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Influence of Water Availability on Food Crop Production in Semi-Arid Areas in Kibwezi District, Makueni County, Kenya

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Abstract: Ecosystems provide essential services like water regulation and other processes which sustain and fulfill human life by directly or indirectly supporting humans' survival and quality of life. However, there is insufficient knowledge on the influence of water availability as an ecosystem service on food crop production as a livelihood insemi-arid areas Kenya. The objective of this study was to establish the influence of water availability on food crop production as a livelihood in semi-arid areas in Kibwezi district. A Cross-sectional descriptive research design involving use of purposive and simple random sampling was adopted. Primary data was obtained using structured questionnaires to interview a minimum of 384 house hold heads from a study population of 248,704. The results indicated that 70.3% accessed rainwater, 79.2% obtained water from boreholes, and 23.4% from streams, 29.7 % accessed tap water, while only 2.6 % accessed water from springs. Further, 76.6% of the households practiced irrigation out of which 67.3% used more than 500 liters of water. Crops grown under irrigation include maize, spinach, kales, Asian vegetables, fruits, babycorns, tomatoes and onions. Least squares regression analysis was employed to determine the influence of water availability on food crop yields. The results showed that 67.2% of the variation in total rainfed crop yields in Kgs was explained by total monthly rainfall amounts for short rains (r^2= 0.672, p< .01) while 51.9% of variation in total irrigated crop yields in Kgs was explained by total amount of water used for irrigation in one season (r^2=0.519, p<.01). The study concluded that water availability majorly influence the variation of total food crop yields for both rainfed and irrigated crops in Kibwezi district. The food crops are grown for consumption and local sales from which the income obtained is used to acquire basic family needs like clothing, shelter, medicine, paying school fees hence improving their well-being.
Keywords: Water availability, rainfed irrigation, food crop production, livelihood, basic needs.

INTRODUCTION

Global policy interest in ecosystem services has increased in the past two decades with various studies being undertaken, because of the significance of ecosystems in providing services which are important to the livelihoods of rural people in developing countries [1, 2, 3]. Due to serious threats to ecosystem services in Africa, most researches have focused on the ecological and social impact of extraction of natural resources and other human activities[4] with little focus on the influence of water availability – an ecosystem service,on rural livelihoods. In East Africa, more than seven in ten poor people live in rural regions, with most engaged in ecosystem dependent activities, such as small-scale farming, hunting, handcraft selling, logging, livestock rearing or other ecosystem products [5]. However, these studies did not critically examine how water from these ecosystems significantly influences food crop production.

The regulating ecosystem services are a significant component of diversified livelihood portfolios both for home consumption and income generation [5]yet; there is paucity of information on the influence of water availability on food crop production as a livelihood in Kenya's rural areas. Kibwezi district has relatively many ecosystems evidenced by the UN gazzetted forests [6] and wetlands inform of rivers, streams and springs. Despite the few studies done in Makueni county [7, 8, 9] on ecosystem services, there ishardly no study which has been conducted on the influence of water availability as an ecosystem service on livelihoods specifically food crop production hence the need for carrying out this study.

LITERATURE REVIEW

Many aspects of the world's hydrological (water) cycle are regulated by the natural functions of ecosystems and associated geophysical processes which lead to availability of fresh water, essential for growing food, drinking, personal hygiene, washing , cooking among other uses [10]. A study by Anderson *et al.*[44] concluded that about 268 million people living in Africa’s arid and semi-arid areas (’drylands’), which comprise 43% of the continent’s surface area, 75% are rural dwellers whose livelihoods exhibit a strong reliance of ecosystems services. However, the study paid little attention on how water availability as an ecosystem service influence livelihoods of the rural dwellers. According to Pantaleo *et al.*[11], wetlands ecosystems in Tanzania provide wide ranges of economic benefits to the surrounding communities. For example, 95% of domestic, irrigation, industrial and livestock water was from the wetland ecosystems, 80% of traditional irrigation schemes depended on water from the wetland ecosystems, 95% of rice and vegetation production depended on water from the wetlands ecosystems. The study concluded that these ecosystems are often overlooked, UN appreciated and taken for granted. However, this study did not examine how water used from these ecosystems significantly influenced the crop yields obtained from irrigation.

A study by Rweyemamu, [12] reported that the wetlands of Bahi, Tanzania have enabled cultivation of paddy rice which contributed significantly to household food security generating 65.4% of the total household food crop production with the surplus production being sold for income. However, this study gave little attention on how water available from these ecosystems significantly influenced food crop production in the region. Other studies have concluded thatsince water is essential for life, the ecosystems associated with rivers and wetlands acquire special significance in dry land areas, being green corridors in an otherwise arid landscape, supplying a range of services that are of value to people [13]. However, these studies did not critically examine how water available from these ecosystems significantly contribute to the livelihoods of the riparian communities specifically food crop production. Further, Silvestri *et. al.*,[14] concluded that in areas with less rainfall, food crop production is possible and around more permanent water sources through irrigation. The relationship between the total amount of rainfall and crop yields obtained from the rainfed crops was not highlighted in the study. Mogaka[15] indicated that households in Kenya, living within a distance of 5 kilometres from the forests depend directly on forests for crop farming in different areas.

Forests are ecosystems which contribute to presence of rainfall which influence food crop productionyet, this was not highlighted in the study. Further the study paid no attention on how water from the forest ecosystem significantly influences the crop produce from the different areas.Anne *et al.*,[16] carried out a study on hydrology, ecosystem functions and livelihood outcomes on Nyando papyrus wetlands concluding that the wetlands were used for agriculture, grazing and papyrus harvesting. The study did not highlight the influence of water availability on crop production yet ecosystem functions provide services like water regulation which leads to water availability relied for agriculture. Therefore,fresh water is the most important regulating ecosystem service provided by different wetlands like rivers, streams and springs. Despite the above relevant researches on ecosystem services, there are still gaps of knowledge on how water availability influences food crop production as a livelihood specifically in rural areas of Kibwezi district of Makueni county, Kenya.

RESEARCH METHODOLOGY

Study area

Kibwezi district is located in Eastern region of Kenya at 2°24'40" south of the equator and 37°57'54" east of the Prime Meridian. It is one of the five districts in Makueni County. It has five divisions namely; MtitoAdei, Kibwezi, Makindu, Tsavo west and Chyullu hills game reserve, and fourteen locations namely; Kambu, MitotAndei, Masongaleni, Chyullu game reserve, Kikumbulyu, Makindu, Kiboko, Ngwata, Nguumo, Nthongoni, Nzambani, Tsavo West, Twaandu and Utithi. Tsavo west national park and Chyullu hills game reserve are found here. The study location falls between 2^0 30’ and 2^0 0’ and longitudinally falls between 37^o 30’ East and 38^o East. It has an area of $3{,}985 km^2$.

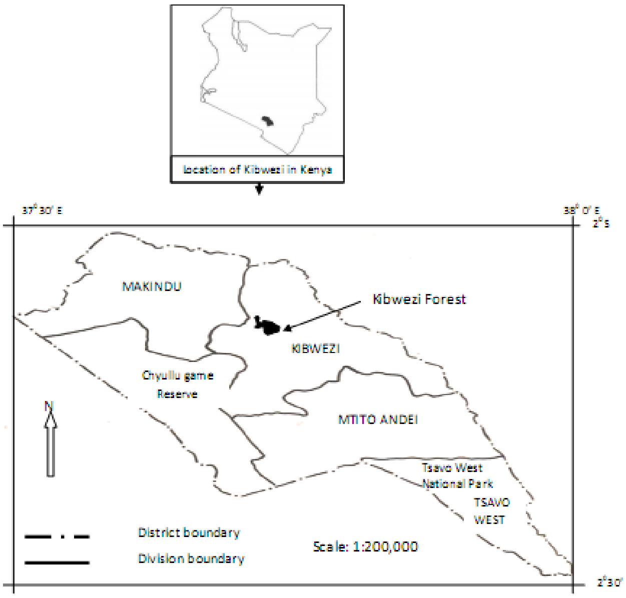

Fig. 1: Map of Kibwezi District
Source: Republic of Kenya, 2009

Research Design

The study adopted a cross-sectional descriptive design because data was collected at once from the study area and described to depict the contribution of ecosystem services on secure livelihoods basing on respondents’ perspectives. Descriptive research is a process of collecting data in order to answer questions concerning the current situation [17]. This survey was appropriate due to constraints of time and finance and hence it enabled the researcher to reduce operational costs and to collect data within the shortest time possible.

Study Population and Sampling Procedure

The study used cluster sampling and simple random sampling techniques to select respondents proportionally from the identified households basing on the list of names from ward executive officers. Cluster sampling technique helps in reducing travel costs and time and permits careful planning of the data collection process[45]. The various administrative clusters included divisions, locations, sub locations, villages and households. Therefore, a minimum sample size of 384 household heads was selected from a study population of 247,843 persons for the study. The list was generated from a computer randomly. Kibwezi district had a population of 247,843 persons (Makueni District Development Plan, 2010). Therefore, the study area had more than 10,000 people; and sample size was guided by the formula: $n = \frac{Z^2 pq}{d^2}$ [17], hence n=384. Where: n= the desired minimum sample size (when target population is more than 10,000), Z= the standard normal deviate at the required confidence level (Marginal error); at 95%, z=1.96, p= the proportion in target population estimated to have the Characteristics being measured.q= 1-P, d= Level of Significance. Therefore: at 0.05 Confidence level, Z =1.96, P= (50% =0.5) Hence; n = $\frac{(1.96)^2 \times (0.5 \times 0.5)}{(0.05)^2}$ = 384.

Thus, a total of 384 household heads were interviewed.

Data Collection Methods

Primary data was obtained from field surveys through the use of structured questionnaires, interviews, filed observation and photography. The structured questionnaires with both closed and open questions were self-administered by the researcher so as to give respondents clarification on questions that they could not understand. Secondary data was sourced from published and unpublished documentation. Quantitative data on crop yields and amount of water used for irrigation was collected using questionnaires and Key Informant Interviews who included two agricultural extension officers, one hydrologist, one officer from Kenya Agricultural Livestock and Research Organization(KALRO), director civic education Kibwezi district and head of Kyai irrigation scheme in Kibwezi location.

Data Analyses and Results Presentation

Data analysis began by coding questionnaire responses on computer coding sheets. Qualitative data on types of food crops grown and uses was analyzed by organizing and systematically creating themes, categories and patterns. The qualitative data was re-evaluated to determine the adequacy of the information, the credibility, consistency and the usefulness in answering the research questions.Quantitative data on crop yields and amount of water used for irrigation was analyzed by using percentages and means.Least squares regression analysis was usedto predict the relationship between rainfall amounts and amount of water used during irrigation and crop yields for both rainfed and irrigated crops. The results on the influence of water availability on food crop production as a livelihood were described and presented in tables, scatter plots, charts, frequencies, percentages and discussions.

RESULTS AND DISCUSSIONS

Sources of Water in Kibwezi District

The study established that there are various sources of water used by the residents of Kibwezi district. Majority of the respondents (70.3%) use rainwater while 79.2% use water from the boreholes, 23.4% use water from streams, and 29.7 % and 2.6 % a water from taps and springs respectively. Examples of the streams include Kiboko, Kibwezi, originating from Chyullu hills, MaangiUvungu- a tributary of KibokoRiver, Thange and Kathekani streams.Examples of the springs include Umani springs found in Kibwezi forest, Kiboko springs, Kibwezi springs and Uzima springs which is protected in Tsavo East national park.Key informant interviews revealed that rainwater was mostly reliable during rain seasons and its quantity was affected by unpredicted rainfall fluctuations (see Appendix 1). Despite the noted fluctuations, the rainwater received in the region is a product of ecological processes from the ecosystems. The results therefore reveal that water is obtained from different wetlands like rivers, streams and springs. This implies that wetlands ecosystems in the study area play a critical role in the provision of freshwater for human consumption and other purposes.

The finding of this study concur with the study by Mujwahuki[18] that 96.9% of the households in Muleba district, Tanzania use rainwater, 83.9% use water from swamps, 79% use water from springs, 23% use water from boreholes while 7% and 4.7 % use from rivers and lakes respectively. The findings further conform to the study by Morton and Kerven, [19] that large volume of water available to people living in dry lands is found in perennial and seasonal rivers that originate at higher elevations. A study by Niemeijir[20] established that water regulation in dry land ecosystems determines the allocation of rainfall for primary production and domestic uses. Further, Hutchinson and Herrman, [21] concluded that approaches to water accessibility in dry land areas range from development of groundwater resources through boreholes for domestic and productive uses. A study by Hesse, [22] reported that dry land ecosystems are also among the world's most variable and unpredictable environments where rainfall is low and erratic and there is high inter-annual climate variability.However, these studies did not specifically highlight that ecosystems play a significant role in contributing to the minimal rainfall available in these regions. Therefore, despite the rainfall variability and in the study area, the study concludes that wetland ecosystems in the area are key sources of water and the availability of rainfall is, by at large regulated and maintained by the ecosystem functioning and processes which support the livelihoods of the people in these areas.

Common Rainfed Crops

The study established that the common types of crops grown include maize, cowpeas, pigeon peas, green grams, beans, sorghum and millet.The total crop yields harvested were recorded in form of sacks where a sack weighed 90 kilograms. The results are summarized in Table 1.

Table 1:Common Rainfed Crops and Total Yieldsharvested by the Respondents

Common Rainfed Crops	Yields in Sacks (1 sack=90 Kgs)					
	0-2 (f) (%)	3-4 (f) (%)	5-6 (f) (%)	7-8 (f) (%)	9 and above (f) (%)	Total Number of Respodents out of 384 (f) (%)
Maize	43 (12.9)	73(22.2)	64(19.3)	57(17.2)	94(28.4)	331(86.2)
Cowpeas	85(41.2)	43(20.9)	39(18.9)	23(11.2)	16(7.8)	206 (53.7)
Green Grams	44(17.3)	48(18.9)	32(12.6)	31(12.2)	99(39)	254(66.1)
Pigeon Peas	82(27.4)	78(26.1)	40(13.4)	47(15.7)	52(17.4)	299(77.7)
Beans	78(35.0)	63(28.3)	42(18.8)	25(11.2)	15(6.7)	223(58.1)
Sorghum	221(73.4)	41(13.7)	12(4.0)	17(5.6)	10(3.3)	301(78.3)
Millet	169(52.2)	89(27.4)	35(10.8)	24(7.4)	7(2.2)	324 (84.4)

Key; f= frequency% =percentage of respondents
Source; Field Data

As depicted from Table 1, the study established that majority (86.2%) of the respondents grew maize with 28.4% harvesting more than 9 sacks, 53.7% grew cowpeas with 41.2% harvesting a maximum of 2 sacks, 66.1% grew greengrams with 39 % harvesting more than 9 sacks, 77.7% grew pigeon peas with 27.4% harvesting a maximum of 2 sacks, 58.1% grew beans with 35% harvesting a maximum of 2 sacks, 78.3% grew sorghum with 73.2% harvesting maximum of sacks, while 84.4% grew millet with 52.2% harvesting a maximum of 2 sacks.This can be interpreted that the respondents harvest enough for family consumption in one season while the surplus is sold locally for extra household income. The study established that the crops are intercropped as a coping strategy to unpredictable rainfall in that when some crops fail other may do well. Interviews with Agricultural Officer in Kibwezi district confirmed that crop cultivation during rainy season is a major livelihood which supports 80 % of food consumed by the households.

The findings of this study conform to a study by Mbuvi & Boon [7] who concluded that in Mwala division of Machakos district, despite the fact that rainfall amounts and distribution rarely meet crop water requirements, rain fed crop production constitutes 70% of household food. Further, a study by Niemiejir *et al*, [20]concluded that in India, the arid and semi-arid tracts contribute over 45% of agricultural production, 53% of the total cropped area, 48% of the area under food crops and 68% of that under non-food crop while, a study by FAO [23] concluded that dry lands account for nearly 80% of output of coarse cereals, 50% of maize, 65% of chickpea and pigeon pea, 81% of groundnut, 88% of soya beans and 50% of cotton. However, these studies did not critically highlight that rainfall is a product of ecological processes from ecosystems which support food crop production as a livelihood in the study area.

A correlation analysis was further undertaken to establish the relationship between total rainfall amounts for short rains season (October, November, December) and total crop yields for rainfed crops(Maize, Cowpeas, Green grams, Pigeon peas, Beans, Sorghum, Millet) harvested by the respondents in Kibwezi district. The results are shown in Figure 3.

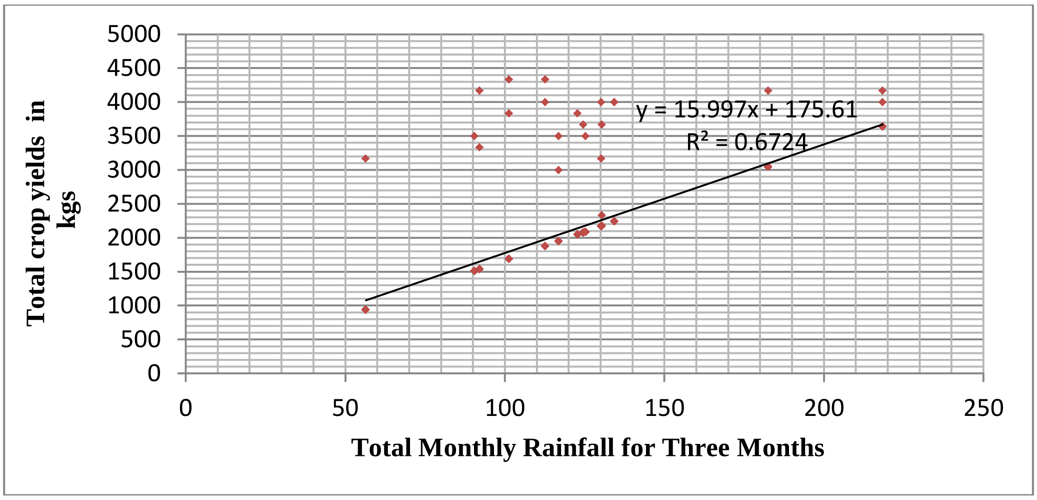

Fig.2: Relationship between Total Monthly Rainfall Amounts (Oct., Nov., Dec.) and Total Crop Yields for Common Rainfed Crops (See Table 4) in One Season (Short Rains-Oct., Nov., Dec. 2014).

The results in Figure 2 shows that the least square regression results of the relationship between the total rainfall amount for three months (October, November, December), and the total crop yields for common rainfed crops (Maize, Cowpeas, Green grams, Pigeon peas, Beans, Sorghum, Millet). The coefficient of determination r^2 yielded 0.672 (r^2 =0.672, p<.01). Rumsey asserted that where r^2 fell between 0.20 and 0.70, one variable (x) explained the variability in (y) variable.Therefore,this shows that 67.2% of the variation of total rainfed crop yields in Kgs in Kibwezi district can be explained by total monthly rainfall for short rains (October, November, December) during the year 2014 (see Appendix 1). Apparently, 32.8% of the variation of the total crop yields can be accounted for by other factors which were not part of this study.

According to Alberto [47], variations in subsistence food crop yields could also be accounted by other non-climatic related factors such as application of fertilizers, use of pesticides, and improved seeds to increase food crop production. Therefore, these results are consistent with a study by Ayanlade *et al.*,[24] who observed a significant relationship between total seasonal rainfall amounts with subsistence food crop yields in Shaki, Ethiopia. Also, similar results were reported by Yengoh *et al.*, [25] that the amount of rainfall and its distribution in different seasons over the years largely influenced the productivity of food crops in semi-arid regions of Africa. Basak, [26], reported that low rainfall amounts may lead to drought events which lead to either yield decline or crop failure. Usman and Reason [27] noted that the distribution and length of the period of rain during the growing season and the effectiveness of the rains in each rainfall event is the real factor that affects crop yields for different rainfed crops. Therefore, it can be deduced that rainfall which results from ecosystems processes is an important factor which influence food crop production in Kibwezi district. The rainfed crops grown in Kibwezi district are subsequently discussed below.

Maize (*Mbemba)*

According to 86.2% of the households, maize is a staple food which is grown in the study area. Maize is grown for the purpose of consumption and local sales when there is sufficient rainfall. Interviews revealed that maize is majorly grown during rainy seasons. Varieties of maize grown include Katumani, KDV1, KDV2, KDV 4, WE 1101, KH 500-21 A., DH02, KCB/DLC and Duma 43. Through interviews, the study established that these species are early maturing, drought and heat resistant, disease and pest tolerant, also able to yield under other stresses. The income is made for buying food, paying fees, buying clothes se they suite the climate and take short time of 3 months to maturity. The study revealed that maize contributes to livelihood of the households through supply of staple food for consumption and local sales.The estimated average income for the two rainy seasons after sale is Kshs.50, 000 for average harvest of 10 bags per household. In respect to the use of income obtained from maize harvests, 90% of the households indicated paying of school fees, health care, and attaining other basic needs like clothing and shelter.

A study by Baigorria*et.al.*, [28]concurred rainfall amount and maize crop production is correlated in that increase in rainfall amounts leads to high yields of maize while decrease of rainfall is associated with decline of maize production. For example, in South East United States in 1988 total rainfall amounts were 500 mm and 500 kg/ha1 maize yield was harvested, whereas, in 1989 there was about above 550 mm of rainfall and 10,000 kg/ha1 of maize yield was harvested. Further, EIAR, [29] reported that maize production in the dry lands is becoming increasingly important, with about 40 percent of the national total maize produced in these drought-stressed areas. For example, a variety of Maize Melkasa -1 it's maturity is 85 days; flowering is 48 days, yield 2.5–3.5 t/ha in research center while in farmers' field 2.5–3.5 t/ha; 1000 its tolerant to rust and blight and is extra-early maturing. This variety is well adapted to low rainfall semi-arid areas of Ethiopia with rainfall ranging 450–570 mm. Therefore, within the same environmental conditions, maize is grown and the residents of Kibwezi district are able to get food for consumption.

Beans (*Mboso*)

The study established that beans are grown by 58.1% of the households in the study area. A bean is a leguminous crop grown in all parts of the study area and is the cheapest source of plant protein for the households in the study area. This crop is intercropped with maize in and in rare cases grown separately. Interviews with the agricultural officer in Makindu division established that the different varieties of beans grown include Kat B; Kat B9; Kat X56. These varieties are early maturing, drought resistant and high yield. The crop is grown for consumption and local sales in the nearby market centers of Kibwezi, Makindu and MtitoAndei. The findings of this study conform to the study by World Bank [30] that cereals and legumes constitute the main crops and basic food for 800 million people in dry lands and that, large part of the dry land population depends on crop as a livelihood and contributes significantly to the gross domestic product and trade. Burke and Lobbell[31] reported that farmers' choices about what crops to grow depended largely on rainfall distribution and amounts. Burke and Lobbell[31] further added that the highly variable rainfall in most parts of Africa force farmers to grow lower-value and high value but drought – tolerant crops such as cassava and beans.

Green Grams (*Ndengu)*

The study established that green grams are grown by 66.1% of the respondents in the study area. The varieties grown are N26 (*Nylon*) and KS20 (*Uncle).* Household interviews revealed this crop is highly preferred due to high yields, good nutritive value, the earliness and drought resilient features and its reasonable good prices. Household questionnaires revealed that this variety is used commonly in paying of school fees. A study by Kidane*et al*. [32] several legumes exhibit good drought and heat resistance, which makes them potentially very valuable for crop diversifications in low rainfall conditions.

Sorghum (*Muvya*)

The study established that sorghum is grown by 78.3 % of the households in the study area. The sorghum (locally known as *Muvya)* species are *Seredu*, *Kari Mtama* I and *Gadam.* The study established that this crop is grown for consumption and local sales. The varieties preferred combine high yielding capacity with earliness, disease and pest resistance. A study by Kidane*et al.*[33]concurred that sorghum is a very important crop in the Ethiopia with a high genetic potential grain yield of 7.0 to 9.0 t/ha. Alves and Setter, [34] noted that sorghum requires annual average rainfall between 450 mm and 650 mm which is well distributed. Other studies by Kikoti[35]; Butler and Kosura[36] established that the diversity of land types and crop types used by different communities living in the same region reduces people's vulnerability by providing livelihood options to fall back on, in case crops or landscapes are negatively affected by catastrophes.

Peagon Peas (*Nzuu)*

According to 77.7 % of the respondents, peagon peas are grown in the study. The species grown include Mbaazi 1 and KAT 60/8. The crop is also grown for consumption and local sales. The study found that harvests range from 6-10 bags depending on the size of the farms. Those households with more than 3 Ha farms harvest more than 10 bags. The income generated from selling the extra harvests is used to purchase the family basic needs. The study established that pigeon pea is high value and multipurpose legume crop with similar uses to beans. It is a drought resistant crop which improves soil fertility by fixing nitrogen. Cow peas are also grown in the study area and the varieties include M66, K80, KVU 27-1. A study by Kidane*et al*.[32] concurs that pigeon pea can produce wood for energy supply, biomass for animal feed and thus a multipurpose crop which integrates and livestock production in dry lands ecosystems.

Millet (*Mwee*)

The study established that 84.4% of the respondents grow millet. Interviews revealed that millet is grown for consumption and excess is sold to the local market. The varieties grown include *pearl* millet and *finger* millet. Harvest rage from 5-6 bags of millet per household per season. Each bag is equivalent to 90 Kgs. Interviews with agricultural officer and household questionnaires revealed that a bag is sold at Kshs, 2,800 and this generates an income of Kshs.168, 000 per year per household. This income is used to support the family in acquiring the basic needs like alternative sources of food, clothing, and paying fees and to some extend paying the dowry.

Irrigation

Majority of the respondents (76.6%) were involved in carrying out irrigation in various parts of the study area as shown in Figure 3.

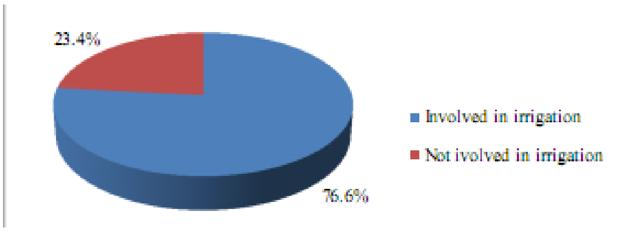

Figure 3: Percentage of Respondents Involved in Irrigation in Kibwezi District
Source, Field Data

The study established that 76.6% of the respondents carried out irrigation while those who were not involved in irrigation were only 23.4.6% of the respondents. This implies that due to water availability, the respondents of the study area are able to carry out irrigation on various food crops for consumption and local sales. Therefore, the local communities in the region rely on water for crop farming as a livelihood. Through observation and household interviews, the study established that irrigation was done along permanent rivers of Kiboko, MaangiUvungu, Thange and Kibwezi. Irrigation along Kibwezi River started in 1950s with 100 acres (40 hectares) under the name KwaKyai Irrigation Scheme. Small pockets of respondents used bucket kits to irrigate kitchen gardens outside the scheme. Through observation and household questionnaires, various vegetables are grown under irrigation by the households along KibokoRiver. According to 76.6% of the households, different food crops are grown for example;Maize, Kales (*Sumuma wiki*), spinanch, cabbages (*Gloria f1 highbrid*), cucumber (*cucumissativus*) sweet peper*(ndulu)*, tomatoes (*roma*), pumpkins (*curubita*), baby corn, fruits like paw paws, watermelon (*cirtrulluslanatus),*Ochre *(Mbinda),*Asian vegetablesfor example *brinjal, ravaya, chilli, okra, karalla, guar, dudhi, turia,* curry leaves, *patra* and *saragua*and onion (see Table 7) .The study established that these food crops are grown for consumption and local sales at nearby market and town centres Kibwezi, Emali, Makindu, MtitoAdei and others transported to major cities of Nairobi and Mombasa.

The findings of this study concur with a study by FAO [23]that past efforts to increase crop production in dryland regions in Africa, from the 1930s to 1970s, centred on the establishment of small scale and large-scale irrigation schemes such as the Gezira Scheme in Sudan, Chokwe Irrigation Scheme in Mozambique, Senegal and in Burkina Faso all creating employment to those working on these farms. UNEP, [37] established that the services provided by ecosystems like water regulation are crucial to fulfilling the needs of a growing population like food provision through irrigation agriculture.Further, FAO, [23] reported that many efforts in dry land sub-Saharan Africa have focused on large irrigation schemes, construction of dams as well as borehole construction, to improve water supply mainly for agricultural production and improvement of livelihoods. Niemeijer, [20] concluded that water provision service is critical for maintaining wetlands within the dry lands, to enable these ecosystems to provide a package of services of great significance to the local communities. Therefore, like in other parts of the world, irrigation is essential for the residents of Kibwezi district since it ensures provision of household food through which surplus is sold for income to acquire family basic supplements.

Amount of Water Used for Irrigation

The total amount of water used by the respondents for irrigationranged from 0 –more than 1000 litres. All the respondents irrigated their farms a minimum of two times in a week. The irrigation was majorly done on dry season (Jan, February, March) when there is very little or no rainfall. The food crops therefore relied on water used during irrigation. Table 2 shows a summary of approximate total amount of water used once during irrigation.

Table 2:Approximate Amount of Water used once for Irrigation by the Respondents

Number of Liters used once during irrigation	No. of Respondents	Percentage (%)
0-100Liters	3	1.1
100-200 Liters	42	14.3
300-400 Liters	51	17.3
More Than 500 Litres	198	67.3
Total	294	100.0

Source; Field Data

As depicted form Table 2, majority of the households (67.3%) use more than 500 liters of water for irrigation per irrigation, 17.3% use 300-400 litres per irrigation, 14.3% use 100-200 litres while only 1.1% uses 0-100 litres of water per irrigation.This can be interpreted to mean that the available wetland of rivers and streams provided water which could be used for irrigating several food crops in the region. The study established that all farmers carried out irrigation twice in a week. Irrigation was done for a period of three months upon which the planted crops could be harvested for consumption and local sales.

Similar results were reported by Morton and Kerven[19] that irrigated agriculture is a specific and important alternative livelihood, which has been increasingly practiced by people in the Horn of Africa. Further, a study by World Bank [30] reported that food crop production through irrigation is an important source of livelihood for the majority of rural people since about 2.5 billion of the developing world's 3 billion rural inhabitants are in households involved in agriculture, with 1.5 billion of these in smallholder irrigation agriculture. Alves and Setter [34] concluded that food crops require soils with moderate moisture during dry seasons hence it's important for subsistence farmers to protect their crops through utilizing the available water sources. Thus in Kibwezi district, households use available water from rivers, stream and springs to do irrigation which leads to production of varieties of food crops for consumption and local sales for household income generation.

Irrigated Crop yields

Total yield harvested from different crops grown by the respondents was recorded in sacks. Each sack was equivalent to 90 Kgs and the harvests were taken for one season. The summary is shown in Table 3.

Table 3: Total Crop Yields Obtained from Crops Grown under Irrigation

Food Crops	Yields in Sacks (1 sack=90 kgs)					Total Number of Respondents
	0-2	3-4	5-6	7-8	9 and above	
	(f) (%)	(f) (%)	(f) (%)	(f) (%)	(f) (%)	(f) (%)
Kales	43 (14.6)	53(18.0)	57(19.4)	64(21.8)	77(26.2)	294(100)
Maize	40(13.6)	50(17.0)	52(17.7)	77(26.2)	75(25.2)	294(100)
Spinach	49(16.7)	53(18.0)	141(48.0)	42(14.3)	9(3.1)	294(100)
Orchards	42(14.3)	35(11.9)	78(26.5)	87(29.6)	52(17.7)	294(100)
Baby corn	137(44.6)	147(50.0)	10(3.4)	00(00)	00(00)	294(100)
Asian Vegetables	239(81.3)	46(15.6)	5(1.7)	2(0.7)	2(0.7)	294(100)
Fruits-pawpaw, watermelon	166(56.5)	89(30.3)	35(11.9)	2(0.7)	2(0.7)	294(100)
Yields in Crates						
Tomatoes	18(6.1)	64(21.8)	73(24.8)	88(29.9)	51(17.3)	294(100)
Onions	94(32.0)	122(41.5)	62(21.1)	10(3.4)	6(2.0)	294(100)

Key; f= frequency %= percentage of respondents
Source; Field data

As depicted from table 3, 21.6% harvested 7-8 sacks of Kales, 25.2% harvested 9 and above sacks of maize,48.0% harvested 5-6 sacks of spinach in a season,29.6% harvested 5-6 sacks of Orchards, 50.0% harvested 3-4 sacks of babycorn,81.3% harvested 0-2 sacks of Asian vegetables, 56.5% harvested 0-2 sacks of fruits, 29.9% harvested 7-8 crates of tomatoes while 32.0% harvested a maximum of 2 sacks of onions in one season. This implies that all respondents who planted food crops could harvest for either consumption or local sales. The yields obtained were sold in the nearby market or town centres of Kibwezi, Makindu, MtitoAndei and others like the Asian vegetables transported to big cities of Mombasa and Nairobi.Thus water available from Kiboko, Kibwezi, Maangi Uvungu and Thange rivers in Kibwezi district have enable the residents in the region to carryout irrigation for food crop production as a livelihood, harvesting different crop yield for consumption and local sales from which income obtained is used to acquire basic family needs.

The results of this study agree with the findings by Pantaleo *et al.*[11] and Rweyemamu, [12], who concluded that 80% of traditional irrigation schemes depended on water from the wetland ecosystems like rivers with 95% of the crop produce being rice and vegetation. Connor and Palta[38] noted that water deficit for at least two months or in the early growing period can reduce food crop yields. Thus, irrigation in Kibwezi district is important in that it ensures constant supply of water which is essential for plant growth hence ensuring food crop production as a livelihood by the residents in the region.

Regression analysis was further undertaken to establish the influence of the total amounts of water used on crop yields obtained by the respondents carrying out irrigation.The results are summarized in Figure 4.

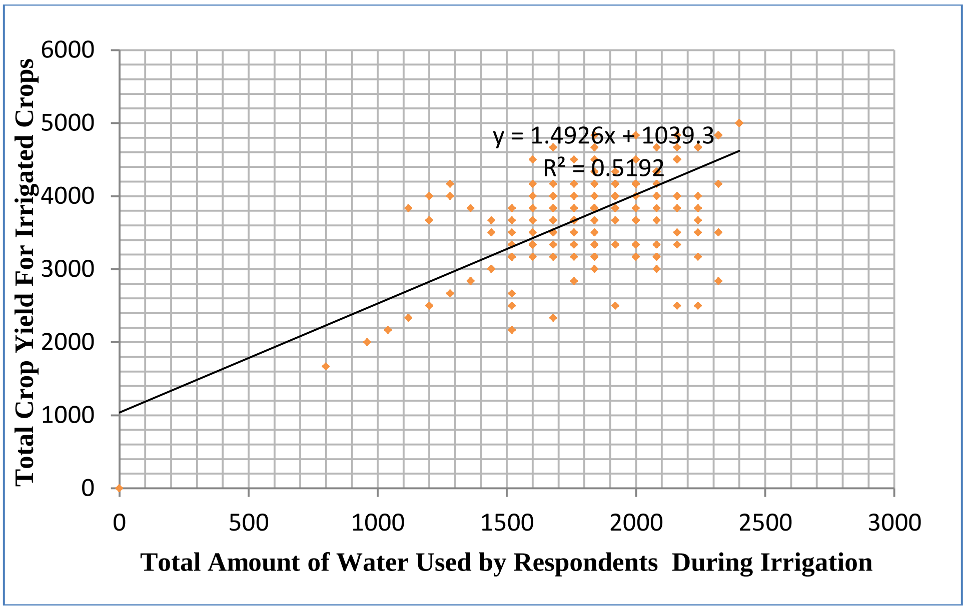

Fig. 4: Relationship between Total Amounts of Water Used by Respondents during Irrigation (Jan., Feb., Mar.) and Total Crop Yields for Irrigated Crops (Kales, Maize, Spinach, Orchards, Baby Corn, Asian Vegetable and Fruits).

Figure 4 shows the least square regression results for the relationship between the total amount of water used by the respondents during irrigation in dry season (January, February, March) and the total crop yields from irrigated crops ((Kales, Maize, Spinach, Orchards, baby corn, Asian vegetables and Fruits). The coefficient of determination r^2 yielded 0.519 (r^2=0.519, p<.01). Rumsey asserted that where r^2 fell between 0.20 and 0.70, one variable (x) explained the variability in (y) variable. Therefore, this shows that 51.9% of the variation of the total crop yields in Kgs from irrigated crops can be explained by the total amount of water used by the respondents during irrigation. Hence, 48.1% of the variation of the total irrigated crop yields can be explained by other factors which were not considered in this study. According to Lal[39] crop yields for irrigated crops can be achieved on agricultural land through use of primary and secondary plant nutrients, liming of acid soils to raise PH, use of herbicides and transgenic insect control among other factors. Therefore, it can be deduced thatwater availability accounts for 51.9% of the total crops yields for irrigated crops because agricultural crops are so dependent on water and purposely adding water beyond what naturally falls as rain is crucial to ensuring plant growth thus increasing crop productivity.

The findings of this study conform to a study by Molden *et al.*, that in irrigated agriculture, water taken up by crops is partly or totally provided through human intervention whereby irrigation water is withdrawn from a water source like a river, lake or an aquifer and led to the field through an appropriate conveyance infrastructure. Further, Burke and Moench reported that for vegetative growth and development, plants require, within reach of their roots, water of adequate quality, in appropriate quantity and at the right time which is best achieved through irrigation from various sources like rivers and streams.According to FAO [23], Plant growth is dramatically affected by the amount of water used during production hence optimum growth and quality of plants leading to good produce can only be achieved if water is supplied throughout the growing period.

It is therefore worthy noting that, the influence of rainfall amounts on rainfed food crop production has the highest influence (67.2%) because rainfall exerts an overall control on water availability for plant growth and is a major factor that determines the production of subsistence crops. Its availability through ecological processes majorly influences crop production. As observed by Medug[41] rainfall are the primary source of moisture and probably the most important factor determining the productivity of rainfed crops. Ramesh and Goswami, [40] reported that food crop production in India was observed to be highly correlated with the seasonal and annual rainfall amounts. Further, Baigorria *et al.* [28] concluded that rainfall is known to be one of the most important weather factors for crop yields. Water availability for irrigation accounts for 51.9% variation in total crop yields for irrigated crops because this water is accessed from rivers and streams which are also relied on for other domestic uses by the local communities. However, the available amount is able to contribute to food crop production through which various crops are raised. Oweis and Hachum[42] concluded that irrigation ensures a constant supply of water, which is essential not only to crops growing but also to the quality of the crop. Further CA, [43] reported that irrigation helps in raising a crop where nothing would grow, more profitable crops are grown and increases the yields of different crops grown.

CONCLUSION

The study concluded that water sources in Kibwezi district are rainfall (70.3%), boreholes (79.2%), streams (23.4%), tap (29.7%), and springs (2.6%). Water availability majorly influence variations in total crop yields grown by the residents of Kibwezi district whereby, the totalamount of rainfall received in Kibwezi district in one season explains 67.2% variations in total crop yields in Kgs for rainfed crops(r^2= 0.672, $p< .01$) while the total amount of water used during irrigation explains 51.9% variations in total crop yields in Kgs for irrigated crops (r^2=0.5192, $p<.01$). Therefore,ecosystems regulate water leading to water availability through rainfall, rivers, streams and spring flows which enable irrigation to be carried out especially in semi-arid areas. Through rainfall and irrigation, morefood crops are grown and harvested for home consumption and local sales from which income is generated for the purchase of goods and services such as supplementary food items, clothing, shelter, educational fees among other social obligations hence improved family wellbeing.

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Appendices

Appendix 1:Rainfall (mm) Distribution in Kibwezi District

Years	J	F	M	A	M	J	J	A	S	O	N	D	Annual Rainfall
2000	3.9	TR	14.5	123.2	2.5	2.4	0.7	3.4	5.1	TR	185.5	179.8	521.0
2001	160.1	1.8	50.9	89.0	0.2	1.9	0.0	0.0	TR	0.1	278.4	148.0	730.3
2002	22.3	7.2	108.1	43.1	30.1	0.4	TR	4.1	19.5	25.9	99.5	131.2	491.4
2003	0.3	34.6	79.5	79.1	34.6	0.0	0.0	TR	0.6	0.6	67.4	65.3	362.0
2004	169.3	63.4	72.2	45.7	0.0	0.3	0.0	0.2	1.2	26.0	33.6	89.3	501.2
2005	4.0	TR	51.6	44.5	28.8	TR	0.4	2.9	1.6	14.5	71.4	6.1	225.8
2006	2.2	0.2	42.5	103.5	45.1	0.0	0.0	TR	6.8	57.2	252.8	363.3	873.6
2007	103.2	5.6	51.7	44.7	5.9	1.1	0.3	TR	TR	12.0	130.5	112.9	467.8
2008	57.7	7.3	222.4	13.4	1.0	0.0	0.0	0.0	1.3	14.2	82.5	5.8	405.6
2009	29.3	13.4	1.2	38.2	13.1	0.3	0.0	TR	TR	75.6	54.5	161.1	368.7
2010	11.8	121.4	160.7	63.6	13.5	0.0	0.0	TR	1.2	3.6	109.0	52.8	537.6
2011	12.9	47.8	111.0	1.5	4.1	0.0	TR	0.1	0.3	26.1	133.0	114.0	450.8
2012	3.7	5.9	24.4	155.1	20.5	19.5	TR	2.5	0.3	1.5	144.7	153.3	521.8
2013	31.2	TR	52.2	83.5	32.1	0.0	0.0	0.0	15.0	0.4	204.9	101.6	520.9
2014	TR	49.0	201.4	42.2	7.2	TR	TR	TR	3.0	TR	117.0	78.1	498.7

Source: Kibwezi District Hydrological Office, 2015 (TR=Trace, Un measurable Amount)