RELATIONSHIP BETWEEN ADOPTION OF WATER HARVESTING, WATER CONSERVATION, IRRIGATION TECHNOLOGIES AND NUTRITION STATUS OF CHILDREN UNDER FIVE YEARS IN CENTRAL DIVISION, ISIOLO COUNTY, KENYA

BY

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Abstract

The food security situation in Africa is declining due to low agricultural productivity caused by decline in land availability, soil fertility depletion, soil erosion and unpredictable rainfall. Kenya remains food insecure and is increasingly relying on emergency food supplies. In 2011, about 2.4 million persons required urgent food assistance up from 1.6 million in August 2010. The high levels of food insecurity are exhibited by high rates of malnutrition above WHO threshold of 15%. Studies show that adoption of water harvesting, water conservation and irrigation technologies have the potential to increase food production and hence improve food availability and income at the household level. A cross sectional survey was conducted in seven farming schemes in Central Division, Isiolo Sub-County, Isiolo County, Kenya. The study objectives were: to assess the level of adoption of water harvesting, conservation and irrigation technologies assess the dietary diversity among households and assess the nutrition status of children under five years of age in the study area. The study was to provide information on the level of adoption of water harvesting, conservation and irrigation technologies in the study area. The study was also to establish the relationship between adoption of water harvesting, conservation and irrigation technologies and nutrition status of children under five years of age. The study adopted Proportion to Population Size sampling with the number of households selected per farming scheme proportional to number of families in the farming scheme.The study targeted 1361 eligible households .A sample size of 257 households was calculated using the Fisher *et al* formula. Households to participate in the study were randomly selected. In the sampled households, demographic data, social economic, adoption of water harvesting, conservation and irrigation technologies as well as anthropometric data and dietary diversity of children under five years of age were collected. Nutritional status data was analysed using ENA-SMART software to generate Z scores. Pearson correlation was used to establish the relationship between quantitative variables and binary logistic regression was used to establish relationship between technologies adopted and the nutrition indices of the children. Results showed that mulching and addition of organic matter was adopted by the highest proportion of farmers, 74.2% and 66.4% respectively but there was low adoption of water harvesting (5.5%). Surface irrigation was adopted by higher proportion of farmers (63%) compared to sprinkler (34.2%) and drip irrigation (0.4%). The number of eating occasions per day and dietary diversity of children in the study area was better compared to other areas in Isiolo. Over three quarters of the children (76.7%) consumed three to four meals per day. In addition, 67.4% of them consumed between four and six food groups while 32.5% consumed less than three food groups. The prevalence of wasting (10.1%), stunting (19.2%), and underweight (23.9%) among children in the farming schemes was lower than in other parts of Isiolo. Binary logistic regression showed no statistical significance between adoption of technologies and nutritional status of children. There is need to train farmers in the study area on water harvesting and efficient methods of irrigation such as drip irrigation. There is also need for continuous monitoring of nutritional status of children under five years of age in the study area.

CHAPTER 1: INTRODUCTION

Food security in Africa is declining due to low agricultural productivity caused by decline in land availability, soil fertility depletion, soils erosion and unpredictable rainfall (Sanchez, 2001). Water scarcity for agricultural purposes is a significant problem for farmers in Africa, Asia and the south-western Asia where 80-90% of water withdrawals are for agriculture (Rosegrant *et al.*, 2002). The report further argues that while farmers in some high-potential regions have been able to increase yields by 4-5 percent in recent years, farmers in the semi-arid tropics of Asia and Africa have only increased agricultural growth by less than 1 percent. Despite declining agricultural production, agriculture plays a central role in increasing food availability and incomes, supporting livelihoods and thus a key factor in efforts to improve food and nutrition security (United Nations Systems Standing Committee on Nutrition, 2010).

Kenya remains food insecure and is increasingly relying on emergency food supplies. In 2011, about 2.4 million persons required urgent food assistance up from 1.6 million in August 2010 (Government of Kenya, 2011). Of the 2.4 million that required urgent food aid, 1.4 million were communities in the Arid and Semi-Arid Lands (ASALs) such as Isiolo district where, the population requiring food aid has been high. For instance, the population requiring food increased from 42% in March 2010 to 59% in March 2011(Government of Kenya, 2010; Government of Kenya, 2011).

In Africa, 20% of children under five years of age are underweight while 39% are stunted (United Nations System Standing Committee on Nutrition, 2010). In Kenya, the prevalence of wasting, stunting and underweight is 7%, 35% and16% (Kenya National Bureau of Statistics and ICF Macro, 2010. In Isiolo, a multiple indicator cluster survey conducted in 2008 showed the prevalence of wasting, underweight and stunting as 12.2%, 22.1% and 15.3% respectively (Kenya National Bureau of Statistics, 2009). The prevalence of wasting in Isiolo is thus higher than national average but the prevalence of stunting and underweight in Isiolo is lower than the national average.

Isiolo district is characterized by low unreliable rainfall of about 580.2 mm annually and high atmospheric temperatures of about 27 °C. Though 80% of the population depend on agriculture (pastoralism and agro-pastoralism), 73.4% live below poverty line (District Development Office, 2005; Government of Kenya, 2002a). Water supply is a major constraint to food production in Isiolo due to its semi-aridity. Besides, the low unreliable rainfall, agricultural production in the district is also hindered by the inability of the farmers to maintain the existing quality of soils, poor water conservation and water harvesting structures (Government of Kenya, 2002a). Harsh climatic conditions coupled with poor soil management practices further reduces soil quality. Decline in soil quality decreases food production potential leading to increase in poverty, malnutrition and poor health.

Potential exists to improve food and livestock production through adoption of water harvesting, water conservation and irrigation technologies. Studies have shown the positive impacts of adoption of water harvesting, water conservation and irrigation technologies. Rosegrant *et al.*,(2002) show that an additional 3-5% of arid areas could be cultivated through run-off rain water harvesting. Some trials of water harvesting methods have proven successful in increasing yield 2-3 times (Rosegrant *et al.*, 2002). A study by Place *et al.*,(2003), showed that adoption of improved fallows and biomass transfer in Western Kenya enhanced the productivity of maize, tomatoes and kales; increased soil organic matter and eliminated weeds. Adoption of high yielding maize varieties in Zimbabwe resulted to improved household livelihoods (Bourdilon, *et al.*, 2003). Adoption of conservation farming resulted to increased productivity of maize in Zambia (Haggblade and Tembo, 2003). Construction of pits has been used to improve soil fertility and consequently food production in Niger (Rosegrant *et al.*, 2002).

Punam and Angwafo, (2011), report increase in the income of farmers involved in an irrigation project in Tanzania. An investigation byMati, (2004) of six different water harvesting and irrigation projects in Kenya showed improvement in income and improved food security at household level.

A longitudinal impact study on an irrigation project by Simondon and Benefice, (2001), showed a decline in prevalence of wasting from 11.4% to 3.8% but an increase in stunting. A study by International Irrigation Management Institute, (1995) assessing the impact of an irrigation scheme showed improvement on nutritional status of preschool children.

Although adoption of water harvesting, conservation and irrigation technolgies have been shown to improve nutrition status and diet diversity of children in other countries, there is no similar study conducted in Isiolo.

1.1 Statement of the Problem

Isiolo is one of the arid and semi-arid districts in Kenya (Government of Kenya, 2002a). Agricultural productivity in the district has been declining due to low, unreliable and erratic rainfall, inability of the farmers to maintain the existing soils' quality, poor water conservation and water harvesting structures, inadequate extension services and severe soil erosion (Government of Kenya, 2002a). The decline in agricultural production has led to food insecurity and deterioration in households' livelihood over time. The high levels of food insecurity are exhibited by the high prevalence of stunting and wasting among children below five years.

The annual average rainfall ranges from 100mm in semi-desert lands in the north of the district to over 600mm in the south. The mean temperature for Isiolo town is about 26.6°C while the mean temperature for Merti division which experiences the highest temperatures is about 27° C and this raises the rate of transpiration and easily destroys the structure of the soil. Pastoralism is the main livelihood source for 65% of the population in the district especially in pastoral divisions like Merti and Sericho. However, loss of livestock during times of droughts greatly affects the food security of the pastoral communities and this makes them prone to food insecurity.

The Ministry of Agriculture through the Nationals Soil and Water Conservation Program (NSWCP) and National Agriculture and Livestock Extension Program(NALEP) advocate adoption of agro-forestry, water conservation, water harvesting, soil erosion control, soil fertility improvement, use of drought tolerant crops, high yielding crop varieties and increasing access to extension services even among farmers in arid and semi-arid areas like Isiolo. All these strategies have been geared towards improving food security. In Isiolo, the Ministry of Agriculture advocate for adoption of tied ridges, basins, furrows and excavated terraces in food crop production areas and retention ditches and semi-circular bunds in grazing fields since 1990s. Although information from the Ministry of Agriculture shows there are irrigation schemes in Isiolo , there is no data on the levels of adoption of water harvesting, water conservation and irrigation technologies and how the adoption of the technologies contribute to the dietary diversity and nutrition status of children under five years of age. Therefore, this study sought to assess the level of adoption of water harvesting, conservation and irrigation technologies in Isiolo Central division and determine the relationship between the adoption of the technologies and nutrition status of children below five years.

1.2 Justification of the Study

Adoption of improved water harvesting, conservation and irrigation technologies have been shown to increase agricultural productivity and consequently, food security (Bourdilon, *et al.*, 2003; Hagglabe and Tembo, 2003; Place *et al.*, 2003). However, studies have avoided measuring the level of adoption of farming practices due to high cost of field work and time required as well as the incremental adoption by farm households makes precise measurement difficult (Hagglabe and Tembo, 2003). This study will provide information on the level of adoption of water harvesting, conservation and irrigation technologies in Isiolo central Division. The study will also measure diet diversity and assess the nutrition status of children and establish the relationship between adoption of water harvesting, conservation, irrigation technologies and diet diversity and nutrition status of children.

1.3 Main objective:

To establish the relationship between adoption of water harvesting, conservation, irrigation technologies and nutrition status of children under five years of age

1.3.1 Specific objectives:

1. To determine the level of adoption of water harvesting, conservation and irrigation technologies among households in seven farming schemes in Isiolo Central Division.
2. To measure dietary diversity of children under five years in Isiolo Central Division
3. To assess the nutritional status of children under five years of age in Isiolo Central Division.
4. To determine the relationship between adoption of water harvesting, conservation and irrigation technologies and nutrition status of children under five years of age in Isiolo Central Division.

1.4 Research questions

1. What is the level of adoption of water harvesting, conservation and irrigation technologies among households in Isiolo Central Division?
2. What is the dietary diversity among households in Isiolo Central Division?
3. What is the nutritional status among children under five years of age in Isiolo Central Division?

4. Is there any relationship between adoption of water harvesting, conservation and irrigation technologies and nutrition status of children under five years of age Isiolo Central Division?

1.5 Conceptual framework

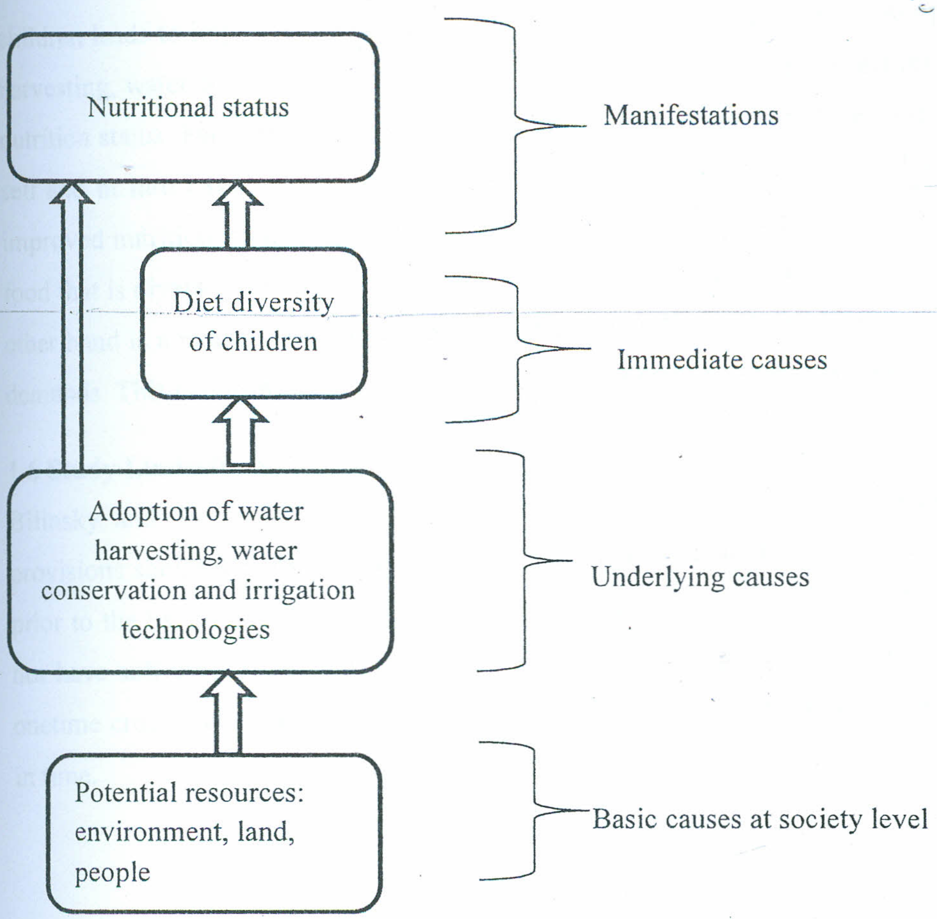

Figure 1.1 Conceptual framework

Source: Adapted from United Nations Children Fund (UNICEF), (1998)

The basic causes of malnutrition are a result of the resources available. These resources include: human resources such as access to extension services, financial resources such as access to credit, natural resources such as access to land for agricultural production. Adoption of water harvesting, water conservation and irrigation technologies are underlying causes of malnutrition. When water harvesting, conservation and irrigation technologies are adopted by a household, the household produces adequate food for household consumption, providing a variety of foods like meat, fruits, vegetables and eggs. Most of these foods, if they were to be bought, would be unaffordable or unavailable for many families. Household food production increases access to food at the household hence adequate dietary diversity among children. Diet diversity is an immediate cause of malnutrition. Adequate dietary diversity among children leads to improved nutrition status (Hodinnot and Yisehac, 2002). Adoption of water harvesting, water conservation and irrigation technologies also have a direct relationship with nutrition status. Families adopting water harvesting technologies produce foods that they can sell and in turn have income which can be used to purchase food for the household hence improved nutrition status of the children. Good nutrition status is a manifestation of intake of food that is diverse hence meeting the nutrition needs of the body. Poor nutrition status on the other hand is a manifestation of eating food that is not diverse hence does not meet the body demands. This is portrayed in the form of wasting, stunting and underweight.

1.6 Study Limitations

Bilinsky and Swindale, (2010) recommend that data on months of adequate household provisions should be collected during period of greatest food shortages such as immediately prior to the harvest to increase the accuracy of recall of the months when the household did not have sufficient food. However, this was difficult to implement because the study was a onetime cross sectional survey and could not wait for the next lean season due to limitations in time.

CHAPTER 2: LITERATURE REVIEW

2.1 Rain-Water Harvesting

Though farmers in arid and semi-arid regions such as Isiolo are hit by water shortage, potential exists to increase agricultural productivity through water harvesting. Water harvesting is an old technology. Archaeological evidence shows that water harvesting was used in crop production in dry areas of North Africa, Asia and America for thousands of years. The technology is most applicable in semi-arid areas where rainfall is low and poorly distributed (Mwangi, 1993; Rosegrant and Perez, 1997; Rosegrant *et al.*, 2002). Arid and semi-arid regions experience significant problems in securing adequate amounts of water for rain-fed crop production. Rainfall unreliability, water loss through evaporation and run-off exacerbates water scarcity problems in arid and semi-arid areas. Though the rainfall may be enough to support crops, it may be distributed unevenly in time thus need for water harvesting technologies. Water harvesting is applicable in areas receiving between 100mm-300mm annually.

Water harvesting has three characteristics as outlined by Oweis *et al.*, (1999). First, it is practiced in semi and arid areas where surface run-off is intermittent. Secondly, it is based on utilization of run-off and requires run-off producing area and run-off utilization area. Thirdly, because of the intermittent nature of run-off, storage is an integral part of water harvesting system. The water is stored directly in soil profile, or in small reservoirs or aquifers.

2.1.1Types of rain water harvesting

Rain-water harvesting techniques are mainly categorized into: in-situ rain water harvesting, internal (micro) catchments, external (macro) catchments systems and roof-top run-off collection (Rosegrant *et al.,* 2002).

2.1.1.1 External (macro) catchments

External catchments rainwater harvesting involves the collection of water from a larger area that is a substantial distance from the area where crops are being grown. External catchments systems include hillside sheet and rill run-off utilization, flood-water harvesting, ephemeral stream diversion and rain water harvesting with storage. Hill side sheet and rill run-off utilization involves collecting sheet or rill run-off from hillsides into flat areas.

In flood water harvesting within stream bed, barriers such as permeable stone dams are used to block the water flow and spread it on the adjacent plain and enhance infiltration. The wetted area is then used for crop production. In ephemeral stream diversion, water is diverted from the stream to the arable cropping areas. Sometimes macro-catchment rain water harvesting can produce high volumes of run-off that can be stored in dams or water holes (Plate 2.1).

Plate 2.1: Retention dam

Source: World vision, Kenya, 2010

2.1.1.2 Internal (micro) catchment

Internal (micro) catchment methods are those in which the catchment area and the cropped area are distinct but adjacent to each. The system is used for growing medium water demanding crops such as maize, sorghum, groundnuts and millet. Micro-catchment rain water harvesting methods include: contour or semi-circular bunds, strip catchment tillage, pitting and the meskat-type system.

Strip catchment tillage involves tilling strips of land along crop rows and leaving appropriate sections of the inter-row space uncultivated to release run-off. Contour bunds (small earth or stony embankments) can also be constructed along contour lines. The embankments trap water behind the bunds allowing deep infiltration into the soil (Plate 2.2).

Plate 2.2: A semi-circular bund constructed in Chumvi Yare, Isiolo district, Kenya

Source: National Drought Management Authority, (2011)

In pitting, small semi-circular pits are dug to break crusted surface. Farm Yard Manure (FYM) is added to pits thus permitting concentration of water and nutrients. Seeds are planted in the middle of the pits (Plate 2.3 and plate 2.4). Planting pits increase crop yields by a combination of moisture conservation and harvesting of runoff from the spaces between the pits (Southern and Eastern Africa Rainwater Network). In addition, soil fertility is restored since the manure and fertilizer cannot be lost through surface runoff. Planting pits are recommended for relatively low rainfall areas, or where moisture conservation is desired, to enable a crop survive drought and increase production.

Plate 2.3: Pitting

Source: Mburu, D. M. (2008).Rain water harvesting for increased agricultural production in Kenya. Paper presented at the 9th General Assembly of the AACC, Maputo.

Plate 2.4: Maize planted on Zay pit

Source: World Vision, Kenya 2008

In the meskat-type of rain water harvesting the cropped area (CB) is immediately below the catchment area (CA) that has been stripped of vegetation to increase run off (Figure 2.1).

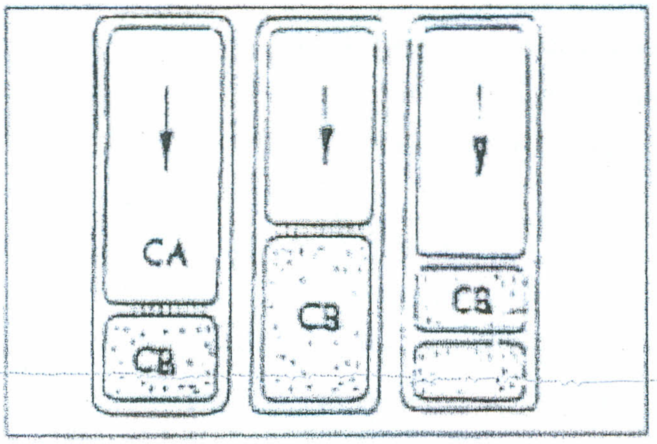

Figure 2.1 Meskat-type of rain water harvesting

Source: The role of rain fed agriculture in the future of global food production by Rosegrant *et al,* 2002.Washington, D.C. Printed by International Food Policy Research Institute.

2.1.1.3 In-Situ Rain Water Harvesting

This is also referred to as water conservation methods. These methods ensure that rain water is held long enough on the cropped area to ensure infiltration. The water conservation methods include: mulching, deep tillage, contour farming and ridging.

Deep tillage is a water conservation technique that improves soil moisture capacity by increasing roughness at the soil surface which increases the time available for water to infiltrate the soil. The increased filtration increases the availability of water in the root zone to aid in plant growth. With increased depth of tillage, significant reduction of surface run-off and increase in crop yields have been shown to occur (Hatibu and Mahoo, 1999). Agronomic practices such as addition of organic matter like Farm Yard Manure and mulching are often used along with other conservation methods to help increase water availability in the soil by improving water holding capacity and reducing soil-water evaporation. Contour bunds constructed using soil or stone or trash embankments and placed along contour also help in trapping rain water and allow for greater infiltration.

2.2.0 Irrigation

Irrigation water is applied by three general methods namely: localized irrigation, sprinkler irrigation and surface irrigation. The choice of the method depends on many factors among them topography, amount of water available, quality of water and soils as well as economic and social considerations.

Irrigation is classified as either supplemental or conventional irrigation. Supplemental irrigation refers to a technique in which a limited amount of water is added to crops during times of low rainfall to ensure enough water is received to support crop growth and stabilize yields (Oweis, Hachum, and Kijne, 1999). Supplemental irrigation is used in areas with slightly greater rainfall of approximately 300-600mm annually. Supplemental irrigation aims to provide enough water during critical growth stages to produce optimal yields per unit of water. In conventional irrigation sufficient water is provided to crops in the entire growing period because rain water may not be sufficient for plant growth for all or part of the season (Perrier and Alkini, 1987). This is practiced in areas receiving 100-300 mm of rain annually.

2.2.1 Major methods of irrigation

Irrigation methods are classified under: surface, localized and sprinkler irrigation methods.

2.2.1.1 Surface irrigation

Surface irrigation involves applying water over the soil surface. Water is conveyed over the soil surface and infiltrates into the soil. Surface irrigation methods include: furrow irrigation and basin irrigation and border irrigation. In furrow irrigation, water is allowed to flow down slope in small channels (furrows) between crop rows. The water is usually conducted from the water source to the area to be irrigated by a big canal (Plate 2.5). In basin irrigation, water is applied to a flat area surrounded by dikes. The water in the basin area continues to percolate into the soil sometime after the stream has been turned off.

Surface irrigation may not be appropriate for porous soils such as sandy soil. Although surface irrigation can be 70% efficient, (Sijali, 2001) argues that less than half of the water applied reaches the plant due to poor irrigation practices. He emphasizes the need for proper designs and better water management.

Plate 2.5: Furrow canal

Source: World Vision, Kenya, 2010

2.2.1.2 Localized irrigation

Localized irrigation systems apply water directly where the plant is growing thus minimizing water loss through evaporation from the soil. Localized methods include: drip irrigation, porous clay pots, porous pipes, and perforated plastic sleeves. In drip irrigation, water is applied into the soil through a small-sized opening directly on the soil surface or buried in the soil. Drip irrigation may help achieve water conservation by reducing evaporation and deep drainage when compared to other types of irrigation such as flood or overhead sprinklers since water can be more precisely applied to the plant roots. Drip irrigation has a high degree of uniformity efficiency (90% or more) since water is applied precisely at the plant roots hence losses to run-off, deep percolation and evaporation are minimal. Drip irrigation is favourable in steep slopes, where water is scarce or expensive (Sijali, 2001). Although drip irrigation is efficient, most drip irrigation equipment is imported and is expensive, so is not widely available to small scale farmer. This has confined the method to commercial farmers and research stations. In addition, drip-irrigation systems are easily clogged especially if poor-quality water is used. Farmers also require training to manage drip irrigation successfully. .

In overhead sprinkler irrigation, water is distributed in pipes under pressure and sprayed into the air so that the water breaks up into small water droplets that fall to the ground like natural rainfall. Compared to surface irrigation, sprinkler irrigation requires less land levelling, can be adapted to sandy soils and requires less labour. However, higher pumping energy is required to lift the water and create enough pressure to operate the sprinklers (Sijali, 2001). The method is 75% efficient with one quarter of the water lost through deep percolation, runoff and evaporation losses. Porous clay pots have also been used as a method of irrigation in which water is stored in clay pots buried in the ground, from where it is slowly released to the plants. This method is good for fruit trees.

2.3 Water harvesting, conservation and irrigation technologies promoted in Isiolo

According to Government of Kenya, (2005) many water harvesting, water conservation and irrigation technologies have been promoted through farm visits, field days and farm demonstrations. Some of the soil and water conservation technologies promoted included: bench terraces, contour farming, grass strips, unploughed strips, retention ditches, cut-off drains, trash lines, stone lines as well as gully control. Rain water harvesting technologies promoted included: contour bunds, semi-circular bunds, water spreading bunds, negarims, trapezoidal bunds, roof water catchment and road run off catchment.

Planting of drought tolerant crops and early maturing crops such as sorghum, cowpeas, pigeon peas and beans was also promoted since the district is water stressed. To reduce water loss in irrigated areas, the department encouraged farmers to use sprinkler and drip irrigation methods. Addition or organic matter such as farm yard manure, animal manure has been promoted to restore soil fertility.

2.4 Adoption of water harvesting, conservation and irrigation in Isiolo

According to the Ministry of Agriculture, as at end of 2002, Isiolo district had 21 irrigation schemes as shown in Table 2.1.

Table2.1: **Irrigation schemes in Isiolo district**

Scheme	Water source	Irrigation area (Ha)	Crops grown
Kinna	Kinna streams	60	Maize, tomatoes, onions, beans, kale, fruits
Rapsu	Bisadi	14	Maize ,beans, kale, tomatoes
Daranjani	Kinna streams	20	Maize ,beans, fruits, tomatoes,
Kambi Sheik	Isiolo river	20	Maize ,beans, kale, tomatoes, onions, bananas
Kilimani	Isiolo river	20	Maize ,beans, kale, tomatoes, onions, bananas
Maisha Bora	Isiolo river	10	Maize ,beans, kale, tomatoes, onions
Mali Tano	Isiolo river	20	Maize ,beans, kale, tomatoes, onions,
Ngaremara	Ngaremara river	5	Maize ,beans, kale, tomatoes, onions
Gambela	Ngaremara	15	Maize ,beans, kale, tomatoes, onions
Lobarua A	Lobarua spring	10	Maize, beans, tomatoes, onions
Atir	Ngaremara	8	Maize, beans, tomatoes
Chumviere	Ngaremara	4	Maize, beans, tomatoes
Malkadaka	Ewaso	No data	
Komboloa	EwasoNyiro	100	Maize, cow peas, green grams, kales, onions, potatoes, tomatoes
Muchuro	EwasoNyiro	80	Maize, cow peas, green grams, kales, onions, potatoes, tomatoes

Garfasa	EwasoNyiro	90	Maize, cow peas, green grams,
Garfasa D	EwasoNyiro	40	Maize, cow peas, green grams,
Ganna	EwasoNyiro	0.8	
Gobo	EwasoNyiro	23.2	
Kayo	EwasoNyiro	25.2	
Awarsitu	EwasoNyiro	19.2	

Source: Government of Kenya, (2005)

The government, through the Kenya Food Security Steering Group is also working with Non-Governmental Organizations such as World Food Program and Action Aid to promote contruction of water harvesting, water conservation and irrigation techologies through Food for Assets Program (National Drought Management Authority, 2011). Although there is information on the number of irrigation schemes in Isiolo, there is not data on the proportion of farmers that have adopted the techologies. In addition, there is no study that documents relationship between adoption of water harvesting, water conservation and irrigation technologies and nutrition status of children in Isiolo.

2.5 Impact of adoption of water harvesting, water conservation and irrigation on food security

Water harvesting has been shown to improve crop yield. For instance, terracing (digging a ditch and throwing the soil up-slope to form an earthen wall), practiced in Machakos, Kenya maximizes erosion control and rainwater retention and increased average corn yields on terraced lands 50 per cent higher than on un-terraced lands (Rosegrant and Perez, 1997). Experiences from Zambia show that maize yield can be tripled with rain water harvesting through conservation agriculture which includes minimum tillage, crop rotations and cover cropping (Haggblade and Tembo, 2003).

A study conducted in Niger found that use of V-shaped micro-catchments led to higher sorghum and millet yields greater than the national average yields of sorghum. Trials of water harvesting methods in Kenya, Burkina Faso, Niger, Sudan and Tanzania have increased yields 2-3 times those achieved in dry land farming (Food and Agriculture Organization, 2000).

Rain water harvesting also minimizes the risk of crop failure during droughts, intra seasonal droughts and floods (Mati *et al.,* 2005). In addition, rain water harvesting reduces women's burden of collecting water for domestic use, leaving time for other productive activities. It also gives opportunity for the girl child to attend school and provides a relatively safe and clean source of drinking water, minimizing incidences of water borne diseases. Moreover, adoption of water ponds in Lare division, Nakuru district, Kenya, resulted in improved livelihoods of the communities through increased food and water security.

An evaluation of Morulem irrigation in Turkana which is an arid land like Isiolo showed most scheme farmers were able to produce enough grain to feed their family throughout the year; vegetables and fruits are being sold on the local market in an area where it has never been available before (USAID and World Vision, 2001).

An investigation on six different water harvesting and irrigation projects in Kenya showed improvement in income, housing and food security at household level (Mati, 2004). In India, adoption of drip and bucket irrigation projects by women improved access to fresh vegetables, fruits and improvement in nutritional intake (Regassa *et al.*, 2005).

A study by Place *et al.,(*2003) showed that adoption of improved fallows and biomass transfer in Western Kenya enhanced the productivity of maize, tomatoes and kales; increased soil organic matter and eliminated weeds. Adoption of high yielding maize varieties in Zimbabwe resulted to improved household livelihoods (Bourdilon, *et al.*, 2003). The study further report that sale of surplus maize enabled farmers to purchase solar panels, livestock, water pumps, build improved houses, purchase food and clothes besides paying for school fees.

Adoption of conservation farming which involved retention of crop residues, land preparation using minimum tillage methods, rotation with nitrogen fixing legumes, water harvesting, use of hybrid maize seeds and application of inorganic fertilizers resulted to increased productivity of maize in Zambia (Haggblade and Tembo, 2003). Construction of pits 20-30 centimetres in diameter and 15-20 centimetres deep, dirt from the hole placed around it and the hole filled with manure have been used to improve soil fertility and consequently food production in Niger(Rosegrant *et al.*, 2002).

Punam and Angwafo, (2011) report an 86% increase in the income of farmers involved in a Participatory Irrigation Development Project in Tanzania. An investigation by Mati, (2004) of six different water harvesting and irrigation projects in Kenya showed improvement in income and improved food security at household level. A study by Namara, *et al.*, (2005) showed adoption of drip and bucket irrigation helped women grow vegetables, which was used primarily for household consumption, while the surplus was sold to income.

2.6 Impact of adoption of water harvesting, water conservation and irrigation on nutrition status of children

A longitudinal impact study on an irrigation project by Simondon and Benefice, (2001), showed a decline in prevalence of wasting from 11.4% to 3.8% but an increase in stunting. The prevalence of stunting was inconsistent since it decreased within the first two years then increased. Moreover, a study by International Irrigation Management Institute, (1995) assessing the impact of an irrigation scheme showed improvement on nutrition status of preschool children.

A study by Niemeijer *et al.* (1988) showed difference in nutrition status among children whose parents worked in an irrigation scheme in Western Kenya. Children of farmers who depended on irrigated rice, had individual farms outside the scheme and could diversify the crops were better off than children of resident tenants who depended entirely on income from the irrigation schemes.

A study by International Irrigation Management Institute, (1995) showed impact of irrigation on nutrition status of preschool children. An area under irrigation had lower prevalence of stunting and underweight compared to a new area under development for an irrigation scheme. A study by Hlanganise, (2010) showed that adoption of in-field rain water haversting technology had a positive impact on household food security. The intake of vitamin A and C improved considerably during wet season. In addition, 80% of respondents could afford three meals a day.

A five years follow up on the impact of rice irrigation on nutrition status of preschools by Simondon and Benefice, (2001) showed a decline in wasting among preschool children from 11.4% to 3.8%. However, levels of stunting were inconsistent. The stunting levels decreased within the first two years then increased. At the end of the five years, stunting had increased from 21.5% to 23.5%. The study showed that prevalence of chronic energy deficiency (BMI < 18.5 kg/m2) in men fell from 22.5% in 1990 to 6.6% in 1991 and thereafter increased to 13.0% in 1995 but no significant variations were found among women. In conclusion, the study showed that the onset of irrigated rice cultivation was followed by a decrease in the prevalence of wasting among children and chronic energy deficiency among adults. However, the cause of increase in stunting could not be explained.

A study by Kirogo *et al.*, 2007 conducted in semi-arid Kieni in Nyeri, Kenya showed significant difference between households that accessed irrigation compared to those who did not. The children of households that accesses irrigation had significantly higher weight-for-age Z-score than from those who did not access irrigation. The prevalence of stunting was also significantly lower in among children whose parent accessed irrigation.

However, some other studies have also shown negative effect of adoption of irrigation. According to Hossain *et al.*, (2005), an increase in rice production resulting from investments in small-scale irrigation in Bangladesh led to increased rice intake and reduced dietary diversity among the poorest households.

Although there are studies that show improved nutritional status for children among households practicing irrigation, there is no study that establishes the relationship between adoption of the technologies and nutrition status of children under five years of age and therefore the essence of this present study. Domenech and Ringler (2013) confirm that few studies have analysed the impact of irrigation interventions on nutrition, health, and women's empowerment, despite the large potential of irrigation to affect these important variables.

2.7 Measurement of food consumption

Improved household food consumption is measured using several indicators as proposed by (Swindale and Bilinsky, 2005). These include: percentage of households consuming minimum daily requirements, number of meals/snacks eaten per day, number of different food groups eaten, percentage of stunted children and percentage of underweight children by age group.

2.7.1 Measurement dietary diversity

Dietary diversity is a qualitative measure of food consumption that reflects household access to a wide variety of foods and is also a proxy of the nutrient adequacy of the diet for individuals (Food and Agriculture Organization, 2007). Increase in dietary diversity has been shown to lead to an increase in household food consumption, caloric, protein intake, and household income. In addition, a more varied diet is associated with a number of improved outcomes such as birth weight, child anthropometric status, improved haemoglobin concentrations and reduced risk of mortality from cardiovascular disease and cancer (Hoddinot and Yisehac, 2002; Food and Agriculture Organization, 2011).

Conducting dietary diversity is easier than 24 hour recall methods which are time consuming, expensive and require high level of technical skills both during data collection and analysis. FAO, (2007) and FAO,(2011) recommends dietary diversity be measured for a period of 24 hours instead of 3 days or 7 days because 24 hour recall is less subject to recall error and less cumbersome for the respondent. The recall time period also conforms to the recall time period used in many other dietary diversity studies. Other considerations that should be made during collection of data on dietary diversity are whether the period of data collection was a holiday, sources of food eaten and timing of the assessment. This is important since the recall is used as an indicator of what the household usually consumes.

Although dietary diversity is a simpler measure of food security, there are measurement issues that have not been agreed upon internationally. These are mainly which food groups to include in the scores at the individual level for different age/sex groups (FAO, 2011).

2.7.2 Status of diet diversity

Dietary diversity among adults and children in Africa is not satisfactory as shown by several studies. A food consumption survey carried out in urban and peri-urban of Nairobi showed that dietary diversity in Kenya is low with the main food consumed dominated by maize flour and a few vegetables such as kales, cabbages, spinach and few traditional vegetables (Diversity International, 2006). A study by Ekesa *et al.*, (2011) showed that majority of the preschool children (42%) had consumed food items from three or less food groups in the 24 hours preceding the survey thus indicating low dietary diversity.

An integrated health and nutrition survey conducted in Isiolo showed that 57.6% of children 6-59 months consumed food from the minimum four food groups (IMC, GoK and UNICEF, 2011). The mean dietary diversity score was 3.7. Roots and grains had been consumed by the highest proportion of children (24.3%) while eggs had been consumed by 2.6% of the children. This could be explained by the fact that the communities in Isiolo are pastoralist mainly keeping goats, sheep camels and cows (Arid Lands Management, 2010). Milk and milk products had been consumed by 22.8% of the children. Pulses and legumes had been consumed by 10.8% of the children and Vitamin A rich foods were consumed by 9.6% of the children. Another survey conducted in March 2011 showed that among children 6-23 months, 57.6% had consumed food from minimum dietary diversity which is less than 80% target (UNICEF and Government of Kenya, 2011).

2.8 Nutrition status of children in Kenya

KNBS and ICF Macro, (2010) shows that nationally, 35% of children less than five years of age are stunted with 14% being severely stunted. Eastern province, (42%) had the highest proportion of stunted children. In addition, the report shows that a higher proportion (37%) of male children under five years were stunted compared with 33% of female children. Over time there has been minimal decline in prevalence of stunting in Kenya from 1993 to 2008 (Figure 2.2).

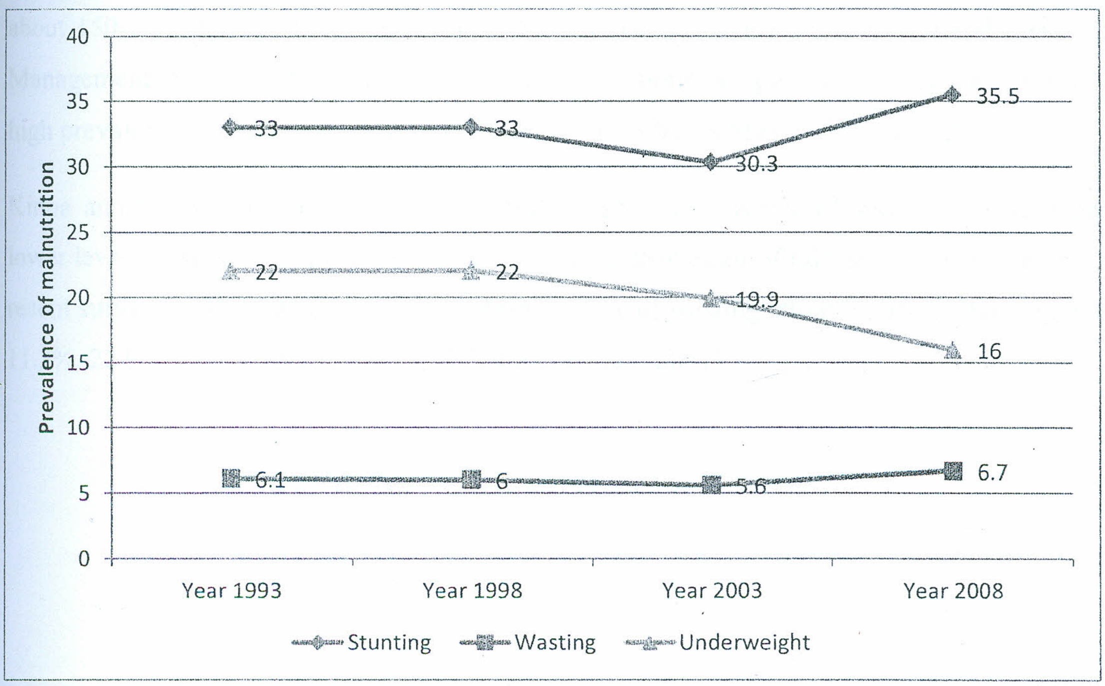

Figure 2.2Trend of malnutrition in Kenya (1993-2008)

Source: Rapid assessment on strategies used to monitor and address stunting in Kenya by Wagah, M. A., 2011, Nairobi. Printed by USAID and RCQHC

In 2009, the proportion of wasted children was 7%, while the proportion of severely wasted children was 2%. North Eastern province had extraordinarily high levels of wasting (19.5%).

The proportion of children who are wasted has changed little since 1993.The report further shows that 16% of children in Kenya are underweight with 4% being severely underweight. Nationally, there seems to have been a decline in the proportion of underweight children between 2000 and 2003 but no change between 2003 and 2008/2009. The prevalence of underweight children is highest (19%) in the age groups 24-35 and 48-59 months and lowest (8 percent) for those less than six months of age. This could be attributed to breastfeeding.

2.9 Nutrition status of children in Isiolo

Numerous nutrition surveys have been conducted in Isiolo district. There seems to have been a gradual increase in prevalence of acute malnutrition since 1994 ranging from 9.2% in 1994 to 28.5% in 2006 as reflected in Table 2.2. Isiolo like other arid and semi-arid districts in Kenya is affected by recurrent droughts hence fluctuations in prevalence of malnutrition (United Nations System Standing Committee on Nutrition, 2006).

Divisions in the very arid agro- ecological zone such as Merti and Sericho divisions receive about 150-250 mm of rainfall per year (Pricewaterhouse Coopers and Arid Land Resource Management Project, 2005). Merti and Sericho divisions are purely pastoral and have had high prevalence of malnutrition as high as 28.5% recorded in May 2006 (Table 2.2).

Kinna and Central divisions, which are both in semi-arid agro-ecological zone, have had lower levels of wasting. These areas receive about 250-650mm of rainfall per year. The most recent survey conducted in Isiolo showed prevalence of wasting, stunting and underweight as 11.3%, 22.9%, 20.6% respectively (UNICEF and GoK 2011).

Table 2.2: Nutrition surveys conducted in Isiolo (1994-2011)

Survey	Survey area	Survey period	% of wasting
Entire district		1994	9.2%
Entire district		June1996	10.0%
Entire district		Feb 2004	15.1%
Sericho, Merti, Oldonyiro		April 2005	15.3%
Kinna, Garbatula, Oldonyiro, Central		May 2006	13.2%
Merti, Sericho		May 2006	28.5%
Merti, Sericho		Nov 2006	12.3%
Isiolo district survey	Entire district	Nov 2007	10.5%
CBS survey	Entire district	May 2007	20.8%
Multiple Indicator Cluster Survey	Entire district	2008	12.2%
High Impact Nutrition Interventions baseline		Feb 2011	19.8%

Source: Nutrition survey reports

2.10 Factors affecting nutrition status of children in Kenya

Mariara *et al.*, (2012) analysed 1993 and 2003 and Kenya Demographic health surveys data. From these data, the mother's age, maternal education, age of children, the number of children in a household and household size are determinants of child nutrition status in Kenya. The study found that mother's age was a positive and significant determinant of children's height which suggested that children's nutritional status improves with the age of the mother. Kenya National Bureau of Statistics and ICF Macro, (2010) also showed that birth spacing determines the nutrition status of children. There was an inverse relationship between the length of the preceding birth interval and the proportion of children who were stunted. This implies that the longer the birth interval, the less likely the child was to be stunted.

Maternal education positively related to nutritional outcomes. Maternal education improves nutrition through better child care practices. Kenya National Bureau of Statistics and ICF Macro, (2010)equally confirms that mother's level of education generally has an inverse relationship with stunting levels. For instance, children of mothers with at least some secondary education had the lowest stunting levels (26%), while children whose mothers had no education or only incomplete primary education had the highest levels of stunting (39-40%).

Mariara *et al.*, (2012) also found that that the mothers' education was more important than the fathers' education in the determination of a child's nutritional status. Child characteristics were also significant determinants of nutritional status. Older children, children of multiple births, boys and children of higher birth order were more likely to be malnourished. The household size was found to be inversely related to children's nutritional status, suggesting competition for food among siblings.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Study area

The study was conducted in seven farming schemes in Isiolo Central Division, Isiolo District. Isiolo receives 400-650 mm of rainfall annually. It is bordered by Marsabit to the north, Garrisa and Wajir to the South East and East respectively. It also borders Tana River, Nyambene, Meru to the South, Laikipia and Samburu to the West. It is located between longitude 36° 60' and 38° 50' east and latitude 0° 5' and 2° north. About 30% of land mass is arid and receives 300-350 mm rainfall annually. The very arid part constitutes 65% of the district and covers central and northern regions especially Merti and Sericho Divisions which are barren and receives 150-250 mm of rainfall annually (Appendix 7)

Agriculture is an important sector in the district. About 80% of the population rely directly on the sector (District Development Office, 2005). The dominant economic activity is livestock keeping especially cattle, camels, goats, sheep and donkeys. However, agro-pastoralism is being practiced by communities to alleviate food insecurity. The main food crops grown include maize, beans, cowpeas, pigeon peas, green peas, cassava, sweet potatoes, bananas and millet, while the main cash crop is cotton. Livestock keeping is also a major economic activity in the district.

3.2 Target population

The study targeted 1361 households practising agriculture in the farming schemes and also with children under five years of age. Respondents to household interviews were head of households. They were asked questions about adoption of water harvesting, water conservation, irrigation and food consumption by the children. In a case where both man and woman were present during the survey, both participated in answering the household interview and only one interview schedule was generated. In case where only the man or woman was present, then he/she was interviewed.

In the event that a child under five years was at nursery school during the household visit, the study team went back to the household in the afternoon to take the measurements of the child.

3.2.1 Inclusion criteria

The study included only farmers that were practising agriculture in the farming schemes. Although the study targeted children under five years of age, only preschool children 12-59 months were selected regardless of their age, sex. The study intended to focus on the dietary diversity of children who had been introduced to complimentary feeding. CBS *et al.*, (2004) show that by 12 months, over 90% of the children are introduced to complementary foods in Kenya. The report also shows that the nutrition status of children deteriorates with age with children aged 12-23 months having the highest proportion of severely stunted children.

3.3 Research Design

The study was a cross-sectional survey. The design was chosen because cross-sectional surveys are good for describing status of the phenomena or relationship among phenomena at a fixed point. The design also is appropriate because the variables under study cannot be manipulated.

3.4 Sample size determination

The minimum sample size, n was calculated using the statistical formula of Fisher *et al* for calculating sample size (Fischer *et. al*, 1991)

$$n=Z^2\,(pq)/d^2.$$

$$=1.96^2\,(0.8x0.2)/\,0.05^2$$

Where n= Minimum sample size for populations greater than 10,000

Z= normal deviant at 95% CI is 1.96

p=Prevalence of population practicing agriculture in Isiolo is 0.80 (District Development Office, 2005)

q= Prevalence of population not practicing agriculture, (1-0.8)

d= Precision of the result desired or (error term), 0.05,

then: n=245 households.

When the population is less than 10,000 the formula is adjusted to have a smaller sample size.

Since in the study the population was less than 10,000(1361 households), the sample size was adjusted as follows:

$$n\,f = n \div \{1+ (n/N)\}$$

Where; n f= desired sample size (when target population is less than 10,000) n = desired sample size (when target population is greater than 10,000)

N = the desired sample size (target population)

Therefore, n f = 245 ÷ {1+ (245/1361)} = 207

This was approximately 207 households. Although the approximate sample size was 207, the study used the sample of 245 households since this was also manageable with the available time and resources. To account for any non-response due to any eventualities such as refusal by households to respond to the interviews as well as errors in schedules, a larger sample was used as recommended by (United Nations, 2005). To make for the adjustment, the study adopted a response rate of 6%. This was derived from the response rates for integrated health survey conducted in 2003 which was 96% (Central Bureau of Statistics [Kenya], Ministry of Health [Kenya] and ORC Macro., 2004). The non-response of 4% was increased to 6% since the area under survey is located in an agro-pastoral community hence high possibilty of nomadism. The adjusted sample size was thus 260 households.The sample size of the children was to correspond to the number of households. However, some housholds practising agriculture did not have children under five years of age hence the final sample of the children was 159.

3.5 Sampling procedures

Although Isiolo District has six divisions, Central Division was purposively sampled due to its accessibility and the presence of farming schemes. Isiolo Central Division has two locations namely: West and East location. East Location was purposively sampled since most of the farming schemes in Central division were in East Location. All the farming schemes in central location were sampled. The study adopted Proportion to Population Size (PPS) sampling with the number of farmers sampled in each farming scheme proportional to the number of farm households as documented by the Ministry of Agriculture, Isiolo (Table 3.1). However, during data collection, there were fewer farmers in BulesDima than documented by the Ministry of Agriculture. This was due to migration of some farmers. As a result, few farmers were interviewed in BulesDima. To cater for this deficit some extra households were sampled in other farming schemes.

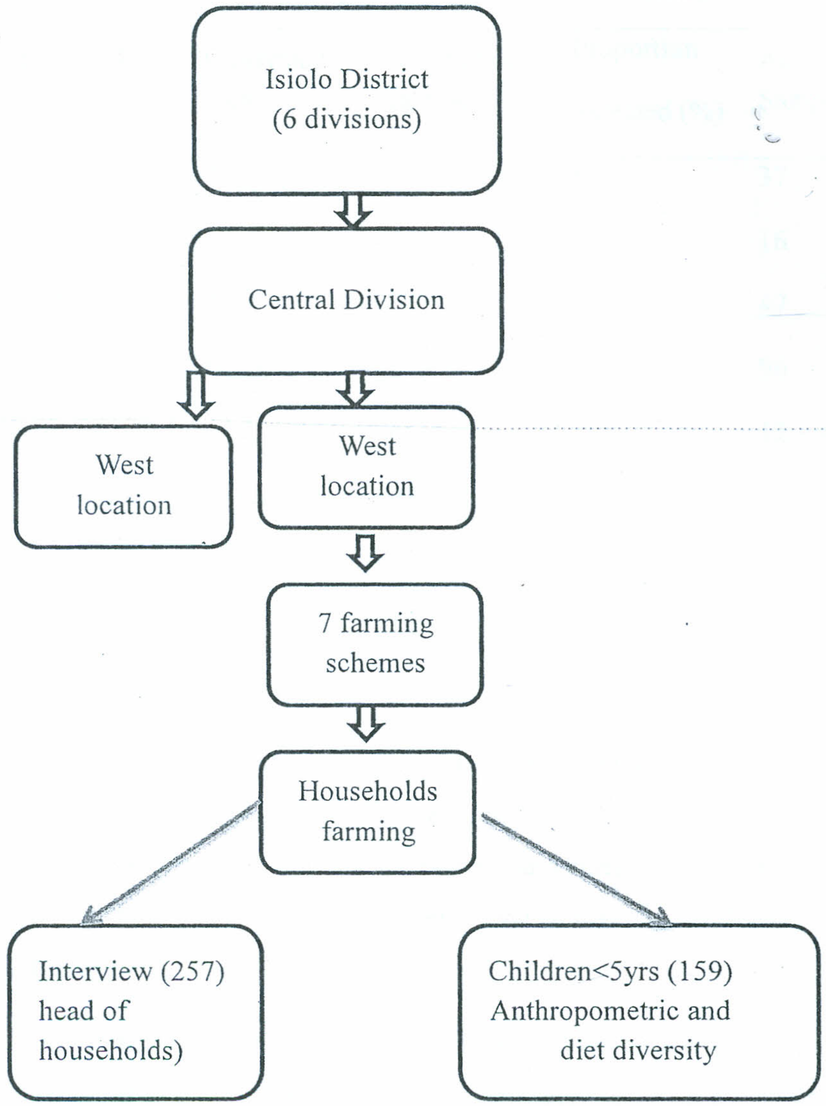

Figure 3.1: Sampling procedures

Table 3.1: Farming schemes and the sample size selected for this study

Farming scheme	Potential acreage	Cultivated area	Number of families	Proportion Selected (%)	Actual Sample size
Ntirim	220	40	91	6.5	37
BulesDima	215	92	230	16.7	16
Maisha Bora	120	35	172	12.7	47
Mutunyi	870	No data	620	45.7	96
Mashambani	40	13	65	4.9	12
KambiGarba	No data	No data	92	6.9	23
MailiTano	150	45	91	6.5	29
TOTAL			1361		260

Source: Government of Kenya, (2002)

Purposive sampling was adopted in the selection of farm households. Only farm households practicing agriculture were interviewed. This was because the study objective was to establish the relationship between adoption of water harvesting, water conservation and irrigation and the nutrition status of children hence the study had to focus on farmers practicing agriculture.

The number of households selected per farming scheme also depended on the number and size of villages as identified by village elders or opinion leaders such as the chairpersons of the farming scheme. Larger villages were allocated a sample proportional to the number of farm households in the villages. The villages in the farming schemes to be visited were randomly selected.

To identify the farm households to be interviewed in a village, cluster sampling was used. The survey team walked to the centre of the village spun a pen and chose the direction of the head of pen to begin the data collection. This was also done if the team reached the geographical boundaries of the village. After the number of farm households to be interviewed is attained, the team proceeded to the next village. This was used because of the large size of the farming schemes.

In all the sampled households selected for interview on adoption of water harvesting, conservation and irrigation, anthropometric measurements of children under five years of age were taken. In households with more than one child, anthropometric measurements for all the children aged 12-59 months were taken. For the purpose of selecting one child per household for correlations, each child per household was allocated an identity number regardless of age or sex. The children were allocated identity numbers 1-3 depending on who was taken anthropometric measurements first.

3.6 Data collection procedures

3.6.1 Training of research assistants

The survey was conducted by the researcher and two assistants. The assistants were trained for two days inclusive of pilot on taking anthropometric measurements at Isiolo District hospital. The training focused on how to interview the households such as avoiding leading questions and taking anthropometric measurements. The training also emphasized the reasons why the survey was being conducted and the importance of assistants in the survey process. Their skill in taking measurements and asking questions was perfected during the data collection process.

3.6.2. Conducting household interviews

Once in a village, the interviewers introduced themselves to the head of household. This involved explaining the objective of the research and showing the authorization letter from Ministry of Agriculture (Appendix 6). During introduction, the interviewer also confirmed if the household was practising agriculture and if there were children under five years of age. The respondent was then assured of confidentiality, and that their participation was voluntary. The interviewer explained to the respondent about the data collection procedures and how long it was estimated to take. This enabled the respondent to give informed consent. To avoid interrupting the attention of the respondent, the household schedule was completed before taking the measurements of the children. After the interview was completed and measurements taken, the respondent were thanked and given a chance to ask any questions they had with regard to the survey. If any questions were raised, the interviewer responded appropriately.

3.7 Measurement of variables

3.7.1 Assessment of adoption of water harvesting, conservation and irrigation technologies

An interview schedule was used to collect demographic data, adoption irrigation and water harvesting technologies, factors affecting adoption of the technologies, crop production and food consumption and anthropometric measurements for children under five years of age. Observation for some of the technologies was done to verify the kinds of technologies adopted.

Based on information from the Ministry of Agriculture, all the technologies measured could be adopted and had been promoted by the Ministry of Agriculture in Isiolo.

The numbers of technologies adopted by an individual farmer were summed up on a score of one (1) for adoption and zero (0) for non-adoption as proposed by Ersado, *et al* (2003) and Namara, et *al*, (2005)

1. Irrigation: drip, sprinkler and furrow (1 score)

External water harvesting

1. Run off or rill catchment (1 score)
2. Flood water harvesting within stream bed (1 score)
3. Ephemeral stream diversion (1 score)

Micro catchment

4. Pitting(1 score)
5. Strip catchment tillage (1 score)
6. contour or semi-circular bund (1 score)
7. Meskat type(1 score)

Water conservation technologies

8. Mulching (1 score)
9. Contour farming (1 score)

10. Ridging(1 score)

11. Addition or organic matter (1 score)

12. Deep tillage (1 score)

The higher the number of individual technologies a farmer adopted, the higher the score. Level of adoption was ranked based on the number of technologies adopted by each of the farmers. Since the mean adoption was 3 technologies (based on a plot of the frequencies of number of technologies adopted by each of the farmers), farmers who adopted less than three technologies were categorized as low adopters while those who adopted three technologies were classified as average adopters. Those who adopted four to six technologies were classified as high adopters.

3.7.2 Measurement of dietary diversity

The study assessed food consumption by children in the household though measuring dietary diversity, number of eating occasions per day and the number of months of adequate household food provisions. Although percentage of households consuming minimum daily caloric requirements is also used as an indicator to measure food consumption, it was not used because it is more expensive and requires very high level of technical expertise and more time to collect and analyze data as indicated by Bilinsky and Swindale,(2010).

The number of eating occasions per day was measured by asking the care givers how many meals children had eaten in the previous 24 hours. The care givers were requested to recall all the types of food eaten by the children during the day until bedtime. To determine if the intake was usual or not, the care givers were asked if the previous 24 hours was usual or normal for the household. This was meant to ensure the 24 hour recall reflected the usual intake and avoid collection of data if the previous day was a holiday or a special occasion. Foods consumed outside the home were not included during data collection since this would increase the risk of overestimating the dietary diversity of household members as guided by Swindale and Ohri-Vachaspati, (2005).

The foods eaten were grouped according to 8 food groups for children (Table 3.2) as proposed by FAO, (2007); Swindale and Bilinsky, (2006) and Swindale and Ohri-Vachaspat, (2005). Besides the 24 hour recall of the foods eaten, the study also investigated the sources of foods. This was used to identify the main source of food for the household. FAO (2007) and FAO, (2011) recommends timing of the survey depending on the objective of the assessment. Since the survey was an assessment of the usual diet of adults and children, the study could be conducted any time of the year.

Table 3.2: Food groups used in measurement of children dietary diversity

1. Grains, roots or tubers

2. Vitamin A rich food plant foods (dark-green leafy vegetables, yellow fruits, carrots, sweet potatoes, mangoes

3. Other fruits or vegetables e.g. citrus

4. Meats, poultry, fish

5. Eggs

6. Pulses, legumes and nuts

7. Milk and milk products

8. Food cooked in oil and fat

Source: Swindale and Bilinsky, (2006)

Dietary diversity was analysed based on scores of low, medium and high as recommended by Food and Agricultural Organization,(2011) as shown in Table 3.3

Table 3.3: Classification of dietary diversity among children

Classification	Number of food groups
Low	< 3 food groups
Medium	4 and 5 food groups
High	≥6 food groups

Source: FAO, (2011)

3.7.3 Assessment of the nutrition status of children

Recumbent length and height was taken using height board. Height boards were made of hard wood and calibrated up to 130 cm as recommended by Kenya National Bureau of Statistics and Ministry of Public Health and Sanitation, (2008).

For children below 85 cm (<24 months) recumbent length was taken with children lying down. For children up to 85 cm (> 24 months), height was taken while they were standing (Kenya National Bureau of Statistics and Ministry of Public Health and Sanitation, 2008). This is because this was how the NCHS/WHO reference children were measured. In addition, individuals measured in the lying position are taller (on average between 0.5 and 1.5cm) than individuals measured in the standing position (Save the Children Fund, 2004) hence need to adopt the same measurement method used in the development of the reference standards.

Before taking measurements, the procedure was explained to the child's mother or care taker. This is because the child cooperates when the mother is at close range and helps to hold the child. The child's shoes and any hair ornament or top knot on the child's head was removed, the child was gently placed on to the board, with the head against the fixed vertical part, and the soles of the feet near the cursor or moving part. For children less than 24 months, the child would lie straight on the middle of the board, looking directly up. One person would hold the child's head firmly against the base of the board, while another person placed one hand on the knees (to keep the legs straight) and placed the child's feet flat against the cursor with the other hand. Two measurements were read and recorded to the nearest 0.1cm.

For children above 24 months, the measuring board was placed upright and the child assisted to stand on the middle of the measuring board. The child ankles and knees were firmly pressed against the board, the child's head, shoulders, buttocks, knees and heels would touch the measuring board. One person positioned the head and the cursor at right angles. The measurement was read and recorded to the nearest 0.1cm.

The weight was measured using UNICEF hanging Salter scale which measure maximum of 25 kilograms and to the nearest 100gms. The scale would be hooked on a tree or door post. The weighing pants were suspended from the lower hook of the scale and scale re-calibrated to zero. Any jewellery on child or too much clothing was removed and the child placed in the pants. The child is left to freely hang without anything touching the child. The scale was read at eye level. The measurement was immediately recorded.

Mid Upper Arm Circumference (MUAC) tape was used to measure the arm circumference. The MUAC tape is graduated in centimetres and millimetres and measures to the nearest millimetre. The mid upper arm circumference was measured on the upper left arm. The mother was requested to remove extra clothing covering the hand of the child. For children who could not be measured on their own, the mother was requested to seat and hold the child on her laps. For children who could be measured alone, the child would stand erect and sideways to the measurer. The mid-point was established by identifying the tip of the shoulder. The child's elbow was bent at right angle and a string used to identify the mid-point between the tip of the shoulder and the elbow. Once the mid-point was marked with a pen, the measuring tape was put around the arm and measurement read to the nearest 0.1 mm and recorded. Caution was taken to ensure the MUAC tape is not too tight or too loose to cause an error in the measurement.

Bilateral oedema was assessed by applying pressure just above the ankle or the tops of the feet for about three seconds. If there is oedema, an impression remains for some time (at least a few seconds) where the oedema fluid has been pressed out of the tissue. A child would only be recorded as oedematous if both feet had oedema.

To ensure collection of precise information about the age of children, the mothers were requested to present health cards or baptism cards. In situations where there were no health cards, the child was compared with the age of children born around the same time in the neighbourhood. A calendar of events (Appendix 6) was also used to estimate the age of a child if the mother does not know the date of birth and has no health cards.

The anthropometric measurements were entered in Emergency Nutrition Assessment for Standardized Monitoring and Assessment for Relief and Transitions (ENA-SMART) software (Golden and, Erhardt, 2008). Weight for Height Z scores (WHZ), Weight for Age Z scores (WAZ) and Height for Age Z scores (HAZ) based on NCHS, 1977 Child Growth Standards were generated using the software. The prevalence of malnutrition was generated using ENA-SMART software based on the classification as shown in (Table 3.4).

Table 3.4 Classification of malnutrition based on Z scores

Level of malnutrition	Z scores
Normal	-1.00 to <1.00 Z score
Severe malnutrition	< 3- Z score
Moderate malnutrition	<-2 to ≥-3 Z score

Source: Save the Children (2004).

Table 3.5 Classification for assessing severity of malnutrition by prevalence ranges among children under 5 years of age.

	Severity of malnutrition			
Index	Low	Medium	High	Very high
Stunting	< 20	20-29	30-39	≥ 40
Underweight	< 10	10-19	20-29	≥ 30
Wasting	< 5	5-9	10-14	≥ 15

Source: United Nations Administrative Committee on Coordination Sub-Committee on Nutrition (2001).

The anthropometric data was exported to SPPS for computing other statistical tests such as correlations and logistic regressions with demographic data and data on adoption of technologies.

SPSS was used to categorize the MUAC data into: severe (MUAC < 11.0 cm), moderate (11.1 cm-12.4 cm), at risk (MUAC 12.5 cm-13.4 cm) and normal (MUAC > 13.5 cm) in line with Sphere Project, 2004 cut offs (Save the Children Fund, 2004). Although the Ministry of Health released new MUAC cut-off for severely malnourished children as 11.5 cm (Ministry of Medical Services and Ministry of Public Health and Sanitation, 2009), a classification based on MUAC of 11.0 cm was used because the data was collected in 2007 before the release of new cut-offs. In addition, using the MUAC cut off of 11.0cm made it easier to compare with the previous surveys conducted in Isiolo since they used cut off of MUAC less than 11.0 cm for acutely malnourished children.

3.8 Data analysis

Data on water harvesting, conservation and irrigation technologies adopted by each farmer was entered in Statistical Package for Social Sciences (SPSS). Mean dietary diversity scores for children were generated using SPPS. The expected proportion is the probability of success on each option. This was calculated using the formulae:

$$\text{Expected proportion} = \frac{100}{\text{Total number of options}}$$

Observed frequencies were generated using SPSS and are calculated using the formulae:

$$\text{Observed proportion} = \frac{\text{Observed Frequency}}{\text{Sample size}} * 100$$

Z test for proportions was used to establish if there was any significant difference between the proportion of farmers who adopted technologies and those who did not. This was carried out using two-proportion Z-test calculator (Joosse, 2011).

Pearson correlation was used to establish the relationship between quantitative variables such as number of years in formal education, age of head of household and the number of meals for children under five years of age. The level of significance was set at $p<0.05$

Binary logistic regression was used to relate the nutrition status of children and the adoption of water harvesting, water conservation and irrigation technologies by the households. During binary logistic regression, Weight for Height Z scores (WHZ), Weight-for Age (WAZ) and Height-for Age (HAZ) were treated as dependent variables while with total technologies (sum total of individual technologies adopted) was independent variable.

3.9 Ethical considerations

Permission to conduct the study among the farmers was sought from the Ministry of Agriculture at the district level (Appendix 6). Measuring nutrition status of children was guided by survey guidelines (Kenya National Bureau of Statistics and Ministry of Public Health and Sanitation, 2008)

At the household level, the consent of the respondents was sought. The respondents were assured of confidentiality. Personal information such as names of the respondents was not recorded in the schedules to ensure anonymity of the respondents. Before taking anthropometric measurements of the children, the parents were requested to reduce clothing from the children but not to leave the children naked. The children were properly handled to avoid psychological torture. During observation of technologies adopted, consent was sought from the farmers to take a photograph of the technology adopted.

3.10 Pre-testing of research tools

Research tools were pre-tested prior to the survey. Although Malhotra, (2004) recommends a sample of 15-30 for pretesting depending on the heterogeneity of the respondents, five households were used in pre-testing. This number was selected because it was possible to do the pre-testing in five households in one day. The study adopted participating pre-test as identified by (Colorado State University, 2011) where the respondents were told that the pre-test was a practice run. The respondents were asked to make comments that could help improve the schedules. The farmers used in the pre-testing were not visited during the actual data collection to avoid any form of bias.

This helped in editing the research questions in the tools as well as contextualizing the survey. Pre-testing was done to: reveal vague questions and therefore rephrased them, reveal deficiencies in schedules, incorporate comments and suggestions from respondents, analyse few schedules to see if the methods of analysis were appropriate. Content validity of the questionnaires was also ascertained through and expert review of the questionnaire before data collection.

CHAPTER 4: RESULTS

The results presented include: social demographic data, social economic data, and adoption of water harvesting, conservation and irrigation technologies, food consumption among children and nutrition status of children as well as the relationship between adoption of technologies and nutrition status.

4.1 Social demographic characteristics of the population

The study investigated various social demographic characteristics. These included age, sex, level of education of head of household, household size, and household leadership structure.

4.1.1 Characteristics of the households

Table 4.1 shows the number of members in a household in Central Division, Isiolo District. The expected proportion is estimated at 11.11% which implied that at least 11.11% of households had each between one to nine members. A test for proportion to compare the expected proportion and the observed frequency indicated that households with five members ($z=1.37$, $n=257$; $p>0.05$) and six members ($z=2.80$, $n=257$; $p>0.05$) had higher proportion than the expected proportion though not significant. Households with one ($z=-1.43$, $n=159$; $P>0.05$), two ($z=-3.81$, $n=257$; $p>0.05$), three($z=-2.24$, $n=257$;$p>0.05$), four($z=-0.61$, $n=257$;$p>0.05$), seven($z=0.00$, $n=257$, $p>0.05$), eight($z=0.41$, $n=257$, $p>0.05$) and nine and above($z=4.84$, $n=257$; $p>0.05$) were lower than the expected frequency but not significant.

The mean household size in the farming schemes was 6.36 people (Table 4.1). The average number of children under five years of age per household in Isiolo was 1.89 children (Table 4.2). Out of the sampled children 86(54.1%) were males and 73(45.9%) were females.

Table 4.1: Number of members in a household in Central Division, Isiolo District

Number of members in household	Observed Proportion (N=257)	Expected proportion	Z-value	P-value
One	21(8.3%)	11.11%	-1.4335	0.1517
Two	9(3.6%)	11.11%	-3.811	0.0001
Three	17(6.7%)	11.11%	-2.2497	0.0245
Four	25(9.9%)	11.11%	-0.6173	0.5371
Five	35(13.8%)	11.11%	1.3723	0.17
Six	42(16.6%)	11.11%	2.8006	0.0051
Seven	28(11.1%)	11.11%	0.0051	0.9959
Eight	24(9.5%)	11.11%	0.4115	0.4115
Nine and above	52(20.6%)	11.11%	4.8412	< 0.0001

Table 4.2 shows the number of children under five years of age per household in Central Division, Isiolo District. The expected proportion was estimated at 20% which implied that at least 20% of the households had one, two, three, four or five children. A test for proportion to compare the expected and the observed frequency showed that households with one child ($z=5.70$, $n=257$; $p<0.0001$) and two children ($z=6.10$, $n=257$; $p<0.001$) were significantly higher proportion than the expected. The proportion of households with three children ($z=-0.09$, $n=257$, $p>0.05$) or five children ($z=-5.48$, $n=257$; $p>0.05$) was lower than expected though not significant. There was no household with four children.

Table 4.2: Number of children under five years of age per household in Central division, Isiolo District

Number of children under five years of age	Observed proportion (N=159)	Expected proportion	Z-value	P-value
One	60(38.2%)	20%	5.7011	< 0.0001
Two	62(39.5%)	20%	6.1084	< 0.0001
Three	31(19.7%)	20%	-0.094	0.9251
Four	0(0%)	20%	-	-
Five	5(2.5%)	20%	-5.4819	< 0.0001

4.1.2 Characteristics of the head of household

4.1.2.1. Age of head of household

The range of age of head of household was 17 to 94 years respectively. The mean age was 42.53 years.

4.1.2.2. Education of the head of households

The mean number of years in formal school was 5.53 years .Out of 257 head of households, 97(37.9%) had not gone through formal education (Table 4.4). About 110(43.0%) had completed primary education and 25(9.8%) had completed secondary education. A further 11(4.2 %) had attended tertiary colleges or universities. A cross tabulation of the sex of head of household against years in formal schools shows that a higher proportion of men 26.6% had no formal education compared to women 11.3% ($p=0.0066$). However, in each level of education there were a higher proportion of men than women. For instance, among the head of households that had completed primary education, 88(34.4%) were men while 22(8.6%) were women ($p<0.0001$). For those who had gone up to secondary level, a higher proportions 21(8.2%) were men compared to women 4(1.6%).This shows more males are educated than females.

Table 4.4: Cross tabulation of Sex of the head of household and the level of education of the head of households in Central Division, Isiolo District

Sex	No formal	Lower primary	Upper primary	Secondary	Tertiary/college	Total
Male	68(26.6%)	10(3.9%)	88(34.4%)	21(8.2%)	10(3.9%)	197(77.0%)
Female	29(11.3%)	391.2%)	22(8.6%)	4(1.6%)	1(0.4%)	59(23%)
Total	97(37.9%)	13(5.1%)	110(43.0%)	25(9.8%)	11(4.3%)	256(100%)
Z-value	2.7	0.4	4.7	1.1	0.6	12.2
P-value	0.0066	0.6623	<0.0001	0.2797	0.5715	0

4.1.2.3 House-hold headship

Table 4.5 shows the household leadership structure among households in Central Division, Isiolo District. The expected proportion was estimated at 16.88% which implied each household leadership structure was in at least 16.88% of the households. A test for proportions to compare the expected from the observed frequency showed a significantly higher proportion were male headed monogamous families (z=20.98, n=257, p<0.0001). Male headed widowed (z=-6.69, n=257, p<0.0001) and female headed with husband absent (z=-5.71, n=257, p<0.0001) were significantly lower than expected proportion. The proportion of male headed polygamous (z-3.36, n=257, p>0.05), female headed widowed (z=-3.87, n=257; p>0.05) and male headed single (z=-1.87, n=257, n=257; p>0.05) were lower than the expected proportion though not significant.

Table 4.5: Household leadership structure in Central Division, Isiolo District

Household leadership structure	Observed proportion (N=257)	Expected proportion	Z-value	P-value
Male headed monogamous	169(66.0%)	16.88%	20.9816	< 0.0001
Male headed polygamous	23(9.0%)	16.88%	-3.3659	0.0008
Male headed widowed	3(1.2%)	16.88%	-6.6977	< 0.0001
Female headed widowed	20(7.8%)	16.88%	-3.8785	0.0001
Female headed with husband absent	9(3.5%)	16.88%	-5.7153	< 0.0001
Male headed single	32(12.5%)	16.88%	-1.8709	0.0614

4.2 Adoption of water harvesting and conservation technologies

Table 4.6 shows adoption of water harvesting and conservation by farmers in Central Division, Isiolo District. The expected proportion was estimated at 8.3% which implied each water harvesting and water conservation technology was adopted by at least 8.3% of the farmers. A test for proportions to compare the expected and the observed proportion indicated a significantly higher proportion adopted mulching ($z=10.99$, $n=257$; $P<0.0001$) and addition of organic matter ($z= 7.42$, $n=257$; $p<0.001$). Even though deep tillage ($z=1.40$, $n=257$; $p>0.05$) was adopted by a proportion lower than the expected, it was not significant. A significantly lower proportion than the expected adopted rill run off ($z=22.44$, $n=257$, $p<0.0001$), semi-circular bunds ($z=-11.06$, $n=257$; $p<0.0001$), meskat ($z=21.90$, $n=257$; $p<0.0001$) and contour farming ($z=20.86$, $n=257$, $p<0.001$). There was no farmer who adopted flood water harvesting, ephemeral stream diversion, pitting or strip catchment.

Table 4.6: Adoption of water harvesting and water conservation by farmers in Central Division, Isiolo District

Technology	Observed proportion of adoption (N=257)	Expected proportion	Z value	P value
Rill run-off	2(0.8%)	8.3%	22.4453	< 0.0001
Flood water harvesting within stream bed	0%	8.3%	-	-
Ephemeral stream diversion	0%	8.3%	-	-
Pitting	0%	8.3%	-	-
Strip catchment	0%	8.3%	-	-
Contour/semi-circular bunds	1(0.4%)	8.3%	-11.0611.	<0.0001
Meskat	4(1.6%)	8.3%	21.9033	<0.0001
Mulching	190(74.2%)	8.3%	10.9969	<0.0001
Contour farming	10(3.9%)	8.3%	20.8625	<0.0001
Ridging	20(7.8%)	8.3%	19.0975	< 0.001
Addition of organic matter	170(66.4%)	8.3%	7.4218	<0.0001
Deep tillage	120(46.9%)	8.3%	1.4029	0.1606

4.3 Adoption of Irrigation technologies

4.3.1 Sources of water

Table 4.7 shows the main sources of water for agriculture among farmers in Central Division, Isiolo District. The expected proportion was estimated at 25% which implied that each water source could have at least 25% of the farmers using water from it. A test for proportion done to compare the expected and the observed proportion showed that a significantly higher proportion used water from river or stream ($z=26.61$, $n=257$; $p<0.0001$) making it the main source of water for agriculture. A significantly lower proportion than the expected proportion used water from borehole ($z=-8.66$, $n=257$; $p<0.0001$), rain water ($z=-8.81$, $n=257$; $p<0.0001$ and from other sources ($z=-9.24$, $n=257$; $p<0.0001$).

Table 4.7: Sources of water for agriculture among farmers in Central Division, Isiolo District

Water source	Observed proportion (N=257)	Expected proportion	Z value	P value
River/stream	246(96.9%)	25.0%	26.6192	<0.0001
Borehole	4(1.6%)	25.0%	-8.6633	<0.0001
Rain	3(1.2%)	25.0%	-8.8114	<0.0001
Others	1(0.4%)	25.0%	-9.2408	<0.0001

4.3.2 Farming systems

Table 4.8 shows the distribution of farming systems among farmers in Isiolo Central Division, Isiolo district. The expected proportion was estimated at 25% which implied each farming system could have at least 25% of the farmers practising it. A test for proportions done to compare the observed frequency with the expected proportion, indicated a significant higher proportion for conventional farming ($z=10.12$, $n=254$, $p<0.0001$) making this system the most widely adopted. Even though supplementary was higher than the expected, it was not significant ($z=1.1$, $n=254$, $p>0.05$). Supplementary and conventional ($z=2.47$, $n=254$; $p<0.05$) and rain fed ($z=8.76$, $n=254$; $p<0.05$) were significantly lower than the expected frequency.

Table 4.8: Farming systems among farmers in Central Division, Isiolo District

Farming systems	Observed proportion (N=254)	Expected proportion	Z value	P value
Conventional	135(52.5%)	25%	10.1216	<0.0001
Supplementary and conventional	47(18.3%)	25%	-2.466	0.0137
Supplementary	72(28.0%)	25%	1.1042	0.2695
Rain-fed	3(1.2%)	25%	-8.7598	<0.0001

Table 4.9 shows the irrigation methods adopted by farmers in Central Division, Isiolo District. The expected proportion was estimated at 14.29% which implied that each method was adopted by at least 14.29% of the farmers. A test for proportions done to compare the observed and expected frequencies, indicated that a significant higher proportion of the farmers adopted surface irrigation ($z=22.31$, $n=257$; $p<0.0001$) making it the most widely adopted followed by overhead sprinkling ($z=9.12$, $n=254$; $p<0.0001$). Localized ($z=-6.37$, $n=257$; $p<0.001$, surface and localized ($z=-6.36$, $n=257$; $p<0.0001$), overhead sprinkling and localized ($z=-6.36$, $n=257$;$p<0.001$), surface, localized and sprinkling($z=-6.36$, $n=257$;$p<0.0001$) as well as rain fed($z=-5.59962$, $n=257$;$p<0.0001$) was significantly lower than the expected proportion.

Table 4.9: Irrigation methods adopted by farmers in Central Division, Isiolo District

Irrigation method	Proportion (N=257)	Expected proportion	Z Value	P value
Surface	162(63.0%)	14.29%	22.3127	< 0.0001
Localized	1(0.4%)	14.29%	-6.3626	< 0.0001
Over-head sprinkling	88(34.2%)	14.29%	9.1202	< 0.0001
Surface and localized	1(0.4%)	14.29%	-6.3626	< 0.0001
Overhead sprinkling and localized	1(0.4%)	14.29%	-6.3626	< 0.0001
Surface, localized and sprinkling	1(0.4%)	14.29%	-6.3626	< 0.0001
Rain-fed	3(1.2%)	14.29%	-5.9962	< 0.0001

Table 4.10 shows the number of technologies adopted by farmers in Central Division, Isiolo District. The expected proportion was estimated at 16.67% which implied each technology had at least 16.67% of the farmers practising it. A test for proportion to compare the observed and the expected frequencies showed that a significantly higher proportion of farmers adopted three different technologies ($z=12.05$, $n=257$; $p<0.0001$ hence the number of technologies highly adopted. A significantly higher proportion than the expected proportion adopted four technologies ($z=3.97$, $n=257$; $p<0.001$). The proportion of farmers which adopted one ($z=4.97$, $n=257$; $p<0.001$), five ($z=-6.31$, $n=257$; $p<0.0001$ or six technologies ($z=6.99$, $n=257$; $p<0.0001$) was significantly lower than the expected proportion.

Table 4.10: Number of technologies adopted by farmers in Central Division, Isiolo District

Number of technologies adopted	Observed proportion N=257	Expected proportion	Z value	P value
None	1(0.4%)	16.67%	-6.9982	< 0.0001
One	13(5.1%)	16.67%	-4.9766	< 0.0001
Three	114(44.7%)	16.67%	12.0565	< 0.0001
Four	66(25.9%)	16.67%	3.9701	< 0.0001
Five	5(2.0%)	16.67%	-6.31	< 0.0001
Six	1(0.4%)	16.67%	-6.9982	< 0.0001

Table 4.11 shows the level of adoption of technologies by farmers in Central Division, Isiolo District. The expected proportion was estimated at 33.33%, which implied that at least 33.33% of the farmers were low, average or higher adopters. A test for proportion to compare the expected and the observed proportions showed a significantly higher proportion ($z=3.86$, $n=257$; $p<0.0001$) adopted three technologies hence were average adopters. A significantly lower proportion than the expected proportion were low adopters ($z=-2.11$, $n=257$; $p<0.001$) and high adopters ($z=-1.74$, $n=257$; $p<0.001$).

Table 4.11: Level of adoption of technologies by farmers in Central Division, Isiolo District

Level of adoption	Proportion of adopting N=257	Expected proportion	Z value	P value
Low (0-2 technologies)	69(27.1%)	33.33%	-2.1187	0.0341
Average (3 technologies)	114(44.7%)	33.33%	3.8667	0.0001
High (>4-6 technologies)	72(28.2%)	33.33%	-1.7446	0.0811

4.5 Food production

4.5.1 Types of crops grown

Table 4.12 shows the types of crops grown by farmers in Central Division, Isiolo District. The expected proportion was estimated at 25%, which implied that at least 25% of the farmers grew each type of food crop. A test for proportion done to compare the observed and expected proportion showed that a significantly higher proportion of the farmers grew cereals and grains as well as horticultural crops ($z=18.69$, $n=257$, $p<0.0001$) hence the most widely crops grown in the area. A significantly lower proportion compared to the expected grew other crops ($z=-8.47$, $n=257$; $p<0.0001$ while a lower proportion, grew roots and tubers ($z=-2.92$, $n=257$; $p>0.05$) though not significant.

Table 4.12: Types of crops grown by farmers in Central Division, Isiolo District

Type of crop grown	Proportion of farmers (N=257)	Expected proportion	Z value	P value
Roots and tubers	44(17.1%)	25%	-2.9248	0.0034
Cereals and grains	194(75.5%)	25%	18.6964	< 0.0001
Horticultural crops	194(75.5%)	25%	18.6964	< 0.0001
Other crops	7(2.1%)	25%	-8.4782	< 0.0001

4.6 Household food consumption

Table 4.13 shows the main sources of food for households in Central Division, Isiolo District. The expected proportion was estimated at 25% which implied that at least 25% of the households got food from each of the sources. A test for proportion was done to compare the expected and the observed frequencies. A significantly higher proportion got food from the market (z=8.3, n=257, p<0.0001). Even though market and own production was higher than the expected proportion, it was not significant (z=3.40, n=257; p>0.05). Own production (-4.07, n=257, p<0.001) and free relief food (z=-7.66, n=257, p<0.0001) was significantly lower than expected frequency.

Table 4.13: The main source of food for households in Central Division, Isiolo District

Main sources of food	Proportion (N=257)	Expected proportion	Z value	P value
Market only	122(47.5%)	25%	8.3301	< 0.0001
Own production only	36(14.0%)	25%	-4.0725	< 0.0001
Market and own production	88(34.2%)	25%	3.4061	0.0007
Free relief food	11(4.3%)	25%	-7.6637	< 0.0001

The staple food in the faming schemes was maize, consumed by 224(87.2%) of the households. Rice was consumed by 32(12.5%) of the households while roots and tubers were staple food to 1(0.4%) of households.

4.6.1 Number of eating occasions per day

Table 4.14 shows the number of meals eaten by children per day in Central Division, Isiolo District. The estimated proportion was 20% which implied that at least 20% of the children ate no meal, ate one, two, three or more than three meals. A test for proportions done to compare the observed frequency with the expected proportion indicated that a significantly higher proportion of children ate three (z=6.58, n=159, p<0.0001) hence widely consumed number of meal followed by more than three meals (z=4.98, n=159, p<0.0001). The proportion of children who ate two meals was lower than the expected frequency though not significant. Children who did not eat any meal (z=5.89, n=159; p<0.0001) and those who ate one meal (z=4.72, n=159; p<0.0001) were significantly lower than the expected frequency. The children who had not eaten any meal the previous day had been sick and the care givers reported that the children had refused to eat.

Table 4.14: Number of meals eaten by children per day in Central Division, Isiolo District

Number of meals per day	Observed Proportion (N=159)	Expected proportion	Z value	P value
Zero	2(1.3%)	20%	-5.895	< 0.0001
One	8(5.0%)	20%	-4.7286	< 0.0001
Two	25(15.7%	20%	-1.3555	0.1753
Three	65(40.9%)	20%	6.5885	< 0.0001
More than three	57(35.8%)	20%	4.9808	< 0.0001

4.6.2 Dietary diversity for children

Table 4.15 shows the number of food groups consumed by children in Central Division, Isiolo District. The expected proportion was estimated at 14.29% which implied that at least 14.29% of the children ate food from each of the food groups. A test for proportion done to compare the expected frequency and the observed frequency indicated a significant higher proportion consumed five food groups ($z=4.93$, $n=159$; $p<0.0001$) and four food groups ($z=4.25$, $n=159$; $p<0.0001$). Even though the proportion consuming three food groups ($z=1.04$, $n=159$; $p>0.05$) was higher than the expected proportion, it was not significant. The proportion that consumed one food group ($z=3.99$, $n=159$, $p<0.0001$), six food groups ($z=-0.57$, $n=159$; $p<0.0001$) and seven food groups ($z=-4.93$, $n=159$; $p<0.0001$) were significantly lower than the expected proportion. The proportion that consumed two food groups ($z=-0.78$, $n=159$; $p>0.05$) was lower than the expected proportion but not significant.

The mean and median dietary diversity score was 4.0(N=159). Based on FAO, (2011) classification, 51(32.5%) of the children had a low dietary diversity score of less than three food groups (Table 4.15 and Table 4.16). About 85(54.1%) of the children were in the medium category of four to five food groups. About 21(13.3%) were in the high category and consumed between six to seven food groups.

Table 4.15: Number of food groups consumed by children in Central Division, Isiolo District

Number of food groups	Observed proportion (N=159)	Expected proportion	Z value	P value
One	5(3.2%)	14.29%	-3.9957	< 0.0001
Two	19(12.1%)	14.29%	-0.7891	0.4301
Three	27(17.2%)	14.29%	1.0485	0.2944
Four	41(26.1)	14.29%	4.2552	< 0.0001
Five	44(28.0%)	14.29%	4.9397	< 0.0001
Six	20(12.7%)	14.29%	-0.5729	0.5667
Seven	1(0.6%)	14.29%	-4.9325	< 0.0001

Table 4.16 shows the classification of dietary diversity among children in Central Division, Isiolo District. The expected proportion was estimated at 33.33% which implied at least there were 33.33% of the children in each classification. A test for proportion was done to compare the observed frequency with the expected proportion which indicated that a significantly higher proportion consumed four to five food groups($z=5.56$, $n=159$;$p<0.0001$). Even though the proportion of children who consumed less than or equal to three food groups ($z=-0.214$, $n=159$; $p>0.05$) was higher than the expected, it was not significant.

Table 4.16: Classification of Dietary diversity among children in Central Division, Isiolo District

Classification	Observed proportion of children (N=159)	Expected proportion	Z value	P value
Low (≤ 3 food groups)	51(32.5%)	33.33%	-0.214	0.8305
Medium (4 and 5 food groups)	85(54.1%)	33.33%	5.5651	< 0.0001
High (≥6 food groups)	21(13.3%)	33.33%	-5.3511	< 0.0001

Table 4.17 shows the proportion of food groups consumed by children in Central Division, Isiolo District. The estimated expected proportion was 14.29% which implied at least 14.29% of the children consumed food from each food group. A test for proportion done showed that a significantly higher proportion consumed food with oils ($z=27.02$, $n=159$; $p<0.0001$

followed by grains (z=24.14, n=159; p<0.0001) hence widely consumed. Similarly a significantly higher proportion than the expected consumed food rich in vitamin A (z=21.15, n=159, p<0.001), vitamin C rich foods (z=11.96, n=159; p<0.0001), pulses (z=15.67, n=159; p<0.0001) and milk (n=4.57, n=159, p<0.0001). Even though meat (z==0.72, n=159; p>0.05 was consumed by a proportion higher than the expected, it was not significant. Eggs were consumed by a lower proportion compared to expected proportion though not significant (z=-2.87, n=159, p>0.05).

Table 4.17: Proportion of food groups consumed by children in Central Division, Isiolo District

Food group	Observed proportion N=159	Expected proportion	Z value	P value
Grains	129(81.3%)	14.29%	24.1438	< 0.0001
Vitamin A rich foods	116(73.0%)	14.29%	21.1533	< 0.0001
Vitamin C rich foods	75(47.5%)	14.29%	11.9656	< 0.0001
Eggs	10(6.3%)	14.29%	-2.8788	0.004
Meats	26(16.3%)	14.29%	0.7242	0.4689
Pulses	92(57.8%)	14.29%	15.6767	< 0.0001
Milk	42(27.0%)	14.29%	4.5794	< 0.0001
Oil	142(89.3%)	14.29%	27.0263	< 0.0001

4.7 Nutrition status of children

Table 4.18 shows the nutrition status of children in Central Division, Isiolo District. Using NCHS references, Weight for Height Z scores, the prevalence of global acute malnutrition (<-2 z-score and/or oedema) was 16(10.1%) among the sampled children. The prevalence of severe acute malnutrition was 0(0%). The proportion that was mildly wasted (<-1 to≥-2 Z score) was 56(36.1%).

Using Height for Age Z scores, the proportion of severely stunted children was 7(4.5%) while the proportion moderately stunted was 23(14.7%). The prevalence of total stunting (<-2 z-score) was 30(19.2%). Using Weight for Age Z score, the proportion of severely and moderately underweight children was 4(2.5%) and 34(21.4%) respectively hence prevalence of total underweight (<-2 z-score) was 38(23.9%). Mid Upper Arm Circumference (MUAC) was used to assess the level of malnutrition (Table 4.19). Based on this index, 3(1.9%) were moderately malnourished (MUAC<11.5 cm) while 8(5.1%) were at risk (MUAC 12.5cm-13.4cm).

Analysis of the nutrition status using WHO 2005 references and NCHS, 1977 references shows some difference in the prevalence for all the three indices WHZ, WAZ and HAZ (Table 4.23). For instance WHO references give the total wasting (<-2 z-score and/or oedema) as 13(8.2%) while NCHS references give 16(10.1%). For stunting, WHO references give higher prevalence 43(27.0%) while NCHS prevalence is lower 31(19.5%).

Analysis of anthropometric by categories 12-23months and 24-59 months showed that 7(22.6%) of children aged 12-23 months was stunted, compared to 24(18.8%) of children aged 24-59 months (Table 4.26). However, there was no significant difference in the prevalence of stunting between the two age groups (z value=0.2275, p value=0.8201 95% CI [0.1827,-0.1447]. For WAZ proportion of underweight was 10(32.3%) among children aged 12-23 months compared to 31(24.2%). For wasting, a higher proportion 5(16.1%) of children 12-23 months was wasted compared to 11(8.6%) for children 24-59 months.

Table 4.18: Nutrition status of under-fives in Central Division, Isiolo District

Category of malnutrition	% Underweight	% Wasted	% Stunted
All children 12-59 months N=159			
NCHS, 1977reference			
Severe	4(2.5%)	0(0%)	7(4.5%)
Moderate	34(21.4%)	16(10.1%)	23(14.7%)
Total	38(23.9%)	16(10.1%)	30(19.2%)
Prevalence of malnutrition among children 12-23 months by NCHS (n=31)			
Severe	0%	0%	1((3.2%)
Moderate	10(32.3%)	5(16.1%)	6(19.4%)
Total		5(16.1%)	7(22.6%)
Prevalence of malnutrition among children 24-59 months by NCHS (n=128)			
Severe	4(3.1%)	0%	6(4.7%)
Moderate	27(21.1)	11(8.6%)	18(14.1 %)
Total	31(24.2%)	11(8.6%)	24(18.8%)

Table 4.19: Prevalence of wasting by MUAC among children in Central Division, Isiolo District

Category of malnutrition	Proportion N=159
Severe (MUAC<11.0 cm)	0%
Moderate (MUAC<11.4-12.5cm)	3(1.9%)
At risk (MUAC 12.5cm-13.4cm)	8(5.1%)
Normal (MUAC>13.5cm)	147(93.0%)

4.8 Correlation of variables in the study

Table 4.20: Correlation of MUAC and other anthropometric measurements of children under five years of age in Central Division, Isiolo District

Variable correlated with MUAC	Correlation coefficient	P value
Weight-for-age	0.577	0.000
Height-for-age	0.205	0.010
Weight-for height	0.593	0.000

Correlation between MUAC and other nutrition indices show that MUAC has fair positive correlation with weight for height and weight for age (Table 4.20). However, it has a weak positive correlation with height for age.

Table 4.21: Correlation of years in formal education of head of households and other variables among in Central Division, Isiolo District

Variable correlated with years in formal school	Correlation coefficient	P value
Household size	-0.334	0.000
Number of meals for children	0.256	0.005
Number of under-fives	-0.317	0.005
Diet diversity of children	0.226	0.015
Age of household head	-0.429	0.000

The number of years in formal school had a significant positive correlation with the number of meals eaten per day by children and dietary diversity of children. However, the number of years in formal school had negative significant correlation with household size, number of children under five years of age in household and age of head of household. The age of the head of household significantly correlated positively with household.

4.9 Relationship of adoption of water harvesting and irrigation technologies on nutrition status

The results of logistic regression for Weight for Height Z scores (WHZ score), Height-for Age Z scores (HAZ) and Weight-for Age (WAZ) individual and total technologies are summarized in Table 4.22

Table 4.22: Results of binary logistic regression

Index	Relative odds	P value	Odds ratio (upper, lower limits 95% CI
Child id 1(n=116)			
WHZ	1.143	0.847	0.294; 4.437
WAZ	1.011	0.983	0.378; 2.703
HAZ	1.054	0.926	0.349; 3.184
Child id 2(n=38)			
WAZ	0.600	0.592	0.93; 3.878
HAZ	0.256	0.133	0.43; 1.516

For the children labelled one (id=1,n=116), for weight for height z score, households that adopted three or more than three technologies were 1.143 times likely to have normal child (p=0.847; CI 95 % [0.294, 4.437]. For weight for age z score, households that adopted three or more than three technologies were 1.011 times likely to have a normal child (p=0.983, CI at 95% [0.378, 2.703].For height for age, households that adopted three or more than three technologies were 1.054 times likely to have a normal children (p value=0.926, CI 95 % [0.349, 3.184].

For the children labelled two (1d=2, n=38), for weight for age, households that had adopted three or more than three technologies were 0.600 times likely to have normal child (p value=0.592, CI 95% [0.93, 3.878]. For height for age, households that adopted three or more technologies were0.256 times likely to have a normal child (p value=0.133 95 CI at 95% [0.43; 1.516].

Binary logistic regression was also performed for weight for age, weight for height and height for age and individual technologies as covariates: rill run-off, flood water harvesting within stream bed, ephemeral stream diversion, pitting, strip catchment, contour/semi-circular bunds, meskat, mulching, contour farming, ridging, addition of organic matter, deep tillage. All technologies were excluded from the logistic regression equation.

This could imply that although not significant, individual technologies do not influence nutrition status but a mix of the technologies is likely to influence the nutrition status of children.

CHAPTER 5: DISCUSSIONS

5.1 Demographic data

5.1.1. Household size

The mean household size in the farming schemes was 6.36 slightly higher than the mean household size of 6.0 members reported by the Kenya Bureau of Statistics (KNBS), 2006; United Nations Children Fund (UNICEF) and Arid Land Management Project (ALRMP), (2006). About 104(41.2%) households had more than seven members a figure that is higher than the findings from 2003 and 2008 health demographic surveys (CBS, MOH and ORC Macro, 2004; KNBS and ICF Macro 2010). The 2003 and 2008 health demographic surveys reports that households with more than seven members were 18.8% and 16.5% respectively. According to the study, the mean number of children below five years per household in Isiolo was 1.87 children higher than the 2008 nutrition survey finding of an average 1.2 children under five years of age in Isiolo is 1.2 (Action Against Hunger(USA), 2008).

5.1.2 Age of head of household

The minimum and maximum ages of head of households were 17 and 94 years respectively with the mean age, 42.53 years. The age of the head of household significantly correlated positively with household size. Although the correlations were weak the findings indicate that older head of households are more likely to have married and have had more children thus large households. This confirms Kenya National Bureau of Statics, (2006) proposition that age of household head and household size are likely to be correlated.

Years in formal school decreased with increase in the age of head of household. This agrees with the proposition that younger people are attaining higher levels of school than older people (CBS, MOH and ORC Macro, 2004). For instance, among head of households aged 55-59 years, 2.6 % had attained secondary education and above while among those aged 25-29 years 9.2% had attained secondary education and above (CBS, MOH and ORC Macro, 2004).

5.1.3 Education level of head of household

From cross tabulation of age, sex and the level of education of the head of households several conclusions can be drawn. In each level of education there were a higher proportion of men than women. For instance, for those who completed secondary education 88(44.7%) were men compared to 21(10.7%) women. A similar trend is exhibited for those who reported having attained an education beyond the secondary school level. A majority of the head of households had completed primary education. The proportion of the head of households that had completed secondary and post-secondary education decreased with increase in the level of education. About 45(17.6%) of head of households above 55 years of age 45(17.6%) did not have formal education.

Monthly income, amount of money spent on agricultural inputs, number of meals eaten per day by children, dietary diversity of children and adult dietary diversity all increased with the increase in the number of years in formal school. Although the correlation coefficients observed in this study are weak, more years in formal school leads to acquisition of knowledge and skills that results to adoption of better farming techniques, thus more income (Chomba, 2004; Tesfay, 2008).

The household size, number of children under five years of age in a household, size of owned land, the duration the head of household had practiced irrigation, age of head of household and size of total land holding all decreased with an increase in the number of years spent in formal schooling. This is corroborated by the CBS, MOH and ORC Macro, (2004) report that argues that men and women who have little education enter into marriage earlier thus more likely to have more children and thus larger households. The report further cites increased use of modern family planning methods with increase in the level of education. The use of modern family planning methods increases from 8% among married women with no education to 52% among women with at least some secondary education (CBS, MOH and ORC Macro, 2004). As a result, more education is likely to result in smaller family sizes.

5.1.4 Household headship

Of the head of households interviewed, a majority, 198(66.0%) were males while 59(23.0%) were females. This is in agreement with the findings of the Kenya Integrated Household Budget Survey (KIHBS) conducted in 2005, which reports that in all the districts in Kenya, except Samburu, and Bondo, a majority of households are predominantly headed by males (Kenya National Bureau of Statistics, 2006).

5.2 Social-economic characteristics

5.3 Adoption of water harvesting and conservation technologies

Water conservation methods had been adopted by a high proportion of farmers with mulching being adopted by the majority of the farmers, 190(74.2%). None of the farmers had adopted strip cropping, pitting, ephemeral stream diversion and flood water harvesting.

Although there is no data on the level of adoption of water harvesting in Isiolo, extensive research shows that the technologies increase crop production. For instance, Liasu *et al.*, (2007) show that addition of mulch has a complimentary effect of fertilizers, and increased the yield and growth of tomato plants because it releases nutrients to the soil after decomposition. Research conducted among yam farmers in Nigeria by Akinola and Owombo, (2011) also shows higher values of gross margin and net income recorded by the adopters of the mulching technology as compared to non- adopters.

5.4 Adoption of irrigation technologies

Isiolo River is the main source of water for irrigation among the farmers in farming schemes. In all the farming schemes, majority of the farmers, 135(52.5%) reported to be providing crop with sufficient water in the entire period (conventional irrigation) because rain water is not sufficient. About 47(18.3%) added limited water to crops during times of low rainfall to ensure crops received enough water to support crop growth and stabilize yields. About 72(28.1%) of farmers reported to have been practicing a mix of supplementary and conventional irrigation. Only 3(1.2%) were practicing rain fed irrigation. These findings agree with views of officers in the Ministry of Agriculture that conventional irrigation is the major technology adopted by farmers in Isiolo central division, Merti, Kinna, Oldonyiro and Sericho divisions.

Water is conducted to the farms using furrow method by most of the farmers, 162 (63.0%). Fewer farmers practice sprinkling irrigation, 88 (34.2%) and only 1(0.4%) practice localized irrigation. To promote efficient water conveyance and water saving technologies, the Ministry of Water, Isiolo had instructed farmers to construct water intakes and convey water to the farms using water pipes rather than using furrows. Farmers who were not able to construct intakes such as shown in Plate 5.2 at the river were denied permission to use furrows. The furrows were covered up with soil by the Ministry of Water (Plate 5.3).

The need to conserve water for irrigation in Isiolo is imperative. Over use of water in Isiolo River by the farmers upstream has recently been blamed as the cause of shortage of water for domestic use in Isiolo town (Hussein, 2011).

Characteristically, Isiolo central receives very heavy rainfall over a short period of time. This result in a large mass of run-off water which forms a temporary stream during a rainy season such as shown in Plate 5.4.The mass of water flows into River Ewaso Nyiro. There is thus great need to harness the rain water run-off and use it during the dry season. In line with the government strategy for revitalizing agriculture, promotion of water harvesting technology on farms to reduce reliance on rivers resources is an essential component of water management (Government of Kenya, 2004). Harvesting water in man-made dams would also help farmers store water that could be used at a later date. Small dams along the river help stabilize river flow and conserve run-off.

5.5. Number of meals per day

Although, the number of meals consumed by children in the farming scheme was better than in pastoral areas of Isiolo such as Merti and Sericho, Save the Children, (2006a) reports that in a good year, children in Isiolo take 4 meals per day while adults take three meals. This indicates that the proportion of children that had taken three meals and above, 122 (76.7%) was indicative of some food insecurity in the study area. This could be attributed to the severe drought that had hit the entire district in 2006, with short rains only experienced in October-December 2006 (United Nations System Standing Committee on Nutrition, 2006). The drought led to high rates of malnutrition in the district with pastoral divisions of Merti and Sericho hardest hit, recording Global Acute Malnutrition of 28.5%, the worst since 1996 (Save the Children, 2006a).

A comparison of the number of meals between pastoral areas and the farming schemes, shows that a higher proportion of children, 57(35.8%) in farming schemes compared to 18(2.8%) in pastoral areas had consumed more than three meals. This shows the situation in the farming schemes was better. The food insecurity could also be attributed to the fact that some of the families in the farming schemes, especially Maisha Bora, Mashambani. Maili Tano had halted irrigation for several months before the study. This was because the Ministry of Water prohibited farmers from using furrows to conduct water from the river to their farms. Since majority of the farmers were using furrows as the main water conveyance method, after the Ministry of Water directive, they had to stop irrigation temporarily. This in turn could have led to food insecurity.

5.6 Dietary diversity for children

Over half 106(67.4%) of the children had a dietary diversity falling between medium and high as classified by FAO, (2011). Only 51(32.5%) of the children were in the low dietary diversity category. Although a survey by IMC, GoK, UNICEF, (2011) and the current study were conducted at different times, comparison of proportion of children consuming individual food groups, shows consumption in the farming schemes was better. For instance, in the farming schemes, about 81.3% of the children had food composed of roots and grains compared to 20.7% in the study by IMC, GoK, UNICEF, (2011).

Consumption of pulses, fruits and vegetables, vitamin A rich foods was equally higher among the children in the farming schemes. This could be explained by the fact that the pulses, fruits and vegetables were grown in the farming schemes. For instance, in the current study, grains were consumed by 129(81.3%) of the children. This compare with the findings that 194(75.5%) of the farmers grew maize. Horticultural crops were grown by 194(75.5%) of the farmers while consumption of vitamin A and C rich foods were grown by 116(73.0%) and 75(47.5%) of the farmers respectively.

However, comparison of the two surveys shows that in both surveys, eggs, poultry and fish were consumed by the least proportion of children. The difference in the two surveys could be explained by the difference in the study areas. The study by IMC, GoK, UNICEF, (2011) survey was conducted in the larger Isiolo district covering three divisions while the current study was carried out in farming schemes in Central Division.

Even though the majority of the children 101(67.4%) consumed food from four to seven groups, there is need still to encourage the mothers to diversify the diets of the children in the sampled area. Analysis of the food groups eaten by children show that grains and fats/oils had the highest percentage of consumption while meats and eggs had the least consumption.

Vitamin A rich fruits such as mangoes and vegetables had been consumed by 111(73.1%) of the consumed fruits rich in Vitamin A especially in the previous 24 hours. The consumption of the Vitamin A fruits could have been attributed to the fact that the survey was conducted during a season with plenty of mangoes. From market surveys and informal discussions with the traders in markets within the farming schemes and in Isiolo town, foods rich in vitamins such as mangoes, guavas, kales, tomatoes, spinach and traditional vegetables are from the farming schemes hence (Plate 5.1) Even though, over half of the children consumed fruits rich in vitamin A, World Health Organization(WHO), Pan American Health Organization(PAHO), (2004, p. 22) recommends that Vitamin A rich-fruits and vegetables should be eaten daily by children below five years. This recommendation is based on benefits associated with preventing vitamin A deficiency and the possibility that consumption of such foods help meet the needs for many other vitamins.

Ettyang *et al.,* (2004) report that if the prevalence of infant stunting (HAZ< - 2 SD), is ≥ 30% or wasting (WHZ < - 2 SD) is ≥ 10%, risk of vitamin A deficiency is present. Comparing this with the nutrition status of children in the farming schemes in Isiolo, where prevalence of stunting (< - 2 SD) was found to be 30(19.2%), and wasting (< - 2 SD) was 15(9.7%), then children in the farming schemes are not at risk of vitamin A deficiency. However, SCN, (2001) and SCN, (2010), recommend that in countries with the prevalence of Vitamin A deficiency above 15%, children 6-59 months should receive a high dose of vitamin A supplement. Vitamin A deficiency among children in Kenya is much higher at 84.4% (SCN, 2010).

Slightly less than half of the children had consumed foods rich in vitamin C such as citrus fruits and guavas as well as vegetables. This equally falls below WHO recommendation that vitamin C rich foods should be consumed daily to enhance iron absorption (WHO and PAHO, 2004). Proteins of high biological value such as meat, poultry or eggs, beans were consumed by 35(22.6%) of the children. Not all children had eaten plant-based proteins such as legumes which had been consumed by 91(58.1%) of the children. WHO and PAHO, (2004) recommends that meat, poultry or eggs should be eaten daily or as often as possible to be able to meet micronutrient needs.

Milk was reported to have been consumed by 42(26.9%) of the children in the previous 24 hours. Milk and dairy products furnish good quantities of calcium, vitamin A, B vitamins, and protein to the diet. Milk is considered a complete food since it contains essential amino acids. It should be consumed regularly by children below five years. The intake of milk among the children in the study population is inadequate. This could be explained by the finding that only 6(2.3%) and 31(12.1%) reported to have income from livestock keeping or a mix of both respectively.

Food with some oil had been consumed by 140(89.2%) of the children the previous day. This is commendable since fat provides essential fatty acids, facilitates absorption of fat soluble vitamins and enhances dietary energy density and enhances sensory qualities of food.

Consumption of foods from at least 4 food groups on the previous day would mean that in most populations, the child had a high likelihood of consuming at least one animal-source food and at least one fruit or vegetable that day, in addition to a staple food such as grain, root or tubers (World Health Organization, 2007). Although more than half of the children had attained minimum dietary diversity, there is need to emphasize consumption of meat, milk and milk products.

The dietary diversity could be attributed to the farming. Among the farmers interviewed, market and own production was the main sources of food for the most of the households 246 (97.7%). Comparing with other nutrition surveys conducted in Isiolo, the proportion of farmers relying on relief food in the farming schemes was 11(4.3%), much lower than in non-farming areas. For instance, population in Merti and Sericho divisions, which depended on relief in May, 2006 was 50.8% (Save the Children, 2006a) and 83% in Nov 2006 (Save the Children Kenya, 2006b). This showed that farming had improved the economic power of the population in the farming schemes hence fewer people depended on relief as the main source of food.

5.7 Nutrition status of children

The nutrition status of children was determined using three indices Weigh for Age Z score (WAZ), Height for Age Z score (HAZ) and Weight for Height Z score (WHZ). MUAC was not used to determine the nutrition status since it's used mainly as a screening tool for entry to emergency programmes (Save the Children Fund, 2004).

The prevalence of global acute malnutrition was 16(10.1%) which was beyond the expected prevalence of 2-3% in developing countries (United Nations Administrative Committee on Coordination Sub–Committee on Nutrition (ACC/SCN), 2001). Within the WHO classification (World Health Organization, 2011), prevalence of wasting between 5-9% is classified as medium and depicts poor nutrition with the need to monitor situation as recommended by United Nations High Commission for Refugees and World Food Program, (2009). Based on WHO cut-off levels, the prevalence of stunting in this study was low and that of underweight was high.

Correlation between MUAC and other nutrition indices show that MUAC had fair positive correlation with weight for height and weight for age. However, it had a weak positive correlation with height for age. World Health Organization and UNICEF,(2009), shows that the prevalence of severe acute malnutrition defined using weight for height Z score and MUAC is comparable. In the current study, weight for height showed 0% prevalence of severe wasting (-3 SD) similar to prevalence of severe acute malnutrition defined by MUAC <11.0cm.

5.8 Comparison of the study with other nutrition surveys

The study also compared the level of malnutrition with the previous surveys that could be retrieved from secondary data. Even though there were differences in study areas a few general conclusions can be drawn from the comparison. The prevalence of wasting was lowest in the farming schemes in Isiolo Central division, 16(10.1%). For instance the prevalence of malnutrition in Merti and Sericho divisions which are more arid was 28.5% in May 2006(Save the children, 2006a). The relatively lower rates of wasting could be attributed to small scale farming conducted by households

5.9 Relationship between adoption of water harvesting, conservation, irrigation technologies and nutrition status

Binary logistic regression of the technologies and weight for height, weight for age and height for age showed that adoption of more technologies has no significant relationship with stunting, underweight and wasting. Although there was no significant relationship, households that adopted more than three technologies were more likely to have children who were well nourished. A household that adopted less than three technologies was 1.011 times more likely to have an underweight child, 1.054 times more likely to have stunted child and 1.143 times more likely to have a wasted child. Although this was not a longitudinal impact study, the study shows that adoption of water harvesting and irrigation is more likely to improve nutrition status of children.

Although the study found no significance between the adoption of technologies and nutrition status of children, this could be due to several reasons. The level of adoption of technologies is low hence maximum benefits of the adoption could not be realized by all the households. For instance only 7(2.73%) of the farmers had adopted any form of water harvesting technology. A higher proportion had adopted mulching, contour farming, ridging, addition of organic matter and deep tillage most of which are only successful if there is water. For those who adopted irrigation, majority used furrow method, 162(63%). Drip and sprinkler irrigation was used by 1(0.4%) and 88(34.2%) respectively. The implication of this was that, with the Ministry of Water enforcement to ensure efficient water usage to avert water crisis, some farmers could not continue with farming due to lack of water. Number of meals eaten and levels of wasting show the farming schemes are better off than other parts of Isiolo. Increased adoption of the technologies would produce higher benefits.

The study is consistent with other studies investigating the impact of adoption of technologies. A study by International Irrigation Management Institute, (1995) in SriLanka showed the impact of irrigation on nutrition status of preschool children. An area under irrigation had lower prevalence of stunting and underweight compared to a new area under development for an irrigation scheme. A study conducted in Capetown, south Africa showed that adoption of in-field rain water haversting technology had a positive impact on household food security. The intake of vitamin A and C improved considerably during wet season. In addition, 80% of respondents could afford three meals a day (Hlanganise, 2010).

A longitudinal study condcuted in Senegal by Simondon and Benefice, (2001) showed a decline in wasting among preschool children from 11.4% to 3.8% . This study was a five year follow up on the impact of rice irrigation on nutrition status of preschools. However, levels of stunting were inconsistent. The stunting levels decreased within the first two years then increased. At the end of the five years, stunting had increased from 21.5% to 23.5%. Similary, the study showed that pprevalence of chronic energy deficiency (BMI < 18.5 kg/m2) in men fell from 22.5% in 1990 to 6.6% in 1991 and thereafter increased to 13.0% in 1995 but no significant variations were found among women. In conclusion, the study showed that the onset of irrigated rice cultivation was followed by a decrease in the prevalence of wasting among children and chronic energy deficiency among adults. However, the cause of increase in stunting could not be explained.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study sought to assess the level of adoption of water harvesting, conservation and irrigation technologies in seven farming schemes in Isiolo Central Division, Isiolo Sub-county, assess the dietary diversity among households in the target area and to assess the nutrition status of children under five years of age in the target area. The study also sought to establish the relationship between adoption of water harvesting, water conservation and irrigation technologies and nutrition status of children under five years of age. From the study the following conclusions were drawn:

1. Among all the households, the highest proportion adopted mulching, addition of organic matter and deep tillage as water and soil conservation technologies. There was low adoption of water harvesting technologies. In addition, most farmers used furrow irrigation compared to sprinkler and drip although drip and sprinkler irrigation are more efficient

2. Most of the children consumed three to four meals per day from 4-5 food groups. Over half of the children consumed food from grains, vitamin A rich foods, vitamin C rich foods and pulses. Slightly over a quarter consumed milk and less than a quarter consumed eggs and meats.

3. The prevalence of wasting, stunting and underweight among children in the farming schemes was lower than other areas in Isiolo.

4. The study established that there was no significant relationship between nutrition status indices and water harvesting, water conservation and irrigation. However, from the relative odds, households that had adopted more than three technologies were more likely to have a normal child.

6.2 Recommendations

For improved level of adoption of water harvesting, conservation and irrigation technologies the following recommendations are suggested:

1. Households in the study area should be trained on water harvesting technologies and efficient methods of irrigation such as drip irrigation and sprinkler.

2. Farmers should be encouraged to increase consumption of protein foods such as eggs, meats and milk among children below five years

3. There is need for continuous monitoring of the nutrition status of children under five years of age in the study area to be able to design programs to address malnutrition

4. Farmers should be encouraged to adopt different water harvesting, water conservation and irrigation technologies which increase the likelihood of having well-nourished children

6.3 Recommendations for further study

The current study focussed on the relationship between adoption of water harvesting, water conservation, irrigation technologies and nutrition status of children under-fives in Isiolo. Although there was no relationship, future study could determine the relationship between adoption and nutrition status of women in an arid and semi-arid area.

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