively cultivated for the last 25 years or more. There are clearly opportunities for up-scaling of Infield Rain Water Harvesting (IRWH) from household food gardens to communal croplands. "Results of research station experiments demonstrate that maize yields increased by up to 50%, compared with conventional production techniques" says Gerhard. Innovative procedures have been developed and tested to identify suitable soils for rainwater harvesting. Through modelling the minimum area of farmland has been determined to meet the food security needs, expressed as either income or caloric requirement. "Through technology exchange the application of IRWH expanded to more than 1 000 households in 42 rural villages around Thaba Nchu" says Dr Backeberg in his presentation.It has also been shown that Infield Rain Water Harvesting (IRWH) is viable in terms of conservation of soil and water resources, reduction of risk, social acceptability and economic feasibility. However, delineating suitable soils and calculating sizes of land holdings is only part of the solution to improve water productivity and rural livelihoods. Surveys in the area have shown that low levels of education are found amongst household members and that widespread poverty exists. Although the expectation is that exploitation of this land can enable households to produce enough staple grain crops for own consumption and also earn cash income with sale of surpluses, various obstacles have to be overcome.

In his presentation he mentioned that the current state of land use at Thaba Nchu is the result of a history of conflicts over legitimate rights and economic means to earn livelihoods. As for the whole of South Africa, a process of land reform is under way, which involves amongst others obtaining tenure security because of past discriminatory practices. The contention is therefore that communal croplands will only be accessed sustainably with secure land tenure arrangements. A pilot project to develop a land register of holdings by households on the communal croplands has confirmed the near collapse of the land tenure system. After consultation a participatory process has started to formulate rules that explicitly define the land holding and ensure exclusive use of the land for cultivation. Various formal groups have been established to ensure enforcement of rules and enable transfer of use rights by means of share-cropping or leases between those who are interested and not interested to farm. Successful up-scaling of IRWH will again require demonstration plots to change unrealistic perceptions regarding prospects of conventional tillage.

Farmers, who are mostly women, must also receive skills training and have aspirations to improve livelihoods through more productive farming activities. "The available guide for farmer trainers and facilitators should be implemented for practical skills development to the benefit of women and revitalisation of rain-fed farming" says Backeberg. Further applied research is also being undertaken to investigate appropriate marketing channels of food crops, financing of production inputs and support services of extension which have to be provided to farmers.

2.5.2.3 Ethiopia experience

In the present day Ethiopia, the pastoralists and agro-pastoralists accounts up to 6 million people and occupy an area of more than 61% of the total national area of Ethiopia. Out of the national livestock population about 40 % of the cattle herd, three quarter of the goats and 100% of the camels are found in pastoral and agro-pastoralist areas. Moreover, the pastoral and agro-pastoral areas are serving as the major source of irrigation schemes government and private settlements, hydroelectric power, live animals for export and tourist attractions (Moyo et al, 2005). Surprisingly today these pastoralist areas are known for their drought, famine and dependency on food aid. Government regimes through history have never integrated them in to the national economy; rather they were considered lawless and conflicts-ridden. The development of settlement and irrigation schemes in the name of modernizations which paralyze the dry and wet season's source of pasture and water was the outcomes of such mentality. The cumulative effect of the historical neglect, top down approaches, development of inappropriate technologies, poor marketing and extension system and failure to appreciate the rationale behind the pastoralism strategies were attributing to the crisis in pastoral areas (Hogg, 1997). Since 1997 there has been serious drought in the Horn of Africa, which can be partially attributed to the global climatic changes. Added to this, conflicts and insecurity have become the rule rather than an exception in the Horn over the past few decades. The Ethno-Somali war of 1977/78 and the civil war in Somalia in late 1980s and early 1990s created many manmade crisis including refuges, returnees Internally Displaced Persons (IDPs) and land degradation. As emergency interventions, water storage and fodder distribution which are expensive operations were common phenomenon in Somali region and greatly harmonized the ecological and human eco-system and attributed to food security for the local community. The overall aim was to reflect on the role of 'Haffir' dams in ensuring food security and sustainable resource management. Participatory discussions were conducted among the different community groups (ethnic groups, elders, women, water and environment committee, the poor and better-off), to promote acceptability and adoption of the technologies. Field observations on vegetation cover and water sources were made during both the dry and wet seasons. The study area, the district of Gashamo is located south East of Ethiopia about 400km east of Jigiga, Somali Region capital. It has a semi-arid climatic zone with bimodal rainfall in April - June (Gu) and October- December (Dayer). Usually the rainfall is unreliable both in space and duration. Camel, goats and sheep are the dominant livestock in the district. The estimated population in Gashamo district was over 130,000 people distributed over 129 villages. The dominant clan in the district is Issaq, which has many sub clans including Haber-Yonis and Haber-Jealo. Generally it has poor transport and communication infrastructures, social services and poor marketing. Drought and famine, livestock disease, soil erosion by wind and water, influxes of refuges had plagued the district. As a survival strategy most people depend on livestock sector, while the others are involved in petty trades, daily labour, selling of Berka water and remittances from relatives abroad (Yohannes, 2002).

According to a report "water harvesting technologies in assuring food security: lessons from the pastoral areas of Somali Region, Ethiopia", most of the chronic food insecure areas of Ethiopia are those of the pastoralists and agro pastoralists. The cumulative effect of the historical political marginalization of pastoralists in decision-making and recurrent drought and famine had attributed to the prevailing crisis. Moreover, many pastoralists had been losing their livestock assets and dropping out from pastoralism to cover the water expenses for private 'Birkas'. Conflicts between clans and sub clans on the use of scarce water and pasture are also becoming a rule than an exception in these areas. Moreover, the emergency interventions with water storage and fodder bulking were not only expensive but have minimum impact to the magnitude of the problem.

An assessment of success stories in water development and food security in the pastoral and agro-pastoral areas of Somali Region in Ethiopia goes to the local NGO Hope for the Horn. The

NGO has introduced 'Haffir' dams with a holistic approach consisting of community nursery development, afforestation and closure areas, fodder bulking sites, use of different soil and water conservation techniques and the establishment of environment and water committees. With the NGO strategy of spatial distribution of blue (water points) and green belts (fodder bulking) more than 17 'Haffir' dams had been evenly established across 400 kms stretch. Participatory monitoring and evaluation is also widely practiced which attributes to the reorientation of the design of the dam and approaches in the development process. Generally the success stories of the water harvesting technologies is based on the adaptive continuity of external intervention with the harmony of local resources, improvement of livelihood and resilience to drought, local institutional building and added values to the innovative capacity of the community to solve their problems. However, 'Haffir' dams have some challenges such as the expansion of settlement around water points and community dependency on the technology.

Major sources of water in the pastoralist areas include natural ponds which are usually naturally located on depressions or concave slopes. The small ponds are locally known as Qayder and the relatively bigger ones are the Harro. Some of the ponds serve during the rainy season (Gu and Dayer) others serve few weeks in the dry season (Hagaya and Jelaal). There is no special water management and sanitations and all livestock enter to the water points. Consequently the trampled soil becomes very lose and easily washed out by wind and water to be deposited in the ponds. This constant siltation contributes to the short life span of the ponds; locally made ponds which are very old men made ponds, locally known as 'Balliyo'. Even the pastoralists no longer know who originally excavated them. Although small in number they are widely distributed in a range of 100 to 200kms through the Degahbour zone to prevent over concentration of animals in one spot and also to minimize conflicts. It is usually the poor people who previously lost their livestock due to drought who temporally camp on such spots and manage these water points. For the systematic serving of watering the animals the camel owners in return give them some milk. Still the system is functional but in a diminishing trend with the introduction of 'Birkas' and 'Haffir' dams (Johannes et al, 2002); earth dams which with the help of the government and some NGOs, some of the natural ponds were excavated by machinery in a semi-circle form all over Somali region. An observation in Aware camps and Gashamo area indicates that by and large such ponds are now silting up as they do not integrate the water management and catchments rehabilitation. Still such intervention is prevailing under emergency interventions by NGOs and government due to their inability to learn from past mistakes; private Birkas which are in-ground tanks lined with stone and concert and used to collect and store run-off rainwater for human and livestock consumption usually practiced in the Gashamo area of Ethiopia. It was introduced in the 1950s from the British colony and considerably increases in the 1970s following the drought and 1980s following the civil wars in Somalia and incoming refuges. The local administration of Gashamo estimated there are more than 20,000 'Birkas' in the 129 villages. However, currently 30 to 40% of the 'Birkas' are not functional. Some are too old and have become too expensive to maintain. Others are cracked due to plant roots and some are bad due to poor quality of construction and do not stay long. Generally the development of Birkas in Gashamo areas has contributed to decreased water scarcity and has created a constant source of income through the sale of water. However, this source of water has a combination of problems which include siltation, poor sanitation and malaria infestation due to increased mosquito infestations. Moreover, such intervention was a turning point from communal resource management to individual resource ownership based on profit making. Today the construction of Private Birkas has been diminishing due to the weakness of economic strength of the community and expansion of construction of water points by government and NGO supports and also Haffir dams which were introduced in Somali region from Sudan through the United Nation High Commission for Refugees (UNHCR) in the refugee camps of Aware. Originally the design was meant to collect water only for human consumption. Hope for the Horn, a local NGO closely working with pastoralists had been continuing to modify the technology by accommodating some of the feedbacks of the pastoralists. The Haffir dams made by machinery were to serve both livestock and human beings. The main dam and the silt trap were supplemented with outlet canal attached to two shallow wells where water is pumped to the elevated distribution cistern and further through gravity distributed to the livestock troughs and human collection points. The cost of constructing an average Haffir dam with a capacity of 60,000 cubic meters of water accounts about 1.4 million Ethiopian Birr (one dollar is about 8.5 Birr). It is assumed such volume of water is sufficient to supply up to 20,000 people and their animals with adequate water for three to four months. As a system, the Haffir dams are integrated with environmental rehabilitation where the command area is closed, afforested and complemented by site specific soil and water conservation techniques like micro basins, soil bunds and check dams.

The biological and physical measures applied were acting as silt traps and also for fodder bulking. The check dams were made from the locally available materials using dead branches and living trees. The nurseries were also producing dominantly indigenous multi-purpose trees (fodder, fruit and medicinal values) and few fast growing exotic pants were also introduced to the system. The water and environmental committees which consists elders, women and youth are established at the onset of the Dam construction.

Currently there are a total of 17 Haffir dams constructed across the 400 kms, with an average distance of 60 kms from each other. These dams which serve as a blue (water) and green (fodder) belts cover the five districts of Gashamo (5 Haffir dams), Aware (5 Haffir dams), Harshen (3 Haffir dams), Kebrebehyah (3 Haffir dams) and Jigiga (1 Haffir dam). The spatial distribution of the blue and green belts is based on the consideration of different factors, such as the distribution of other sources of water (natural, traditional and Birkas), clan and sub-clan distribution, mobility patterns and reciprocity among the clans with territorial fluidity. The Monitoring and Evaluation of the physical parameters include survival rate of the seedlings, diversity of plants and fodder availability, gully stabilization and silt accumulation in the dams among others. However, the community has their own informal observations dealing with the socioeconomic factors such as mobility ranges, conflicts, and expansion of settlements, spread of livestock diseases, malaria infestations, and access to fodder and technological appropriateness. The local NGO has an opportunity to accommodate such innovative local observations through the regular meetings with the community during the trainings as a phase out strategy, workshops and exchange visits. Moreover, the feedback of the community had attributed to the continuous modification of the Haffir dam designs, less disturbance of the ecology during dam construction, geographical expansion of dam construction and gives more focus on multipurpose indigenous plants and fruit trees in the nursery development.

A key component which ought to be learnt from the Ethiopia experience is the use of indigenous institutions and high community participation in planning and all other subsequent activities. Through the existing local institutions usually led by elders the location of the Haffir dam sites is determined. The dam sites are mostly located on natural ponds with high storage capacity and low problem of seepage. Moreover, the elders consider the dry and wet grazing pattern and the reciprocity among the different clans and sub clans. There was also high intensification of biodiversity. Due to the synergetic effect of the different water harvesting technologies quick vegetation cover was made possible to minimize water and wind erosion, less siltation of dams, access to clean water and stimulated the multiple uses of plants for fodder and medicinal use. To many of the private Birka owner's desiltation expenses are enormous and pose serious problems. This is also compounded by the contamination of the water, as they are not far from the villages. After observing the site of the Haffir dams some of them had proposed to use small silt traps and expand their closure area to minimize the contamination of the water. Overcoming the scarcity of water stimulates restocking and diminishing of emergency intervention with water storage and fodder supply. Many pastoralists use to sell their livestock to cover the cost of livestock watering. " I had more than 50 camels and more than 100 shoats. During the very serious drought (between January and April) I had sold two camels with 3 million Somali shillings to cover the 4-5 months water cost. Today the cost of water in the Haffir dam is almost free." A pastoralist from Gasahmo. Moreover, with availability of dams many pastoralists have shifted their investment from Birka construction to small shops and petty trades and many schools were established due to the availability of water. The more the economic diversification the less will be affected by the drought cycle.

There is need to empower the pastoralists in decision making. The foundation of pastoralism is common resource management which is complemented with reciprocity and traditional social safety nets. However, this was deteriorating with the intervention of private Birkas which are coined to profit making of individuals. However, the introduction of the common Haffirs contributes an enabling environment for a communal concern of the pastoralists through the different committees created. Moreover, with the election of women in the water and environment committees, it creates a foundation for women's involvement in development issues of their locality.

There were also minimized conflicts on resource uses. The strategy of the blue and green belt had minimized the pressure on specific water sources and consequent overgrazing and land degradations. Before the Haffir dams construction the Gashamo pastoralist used to travel frequently long distances to Aware and Somaliland, where some times end up with some conflicts when the water becomes scarce. Now when some of the clans and sub-clans have water points at their locality they feel they have something to offer and the reciprocity will be with mutual understandings and less room for conflicts to occur. The stakeholder had also mentioned some of the threats from Haffir dam development, such as the spread of livestock diseases due to high attraction of livestock, habitat for Malaria with the expansion of settlements around the dams and less attention was given to the construction and maintenance of the other sources of water.

The promising achievements of food security and sustainable resource management through water harvesting technologies were as the result of a combination of factors. These fundamental factors attributing to the success stories includes addressing of community felt needs, working with the existing local institutions, empowerment of the community in decision making, spatial distribution of water sources (representing clans and sub-clans), establishment of strong and devoted water and environmental committee and the use of training as a phase out strategy (Moyo et al, 2005). Moreover, the undesired outcomes of the Haffir dam construction can be minimized with regular participatory and dynamic monitoring and evaluations which encompasses beyond the local boundary. Furthermore, the overdependence on the Haffir dams needs to be minimized with the strategic planning of synchronization of the different sources of water.

2.6 Local Government Initiatives

2.6.1 Arid Lands Resource Management Project

Apart from the Ministry of Agriculture, Arid Lands Resource Management Project (ALRMP) is also promoting water harvesting for food production through the use of drip irrigation and greenhouses aimed at providing practical solutions to some food security and environmental degradation challenges and to strengthen community resilience to drought. (ALRMP,2010).ALRMP provides investment funds for construction of water harvesting structures and also help small scale farmers to procure irrigation kits, comprising greenhouses and agricultural inputs for intensive horticultural production, and also organises specific skills training and other capacity building interventions. Through private sector partnerships, the project has so far procured 18 irrigation kits for communities in Makueni, Tana River, Malindi and Kilifi districts (Source: ALRMP Annual Report 2010/11).

2.6.2 The Turkana Experience

National and local government policy has been based on the assumption that pastoralism is unsustainable, and that settlement is the modern way of life. Initially, OXFAM saw the rainwater harvesting intervention as supporting settlement, but the aim evolved into sustaining marginal pastoralists in their way of life rather than as the sole means of livelihood for destitute famine-refugees in camps. This group, with only a few sheep or goats were especially vulnerable to drought.

A major water harvesting project was initiated as a result of the famine of 1979/80 in Turkana. It is not clear that the project originated from people's own priorities rather than an immediate need for food. Part of a post-famine rehabilitation project involved a food-for-work programme that introduced new technologies, such as rainwater harvesting, to rehabilitate the land. OXFAM funded this work as well as other successive projects in the subsequent period (Otieno, 2007).The project moved to a new pilot phase in 1985, aiming to demonstrate the potential for increased sorghum cultivation for food security with use of rainwater harvesting technologies. This was centred on working with ngireria, semi-permanent settlements along watercourses where sorghum growing is common. It became more participatory in approach by 1988, when the project was handed over to a Management Board, with representation of traditional leaders, local committees and technical and administrative staff - the latter salaried. In a further development, the project became an integrated pastoral development project, diversifying to other activities such hides and skins marketing, credit for tool purchase, storage for seeds and harvest and animal health programmes.

Food for Work programmes as used in this project has a patchy record of success in introducing new technologies. However, this intervention had the advantage of building on existing knowledge assets and skills. There was a tradition of using runoff in the wet season for livestock and sorghum gardening among many of the Turkana groups. This stresses the need to use indigenous technical knowledge (ITK) of the beneficiaries if success for water harvesting projects is to be realised. It was the case with the Mwethia Groups in Ukambani which were used to implement very successful soil and water conservation programmes in the 1980s-1990s under the Ministry of Agriculture's SIDA funded National Soil and Water Conservation Programme (NSWCP).

The interventions in Turkana involved the introduction of improved technology of a type and scale appropriate to the availability of local resources, particularly labour. Large water harvesting structures especially the water spreading bunds and the negarims were modified to suit the size of traditional sorghum gardens. Because the first phase involved Food for Work, a significant amount of civil works was the focus. The earth-moving work required a high labour input. The project began by training local technicians to provide training to their local communities in design and construction of earth bunds and stone spillways. The latter, being especially labour-intensive, were soon modified to erimito - lateral spillways built on the end of a bund. From the beginning there was the development and modification of the technology, in partnership with the gardeners.

In the later phases of work, when such high external support was no longer available, and where the flat land made it possible, much less labour-intensive, smaller-scale technologies were used. These included grass strips and stone lines that, along with levelling, retain water in the gardens. The gardens were also levelled, spreading the water over the garden and therefore increasing the yields. However, in areas where crop production is a novelty it may be risky to provide incentives such as food for work rations to potential beneficiaries participating in the construction of such a crop production system. It has often been experienced that people consider it mainly as a job opportunity and may lose any interest in the scheme once the project and the incentives has come to an end. Once again this highlights the potential danger of incentives, rather than genuine motivation, which should be the driving force (Otieno, 2007).

As discussed earlier, negarim micro catchments have been developed in Israel for the production of fruit trees, but even there the returns on investment have not always been positive. It is not a cheap technique, bearing in mind that one person-day is required to build (on average) two units, and costs per unit rise considerably as the micro catchment size increases. It is difficult to generalize about the socio-economic factors concerning trapezoidal bunds, as different variations are found in different circumstances. As mentioned previously, there are examples of similar structures being used traditionally in Sudan -where they are often made by hand, without assistance from any agency and evidently perform well. On the other hand trapezoidal or similar bunds have been installed in other places under projects using food-for-work labour or even heavy machinery. When this has been done without any significant beneficiary commitment the bunds have been quickly abandoned. The amount of earthmoving necessary for trapezoidal bunds means that their construction usually requires organized labour or machinery and is normally beyond the scope of the individual farmer. However, where adequate motivation exists, there is considerable scope for the technique which has a traditional basis and does not require new farming skills. Trapezoidal bunds were designed for Turkana District when a widespread food relief operation was underway in 1984. A policy of food-for-work had followed the free distribution of food at the beginning of the crisis. The first attempts at water harvesting, based on contour bunds, were not well designed or supervised. The result was extensive bunding which was not useful - and not used. The design for trapezoidal bunds was based on scientific principles and the best available data on rainfall and runoff. There was a deliberate policy to "over-design", as food-rewarded labour was not limiting and it was desired to make the structures as maintenance free as possible. By 1987 about 150 trapezoidal bunds had been constructed for the production of quick maturing food crops including sorghum and cowpeas. The Turkana Water Harvesting Project, a small NGO in the northeast of the District, has modified the basic design for local conditions. Although the line level is used for setting out the bunds, catchment sizes are estimated by eye and the experience of locally trained technicians (Mati et al, 2003).

Water spreading bunds are often applied in situations where trapezoidal bunds are not suitable, usually where runoff discharges are high and would damage trapezoidal bunds or where the crops to be grown are susceptible to the temporary waterlogging, which is a characteristic of trapezoidal bunds. The major characteristic of water spreading bunds is that, as their name implies, they are intended to spread water, and not to impound it. Water spreading bunds are traditionally used for annual crops, and particularly cereals. Sorghum and millet are the most common. One particular feature of this system, when used in arid areas with erratic rainfall, is that sowing of the crop should be undertaken in response to flooding. The direct contribution by rainfall to growth is often very little. Seeds should be sown into residual moisture after a flood, which gives assurance of germination and early establishment. Further floods will bring the crop to maturity. However if the crop fails from lack of subsequent flooding - or if it is buried by silt or sand (as sometimes happens) - the cultivator should be prepared to replant. In this case, an opportunistic attitude is required. Because water spreading usually takes place on alluvial soils, soil fertility is rarely a constraint to crop production. Weed growth however tends to be more vigorous due to the favourable growing conditions, and thus early weeding is particularly important (Ministry of Agriculture and SIDA, 2006).

As the implementation of water spreading systems is a relatively large-scale exercise, consideration has to be given to community organization. One particular problem is that the site of the activity may be distant from the widely scattered homes of the beneficiaries. They are usually used to spread floodwater which has either been diverted from a watercourse or has naturally spilled onto the floodplain. The bunds, which are usually made of earth, slow down the flow of floodwater and spread it over the land to be cultivated, thus allowing it to infiltrate. In areas where crop production is a novelty it may be risky to provide incentives such as food for work rations to potential beneficiaries participating in the construction of such a crop production system. It has often been experienced that people consider it mainly as a job opportunity and looses any interest in the scheme once the project and the incentives has come to an end. Once again this highlights the potential danger of incentives, rather than genuine motivation, which should be the driving force.

In Turkana District a lot of water harvesting initiatives has been undertaken as a response to the highly vulnerable context of famine, affecting Turkana herders in northwest Kenya. The Turkana are semi-nomadic pastoralists, mainly dependent on their herds of cattle, camels, sheep and goats. Their nomadic lifestyle is a way of coping with periodic drought, moving animals to fresh pasture and water sources, but this way of life is increasingly difficult, with less and less natural capital accessible to them (Watson et al, 1997). Among other productive activities being promoted as a result of water harvesting initiatives include sorghum gardening which is being practised by a number of groups within the Turkana. It is mainly the women of these communities who have the knowledge and skills required to produce crops in this arid environment. They are also the main beneficiaries since food is becoming available and long distance treks in search of water are being reduced. Fast-growing varieties are planted in depressions and areas reached by flooding, and harvested before the dry-season migration, which occurs from December to March.

Critically though, the larger bunds are the technology offering greatest returns on investment, but they are too demanding of labour at a time when food supply is not adequate to support heavy work. The less labour-intensive technology is the one appropriate to the vulnerable group concerned if food for work is to be used. The alternative is for the government to deploy heavy earth moving equipment to do the excavations. Apart from saving on hand labour thus reducing drudgery for the benefitting communities the pace of implementation will also be faster.

By 1996, there were approximately 4,500 people though only 750 members were involved in rainwater harvesting in the two project areas at Lokitaung and Kakuma Divisions in Turkana, either working on traditional or project-initiated gardening sites. It is hard to say exactly how many people have benefited from the project. By 1997, about 350 gardens were improved and perhaps between 2000 and 3000 people have gained significantly from the gardens. In total, about 50 people were fully trained as artisans (20 employed until 1996, though only 9 were kept in work by local committees' in1997) and the entire garden owners were trained to a level where they could maintain and adapt the water harvesting structures themselves. Since these skills were not being focused on people likely to migrate for other opportunities, they have remained in the community, and replications outside the communities have been poor (Watson et al, 1997). Natural capital (land) was enhanced, in that yields were increased as shown in Tables 2.1 and 2.2 below. Yield data were difficult to get but generally, yields were highest from the bund technology, followed by the stone lines and the grass lines, dependent on their water retention. Human capital was also increased by the greater availability of sorghum for food, since it has to be bought if not grown. The main use in bad years was in exchange for cash as Stover (sorghum stalks) can also be sold in some cases for thatching. Households also increased their levels of stock significantly over time according to the evaluation - and fodder was provided to them through the gardening (Stover). The other main uses were for building social capital, giving away sorghum to relatives and friends.

Table 2.1 Number of New gardens constructed in Project Areas since 1992 (Watson and N'guma, 1997)

	1992	1993	1994	1995	1996	1997	Total to date
Lokitaung Division	0	13	24	24	3	2	251
Kakuma Division	19	4	0	7	3	9	96

Table 2.2 Comparisons of yields between traditional and improved gardens (90 Kg Bags)

	Traditional Gardens	Improved Gardens
Good Rainfall	5	5
Medium Rainfall	1	2-4
Poor Rainfall	0	0.5-1

The evaluation found a degree of sustainability. Because of the benefits realised from these innovations, it is likely Turkana farmers will continue to plant in their improved gardens and remain motivated to maintain their water harvesting structures, with or without the services of the experts or the technician. Expansion would however proceed more slowly. The key finding of the evaluation was that, while yields had not increased significantly in good years, they were higher in average years, and most importantly, there were still yields in bad years. In years of low rainfall, marginal pastoralists were not exposed to the need to reduce stocks to dangerously low levels, or to draw excessively on strained social capital. Instead they kept some seed for the next year and some food for consumption. In medium years they had more to exchange for animals or cash, or to build social capital. Since 'good' years are less common, overall yields are increased with improved gardens. This was therefore an important intervention, though the evaluation concludes that cultivation could have been extended, and yields could have been further improved, by pest control measures in particular. In fact the project had been working on botanical pest control, but had not disseminated their success. Possibly, this should have been done in more active partnership with committees and the artisans. Overall, a simple technology, building on existing knowledge and practice, was shown to deliver significant vulnerability reduction, though this could have been improved further with complementary technological interventions. Long-term vulnerability was also reduced, because soil erosion was minimised and soil fertility was enhanced. There was a risk of erosion if bunds were breached, but this was not a significant contribution given the small proportion of acreage affected. More importantly, there could have been many more pastoralists already practising sorghum cultivation, whose livelihoods could have been made more secure if the project had succeeded in better addressing institutional issues.

A key point is that the project remained limited to the micro-level. There was little focus on working with local government, as a route to replication. No project representatives were sent to Local, Divisional or District Development Committees. Since the initiation of the project, there has been a clear focus on pushing for more enabling policies in relation to pastoralists. During the project lifetime, there was no engagement with the private sector and the market for the artisan services was never adequately investigated. Fortunately, the individual household investment of labour and the benefits were clear enough to ensure the sustainable use of the technology, and even some dissemination. An intervention supporting cultivation could only reach those pastoralists with access to gardens and the capacity to cultivate them, which excluded both the richer people and the poorest. Though there were customary rights to the garden plots, gardens could also be hired in return for seed and a share of the crop. Under the project, unused plots were allocated in consultation with elders. Thus, the constraint was not land ownership, but one of labour. The poorer ones who were less represented were widows or unmarried mothers with no stock and limited accessibility to child labour. There was no paid labour in the gardens, and the only benefit to these poorest groups was that widows might be given sorghum for helping at times of peak demand. The main beneficiaries were marginal pastoralists; the middle groups according to participatory wealth ranking, with some stock, say a few sheep or goats, but no cattle.

However, there was a clear gender focus, which strengthened the position of the more vulnerable within households headed by men. The remark was often made to the evaluators that 'gardens are women's livestock'. Most owners of gardens were women, and since it is a woman's responsibility to provide food for the household, so her status as provider is enhanced through higher yields. Women also, in the main, control the use and exchange of sorghum, though once exchanged for livestock, it falls into male control. Women's social capital is built through hospitality using sorghum. Women's human capital was also built up their knowledge and skills which were recognised and enhanced. They formed half the trainees on each course - this was especially with the artisans. Men too contributed labour to build the structures and even to cultivate when there were few livestock to occupy them - the technology did not alter the gender division of labour. There were better returns to women's labour (and with no significant extra work to maintain structures) as a result of the interventions.

In general, the intervention made an important contribution to diversifying the assets, for women in particular. A limitation was that the initial diversification of livelihood options for the artisans was not sustained, and the opportunity for lasting changes in gender roles was not exploited. During the project, women were enabled to earn income as artisans, but this income dried up soon after external support was withdrawn. This was related to the lack of institutional sustainability. The Board did not adequately represent women's interests, nor was their management capacity enhanced. The activity is aimed at empowering communities to identify and sustain natural resources and drought management initiatives, especially those that can provide employment for the youth. The beneficiary community members grow horticultural crops, which provide important income generation opportunities, especially during drought (Watson et al, 1997).

Further, the recent discovery of oil deposits in Lokichar, Turkana County has stirred interest in a region that has largely been ignored for decades (Sunday Nation, April 1, 2012). It also raises the prospect that, as an expected flood of investors and speculators get into the county, the culture of the region may also be fundamentally transformed for better or for worse. There is also the expected assimilation of people from other cultures which is expected to have an impact on the cultural activities of the Turkana people. Meanwhile, River Lokichar remains a dry river bed and the only hope for these people is runoff water harvesting if they are to be food secure.

2.6.3 The Water Harvesting for Food Security Project

The ASAL areas in Kenya are food insecure since the rain fed agriculture is hampered by inadequate moisture precipitated by erratic and poorly distributed rainfall. Most of these areas rely on the government food relief programmes to meet their food requirements. Livelihoods in ASAL are basically dependent on the natural resources available, particularly soil and water. This calls for the harnessing of the available runoff water to alleviate food insecurity in these regions. In the Kenyan Vision 2030 and the Agricultural Sector Development Strategy, the Government has put emphasis on expansion of irrigated agricultural land through water harvesting.

To address the above, the Ministry of Agriculture has been implementing the Water Harvesting for Food Security Project since 2006 with some level of success. Water pans and small Dams have been constructed mainly in the ASAL areas thus increasing the storage capacity. Improved water management technologies and agro forestry nurseries are also being promoted and there is quite a good level of up-scaling by the communities and stakeholders (Ministry of Agriculture, Water Harvesting Guidelines, 2010).

Several challenges have been experienced during the last 5 years of implementation. These include low funding levels, high cost of construction, lack of adequate machines and other specialized tools and lack of clear project implementation guidelines. There are also reported cases of lack of transparency and accountability in the use of water harvesting funds and adequate monitoring and evaluation systems are not in place. In this connection, there is a need to ring fence the funds so that they go to the intended purpose. In the current setup, administration of the funds has been poor leading to poorly designed and implemented structures. Implementation structures are required to ensure proper accountability of the resources. There is also need to is carry out proper and activity guided Monitoring and Evaluation in good time so as to add value.

This project is targeting mostly those districts that are ASAL in order to alleviate food shortages. To achieve this, proper community mobilization must be carried out to enhance ownership and stimulate replication of technologies. The National Agricultural and Livestock Extension Programme (NALEP) have covered almost the whole country and many communities are already mobilized and community action plans have been developed. This creates a good entry point in to the community. Sites should be identified preferably in NALEP covered areas where communities have identified water as a key priority and have indicated in their Community Action Plan.

Proper community mobilization must be carried out to enhance ownership and stimulate replication of technologies. The National Agricultural and Livestock Extension Programme (NALEP) have covered almost the whole country and many communities are already mobilized and community action plans have been developed. This creates a good entry point in to the community. Sites should be identified preferably in NALEP covered areas where communities have identified water as a key priority and have indicated in their Community Action Plan.

The sites selected must be ideal for either a water pan or a dam. It should be good enough for the structure and other downstream facilities e.g Water point, demonstration plot, tree nursery, cattle trough etc. The site must be available for use by the group and the larger community. Where no public land is available, the owner of the land should go into an agreement with the group through a written MOU signed by the Provincial Administration and the DAO. Laws and legislations governing the implementation of projects in the country must be followed. These include the NEMA and WARMA rules. Proper Environmental Impact Assessments must be carried out so as to identify the negative impacts and incorporate interventions to mitigate them. The activities will be done by the implementing staff led by a National Environment Management Authority (NEMA) registered lead expert. The provincial Agricultural Engineer (PAE) will give guidance on the activity and distribute the various lead experts from the ministry personnel in the provinces. There will be no contracting of this activity.

Key stake holders will be involved at all levels of the project. The key stakeholders include the communities, Constituency Development Fund (CDF), Local Authority Transfer Fund (LATF), Non Governmental Organizations (NGOs)s, Churches, politicians etc. Stakeholders should be able to support the activity with funds and teaming up together is encouraged although records must show clearly all the individual contributions. The committees must be involved during project implementation and monitoring. Benefiting communities should be sensitized on the need to contribute to the project to enhance ownership and sustainability during mobilization. The contribution may be in terms of manual labour, catchment conservation, locally available materials etc. Time to attend meetings should not be quantified as a contribution but should rather be seen as a commitment to the project. The community must start working on the catchment before the actual construction work starts. The community will contribute an average 30 % of the project cost.

All structures must be designed properly, documented and approved by the Provincial Office. Agricultural Mechanization Services (AMS) stations will play a key role in this activity. The Provincial Agricultural Engineer will coordinate the activity in the Province while the District Agricultural Engineer will implement the activity. Proper documentation should be kept for each site. Although the designs will give the design volumes, the volumes expected should be around 1,000 m^3 for every Ksh. 100,000 allocated. No project will be considered complete without the other technologies like Agro forestry nursery or a Farm demonstration with Drip Kit. The nurseries have been factored in the provision of seedling for the 10% tree cover.

Funds will be utilized according to table 2:3 below. As a basic engineering principle, the construction and its associated facilities should take approximately 80 % of the total funding. The remaining funds will be used for logistics which include Environmental Impact Assessment

(EIA), subsistence allowance, fuel, mobilization, etc. Construction includes, the water harvesting structure itself, downstream facilities, fencing, drip kits, green houses etc. Priority must be given to the water harvesting structure. To enhance accountability, the District Agricultural Engineers and Provincial Agricultural Engineers will be consulted on all the project expenditure as they will be responsible for any misuse of the funds under water harvesting activity. In the spirit of transparency, all participating District Managers must inform all the stakeholders on the availability and amount of funds allocated, schedule of implementation and their roles within the project cycle.

Table 2.3 Funds utilization guidelines for Water Pan/Dam construction

Item Description	**Amount allocated**	**Q1**	**Q2**	**Q3**	**Q4**	**Remarks**
Mobilization	30,000					For purely arid districts
	20,000					For other districts
Survey and Design	30,000					For each site
EIA	70,000					For purely arid districts
	60,000					For other districts
Fuel and maintenance						The balance for logistics is dived in to the two and any other activities according to the work plan.
Daily Subsistence						
Civil Works						This activity takes **80 % of the funding** but priority must be given to water Harvesting structure (Pan or Dam). Stake holders can also provide more funding so as to achieve a bigger volume and purchase the other downstream facilities)
Irrigation Kit						
Fencing						
Green House						
Excavation						
Manual labor						
Pit Latrine						
Watering Troughs						
TOTAL						

Funds for water Harvesting are provided in a one line item. This makes it possible to save from one activity and implement another. Each district will be expected to develop a work plan in line with the budget which should be submitted to the Province or to the counties once they become operational.

2.7 Conceptual Framework

A conceptual frame work is a research tool intended to assist a researcher to develop awareness and understanding of the situation under scrutiny and to communicate it. Well-articulated frame works also assist a researcher to make meaning of subsequent findings (Mugenda et al).

From the literature review the independent and dependent variables regarding the study were identified. The independent variables identified were social economic factors such as training and level of education, gender, age, access to credit, family income; land factors such as land tenure and farm size; cost of water harvesting technologies and level of utilization of the harvested water. The dependent variable is replication and adoption of water harvesting technologies by small scale farmers and increase in agricultural production.

The independent variables identified were likely to influence replication and adoption of water harvesting technologies amongst small scale farmers in Kieni Constituency. A high level of education would affect replication and adoption of water harvesting technologies positively because education enhances the locative ability of decision makers by enabling them to think critically and use information sources efficiently. Access to credit would enhance replication and adoption of water harvesting technologies because the technology is a high capital investment. On family income, low levels would affect replication and adoption negatively. This is because the low level of income cannot meet basic needs and invest into farming activities such as water harvesting because farmers will not afford it due to high costs involved. Training would be expected to increase replication and adoption of technologies because exposure to information reduces subjective uncertainty and therefore, increases the likelihood of adoption of new technologies.

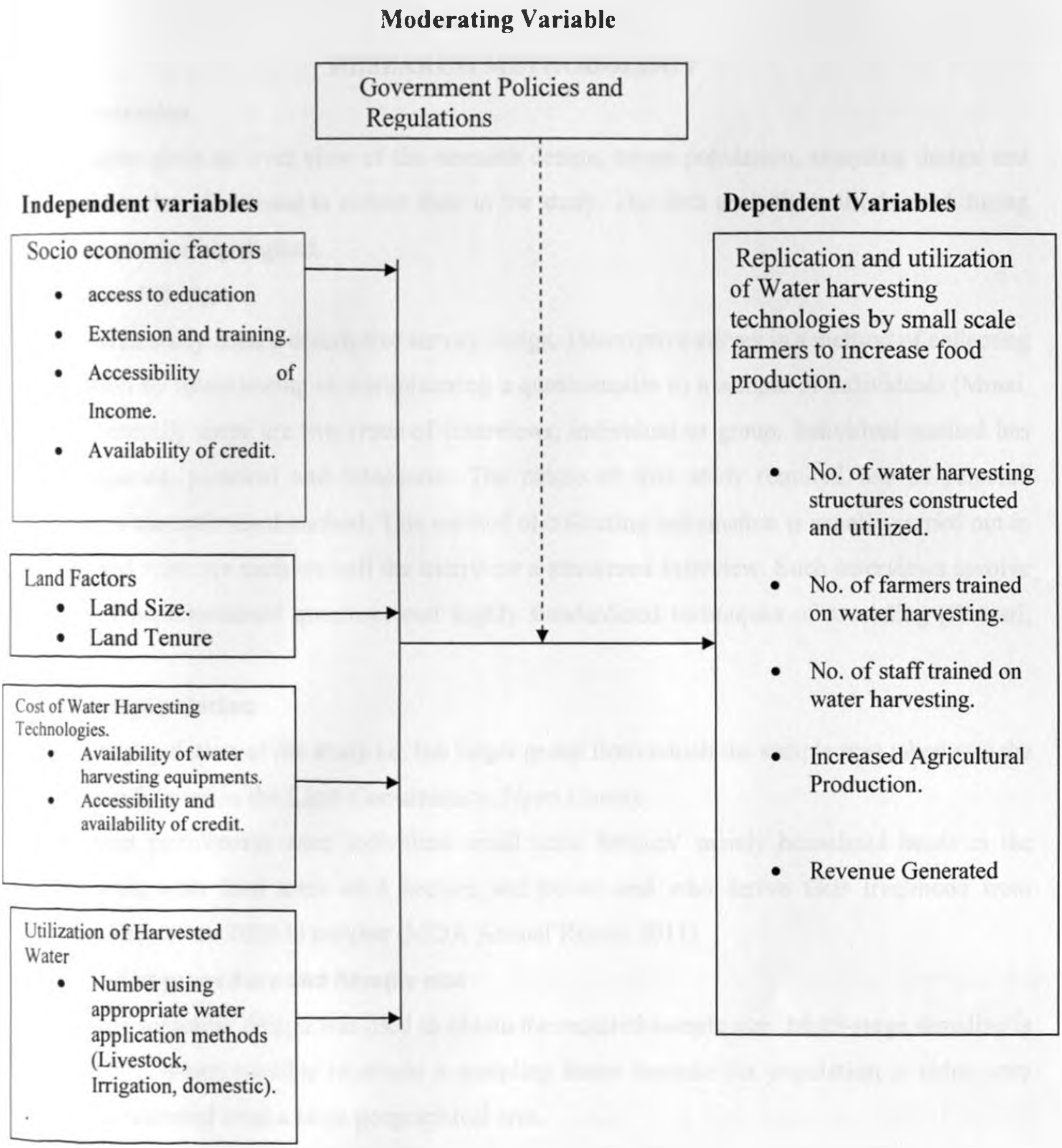

Figure 1 Conceptual framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter gives an over view of the research design, target population, sampling design and the methods that were used to collect data in the study. The data analysis methods used during the study are also highlighted.

3.2 Research design

The research study used a descriptive survey design. Descriptive survey is a method of collecting information by interviewing or administering a questionnaire to a sample of individuals (Mutai, 2000). Generally there are two types of interviews; individual or group. Individual method has two categories, personal and telephone. The nature of this study required use of personal category of the individual method. This method of collecting information is usually carried out in a structured way. As such we call the interview a structured interview. Such interviews involve the use of predetermined questions and highly standardized techniques of recording (Kothari, 1985).

3.3 Target population

The target population of the study i.e. the larger group from which the sample was taken was the small scale farmers in the Kieni Constituency, Nyeri County.

The subject participants were individual small scale farmers' mainly household heads in the sample area, with land sizes of 2 hectare and below and who derive their livelihood from farming. They were 2000 in number (MOA Annual Report 2011).

3.4 Sampling procedure and Sample size

Multi-stage sampling design was used to obtain the required sample size. Multi-stage sampling is used when it is not possible to obtain a sampling frame because the population is either very large or is scattered over a large geographical area.

Kieni Constituency has 7 locations. There are 2 locations namely Kabaru location in Kieni East and Endarasha location in Kieni West which does not require any supplementary irrigation for crops to grow to maturity. The remaining 5 locations are rainfall deficient and requires supplementary irrigation if the crops, mainly maize will grow to maturity. Of these 5 locations, one location was randomly selected. The Location has 5 sub locations. The area was divided into

5 blocks following the existing sub location boundaries. Subsequently, a sample unit was selected at random.

Since this study was conducted in one community with similar farming practices and in same locality, the study population is therefore considered homogeneous. The researcher targeted 10% of the population since in descriptive study 10% of accessible population is considered enough (Mugenda and Mugenda 2003; Mutai, 2000). A sample size of 240 was used and this translated to a sample size of 48 in each study block.

3.5 Data collection

The research was conducted by collecting primary and secondary data. Primary data was collected using questionnaires with the help of local research assistants who were conversant with the area. Pre testing of the questionnaires was done before actual administering to the respondents. Secondary data was collected using personal interviews and semi structured questionnaires.

The questionnaires were in two sets. One set was administered to household heads and was used to capture data on factors influencing adoption of water harvesting technologies amongst small scale farmers in Kieni Constituency. It was also used to get information on the socio-economic status of the households.

The second set of questionnaire was administered to extension officers in order to get information on their perception on the factors influencing adoption of water harvesting technologies by small scale farmers in the Constituency. This information was used to validate the data collected using questionnaires from the small scale farmers.

3.6 Validity of instruments

Validity is the degree to which an instrument measures what it is intended to measure (Mugenda and Mugenda 2000). The researcher took measures aimed at enhancing the validity of the research results. These included making the questions as simple as possible so that the respondents will find it easy to answer. The study also used more than one method of data collection in order to validate the results. Household heads were interviewed and extension workers filled the respective questionnaires in order to validate the results.

3.7 Reliability of the instruments

Reliability is the consistency of results in several applications (Mugenda and Mugenda 2000). To increase the reliability of the data, the researcher employed test-retest technique. This was achieved through pre-testing the questionnaires with at least 20 household heads and 5 extension workers after two weeks. The necessary changes in the research instruments were made to enable them to be better understood. This was mainly through giving necessary instructions and simplifying the language to ensure correct interpretation. The researcher also used consistent and systematic questions in the questionnaire.

3.8 Data analysis

After collecting the data, the researcher edited the raw data to free it from inconsistencies and incompleteness. This involved a scrutiny of the completed instruments in order to detect and reduce as much as possible errors, incompleteness, misclassifications and gaps in the information obtained from the respondents.

Nominal and Ordinal scale were used in data measuring to make coding and categorizing easier after the data collection. The data was captured and stored in electronic/soft and written/ hard copy formats.

The simplest way to present data is in frequency or percentage tables, which summarizes data about a single variable (Mutai, 2000). Descriptive statistics was used to analyze the data. Microsoft Excel and Statistical Package for Social Sciences (SPSS) were employed to analyze the data. The results were then presented using frequency tables and percentages.

The study adopted a descriptive survey to determine the factors influencing adoption of water harvesting technologies amongst small scale farmers of Kieni Constituency. Multi-sampling design was used to get the subjects on which the research tools were applied to. Questionnaires were pre-tested for validity and reliability. Descriptive statistics were used to analyze the data.

3.9 Ethical Considerations

Before undertaking the research in the field, informed consents were obtained from the respondents in order to allow them to participate voluntarily in the study. The objectives of the research were clearly explained before and after undertaking the research. The researcher maintained utmost confidentiality about the respondents.

3.10 Operational Definition of Variables

The variables were operationalized as indicated in Table 3.1

Table 3.1 Operationalization of Variables

Objectives	Variables	Indicators	Measurement scale	Tools of Analysis	Type of Analysis
To determine how social economic factors influence replication and utilization of water Harvesting Technologies in Kieni Constituency.	**Independent** Social economic factors	Number of households of a given level of education Number of farmers and extension officers trained on water harvesting Number of a given level of income	Ordinal, Ratio	Mean, Percentage	Descriptive
To establish the extent to which land sizes and land tenure systems influence replication of water harvesting technologies by small scale farmers of Kieni Constituency.	**Independent** Land Sizes and Land Tenure Systems.	Number of households of a given farm size. Number of households with valid land ownership documents	Ordinal, Ratio	Mean, Percentage	Descriptive
To find out how cost of Water Harvesting Technologies, accessibility and availability of credit services influence replication of water harvesting technologies by small scale farmers of Kieni Constituency.	**Independent** Water Harvesting Technologies.	Number of households of a given perception of cost of excavation. Number of	Ordinal, Ratio	Mean, Percentage	Descriptive

		households with access to water harvesting equipments Number of households able to access and avail credit facilities.			
To find out how utilization of harvested water influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.	**Independent** Utilization of Water Harvesting Technologies.	Number of households utilizing water harvesting technologies. Number of households using appropriate water application methods. Revenue generated.	Ordinal, Ratio	Mean, Percentage	Descriptive
	Dependent	Number of households replicating and utilizing water harvesting technologies.	Ordinal, Ratio	Mean, Percentage	Descriptive

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter deals with data analysis, presentation and interpretation of findings. It provides the overall findings based on primary and secondary data which was gathered. The data analysis was mainly descriptive. The findings in the questionnaires were analyzed descriptively in percentages and frequencies followed by interpretation.

4.2 Response Rate

A total of 240 questionnaires were given to local research assistants to collect data through interviews. There was 100% return rate. Thirty questionnaires were provided to extension workers who filled and returned all of them 100%.

4.3 Results of socio economic factors influencing replication and utilization of water Harvesting technologies

4.3.1 Gender

The study sought to establish the gender distribution of the household heads.

Table 4.1 Households gender distributions

Gender	Frequency	Percentage
Male	194	81
Female	46	19
Total	**240**	**100**

Information in Table 4.1 shows that the largest proportion of the households' heads were mainly males with a percentage of 81% and females 19%.

4.3.2 Gender distribution on who made decisions on farm activities

The study sought to establish the gender distribution on who made decisions on farm activities.

Table 4.2 Distribution of the households' decision maker

Response	Frequency	Percentage
Male	145	60
Female	42	18
Both	53	22
Total	**240**	**100**

Table 4.2 shows that decisions on the farm were mainly done by males who constitute 60% while females were only 18%. 22% of the decisions were made by both males and females. This implies the decisions regarding replication and utilization of water harvesting technologies were mainly made by males who were likely to influence the use of water harvesting technologies on the farm.

4.3.3 Age

The data sought to establish the age category of the household heads.

Table 4.3 Age category of the household heads

House hold age	Frequency	Percentage	Percentage using Water Harvesting
Less than 35	37	15	5
36 to 50	122	51	13
More than 50	81	34	27
Total	**240**	**100**	**45**

The information in Table 4.3 shows that only 15% of household heads below 36 years were engaged in farming activities. Majority of the household heads were between 36 and 50 years (51%). On Water Harvesting, the results show that use of water harvesting technologies was increasing with age. The aged used some form of water harvesting mainly shallow wells and roof water harvesting (27%).

4.3.4 Households experiencing soil moisture stress in their farms

The researcher sought to establish whether households were experiencing soil moisture stress in their farms.

Table 4.4 Households response on farm soil moisture stress

Response	Frequency	Percentage
Yes	216	90
No	24	10
Total	**240**	**100**

The information in Table 4.4 shows that a majority of the households (90 %) were experienced soil moisture stress in their farms.

4.3.5 The economic factors influencing use of water harvesting technologies

The study looked into educational level, farm size, access to credit, family income, and cost of water harvesting technologies, distance to plants and equipments source and type of road to nearest AMS stations. The findings of the study are presented in the following subsections.

4.3.5.1 Households use of credit

The study sought to establish whether households were using credit to finance food crops production.

Table 4.5 Households' use of credit

Response	Frequency	Percentage	Percentage using Water Harvesting
Yes	84	35	35
No	156	65	10
Total	**240**	**100**	**45**

Table 4.5 shows that 65% of the respondents, who were the majority, were not using credit in food crops production. This was expected from the study because the farmers are known to be risk takers. The formal banking system is also yet to develop credit facilities that suit small scale farming business. The farmers using credit were also investing in water harvesting technologies more (35%) than those not accessing credit (10%).

4.3.5.2 Households family monthly income

The data sought to establish monthly income level of the household.

Table 4.6 Family monthly households' income

Monthly income (Ksh)	Frequency	Percentage	Percentage using Water Harvesting	Average Monthly Income (Ksh)
0-3000	76	32	5	
3001-6000	95	40	10	3,980
above 6000	69	28	30	
Total	**240**	**100**	**45**	

Table 4.6 shows that majority of the households' monthly income was below Kshs 6,000 constituting 72% while only 28 % earned more than Kshs 6,000. The average monthly income was Kshs 3,980. Those with the highest income used water harvesting technologies more (30%) than those with least income (5%).

4.3.6 Households education level

The data sought to establish the household heads highest level of education.

Table 4.7 Household heads level of education

Education level	Frequency	Percentage	Percentage use of Water Harvesting
None	11	5	0
At least primary	95	40	20
Secondary and above	134	55	25
Total	**240**	**100**	**45**

The analysis from Table 4.7 shows that 55% of the household heads had attained secondary education and above while 40% had basic education. This means most of household heads had post primary education hence a high level of literacy. Use of water harvesting technologies was increasing with increase of education level. The highly educated were using it most (25%) while those with no education were not using it at all.

4.4 Results of Land tenure and land sizes

4.4.1 Household land tenure

The study sought to establish the households land tenure.

Table 4.8 Households land tenure

Response	Frequency	Percentage	Percentage using Water Harvesting
Own	148	62	29
Family land	92	38	16
Leased	0	0	0
Total	**240**	**100**	**45**

Table 4.8 shows that the land ownership was mainly individually owned constituting 62%. The family land belonged to several households but the title deed was under one person. Those with individual land ownership mostly invested in water harvesting technologies (29%) compared to those with family land (16%).

4.4.2 Households farm size

The data sought to establish the households' farm size.

Table 4.9 Households farm size

Households farm size	Frequency	Percentage	Percentage Using Water Harvesting	Average farm size	Average Percentage Using Water Harvesting
Below 1 acre	85	35	5		
1 to less than 3 acres	98	41	10		
3 to less than 5 acres	30	13	13	2.2	20
5 and above acres	27	11	17		
Total	**240**	**100**	**45**		

Table 4.9 shows that majority of the households (76%), had a land size of less than 3 acres while only 24% had more than 3 acres. The average farm size was 2.2 acres. There was high land pressure in an effort by the farmers to derive their livelihood from the small land size. The study shows that land size had an influence on land use and consequently use of water harvesting technologies. The size of landholding is positively correlated with replication and utilisation of water harvesting technologies as farmers with bigger landholding size are assumed to have the ability to purchase improved technologies and the capacity to bear risk if the technology fails.

4.5 Results of Cost of Water harvesting technologies

4.5.1 Household perception of cost of water harvesting technologies

The study sought to establish households' perception of cost of water harvesting technologies and their expected benefits.

Table 4.10 Households perception of cost of water harvesting technologies

Response	Frequency	Percentage	Percentage using Water Harvesting
Very high	214	89	25
moderate	20	8	15
low	6	3	5
Total	**240**	**100**	**45**

Table 4.10 shows that an overwhelming majority (89%), felt that construction of water harvesting technologies was very expensive. Those who perceived the cost of water harvesting technologies as very high still had the majority using it (25%).

4.5.3 Households distance to source of water harvesting construction equipments.

The data sought to establish distance to the nearest source of water harvesting construction equipments (Agricultural Machinery Services Stations).

Table 4.11 Households distance to source of water harvesting construction equipments (AMS Stations).

Machinery/Equipment source	Frequency	Percentage	Percentage use of Water Harvesting	Average distance	Average Percentage use of Water Harvesting
Less than 10 km	85	35	35		
More than 30 km	155	65	10	20km	40
Total	**240**	**100**	**45**		

Table 4.11 shows that the average distance to source of water harvesting machineries and equipments which is the Agricultural Machinery Services (AMS) Naromoru station is 20km. Those closer to the AMS station at Naromoru were using the facility more (35%) compared to those of more than 30km (10%).

4.5.4 Condition of road to source of water harvesting construction machineries and equipments

The researcher wanted to establish the condition of the road to the nearest source of water harvesting machineries and equipments and whether there are other sources other than AMS station at Naromoru.

Table 4.12 Condition of road to source of water harvesting machineries and equipments

Response	Frequency	Percentage	Percentage using Water Harvesting
TARMAC	25	10	25
Mar ram	75	31	15
Earth Road	140	59	5
Total	**240**	**100**	**45**

Table 4.12 above indicates that the majority of the respondents (59%) use earth road to ferry water harvesting construction equipments. Those using earth road had the least percentage using water harvesting technologies (5%).

Other sources of water harvesting machineries and equipments are Ministry of Public Works, National Youth Service and Private contractors but they all charge very expensively as compared to the AMS stations.

4.6 Results for utilization of harvested water and its influence on replication of water harvesting technologies

4.6.1 Water harvesting and irrigation use in food crops production

The study wanted to establish the households who were using water harvesting technologies in their farms.

Table 4.13 Households' response on use of water harvesting technologies

Response	Frequency	Percentage
No	176	73
Yes	64	27
Total	**240**	**100**

The information in Table 4.13 shows that majority of households constituting 73% were not using any water harvesting technologies. Only 27% were harvesting and utilizing water on their farms implying that water harvesting technologies and utilization of the harvested water was not a common practise on the farms. The study showed that those using water harvesting technologies and supplementary irrigation are those growing high value crops like capsicum, tomatoes and onions and also those with a greater capacity to invest in modern technologies like green houses and drip irrigation.

4.6.2 Benefits of water harvesting technologies and utilization of harvested water

The study sought to establish whether households thought investing on water harvesting technologies was beneficial or not.

Table 4.14 Households perception of benefits to use of water harvesting technologies

Response	Frequency	Percentage	Percentage using Water Harvesting
Yes	240	100	40
No	0	0	5
Total	**240**	**100**	**45**

Table 4.14 shows that all the respondents, 100% believe that water harvesting and supplementary irrigation will increase agricultural production. Those who thought water harvesting and supplementary irrigation was beneficial used it more (40%) than those who thought not (5%).

4.7 Influence of training on replication and use of water harvesting technologies

The study looked into training as a factor influencing replication and utilization of water harvesting technologies. The findings of the study are presented in the following subsections.

4.7.1 Households trained on water harvesting technologies.

The data sought to establish the households trained on the use of water harvesting technologies and supplementary irrigation..

Table 4.15 Households trained on the use of water harvesting technologies

Response	Frequency	Percentage	Percentage using Water Harvesting
Yes	65	27	35
No	175	73	10
Total	**240**	**100**	**45**

Table 4.15 shows that majority of the households (73%) were not trained on the need to replicate and utilize water harvesting technologies. Those trained on water harvesting had 35% using it, while those not trained had only 10% using the technologies.

4.8 Extension Workers Questionnaire Analysis

The study looked into the views of the extension workers regarding to soil moisture stress, replication and utilization of water harvesting technologies by the farmers, cost of water harvesting technologies, credit use in water harvesting and utilization technologies, effect of land tenure and land sizes on replication and utilization of water harvesting technologies by the farmers and the availability and effect of training to both the agricultural extension staff and the farmers on replication and utilization of water harvesting technologies to increase agricultural production. This was to validate the data given by the households. The findings of the study are presented in the following subsections.

4.8.1 Farmers experiencing soil moisture stress.

The data sought to establish from the extension workers whether farmers in their area of work experienced soil moisture stress and hence a need for supplementary irrigation for crop production to validate farmers' data. This was evidenced by crops wilting in the farms.

Table 4.16 Extension workers view on soil moisture stress

Response	Frequency	Percentage
Yes	29	98
No	1	3
Total	**30**	**100**

Table 4.16 shows that majority (98%) farmers in the area experienced soil moisture stress as evidenced by wilting of crops in the farms. This agreed with the households interviewed where majority of respondents experienced crop wilting in their own farms, an indication of soil moisture stress and hence a need for supplementary irrigation if crops are to grow to full maturity.

4.8.2 Extension workers response on farmers' use of water harvesting technologies

The data sought to establish whether farmers were using water harvesting technologies in their farms.

Table 4.17 Extension workers response on farmers' use of water harvesting technologies

Response	Frequency	Percentage
Yes	3	10
No	27	90
Total	**30**	**100**

Table 4.17 shows that very few farmers in the study areas use water harvesting technologies to grow their crops. This agreed with the households interviewed where majority of respondents were not practising any supplementary irrigation in their in their farms mainly as a result of them not having any water harvesting technologies in their farms.

4.8.3 Extension workers response to perception of cost of water harvesting technologies

The data sought to establish the perception of cost of water harvesting technologies according to the extension workers.

Table 4.18 Extension workers' response to cost of water harvesting technologies

Response	Frequency	Percentage
Very high	25	83
moderate	3	10
low	2	7
Total	**30**	**100**

Table 4.18 on extension workers view show that majority of the respondents (83%), recorded that farmers in their area think that the cost of water harvesting technologies is very high. That was corresponding to the results of the households' interview.

4.8.4 Extension workers response on credit use by farmers.

The study sought to establish from extension workers whether the farmers were using credit in food crops production.

Table 4.19 Extension workers views on credit use

Response	Frequency	Percentage
Yes	5	17
No	25	83
Total	**30**	**100**

Tables 4.19 on extension worker's views show that majority of the respondents (83%), recorded that farmers in their area were not using credit facilities for development of water harvesting technologies and for food crop production. That was corresponding to the results of the households' interview.

4.8.5 Extension workers response on training in water harvesting technologies

The study sought to establish from extension workers whether the farmers were demanding training in water harvesting technologies.

Table 4.20 Extension workers views on demand on training in water harvesting technologies

Response	Frequency	Percentage
Yes	20	67
No	10	33
Total	**30**	**100**

Table 4.20 on extension worker's views show that majority of the respondents (67%), recorded that farmers in their area were demanding extension messages on water harvesting technologies mainly through information desks strategically placed in various parts of the constituency. That was corresponding to the results of the households' interview.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of findings, discussions, conclusions and recommendations of the study. The study aimed at coming up with specific data on the factors influencing replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency, Nyeri County. The study sought to evaluate how social economic factors, land size and land tenure, cost of water harvesting technologies and methods of utilization of the harvested water influence replication of water harvesting technologies and utilization of harnessed water by the small scale farmers.

5.2 Summary of Findings

Summary of finding are given in Table 5.1.

Table 5.1 Summary of findings

Objective	Main findings
To determine how socio- economic factors influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.	• Majority of farmers (90%), experienced soil moisture stress in their farms but very few were using water harvesting technologies for supplementary irrigation (27%). • Majority of household heads were males (81%) and also lead in decision making on farms (60%) and are in a better position to influence replication and utilization of water harvesting technologies. • Cost of water harvesting technologies was very high (89%) but family average incomes low (ksh 3,980). • Credit use was low (35%) and average farm

	sizes small (2.2 acres). • Literacy levels were high (55% secondary and above). Use of water harvesting technologies was increasing with increasing education levels with the highly educated using it more (25%). • Majority of the farmers and agricultural extension officers are not trained in water harvesting technologies. Households trained on water harvesting (27%) invested more on the technology (35%) as opposed to those not trained (10%).
To establish the extent to which land sizes and land tenure system influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.	• Majority of the farmers owned land individually (62%) and were able to make decisions on their farms without referring to the family. • Farmers who owned land individually and had land title deeds invested more in water harvesting technologies (29%). • Majority of the households (76%) had a land size of less than 3 acres. Only 15% invested in water harvesting technologies. • Households with more than 3 acres (24%) invested more on water harvesting technologies (30%).
To find out how the cost of water harvesting technologies, accessibility and availability of credit services influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.	• Majority of the households (89%) perceived the cost of water harvesting technologies to be very high but still had the majority using the technologies (25%). • The average distance to source of water harvesting machineries and equipments was long (20 km). Those closer to source of water

	harvesting machineries and equipments (10km or less) used water harvesting technologies more (35%). • Credit accessibility and use was low (35%). Those using credit facilities invested more on water harvesting technologies (35%).
To assess how utilization of harvested water will influence replication and utilization of water harvesting technologies by small scale farmers of Kieni Constituency.	• Farmers able to invest in modern and high value agricultural production systems e.g. green house and drip irrigation systems and production of high value crops invested more in water harvesting technologies.

5.3 Discussion of Findings

The findings of the study are discussed in relation to the objectives.

5.3.1 Soil moisture stress and replication and utilization of water harvesting technologies

The findings of the study reveal that the majority of the respondents (90%) were experiencing soil moisture stress in their farms but very few (27%) were harvesting water in their farms for supplementary irrigation to increase agricultural production. This has resulted in continuous low agricultural production in the constituency and people continue to rely on famine relief constantly. This in spite the fact that the area receives adequate amount of rainfall but all fell over a very short period of time. If this water is harvested in water pans or dams, it can be used to irrigate the crop after rains have subsided to enable the crop to grow to full maturity. The study has revealed that all farmers believed water harvesting and supplementary irrigation will increase agricultural production but adequate training will be required to change farmers perception majority of whom (83%) belief that the cost of water harvesting technologies is very high.

High value horticultural crops like capsicum, tomatoes and tomatoes should be introduced to justify the high cost of water harvesting technologies. Also efficient agricultural technologies like green houses and drip irrigation should be incorporated to ensure efficient use of harnessed water.

5.3.2 Age and education levels

The results of the study show that very few farmers (15%) were below 36 years old. This indicates that the youth in Kieni Constituency were not adequately engaged in farming activities. The findings indicated that majority of the farmers were aged but the study showed that use of water harvesting technologies was increasing with age. This agreed with the literature review. According to Mati (2005), farmers gain more experience and acquaintance with new technologies with age and hence they are expected to have higher ability to use new technologies more efficiently.

Education level in the study area was found to be quite high (primary 40%, secondary and above 55%). The findings showed that replication of water harvesting technologies were increasing with increasing education level. This agreed with the literature review. According to Feder et al (1989), education enhances the locative ability of decision makers by enabling them to think critically and use information sources efficiently.

5.3.3 Credit use and family income

The results show that 65% of the respondents were not using credit in food crops production. The study shows that farmers who were using credit facilities were also investing more (35%) in water harvesting technologies. Credit use is thus very significant in replication of water harvesting and other technologies. These results agree with literature review that small scale farmers are risk takers. The literature review also showed that the formal banking system in Kenya has not developed facilities that suit small scale farming business (MOA strategic plan 2005 – 2009).

Majority of the households' monthly income was below Kshs 6,000 constituting 62% while only 28 % earned more than Kshs 6,000. The average monthly income was Ksh 3,980. Those with the highest income used water harvesting technologies more (30%) than those with least income (5%). This is because the low level of income could not meet basic needs and invest into farming activities such as water harvesting. Thus the results agreed with literature review that farmers of low level of income cannot meet basic needs and invest into farming activities such as water harvesting technologies (Yohannes et al 1989).

5.3.5 Cost of water harvesting technologies, land tenure and farm size

Results of the study indicate that an overwhelming majority (89%) of the farmers felt that construction of water harvesting technologies was very expensive. These findings showed that those who perceived the cost of water harvesting as high still had the majority using the technology (25%). High cost of water harvesting technologies will significantly affect the intensity of investment into the technologies and may also compromise the standards of water harvesting structures but not whether to use it or not (Doss 2000).

The study showed that land ownership was mainly individually owned (62%). Those with individual land ownership invested more in water harvesting technologies (29%) compared with those on family land. This agreed with literature review that farmers with individual title deed will be able to make decisions more firmly and with speed. They can also use title deeds as collateral to access credit which can be invested in water harvesting technologies.

The findings of the study shows that majority of the households (76 %), had a land size of less than 3 acres while only 24% had more than 3 acres. The average farm size was 2.2 acres. This implied high land pressure in an effort to derive their livelihood from the small land size. The study shows that the farmers with bigger portions of land used water harvesting technologies more. This agrees with Doss (2000), who argued that the size of landholding is positively correlated with replication and utilization of water harvesting technologies as farmers with bigger landholding size are assumed to have the ability to purchase improved technologies and the capacity to bear risk if the technology fails.

5.3.6 Distance to source of water harvesting construction equipments

The study showed that the average distance to source of water harvesting construction machineries and equipments, the Agricultural Machinery Services (AMS) Naromoru station was 20 Km average distance to fertilizer source was only 2km.Those closer to the AMS station were using the facility more (35%) compared to those of more than 340 Km (10%).. This agreed with literature review that the distance to source of water harvesting construction equipments may affect decision on whether or not to use technology and the intensity of use (Langyintuo and Mekuria, 2005).

5.3.7 Farmers utilization of harvested water

The study showed that those using water harvesting technologies and supplementary irrigation are those who are able grow high value crops and also those with a capacity to invest in modern technologies like green houses and drip irrigation.

5.3.4 Training in water harvesting technologies

The findings of the study showed that majority of the households (73%) were not trained on the use of water harvesting technologies and supplementary irrigation and the need to invest on the technologies for increased agricultural production. Those trained on water harvesting had the majority using the technology (35%) as opposed to those not trained (10%). This agrees with the theory that exposure to information through training reduces subjective uncertainty and therefore, increases the likelihood of adoption of new technologies (Langyintuo and Mekuria, 2005).

5.4 Conclusions

The following conclusions were made from the study. Majority of the farmers were not using water harvesting technologies nor any supplementary irrigation for crop production and they continued to experience soil moisture stress as a result of inadequate and unreliable rainfall. Consequently, their crops rarely grow to maturity causing the community to be dependent on famine relief constantly. The perception among the farmers that water harvesting technologies were very expensive need to be addressed through training and by introduction of high value crops to justify the high costs of construction. Family incomes were low and measures like value addition and introduction of high value crops could be introduced to boost the incomes. Credit use which is essential if farmers are to invest in the costly water harvesting technologies for crop production was low and needs to be addressed urgently. The youth were not engaged in farming and this would impact negatively to farming activities in the future. Machineries and equipments for water harvesting were not readily available and there is need for the government to invest more on these. Private sectors should also be encouraged to invest in water harvesting machineries and equipments to make them more readily available to farmers and at reduced costs. The study clearly positively correlate literacy levels with investments on water harvesting technologies. Literacy levels were high and should be taken advantage of to introduce modern farming technologies and especially water harvesting to boost agricultural production. Farm sizes were very small and can only support intensive and modern agricultural farming practices like green houses which can be supported with introduction of simple water harvesting technologies and efficient water application methods like drip irrigation. Family incomes were low and measures like value addition could be introduced to boost the incomes. High value horticultural crops like capsicum, tomatoes and onions can be introduced to justify the high cost of investing in water harvesting technologies. Sub- division of land into uneconomic units which does not leave room for water harvesting and other technologies should be controlled. Farmers should be given land ownership documents like title deeds which may be used as collaterals to access credit to invest in water harvesting and other appropriate agricultural technologies. The level of training in water harvesting technologies for both the ministry of agriculture extension staff and the farmers was found to be very low and needed to be stepped up. The analysis of the extension workers questionnaire revealed that their views on use of water harvesting technologies, cost of construction of water harvesting technologies, use of credit and training in water harvesting technologies agreed with that of the farmers. This was a major means of validating the farmers' data.

5.5 Recommendations

The following recommendations were made from the study. Policy makers should put in place mechanisms to lower the cost of water harvesting technologies. This is because farmers perceived it to be very high and supplementary irrigation is very significant in increasing agricultural productivity. Credit schemes which are friendly to small scale farmers should also be introduced because credit use was found to be low in Kieni Constituency, Nyeri County.

Training strategies targeting the youth to be engaged in farming activities should be introduced. This will ensure the survival of the industry in the future. There should be introduction of intensive high value crops and modern technologies like green houses and drip irrigation suitable for the small farm sizes. Farmers should also be trained on value addition in order to boost family incomes.

5.6 Suggestions for further research

The following areas are recommended for further research;

1. Further research should be carried out in order to establish strategies of engaging the youth in farming. This would safeguard the future of the industry. It would also create jobs and ensure food security.

2. Further research should be carried out in order to establish strategies of farming as a business, increase value addition and introduce high value crops which can do well in the area. This would boost family incomes which were found to be low in the area of study.

3. Further research should also be carried out in order to establish minimum land sizes acceptable for arid and semi arid (ASAL) areas for agricultural purposes.

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APPENDICES

APPENDIX 1: LETTER OF TRANSMITTAL

Charles M Muchemi,
P.O.Box 1905,
Nyahururu
Date....................

To: ....

....

....

....

RE: Letter of Transmittal of data collection

I wish to inform you, that I am undertaking research for my Masters of Arts degree in Project Planning and Management in the University Of Nairobi.

The study deals with the factors influencing replication and use of water harvesting technologies in Kieni Districts, Nyeri County.

Your assistance on data collection will be appreciated as the study will assist beneficiaries. Please answer the questions honestly and completely. The information you give shall be treated as confidential.

Attached please find questionnaires which you are required to fill and provide information by answering the questions.

Please fill questionnaire urgently and accurately once you receive it.

Thank you.

Yours Faithfully,

Charles Muthee Muchemi
Mobile 0722 – 152 822

APPENDIX 2 QUESTIONNAIRE ON HOUSEHOLDS INTERVIEW

Instructions

Please tick in the correct box or fill in the blank spaces provided.

Section A: General information

I Identification of household

i) Questionnaire number...

ii) Date...

iii) Enumerator's Name..

iv) Location..............................Sub-location...............................

Village...

v) Is the respondent the household head? Yes [ ]

No. [ ]

vi) If not, what is the relationship with the household head?

Wife [ ]

Husband [ ]

Son [ ]

Daughter [ ]

Other [ ]

(specify)...

II The household Head

i) Gender........................... 1. Female [ ]

2. Male [ ]

ii) Occupation .... 1. Farmer [ ]

2. Employed [ ]

3. Business [ ]

4. Others [ ]

Specify..

iii) Marital Status ....1. Single [ ]

2. Married [ ]

3. Others [ ]

Specify..

iv) Age bracket

1. Below 35 years [ ]

2. 36 -50 years [ ]

3. Above 50 years [ ]

v) Highest education level attained

A. None [ ]

B. Primary [ ]

C. Secondary [ ]

D. Tertiary [ ]

vi) Average monthly income

1. 0 -3000 ksh [ ]
2. 3001-6000 ksh [ ]
3. 6001 -9000 ksh [ ]
4. 9001 and above [ ]

vii) Housing

Type of main house used by the household

1. Stone [ ]
2. Timber [ ]
3. Mud walled [ ]

viii) Type of Roofing

1. Tiles [ ]
2. Iron Sheets [ ]
3. Thatch [ ]

ix) Land size and tenure

Land farm size

1. Below 1 acre [ ]
2. 1- 2acres [ ]
3. 2- 3 acres [ ]
4. Below 4 acres [ ]
5. Below 5 acres [ ]
6. Above 5 acres [ ]

x) Ownership status of the land

1. Own [ ]
2. Leased [ ]
3. Family land [ ]

4. Others (specify)..

Who makes decisions on farm activities?

1. Husband [ ]

2. Wife [ ]

3. Son [ ]

4. Others [ ]

Specify……………………………………………………………...

Section B: Social Economic issues

i) Do you use irrigation for food crops production?

1. Yes [ ]

2. No. [ ]

ii) If yes, where do you get your water from?

1. Nearby river or spring [ ]

2. Water tank from roof water [ ]

3. Water hole/ water pan [ ]

4. Others

(Specify)…………………………………………………………………………………

iii) What is the main source of capital required in the farm activities?

1. Own Capital [ ]

2. Credit [ ]

3. Others (specify)……………………………………………..

iv) What do you use to construct water pans/ water hole?

1. Machinery [ ]

2. Animal draft power [ ]

3. Hand [ ]

4. Others

(Specify)...

v) Have you ever tried to access equipment for water harvesting?

Yes [ ]

No [ ]

vi) If yes, did you succeed and if no, why not?

....

vii) How do you rate the cost of excavating water pan or other water harvesting structures?

1. Very High [ ]

2. Moderate [ ]

3. Low [ ]

Section C: Land Productivity

i) Do you experience low crop production?

Yes [ ]

No [ ]

ii) If yes what are the main causes?

1. Lack of enough rain [ ]
2. Soil infertility [ ]
3. Bad seed [ ]

4. Poor crop husbandry [ ]

5. Others (specify)

....

Iii) Do you experience crop wilting in your farm?

Yes [ ]

No [ ]

iv) If yes, do you try any supplementary irrigation?

Yes [ ]

No [ ]

v) Are there any benefits you attribute water harvesting?

Yes [ ]

No [ ]

vi) If yes, please give the main benefits.

1. Increased crop yield [ ]
2. High quality crops [ ]
3. Increased returns to investment [ ]
4. Others (specify) ....

Section D: Training on water harvesting

i) Have you been trained on water harvesting?

Yes [ ]

No [ ]

ii) If yes, when were you last trained?

1. Within the last one Year [ ]
2. Within the last two Years [ ]
3. Within the last three years [ ]
4. four years and above [ ]

iii) Have you been practicing what you learned?

Yes [ ]

No. [ ]

iv) If not, why have you not been able to practice?

High cost of construction [ ]

Lack of specialized tools [ ]

Lack of credit [ ]

Other (specify)..

Section E: Water harvesting Methods Practiced.

i) Have you been practicing water harvesting in your farm?

Yes [ ]

No. [ ]

ii) What are the major water harvesting methods? (List in the order of preference-Roof water catchment, water hole, water pan, infiltration ditches, others)

1. ....

2. ……………………………………………………………………………………..

3. ……………………………………………………………………………………..

4. ………………………………………………………………………………………

5. ………………………………………………………………………………………

Others (Specify)………………………………………………………………………………

ii) What is your main challenge which you have been facing when implementing the methods mentioned above?

1. High cost of construction [ ]

2. Lack of specialized tools [ ]

3. Lack of credit/ finances [ ]

4. Others (Specify)…………………………………………………………

iii) Are your water harvesting technologies measures adequately improving crop production in your farm?

Yes [ ]

No [ ]

iv) If No what are the reasons? ………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

We have now come to the end of our interview. I take this opportunity to thank you very much for your cooperation.

APPENDIX 3 QUESTIONNAIRE FOR EXTENSION WORKERS

Instructions

Please tick in the correct answer or fill in your response as applicable.

1. How many years have you been in extension services.................................
2. Which is your area of work...
3. Do farmers in your area practice any supplementary irrigation? Yes [ ] No [ ]
4. If yes, where do they get the water from

   i)..

   ii)...

   iii)...

   iv)...

   v) Others (Specify)...
5. Do farmers in your area practice water harvesting technologies.........................
6. If yes list the common type of water harvesting technologies practices (Roof water catchment, water pans, Springs water holes, pumping from rivers, others specify)

   i) Roof water catchment [ ]

   ii) Water Pans [ ]

   iii) Springs [ ]

   iv) Water Holes [ ]

   v) Pumping from Rivers [ ]

   v) Others (Specify)..
7. If no, what are the main reasons for not using water harvesting technologies

   i) Lack of knowledge [ ]

   ii) Lack of Finances [ ]

   iii) Lack of specialized tools and equipments [ ]

   iv) Others

   (Specify)..

8. Do farmers in your area demand to be trained on water harvesting technologies?

Yes [ ] No [ ]

If yes, list 3 preferred methods in order of importance from the choices given (roof water catchment, underground tank, water pan, infiltration ditches)

i) ....
ii) ....
iii) ....
iv) Others
(Specify)..

9. How is water harvesting perceived by farmers?

Positively [ ] Negatively [ ]

If negative, list the 3 main reasons given by the farmers in order of importance from the choices given (lack of specialized tools, too costly, does not pay back, lack of credit, small land sizes, lack of trainings on water harvesting)

i) ....
ii) ....
iii) ....
iv) Others
(Specify)..

10. Are there gender limitation by the farmers in use of water harvesting technologies?

Yes [ ] No [ ]

If yes what are the limitation for (i) Female.......................................

(ii) Male ....

11. Agricultural Extension these days is demand driven. Do farmers demand for water harvesting messages? Yes [ ] No [ ]

If no, give 2 main reasons.

i)..

ii)..

11. Are there challenges cited by farmers that could be hindering adoption and use of water harvesting technologies? Yes [ ] No [ ]

If yes, give the 3 main challenges i)...

ii)...

iii)...

12. Are there government policies that may be discouraging farmers from adopting water harvesting technologies in your area? Yes [ ]

No [ ]

If yes list the 3 main ones from the choices given in order of importance (high cost of construction, lack of credit, high poverty levels, small land sizes, land tenure systems, few extension officers)

i) ....

ii) ....

iii) ....

iv) Others

(Specify)..

13. When were you last trained on water harvesting technologies?.

1 year [ ] 2 years [ ] 3 years [ ] over 3 years [ ]

We have now come to the end of our interview. I take this opportunity to thank you very much for your cooperation.