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Socioeconomic Perspectives of Jain Irrigation Project in Kibwezi, Kenya

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Executive Summary

Poverty reduction is an overriding goal for most countries in sub-Saharan Africa (SSA) where majority of the poor live in rural areas mostly depending on rain-fed agriculture for their livelihoods. On the other hand, small-scale irrigation provides a large potential for achieving the region's overarching goals of food security and poverty reduction. This study was therefore designed to evaluate the socioeconomic impacts of the Jain Drip Irrigation Project in Kibwezi, which was implemented to address food security and income generation.

The specific objectives of the study were to: collect and review all the available data on the overall performance of the project, particularly on the agricultural, social, institutional and commercial aspects; carry out economic and social analysis on the performance of the project; evaluate the impact of the project, especially to determine its contribution towards the standard of living, income generation, employment creation and the potential to reduce rural to urban migration and dependence on drought relief; and document lessons learnt about what has made the project achieve or not achieve stipulated project objectives.

In the short term, the Jain drip irrigation project brought immediate benefits, which included increased crop and livestock production for food and sale, translating to increased income and employment, especially for the youth and women. The cyclic annual dependence on relief food was eliminated, especially when implementation of the project was at its peak. The outcome from the project implementation was improved livelihoods in terms of improved health, better security and housing, as well as improved family relationships.

However, the benefits from the Jain drip irrigation project were short-lived because there was minimum involvement of beneficiaries' right from the start of the project. The users were not sensitized or trained on the use of water (a public good) and there were no management and leadership structures in place to manage the project. This resulted in what is termed as the "Tragedy of the Commons" (where the public good-water- is used by all but the benefits are entirely private), where users were maximizing gains, resulting in mismanagement.

Politicians also interfered with the project by pitting the users against one another, thus not allowing project design rules to be followed; an institutional failure. This resulted in farmers in Kwa Kyai (the water source) not willing to share the water with Kake and Masimbani by closing the water valves. There was also no maintenance of the drip lines, to the extent that there were leakages resulting in water losses. Drip lines were then vandalized and used for unintended purposes. Other partners who would have built capacity among the end users of the irrigation project were also not involved.

The failure of the Jain irrigation project brought about animosity in the community because of the conflicts that resulted from its mismanagement. After the project ended, the once improved livelihoods that came with the Jain Drip Irrigation Project deteriorated; food insecurity set in, incomes reduced, unemployment increased, thus prompting men to leave home to seek employment elsewhere; exacerbating rural-urban migration.

Despite the failure of the irrigation project, the users learnt the importance of collective action, good governance and management of a public good to make it beneficial to every stakeholder, and for sustainability. According to the farmers who attended the Focus Group Discussions (FGDs), the project implementers should have managed the project for at least one year before handing it over to the local communities.

It was recommended that the National and County governments should revisit the issue of irrigation in Kibwezi, with a view to more efficiently using the available water for irrigation and serving more farmers. It is also important that such effort should sufficiently involve the local community, particularly those in Kwa Kyai who are currently benefiting from the water under flood irrigation. A committee to manage the water use should then be put in place where all benefiting communities are represented with an overseer from the government. The beneficiaries should also be sufficiently trained both on water management and production of crops under irrigation. Other relevant government ministries, such as Agriculture, Livestock and Fisheries and Office of the President should be involved.

Background

Poverty reduction is an overriding goal for most countries in sub-Saharan Africa (SSA) where majority of the poor live in rural areas, mostly depending on agriculture for their livelihoods. However, agricultural productivity in this region remains weak and uncompetitive due to non-adoption of improved technologies, weak linkages and interaction between stakeholders, poor infrastructure and unfair competition from open market operations, among other factors (Kirsten, *et al.,* 2009). In addition, the agricultural sector in SSA, is highly constrained by its dependence on rainfall, which limits production to one or two seasons per year mostly in the high and medium potential areas; although, currently there is increased vulnerability due to climate change, which is exacerbated in the drier areas. Thus, small-scale irrigation provides a large potential in sub-Saharan Africa (SSA) for achieving the region's overarching goals of food security and poverty reduction (Namara *et al.,* 2010).

In Kenya, the agricultural sector is a major driver of the economy and livelihoods for majority of the population through provision of employment, food security, and foreign exchange earnings (ASDS, 2010; ASTGS, 2019). Over 80% of the country is arid and semi-arid lands (ASALs) and only 17% is classified as medium to high potential (ASDS, 2010).

Despite the fact that most of Kenya's landmass is in ASALs, most of its agriculture is rain-fed. As a result of its strong reliance on rain-fed food production systems, the country has become increasingly vulnerable to food supply disruptions and shortages. However, this challenge could be reduced considerably through increased development and use of water irrigation in both smallholder and large irrigation schemes. Kenya's level of irrigation is low; less than 1% of the landmass (ASTGS, 2019). However, the Government of Kenya targets to irrigate over 803,000 hectares of land by 2025 from the current 105,000ha (FAO, 2015). In addition, according to Kenya's long-term development blueprint, Vision 2030 (covering 2008 to 2030), the government targets to strategically develop more irrigable areas in ASALs, as well as intensify production in the already existing cultivated land through small and large-scale irrigation. The indicators of irrigation potential in the area include availability of water from perennial rivers or dams; ability to irrigate with minimal cost, e.g. water flowing by gravity; and agricultural potential for growing high value crops that can sustain cost of irrigation. In addition, the farmers recognize the need and are eager to irrigate.

Kang'au (2011) revealed that irrigation agriculture in Yatta and Kakuzi had challenges that included lack of market information, over-reliance on traditional irrigation and lack of technical assistance. From the findings, they recommended a multi-approach strategy towards irrigated agriculture and clear policies regarding water use for agricultural production to reduce water withdrawals and wastage, with a structured monitoring and evaluation system.

It is notable that over time there has been a shift in the irrigation policy in Kenya from the unsustainable top down management of large irrigation schemes to facilitation by the government with greater involvement of the community participating in planning, implementation and operations (Muteero and Kabutha, 2000; Ngigi, 2002). This policy shift emphasized greater beneficiary participation through cost sharing, cost recovery and gradual liberalization and increased private sector involvement (Ngigi, 2012).

Problem Statement

Food insecurity and low income generation among rural households is the major problem of majority of Kenyans, including high poverty levels that are estimated to be about 46%. Both large and smallholder irrigation activities have been promoted as a means of ensuring food security as well as improving the living standards of rural people. One of the initiatives included the Smallholder Drip Irrigation Project at Kibwezi, Kenya. However, information on the socioeconomic impacts on the targeted communities of such irrigation projects was scanty. Often, questions are raised about the socioeconomic impacts and sustainability of smallholder irrigation projects. Specifically, such questions include:

- Are smallholder irrigation projects economically viable?
- What are the key socioeconomic impacts of the irrigation projects?
- Are the projects sustainable?
- Are farmers able to manage these projects after withdrawal of donor support?

Nonetheless, despite the many challenges encountered in irrigation agriculture, there is great potential in irrigation activities in the country.

History of the Kibwezi Drip Irrigation Project

The drip irrigation project is located in Kibwezi East and Kibwezi West Sub-Counties and covered three schemes: Kwa Kyai, Kake and Masimbani. It is situated next to Dwa Sisal Estate, which uses the Dwa natural spring water, adjacent to River Kibwezi for irrigation.

The Kwa Kyai Scheme was started by the management of Dwa Sisal Estate, whose workers (mainly from the Akamba community) were settled and each household allocated about two acres. A furrow irrigation system was introduced to the scheme in 1952, which could irrigate up to 400 acres. Kake was the ancestral land of the Akamba people, while Masimbani, now a settlement scheme, was initially leased to DCK, a German firm, which was producing flowers. When their lease ended in 1982, the Germans left and the land was subdivided and given to individuals. The demarcation and settlement happened in 1992 with settlers coming from Kyulu, Kasayani and Kalembwa/Kalembani.

The quest for irrigation water in Kake and Masimbani followed different trajectories. In 2005, a group of 800 farmers in Masimbani wrote a proposal requesting for water from development partners and well-wishers. Later, this proposal was given to Hon. Charity Ngilu, the then Minister for Water Development. Around the same time in Kake, 35 farmers from two groups (Kevanda Women Group and Kasemeni Self-Help Group) visited Utuone Development Organization (UDO) in Machakos, whose leader was linked to a development organization called *"Excellent"* and which was searching for water. The group leader also linked them to Hon. Charity Ngilu who promised to explore the possibility of supplying water to the three schemes using the already available water that was being used in Kwa Kyai Scheme. Consequently, Hon Ngilu sought for irrigation experts from India (Jain Irrigation System) to work with local experts.

A team of irrigation experts, comprising county representatives and National Irrigation Board (NIB) was then sent from Makueni to undertake the survey of the proposed irrigation scheme. The survey found that, to change from furrow to drip, 800 acres could be irrigated with the same amount of water that had irrigated400 acres under furrow irrigation in Kwa Kyai. The extra water could be provided to Kake and Masimbani using drip irrigation, which were then under rain-fed farming.

Consequently, the local irrigation experts, together with Jain[1] Irrigation experts, under the leadership of the National Irrigation Board (NIB) were instructed to put up structures for drip irrigation in the three schemes. It was not clear from the findings why Jain irrigation experts were chosen or if there was tendering. The irrigation design was such that 400 acres were to be in Kwa Kyai, and 200 each in Masimbani and Kake.

Organization and Objectives of the Drip Irrigation

After the irrigation infrastructure (Inlet (Figure 1), drip lines, filtration and fertigation chambers, and pump houses) was laid out at the three scheme sites, the management of the irrigation water was left to water committees, composed of locals within each scheme. The committees were charged with the responsibility of maintaining the irrigation infrastructure, rationing of water among users, conflict resolution and water catchment conservation.

Figure 1: Inlet for the Drip Irrigation System

The aim of the project was to ensure that each household had one acre under drip irrigation. However, only land along the pipeline could be irrigated, implying that farmers not adjacent to the pipeline could not irrigate. Therefore, to ensure that all the targeted farmers accessed the irrigation water, there were differences in operations in each scheme. For instance, in Masimbani, each household adjacent to the pipeline could irrigate three acres; one acre for themselves and two acres for two other farmers (not adjacent to the pipeline) on mutually agreed terms. The government initially covered the labour costs for management of irrigation infrastructure, including security, repairs and maintenance costs (e.g. the fertigation unit, Figure 2). These costs were to be passed on to the respective irrigation committees once the new arrangement stabilized.

[1] Jain was nominated by the Indian Government on a government to government procurement agreement.

The farmers who had access to water were organized into groups of fifty; each group was expected to grow one crop per season while rotating with other crops in subsequent seasons, thus establishing a crop rotation system in the scheme. The idea was to produce sufficient volumes of the preferred crop to facilitate collective marketing. Demonstrations were undertaken on production and marketing of proposed commodities: green maize, baby corn, watermelon and tomatoes. Each farmer then grew the crop they had been trained on by the Ministry of Agriculture and chemical companies.

In Kake, although the quest for irrigation water was initiated by 35 farmers, the scheme was planned for at least 200 farmers, each with one acre under irrigation. However, the 35 decided to each have as many acres as they wanted, with some of them irrigating up to 7 acres. On the average, the committee members each had four acres, while ordinary members took 2 acres each. Although they got the water for free, in a quest to get to the 200 farmer requirement, which had been agreed upon by the scheme water management committee, they started selling the water to other farmers at a cost of KES 50,000 per acre per season. This was exacerbated by each farmer making individual agreements with the farmers they sold water to without necessarily following the guidelines. Some of the non-members were able to pay, while others were unable, thus causing confusion and conflicts. Internal mechanisms were put in place to handle grievances, which were addressed in committee meetings or general baraza, when organized for all members in the scheme. But this did not solve the problem of exploitation.

Figure 2: Water Purification and Fertigation Unit

In Kwa Kyai, all the 400 farmers under furrow irrigation were targeted for drip irrigation. However, due to internal squabbles, not all farmers accepted drip irrigation. For every three acres, a gate valve was installed; but some farmers did not allow water to go past their fields, which created further conflicts among members. As a result, at the farthest points of the scheme, the water pressure was low and such farms were unable to receive the water.

The objectives of the drip irrigation system were to (i) efficiently use available irrigation water in Kwa Kyai and the adjacent schemes of Kake and Masimbani, (ii) increase area and production under irrigation, and (iii) increase food security and farmer incomes through enhanced input use and linkages to markets.

Objectives of the Socioeconomic Impact Assessment Study

Literature shows multiple benefits of irrigation projects (Mathew *et al.,* 2018). However, there are differences in the extent of the benefits partly due to differences in design, scale, enterprise and location of such projects. With respect to the drip irrigation project in Kibwezi, little information was available on its possible socioeconomic impacts. Therefore, this study was designed with the broad objective of

“evaluating the socioeconomic impact of the Drip Irrigation Project in Kibwezi”. Specifically, the specific objectives were to:

1. Collect and review all the available data on the overall performance of the project since it started operation, paying particular attention to the agricultural, social, institutional and commercial aspects.
2. Carry out economic and social analysis on the performance of the project.
3. Evaluate the impact of the project, paying particular attention to its contribution towards standard of living, income generation, employment creation and the potential to reduce rural to urban migration and dependence on drought relief.
4. Document lessons learnt about what has made the project achieve or not achieve stipulated project objectives.

Methodology

Approach and Study Site

The study utilized a mixed research approach, where both qualitative and quantitative data were used. It was conducted in Kibwezi sub-County, Makueni County (Figure 3), which occupies a land surface area of 1,876km^2 with a projected human population of 333,347 in 2017. The study area, which was partly in Kibwezi East and Kibwezi West constituencies, has infertile lowlands characterized by insufficient rainfall of 351.9 to 687.4mm per annum (RoK, 2013).

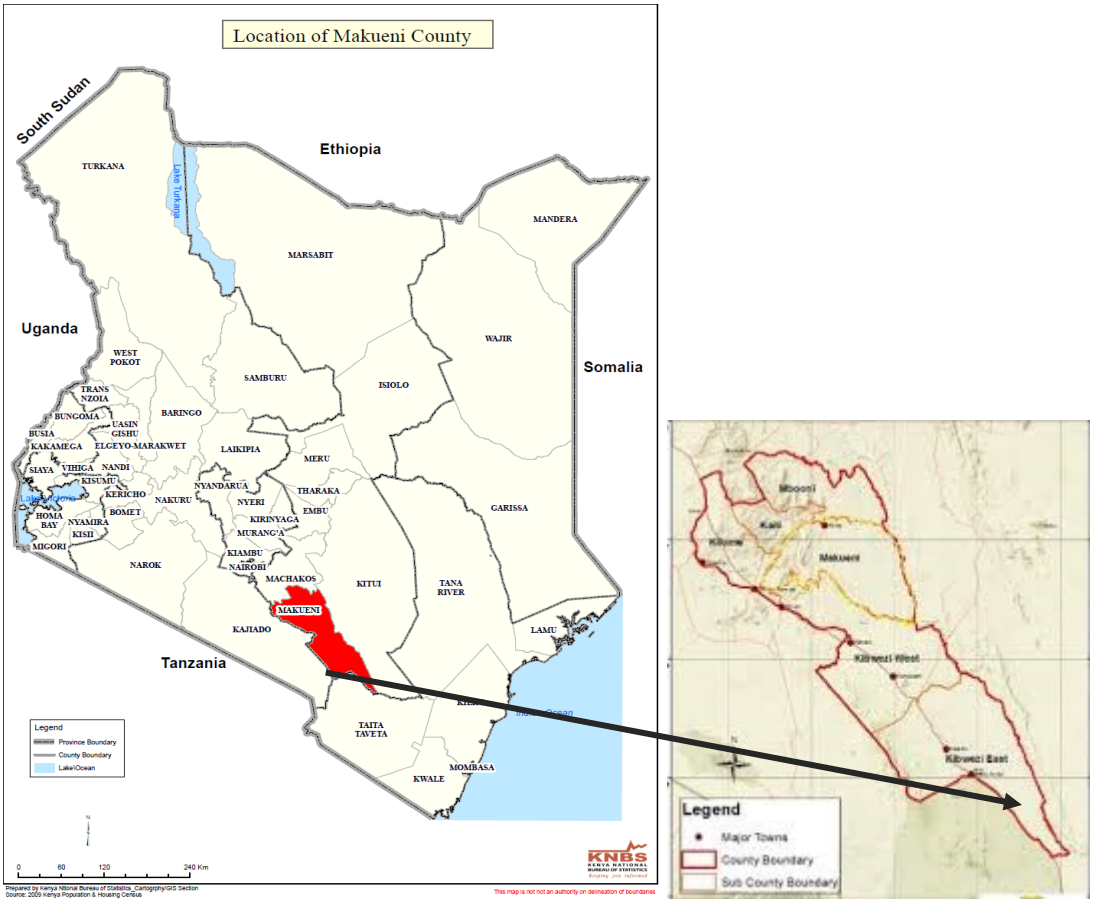

Figure 3: Map of Kenya showing Makueni County (Source: KNBS, 2018)

Data Collection

Mixed methods were used to collect data from farmers who participated in the project. The target was 30 households in each scheme, plus 10 more, to take care of inconsistencies or gaps in data set, so a total of 120 farmers were targeted. However, in Masimbani, where many households turned up, they could not be turned down for socio-cultural reasons. Furthermore, the interviews were done at no extra cost. In the end, the survey responses were 126 farmers, distributed as follows: 38 in Kwa Kyai, 38 in Kake, 49 in Masimbani. The data were collected on various aspects of both irrigated and rain-fed agricultural production, including agricultural input and output data; access to production, marketing and financial services; number of months adequate food was available from local production and/or

purchased from the markets; the frequency at which various food categories were consumed by each household; and various sources of household income. Data were collected in March-April 2019.
In addition to the formal survey, three (3) Focus Group Discussions (FGDs), one for each scheme using a checklist, and five (5) Key Informant Interviews (KIIs) were held using interview guides. The KIIs were conducted with the irrigation engineer, area assistant chief, the chairperson of Kwa Kyai scheme, chairperson of Masimbani scheme, and the Water Resource User Association (WRUA) officer. The purpose was to obtain more insights into the main issues of the irrigation project. Desktop literature reviews complemented the data and information collected through primary sources.

Data Analysis

For the purpose of this study, the unit of analysis was the farming household, defined as "*all the people residing in a single homestead and sharing resources and activities, whether they are related or not".* However, to determine the impacts on livelihoods and incomes, household members residing elsewhere but getting a share from the incomes of the rural households were considered in the analysis. This is because dependence on farm income represents another form of expenditure for the farming household.
Data collected were analysed using descriptive statistics on key indicators of interest. To assess the influence of the project from the society's point of view, economic analysis was performed retrospectively using the before and after approach to measure the effects of the intervention. Scenarios were considered to assess the changes (used as proxy for impact) in key variables of interest, such as food security, access to services and dynamics in society. Since drip irrigation was introduced in 2012 and lasted for about one and half years, the 2012 data were considered to represent the *before project* scenario, 2014 data as the *peak project intervention scenario* and the 2018 data as the *after project scenario*. Because there is generally an inverse relationship between recall and precision, it was expected that the results would have high standard errors (SE) and large confidence intervals (CI) with a possibility of committing a Type II error. However, due to data limitations, other methods of impact analysis, such as with and without project approach, and propensity score matching (PSM) were not possible for this study.
This project impact analysis was guided by examining the components of Development Assistance Committee (DAC) criteria: relevance, effectiveness, efficiency, impact and sustainability. In addition, lessons learnt were documented, capturing what worked and what did not work, and why.

Results and Discussion

Household Socioeconomic and Farm Characteristics

Age of the Head of the Household

The three Jain irrigation areas had both male and female household heads with ages ranging from 18 to 60 years; the majority being above 45 years (Figure 2). However, there were more male-headed households aged 60 years, compared to female. This concurred with other studies that found ages of the farming population in Kenya to be above 50 years (Afande *et al.,* 2015; FAO, 2017).

Household Demographics by Location

Household demographics in the three study locations revealed that adult male and female were the lowest population, compared to the youth and children population (Figure 4). This means the productive population was lower than the dependent population, an indication that only a few members of the population were responsible for the welfare of the majority. Specifically, across the study sites, the population of female children was the highest, except in Kwa Kyai where the highest population comprised male and female youths (Figure 4). Also, in Kake adult female constituted the least number, while in Masimbani, the male youths were the least.

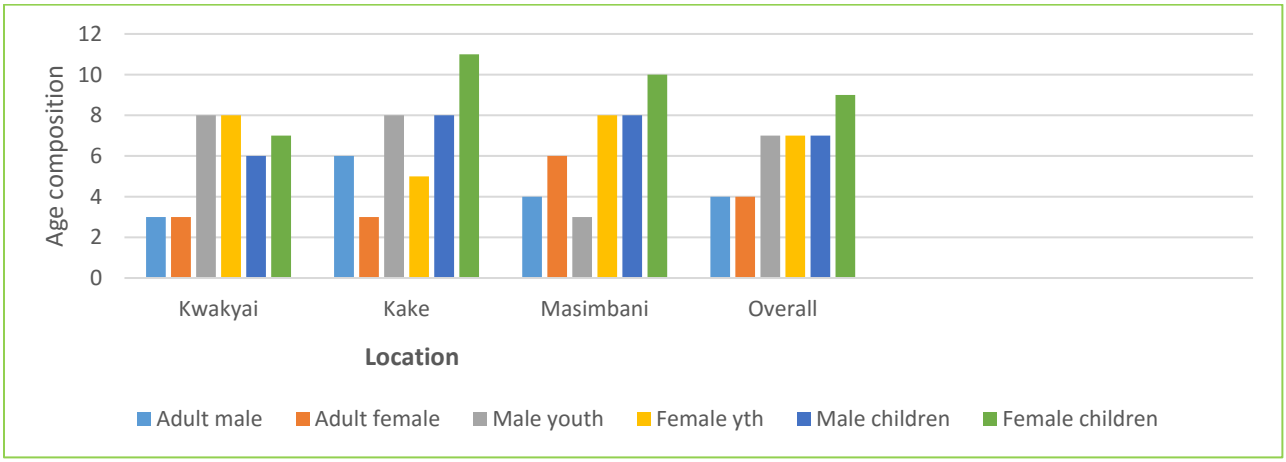

Figure 4: Household demographics in Kwa Kyai, Kake and Masimbani

Level of Education of Household Members

Across the three schemes and age brackets, there were higher numbers of members who attended primary and secondary schools than college and university (Table 1). Each of the schemes had members of each age bracket attending primary and secondary schools, with Kwa Kyai having more than Kake and Masimbani. Notably across the schemes, male and female youths (18-35 years) had members at all educational levels, including colleges and universities. No adult male or female over 35 years was in university; one adult male was in college at Masimbani.

Table 1: Mean number of members per household in various age brackets and educational levels

	Kake				Kwa Kyai				Masimbani			
Age bracket	**Pri**	**SS**	**Col**	**Uni**	**Pri**	**SS**	**Col**	**Uni**	**Pri**	**SS**	**Col**	**Uni**
Adult male (>35 years)	1	1	0	0	1	1	0	0	1	1	1	0
Adult female (>35 years)	1	1	0	0	1	1	0	0	1	1	0	0
Male Youth (18-35 years)	1	1	1	1	2	2	1	1	1	1	1	2
Female Youth (18-35 yrs)	1	1	1	1	1	1	1	1	1	1	1	1
Male children (<18years)	2	1	0	0	2	1	0	0	1	1	0	0
Male children (<18years)	2	1	0	0	2	1	0	0	1	2	1	0

Key: *Pri = Primary, SS=Secondary School, Col= College, Uni=University*

Primary Occupation of the Household Head

The primary occupation of the respondent household heads was crop farming (56.3%), mixed farming (23%), own business (9.6%), and formal employment (5.6%). Other occupations made up 5.8% of the total occupations.

Source of Income

In 2014 and 2018, formal employment generated more income for both male and female-headed households, with male-headed households (MHH) earning higher income than female headed households (FHH). Similarly, MHH earned more income from business and farming, compared to FHH in 2014 and 2018. The difference in income from casual employment was small in both years for MHH and FHH. For both groups, the lowest earnings were from casual employment, followed by farming for the two years under consideration (Figure 5).

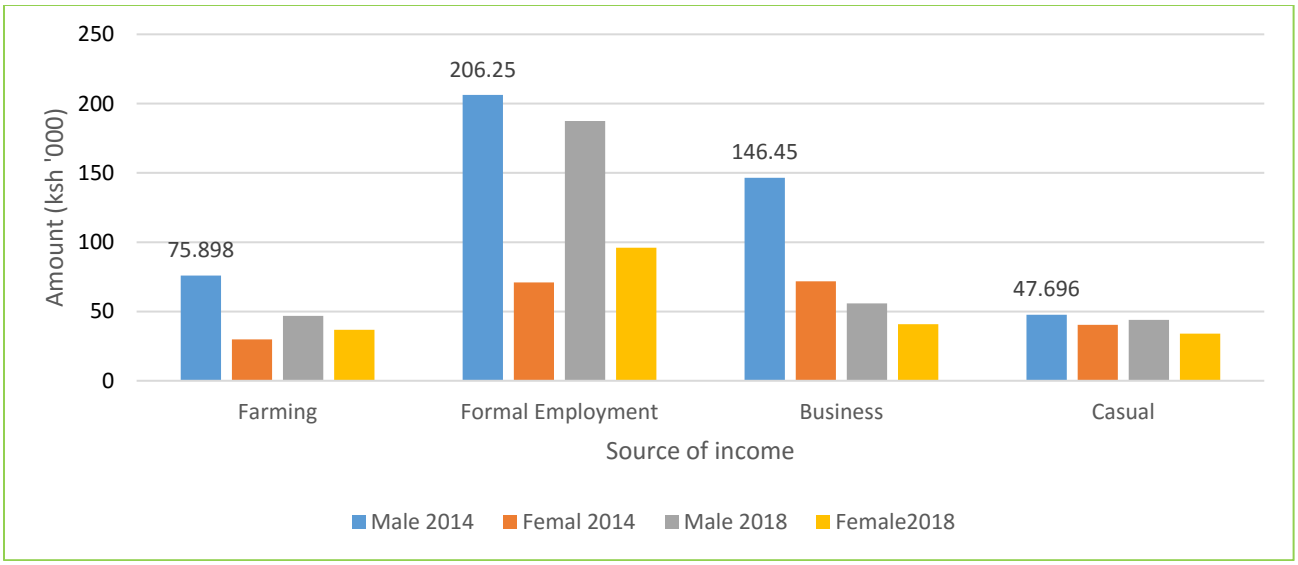

Figure 5: Sources of income in 2014 and 2018 by gender

Annual Household Expenditure

The data show that FHH spent more on food, education and health than MHH in both 2014 and 2018 (Figure 6). In 2018, although the two groups had increased expenditure on health, FHH had a larger increase than MHH, while MHH had a slightly higher food and health expenditures than FHH. The results also show that the burden of household expenditures, especially on healthcare, was more on FHH than MHH.

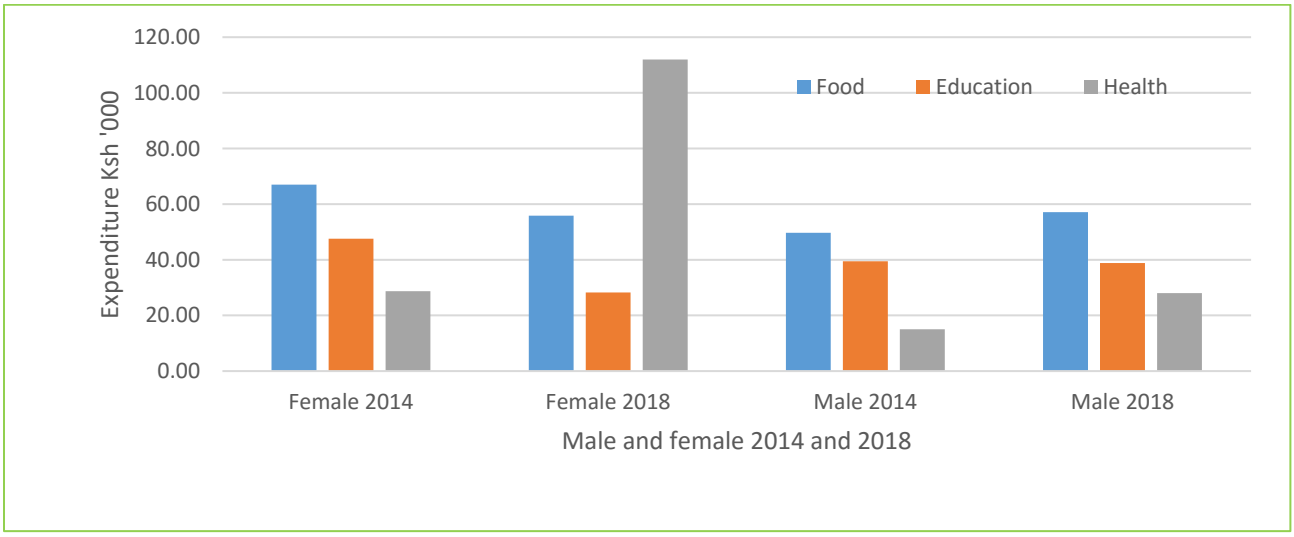

Figure 6: Household expenditure by gender in 2014 and 2018

a) Male expenditure in 2014 and 2018

The data also show that male-headed households spent more on food (Ksh 57,603.07) in 2014 and 2018 than on any other item, while their second highest expenditure was on education (Ksh 42,127 and Ksh 39,434.2) (Figure 7).

Figure 7: Male HH expenditure in 2014 and 2018

b) Female in 2014 and in 2018

Female-headed households spent significantly more on health (Ksh 111,958.33) in 2018 than on any other expenditure in both years (Figure 8). There was also higher expenditure on food and education in 2014 than in 2018.

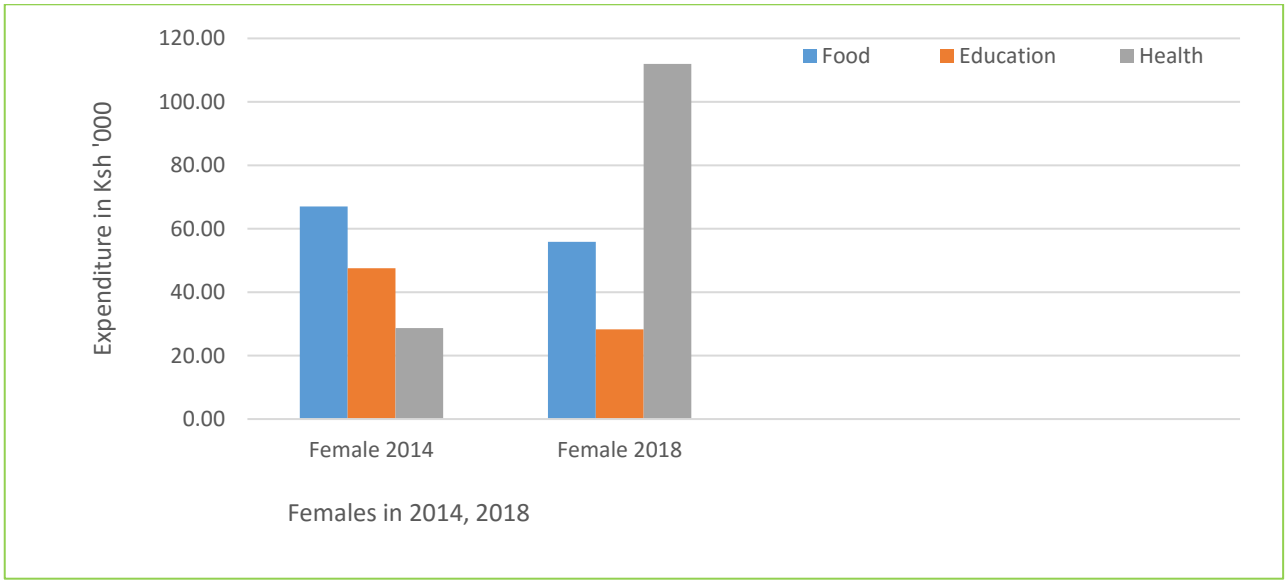

Figure 8: Expenditure by females in 2014 and 2018

c) Overall expenditure for 2014 and 2018

Overall expenditure on food was higher than other expenditures for both years, followed by education and health (Figure 9). The differences in food and education expenditures for the two years did not change much; health expenditure was higher in 2018 than 2014.

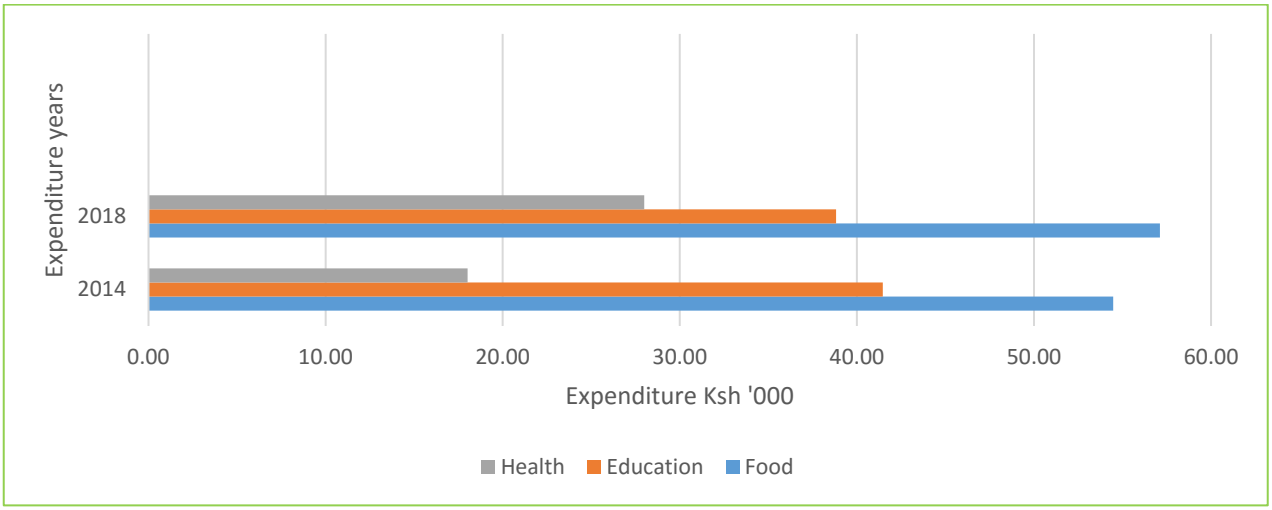

Figure 9: Overall household expenditure in 2014 and 2018

Access to Production Resources and Services

Location and size of farm under irrigation

Most respondents had their farms next to the homestead, regardless of whether the farms were under irrigation or not. However, over 20% of the households with fields under irrigation (for both 2012/2013 and 2018) cultivated them at least one kilometre away, compared to fields without irrigation; this is a positive indicator of how arable land increases with water availability. But land sizes under irrigation reduced from an average of 1.61 acres in 2012/2013 to 1.06 acres in 2018. This could be attributed to the fact that farmers at Kwa Kyai were opposed to sharing of irrigation water with farmers of the new irrigated schemes in Kake and Masimbani (as later shown by the Masimbani FGD data). They (Kwa Kyai) therefore abandoned drip irrigation and cut off the water that was supplying the new schemes in Masimbani and Kake, leading to the collapse of the drip irrigation in those schemes. Thus, farmers at Kwa Kyai reverted to furrow irrigation and their area under irrigation increased from 2 acres in 2012 to about 6.50 acres in 2018.

The main forms of land tenure were: owned with title deed (64%), owned with no title deed (14%), and lease system (11%). Apart from Kwa Kyai and Masimbani where ownership with title was about 70% for both male and female-headed households, only 43% of female-headed households and 65% of male headed-households had title deeds for their lands in Kake.

Livestock ownership by gender

Cattle, goats and chicken were the livestock in the study sites; and the male-headed households had more livestock than their female counterparts (Table 2).

Table 2: Household ownership of main kinds of livestock kept by gender

	Male Headed HH		Female Headed HH		Overall	
Type of livestock kept	**Proportion owning livestock %**	**Average number of animals owned**	**Proportion owning livestock %**	**Average number of animals owned**	**Proportion owning livestock %**	**Average number of animals owned**
Cattle	75.6 (n=62)	4 (3)	64.7 (n=22)	3 (2)	72.4	4 (3)
Goats	86.6 (n=71)	11 (20)	82.4 (n=28)	7 (4)	85.3	10 (17)
Chicken	76.8 (n-63)	23 (26)	85.3 (n-29)	21 (17)	79.3	22 (23)

Figures in brackets for the "averages" are standard deviations

Affiliation to socioeconomic groupings

a) Membership of various socioeconomic groups (organizations)

In the study area, membership of socioeconomic groups (organizations) was widespread. About 54% of household heads were affiliated to at least one socioeconomic group (Table 3). Further, the results show that before the introduction of drip irrigation, there were 34 groups to which farmers in the study area belonged. This is compared to 22 group in the drip irrigation period and 12 groups after the collapse of the drip irrigation scheme. The decrease in group affiliations could be attributed to the fact that drip irrigation is labour–intensive for production and marketing activities, such that farmers did not have time for group meetings. Also, access to water and drip irrigation was based on cluster of groups and thus, made it easier to serve groups than individual farmers. Membership of organizations facilitated access to diverse services, such as health, education, finance, information and other resources (water, land). It also afforded members social protection from the vagaries of insecurity and weather.

Table 3: Proportion (%) of diversity of activities among Social Networks

Focus of social network	Before Drip Irrigation (n=14)	During Drip Irrigation (n=28)	After Drip Irrigation (n=43)	Overall (n=85)
Merry Go Round &Table Banking	42.8	28.6	25.5	29.5
Environmental Conservation	0	25.1	25.1	21.5
Welfare	35.5	21.6	20.7	23.6
Crop production	0	10.8	11.5	9.6
Livestock production	7.1	3.6	9.2	7.1
Off-farm economic activities	14.6	10.3	8.0	8.7
Sample (n)	14	28	43	85

b) Perception on group membership

Group members had various perceptions about the influence of group membership on access to water before, during and after the drip irrigation project (Table 4). On ease of access to water, 33.3% of the respondents indicated more access to water; this reduced to 21.1% during the drip irrigation period and later to 'no access' after the irrigation project. On the other hand, there were more members who felt that the group had no influence on water access throughout the period.

Table 4: Perception of of group members on HH access to irrigation water

Perception	Before Drip Irrigation (n=24)	During Drip Irrigation (n=19)	After Drip Irrigation (n=9)	Overall
Members could easily access water	33.3	21.1	0	23.1
Group has no influence on members' access to water	66.7	78.9	100	76.9

Access to Credit

The basic role of credit in agriculture is to provide capital to acquire productive assets, land and/or machinery. It is the means for many farmers to expand their operations to meet the increasing demand for agricultural products as well as provide the means for the development of new agricultural enterprises. The study of Memon *et al.* (2016) on the role of credit in agricultural development in Qambar District, Pakistan, concluded that agricultural credit enables farmers to get best agricultural production through timely acquisition of inputs. Similarly, Zeller *et al*. (2002) found that in Bangladesh, credit access had a significant and strong effect on both income and food consumption. In contrast, Diagne and Zeller (2001) found that low profit levels can come from a number of factors, including low investment and misallocation of inputs.

With respect to this study, only 5.5% of the household heads sampled had access to credit for agricultural purposes. This was evenly distributed between male and female-headed households, although no household head from Masimbani scheme received credit. There were two forms of credit (cash and in-kind) that were accessed; but only adult male and female (>35 years of age) had access to them. However, there were no statistical differences in number and gender of household members who received credit in 2013 and 2018. In both years, less than Ksh50,000 worth of loans were received with the purpose of assisting farmers to purchase farm inputs, such as seeds, fertilizers and other agrochemicals, as well as pay for labour.

In 2013, the loans were mainly obtained from a non-government organizations (NGOs), local money lenders, contractual out-grower arrangements through a microfinance institution and a commercial bank. In 2018, the loans were mainly obtained from a local money lender, group/ table banking, and commercial bank.

The perception of heads of households with respect to credit services among the limited number that received credit were sought using a 5-point Likert Scale (1 = very dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; and 5 = very satisfied). The results on farmer satisfaction to credit services varied

and were inconclusive, with regard to the categories of: very dissatisfied, satisfied and very satisfied. It can be concluded that there were a few farmers in the study area with limited access to credit; hence, there was no discernible impact linked to credit access.

Access to Resources and Services for Household Wellbeing

The distance to healthcare services was consistently longer for female-headed households; private hospitals were the furthest healthcare services (Table 5). The distance to water sources for domestic use was the farthest (2.6km), followed by the distance to water for animals (2.1km), while the distance to water sources for irrigation was the shortest (0.5km). Over 70% of the respondents went further to get water for immediate use and for their animals, while the water for irrigation was nearest, although only about 20% benefitted. This possibly provoked people to sabotage irrigation facilities in order to get water for immediate use.

The energy sources were mainly firewood (94% for male-headed households and 100% for female-headed households), charcoal (36% for male-headed households and 27% for female-headed households) and paraffin (23% and 16% for the two groups, respectively). This corroborated with the national average of 94% for people in the rural areas using firewood (IEA, 2015). These are rudimentary energy sources that increase greenhouse gas emissions. Firewood is especially a burden to women because they have to spend a long time looking for it.

Table 5: Access to services and resources

Service	Name	Distance (km)			Proportion (%)	
		Male Headed HH	Female Headed HH	Overall	Male Headed HH	Female Headed HH
General	**Specific**					
Health	Chemist	5.76, (5.37), n=119	8.29, (4.90), n=49	6.50 (5.26), n=184	19.1, (n=89)	18.9, (n=37)
	Government Hospital	6.10 (5.28)	6.96 (7.68)	6.35 (6.07)	97.8	100
	Private Hospital	8.32 (5.27)	8.50 (3.77)	8.37, (4.82)	15.7	13.5
	Other				1.1	0
Water	Portable	2.6 (3.19), n=132	2.6 (2.22), n=52	2.6 (2.92), n=184	73 (n=89)	75.7 (n=37)
	Animals	2.3 (1.54)	1.5 (1.08)	2.1 (1.47)	43.8	35.1
	Irrigation	0.6 (1.26)	0.1 (0.06)	0.5 (1.11)	25.8	21.6
	Other	1.4 (1.45)	5.0 (3.61)	2.8 (2.89)	4	8.1
Energy source	Paraffin	1.5 (1.26), n=140)	0.9 (0.60), n=56	1.3 (1.16), n=196	23.6 (n=89)	16.2 (n=37)
	Firewood	1.8 (2.22)	2.3 (1.92)	2.0 (2.14)	94.4	100
	Charcoal	1.7 (1.79)	1.2 (1.49)	1.6 (1.72)	36	27

Other	8.9 (7.14)	7 (11.27)	8.2 (8.15)	16.9	10.8

Agricultural Water Management

Drip irrigation was the most popular form of irrigation in 2012/2013, with 56% of irrigation users (Table 6). This was followed by canal irrigation, at 27% of the respondents. In 2018, canal irrigation was the most popular form (97%) in Kwa Kyai, where it was practised. This result corroborated the FGD data, in where drip irrigation (JAIN) was abandoned because of mismanagement and political interference. However, the proportion of respondents that were not using any form of irrigation reduced from 82% in 2012/2013 to 67% in 2018.

Other water management practices that were used were the *in situ* water harvesting structure (mainly *Zai* pits, pitting, stone bunds, bench terracing, Fanya Juu/Chini, strip cropping, contour farming, trash lines, and deep tillage) and, to a small extent, mulching, agroforestry, conservation agriculture and the *ex-situ* water harvesting structures (cut-off-drains, water pans, micro-catchment, and road-runoff). Agroforestry was adopted by a very few farmers. The KII from Kibwezi WRUA reported: "We have had several tree planting sessions by the county, but no follow up is made". Between 35% and 40% of the respondents were not using water. Table 6 shows the data of fields with and without irrigation water for 2012 and 2018 seasons.

Community knowledge of water resources users associations (WRUAs) is critical for any community, particularly in areas such as Kibwezi sub-County, where the water resource is scarce. WRUA is an association of water resource users, riparian land owners and other stakeholders who are formally and voluntarily associated for the purpose of cooperatively sharing a common water resource. The functions of WRUAs are to: promote controlled and legal water use activities; promote efficient and sustainable use and management of water resources; promote water conservation practices to ensure sufficient water reserves for all the users; facilitate reduction and resolution of water related conflicts; and promote catchment conservation measures to improve water quantities and quality.

The current study revealed that there was no gender difference in knowledge of WRUAs. Only 27% and 32.6% of female and male-headed households, respectively, were aware of WRUAs in the study area. Overall, only 28% of those with knowledge on WRUAs were part of WRUAs. There were no differences in participation in WRUA activities among gender. Where heads of households were recruited into WRUAs, it was universally done through the sub-chiefs, elders or neighbours. The motivation for joining WRUAs was to benefit from the water, and to ensure efficient and equitable use of water; although, there were several factors that contributed to the success or failure of WRUAs (Table 6).

Table 6: Community reasons for hindering or promoting effectiveness of WRUAs to support development of the Irrigation Scheme

Hindering	Promoting
1. WRUA is not performing well hence the community has a negative attitude	1. Good leadership and unity among members to repair canals and report vandalism of irrigation resources

towards WRUA, hindering its effectiveness	
2. Villagers are against some of the set rules such as planting close to water points and rationalizing water days	2. Women employment & their voluntary contribution of labour to the project
3. No cooperation between farmers and WRUA	3. Creation of more community awareness on the project e.g. benefits of the scheme, environmental conservation etc.
4. Misusing water from the river	4. Joint monitoring and evaluation of irrigation activities
5. Lack of unity from other community members / greed among members	5. More collaboration with the RUAs for efficient water use management
6. Insecurity for agricultural resources in the area	6. Good management of water resource
7. Heterogeneous village	
8. Drinking livestock	
9. Deforestation	

Crop Production and Marketing

This section presents an analysis of the different crops produced in the area with and without irrigation and how they were marketed.

Crop production

Table 7 shows the 12 most popular crops grown between 2012 and 2018 with and without irrigation. The data show that cowpeas, green grams, green maize and dry maize were grown over the years regardless of whether the land was under irrigation or not; while sorghum was grown by only 6.7% of the respondents in 2018 under irrigation. The FGD data in Masimbani showed that sorghum was unpopular because of bird damage and that maize was one of the four main crops over the years. An analysis of all the crops in each category shows that in the year 2018, irrigation influenced the production of horticultural crops. The FGD data at Kwa Kyai also showed that Sukuma wiki (kale) was the main crop grown under irrigation because it fetched good prices. Table 8 shows the percentage of farmers who grew various crops in the years 2012 and 2018 with and without irrigation.

Table 7: Crops cultivated in the study area in 2012 and 2018

	2012				2018			
	Without irrigation % Households (n=126)		Irrigated % Households (n=126)		Without irrigation % Households (n=126)		Irrigated % Households (n=126)	
1	Green grams	39.7	Green Maize	31.7	Cowpeas	42.9	Green Maize	18.3

2	Cowpeas	38.1	Dry Maize	31.0	Green grams	42.1	Sukuma wiki	11.1
3	Dry Maize	36.5	Cowpeas	25.4	Dry Maize	38.1	Dry Maize	5.6
4	Green Maize	17.5	Green grams	17.5	Green Maize	16.7	Cowpeas	4.8
5	Sukuma wiki	8.7	Sukuma wiki	13.5	Sukuma wiki	11.1	Egg Plants	4.8
6	Egg Plants	5.6	Egg Plants	8.7	Egg Plants	5.6	Cassava	4.8
7	Beans and pulses	3.2	Green Cow peas	4.8	Pigeon peas	5.6	Green grams	4.0
8	Green Cow peas	3.2	Pigeon peas	4.0	Green Cow peas	4.8	Chili	3.2
9	Pigeon peas	3.2	Mango	4.0	Cassava	3.2	Mango	3.2
10	Mango	2.4	Chili	3.2	Beans and pulses	2.4	Papaya	2.4
11	Sweet potatoes	1.6	Cassava	3.2	Mango	2.4	Beans and pulses	1.6
12	Watermelon	1.6	Papaya	3.2	Radish	1.6	Green Cow peas	1.6
13	Grass	1.6	Sorghum	1.6	Apples	1.6	Sorghum	0.8
14	Green beans	0.8	Sweet corn	1.6	Sorghum	0.8	Bitter melon	0.8
15	Chili	0.8	Radish	1.6	Chili	0.8	Coriander (dania)	0.8
16	Sweet corn	0.8	Sweet potatoes	1.6	Capsicum	0.8	Apples	0.8
17	Green	0.8	Apples	1.6	Coriander (dania)	0.8	Bananas	0.8
18	Sorghum	0.8	Bananas	1.6	Banana	0.8	Grass	0.8
19	Radish	0.8	Green beans	0.8	Bananas	0.8	Fodder Legumes	0.8
20	Cassava	0.8	Green paper	0.8				

Table 8 indicates the main perennial crops grown in each scheme. Overall, mangoes (43%) were the most grown perennial crop followed by lemons (14.3%) mainly at Kwa Kyai and Kake where irrigation was available. Papayas and bananas were mainly grown at Kwa Kyai.

Table 8: The Main Perennial Crops by Scheme

Perennial crops	Kake	Kwa Kyai	Masimbani	Overall
Mangoes	50 (N=2)	50 (N=4)	0.0	42.9 (N=6)
Lemons	0.0	25 (N=2)	0.0	14.3 (N=2)
Papaya	0.0	12.5 (N=1)	0.0	7.1 (N=1)
Bananas	0.0	12.5 (N=1)	0.0	7.1 (N=1)

Figure 10: Mangoes and Papaya at the Background. Egg Plants under Dip irrigation at Masimbani

Table 9 shows the types of production systems by gender. More female-headed households (88.9%) practised rain-fed agriculture than their male counterparts (74.5%). On the other hand, more male-headed households (26%) had access to irrigation facilities than female-headed households (11%). Statistical analysis indicated that the variance was significantly different at 2.8% level. An example of drip irrigation is provided in Figure 10.

Table 8: Types of Production Systems by Gender

Production System	Gender			Statistical Test	
	Female	Male	Overall sample	Chi-square	Sig.
Rain fed production	88.9 (N=48)	74.5 (N=111)	21.67 (N=44)	4.836	.028**
Irrigated production	11.1 (N=6)	25.5 (N=38)	78.33 (N=159)		

Figure 11: Drip irrigation system at Kake

Table 10 shows the types of production systems by scheme. The production system at Masimbani was 100% rain-fed, followed by Kake (95%) and Kwa Kyai (34%). The irrigation system of production was mainly practised at Kwa Kyai (66%), compared to Kake (5%) and Masimbani (0%). Statistical analysis indicated that the variance was significantly different at less than 1% level.

Table 9: Types of Production Systems by Scheme

	Schemes	Statistical Test

Production System	Kake	Kwa Kyai	Masimbani	Overall sample	Chi-square	Sig.
Rain fed production	95.3 (N=61)	33.9 (N=21)	100 (N=77)	21.67 (44)	104.357	.000***
Irrigated production	4.7 (N=3)	66.1 (N=41)	0.0	78.33 (159)		

The mean areas harvested (in acres) by scheme varied and was significant at less than 1%. Masimbani had the largest area harvested (1.4 acres) followed by Kake (1 acre) and Kwa Kyai (0.5 acre).

Tables 11 and 12 provide the quantity harvested for each crop by season and analysed by gender of household head and scheme. In season 1, male-headed households produced a higher amount of maize (204kg) than female-headed households (156Kg), but the difference was not statistically significant. Similarly in season 2, male-headed households produced more maize (135kg) than their female counterparts (77kg) and the difference was statistically significant at 2.5%. The maize produced was lower in season 2 than season 1. For pulses (cowpeas and green grams), female-headed households generally produced more (165kg and 146kg) than their male counterparts (133kg and 118kg). The trend was, however, reversed in season 2, with male-headed households harvesting more (171kg and 173kg) than their female counterparts (160kg and 143kg) for cowpeas and green grams, respectively. Tomatoes were mainly produced by male headed households. Figure 11 shows watermelon ready for harvest in 2012/13.

Figure 12: Watermelon ready for Harvest at Masimbani

Kwa Kyai scheme farmers harvested more maize (356kg) than those of Masimbani (130kg) and Kake (83kg) in season 1; the same trend was observed in season 2 for Kwa Kyai (112kg), Masimbani (135kg) and Kake (115kg). The variances of the harvest were significant at less than 1% significance level.

Table 10: Seasonal Mean Quantity Harvested (kg) by Gender

Season	Crop	Gender of the HH Head			Statistical Test	
		Female	Male	All	F	Sig.
Season 1	Cow peas	165.42 (39.16)	133.47 (2304)	142.18 (19.75)	0.51 3	0.478
	Green grams	145.88 (43.41)	118.13 (23.41)	127.76 (21.28)	0.38 1	0.540
	Maize	155.71 (61.54)	204.90 (44.06)	190.14 (35.8)	0.39 3	0.533
Season 2	Cowpeas	159.8 (53.35)	171.35 (34,58)	167.43 (28.83)	0.03 5	0.852
	Green grams	142.5 (59.66)	172.96 (52.98)	162.56 (40.02)	0.12 7	0.723
	Maize	76.79 (14.56)	135.88 (15.57)	117.89 (12.3)	5.36 0	0.025
	Tomatoes		368.75 (110.12)	368.75 (110.1)		

Figures in brackets are standard errors

Table 11: Seasonal Mean Quantity Harvested (kg) by Scheme

Season	Crop	Scheme				Statistical Test	
		Kake	Kwa Kyai	Masimbani	All	F	Sig.
Season 1	Cow peas	142.81 (27.9)	50 (43.9)	157.13 (29.76)	142.18 (19.75)	1.15	0.325
	Green grams	133.33 (30.07)	70 (37.48)	141.43 (37.73)	127.76 (21.28)	0.62	0.543
	Maize	82.86 (23.68)	356.09 (94.73)	130 (26.9)	190.14 (35.80)	6.22	0.003
Season2	Cowpeas	198.17 (51.09)	81.88 (31.08)	173.67 (45.46)	167.43 (28.83)	0.98	0.385
	Green grams	164 (51.09)	51 (16.46)	188.10 (68.95)	162.56 (40.02)	0.57	0.573
	Maize	112.37 (18.87)	135.33 (32.2)	115 (19.22)	117.89 (12.3)	0.241	0.787
	Tomatoes	368.75 (110.1)			368.75 (110.1)		

Figures in brackets are standard errors

Produce Marketing

In 2018, over 98% of the respondents did not schedule/coordinate production with other farmers. They also did not market their crops as a group and had no contracts to produce crops. This was the same for 2012. In 2018, the main crops marketed were green grams, maize, tomatoes, eggplant and cowpeas, and the buyers were middlemen, retailers, wholesalers and processors. Only 20% of those who sold green grams, maize, tomatoes and eggplant were satisfied with these buyers. None of the respondents who sold cowpeas said they were satisfied with any of the buyers. The crops marketed in 2012 were similar to those marketed in 2018 and included: green grams, maize, tomatoes, eggplant, cowpeas and kales. Similar to 2018, no seller was satisfied with the buyers, except 20% of those who sold cowpeas. Figure 12 shows data on the harvesting and packaging of eggplants in readiness for the market.

Figure 13: Harvesting and Packaging of Eggplants at Kake and Masimbani which were grown with drip irrigation scheme

Tables 13 and 14 provide the seasonal total sales for each crop by gender of household head and irrigation scheme. The results depict that marketing was generally poor. The FGD data in Kwa Kyai, however, showed that marketing was good before 2012 when buyers (with vehicles) bought in bulk. They stopped coming for the produce after Jain Drip Irrigation Project collapsed and drastically reduced production. In addition, the county government started charging tax on the vehicles, thus aggravating the problem.

Table 12: Seasonal Total Sales (in Ksh) by Gender

Season	Crop	Gender of the HH Head			Statistical Test	
		Female	Male	All	F	Sig.
Season1	Cow peas	1850 (850)	4350 (1299.04)	3516.67 (1000.47)	1.536	0.283

Season	Crop	Gender of the HH Head			Statistical Test	
		Female	Male	All	F	Sig.
	Green grams	54800 (35119.82)	24548.18 (15515.09)	38161.5 (17756.71)	0.707	0.411
	Maize	921600 (759600)	207311.11 (139735.05)	385883.33 (213481)	0.203	0.819
Season2	Cowpeas	3833.33 (1234.68)	3805.45 (842.41)	3811.43 (692.23)	0.0003	0.988
	Green grams	4501.43 (2305.46)	4464.38 (1668.49)	4475.65 (1327.25)	0.00016	0.99
	Maize	3375 (2625)		3375 (2625)		
	Tomatoes	3375 (2625)		14541.67 (2799.12)		

Table 13: Seasonal Total sales (in Kshs) by Scheme

Season	Crop	Scheme				Statistical Test	
		Kake	Kwa Kyai	Masimbani	All	F	Sig.
Season 1	Cow peas	4150 (1437.88)		2250 (450)	3516.67 (1000.47)	0.764	0.432
	Green grams	26440 (16776.61)	43750	50564.44 (35686.45)	38161.5 (213481)	0.203	0.819
	Maize	10500	476455.56 (280238.44)	166000 (158000)	385883.33 (213481)	0.246	0.787
Season 2	Cowpeas	5850 (1299.04)	2180 (380)	3200 (863.29)	3811.43 (692.23)	2.2	0.156871
	Green grams	3057.78 (866.42)	2675 (925)	5839.17 (2444.41)	4475.65 (1327.25)	0.56	0.583
	Maize		3375		3375 (2625)		
	Tomatoes		14541.67		14541.67 (2799.12)		

Food and nutrition security

Food and nutrition security refers to a situation where all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (ROK, 2017). The Government of Kenya is committed to reducing hunger and malnutrition, and irrigation is one way of increasing food production. This study also investigated the impact of irrigation on food and nutrition security in Kwa Kyai, Masimbani and Kake villages in Kibwezi.

Quantity of own production that was consumed

Tables 15 and 16 show the quantities of the various commodities that were consumed from own production disaggregated by gender and scheme. In both seasons, female-headed households consumed more cowpeas than male-headed households, while the latter consumed more green grams and maize than the former (Table 15).

Table 14: Quantity consumed from own production (in kg) by Gender in 2018

Season	Crop	Gender of the HH Head			Statistical Test	
		Female	Male	All	F	Sig.
Season 1	Cow peas	112.5 (32.02)	101.41 (16.74)	104.43 (14.8)	0.109	0.743
	Green grams	71.76 (31.20)	316.88 (175.35)	231.84 (115.61)	1.0189	0.318
	Maize	61.43 (14.85)	83.06 (11.27)	76.57 (9.08)	1.195927	0.277996
Season 2	Cowpeas	142.63 (54.17)	90.1 (14.35)	167.43 (28.83)	1.43	0.237
	Green grams	57.5 (12.95)	60.26 (15.1)	162.56 (40.09)	0.018	0.896
	Maize	70.36 (12.3)	104.39 (10.12)	117.89 (12.30)	3.914	0.054**
	Tomatoes		66.67 (32.83)	368.75 (110.12)		

Masimbani had the highest consumption of cowpeas and maize in the first season and green grams and maize in the second season (Table 17). Kwa Kyai had the highest consumption of cowpeas in the first season; Kake consumed cowpeas the most in the second season. Tomatoes were indicated only in Kwa Kyai in the second season.

Table 15: Quantity Consumed from own production (in kg) by Scheme in 2018

Season	Crop	Scheme				Statistical Test	
		Kake	Kwa Kyai	Masimbani	All	F	Sig.
Season 1	Cowpeas	89.69 (23.20)	50 (43.59)	123.33 (14.8)	104.43 (14.80)	1.255	0.296
	Green grams	222.86 (169.12)	674.286 (637.8)	93.33 (115.61)	231.84 (115.61)	1.376	0.263
	Maize	57.14 (10.72)	84.35 (18.23)	85.38 (16.19)	76.57 (9.08)	0.982172	0.379823
Season 2	Cowpeas	149 (47.3)	54.63 (21.74)	93.3 (20.99)	167.43 (28.83)	1.443	0.247

	Green grams	57.27 (16.57)	28.75 (6.57)	66.94 (15.49)	162.56 (40.02)	0.6952	0.5068
	Maize	89.11 (12.08)	96.4 (19.12)	97.65 (14.46)	117.89 (12.29)	0.116	0.891
	Tomatoes		66.67 (32.83)		66.67 (32.83)		

Frequency of food consumption per day for various household members

The number of meals consumed on a day during peak food availability was more than during low food availability period by location in both 2014 and 2018 (Tables 17, 18, 19 and 20).

Table 16: Mean number of meals consumed on normal day on peak food availability season by location (in 2014)

Scheme	Adult male	Adult female	Youth (18-35 yrs)	Children (Below 18)
Kake	2.89 (0.052); n=37	2.86 (0.057); n=37	2.87 (0.063); n=30	2.89 (0.079); n-28
Kwa Kyai	2.83 (0.054); n=48	2.83 (0.054); n=48	2.82 (0.064); n=38	2.84 (0.055); n=45
Masimbani	2.86 (0.060); n=35	2.83 (0.063); n=36	2.97 (0.064); n=31	3.10 (0.071); n=31
Overall	2.86 (0.032); n=120	2.84 (0.033); n=121	2.88 (0.033); n=99	2.93 (0.039); n=104
P-Value				<0.05**

Table 17: Mean number of meals consumed on normal day on low food availability season by location (in 2014)

Scheme	Adult male	Adult female	Youth (18-35 yrs)	Children (Below 18)
Kake	2.43 (0.120); n=37	2.43 (0.120); n=37	2.42 (0.129); n=31	2.57 (0.130); n=28
Kwa Kyai	2.54 (0.094); n=48	2.54 (0.094); n=48	2.53 (0.105); n=38	2.68 (0.085); n=44
Masimbani	2.23 (0.136); n=35	2.22 (0.133); n=36	2.37 (0.148); n=30	2.70 (0.109); n=44

Overall	2.42 (0.067); n=120	2.41 (0.066); n=121	2.44 (0.072); n=99	2.66 (0.060); n=102

Table 18: Mean number of meals consumed on normal day on peak food availability season by location (in 2018)

Scheme	Adult male	Adult female	Youth (18-35 yrs)	Children (Below 18)
Kake	2.81 (0.067); n= 36	2.78 (0.070); n=36	2.85 (0.070); n=27	2.89 (0.079); n= 28
Kwa Kyai	2.83 (0.055); n=47	2.83 (0.055); n=47	2.82 (0.064); n=38	2.91 (0.062); n=45
Masimbani	2.83 (0.065); n=35	2.80 (0.069); n=35	2.93 (0.051); n=27	2.93 (0.091); n=29
Overall	2.82 (0.035); n=118	2.81 (0.037); n=118	2.86 (0.037); n=92	2,90 (0.043); n=102

Table 19: Mean number of meals consumed on normal day on low food availability season by location (2018)

Scheme	Adult male	Adult female	Youth (18-35 yrs)	Children (Below 18)
Kake	2.28 (0.130); n=36	2.28 (0.130); n=36	2.31 (0144); 26	2.58 (0.149); n=26
Kwa Kyai	2.36 (0.107); n-47	2.36 (0.107); n-47	2.42 (0.111); n=38	2.57 (0.094); n=44
Masimbani	2.03 (0.133); n=35	2.06 (0.136); n=35	2.32 (0.146); n=28	2.45 (0.117); n=44
Overall	2.24 (0.071); =118	2.25 (0.071); n=118	2.36 (0.075); n=92	2.54 (0.066); n=99

Number of days in a week that different food groups are consumed

Kennedy *et al.* (2011) recognized 12 food groups in assessing food and nutrition security. The classification not only captures the food diversity scores but also the frequency of consumption or access. The classification was applied to the study area. Table 21 shows the frequency (number of days) of household consumption, by gender, of each of the foods one week prior to data collection. The data show that cereals, leafy vegetables, oils and fats, sugar/honey, and milk and milk products were the most consumed food items across gender, while animal protein (meat, egg and fish) was the least consumed. There were no statistical differences observed for the consumption of the various food categories.

Table 20: Frequency of household access to various classes of food

Food Category	Mean number of days in one week food items consumed by gender		
	Male	Female	Overall
Cereals	6.6 (0.1); n=89	6.6 (0.16); n=37	6.6 (0.08); n=126

Roots & Tubers	2.7 (0.21); n=55	2.9 (0.41); n=21	2.8 (0.19); n=76
Leafy Vegetables	5.9 (0.17); n=87	7.0 (0); n=37	6.5 (0.54); n= 124
Fruits	2.4 (0.25); n=53	2.9 (0.48); n=18	2.6 (0.22); n=71
Meats	1.6 (0.14); n=54	1.9 (0.30); n= 21	1.7 (0.13); n=75
Eggs	1.9 (0.24); n=34	1.9 (0.30); n=15	1.9 (0.19); n=49
Fish	1.5 (0.21); n=22	1.5 (0.29); n= 4	1.5 (0.18); n=26
Pulses	4.6 (0.21); n=82	5.2 (0.33); n=33	4.8 (0.18); n=115
Milk & milk products	6.5 (0.16); n=80	6.8 (0.23); n=26	6.5 (0.13); n=106
Oils & Fat	6.8 (0.09); n=78	6.7 (0.21); n=25	6.8 (0.09); n=103
Sugar / Honey	6.5 (0.16); n=84	6.9 (012); n=34	6.6 (0.12); n=118
Miscellaneous foods	7.0 (0); n=75	7.0 (0); n=25	6.8 (0.10); n=100

Main source of food over the past seven days

Tables 22 and 23 show how the farmers sourced their food in 2014 and 2018 respectively, over a typical seven-day period. The data show that cereals were the main foods in Masimbani and Kake, while over 50% of all households in both locations sourced their cereals from own production. However, in Kwa Kyai, the market was the main source of cereals for over 55% of male and 72% of female-headed households. This was likely because Kwa Kyai farmers practised furrow irrigation, unlike farmers in Masimbani and Kake; hence, they planted high value crops, such as vegetables and green maize through irrigation and used the proceeds to purchase low value crops, such as cereals. In Kwa Kyai, the percentage of the quantity of cereals purchased and that produced was much higher for female (73%) than male-headed households (55%). This could imply that female-headed households were more entrepreneurial than the meale counterparts. However, in the two other villages, the ratios were similar for men and women. Exchanging labour for food was not common (9.1%), and was only in Kwa Kyai. This could be because irrigation farming was labour–intensive and irrigation was not available for all farmers in Kwa Kyai. Therefore, farmers with no access to irrigation, could offer labour in return for food. Receiving gifts from relatives was also not common.

Unlike the cereals, the main source of roots and tubers was the market; a small percentage came from own production. In Kake, however, 50% of female-headed households sourced roots and tubers from the market. In Kwa Kyai and Masimbani, male-headed households consistently consumed more roots and tubers from own production, compared to their female counterparts. Vegetables were both from own production and from purchase. Male-headed households in Kwa Kyai and Masimbani consumed at least 50% of vegetables from own production. Fruits and meats were mainly sourced from the market, whereas eggs were from own production. Also, fats, butter, honey and sugar were purchased.

Table 21: Main source of food for a typical week in 2014

Main food source over the past seven days	Kwa Kyai Household (%)		Masimbani Household (%)		Kake Household (%)	
	Male	Female	Male	Female	Male	Female
Cereals:						

1=Own production	42.1	18.2	89.3	90	65.2	62.5
5=Purchase	55.3	72.7	10.7	10	34.8	37.5
6=Exchange labour for food	0	9.1	0	0	0	0
8=Gift from family relatives	2.6	0	0	0	0	0
Roots and tubers:						
1=Own production	32	28.6	18.8	12.5	21.4	50
5=Purchase	68	71.4	68.8	87.5	71.4	50
6=Exchange labour for food					7.1	
7=Exchange items for food			6.3			
8=Gift from family relatives			6.3			
Vegetables:						
1=Own production	50	36.4	53.6	20	26.1	37.5
5=Purchase	47.2	63.7	46.4	80	73.9	62.5
8=Gift from family relatives	2.8	0	0	0	0	0
Fruits						
1=Own production	39.1	40	13.3	12.5	25.7	33.3
5=Purchase	52.2	60	80	87.5	74.3	66.7
8=Gift from family relatives	8.7	0	6.7	0	0	
Meats:						
1=Own production	16	20		28.6	45.5	
2=hunting, fishing	4					
5=Purchase	80	80	100	57.1	54.5	100
6=Exchange labour for food	0	0	0	14.3	00	
Eggs						
1=Own production	87.5	33.3	90	80	87.5	71.4
5=Purchase	12.5	66.7	10	20	12.5	28.6
fish						
2=hunting, fishing	5.6	0	0	0	0	0
5=Purchase	94.4	100	100	100	100	100
Beans and other pules						
1=Own production	16.7	36.4	68	62.5	40	64.3
5=Purchase	80.6	63.6	32	37.5	60	35.7
8=Gift from family relatives	2.8	0	0	0	0	0
Milk and other milk products						
1=Own production	0	18.2	48	83.3	36.4	37.5
5=Purchase	100	81.8	52	16.7	63.6	62.5
Oils and fats			3.7			
1=Own production	0	0	0	0	0	11.1
5=Purchase	100	100	96.3	100	100	88.9
Sugar and Honey						
3=Gathering			3.8			
5=Purchase	100	100	92.3	100	100	100
6=Exchange labour for food			3.8			

Miscellaneous	100	100	100	100	100	100

Source: Survey results, 2019

For 2018, only farmers in Kwa Kyai had access to irrigation water (flood irrigation) and this reflected in their sources of cereals, roots and tubers, vegetables and fruits. In Kwa Kyai, the percentage of respondents who said their main sources of food were own production was much higher than those in Masimbani and Kake: in Kwa Kyai, 26% of female and 63% of male-headed households said their main source of roots and tubers was own production, whereas this was zero for both households in Kake and all female-headed households in Masimbani. For fruits and vegetables also, more than half of the respondents in Kwa Kyai relied on own production, whereas this was less than 15% for the other two villages. This shows the importance of irrigation in these areas. Thus, the families in Kwa Kyai enjoyed better food and nutrition security because of irrigation. Considering that these are very dry areas with a few options for off-farm employment, the villages without irrigation probably had insufficient money to purchase quality foods.

Table 22: Main sources of food over the past seven days in 2018

	Kwa Kyai Household (%)		**Masimbani** Household (%)		**Kake** Household (%)	
Main food source over the past seven days	Male	Female	Male	Female	Male	Female
Cereals:						
1=Own production	31.6	36.4	25.0	80	21.7	12.5
5=Purchase	68.4	63.6	75.0	20	78.3	87.5
Roots and tubers:						
1=Own production	25.9	62.5	20	0	0	0
5=Purchase	74.1	37.5	80	100	100	100
Vegetables:						
1=Own production	52.6	54.5	14.3	10	13	6.3
5=Purchase	44.7	45.5	85.7	87	87	93.8
8=Gathering	2.7	0	0	0	0	0
Fruits						
1=Own production	60	40	10	20	12.5	20
5=Purchase	35	60	90	80	87.5	80
8=Gathering	5	0	0	0	0	0
Meats:						
1=Own production	4	20	8.3	0	30	0
5=Purchase	96	80	91.7	100	70	100
Eggs						
1=Own production	80	50	100	80	85.7	80
5=Purchase	20	50	0	20	14.3	20
Fish						
2=hunting, fishing	13.3	0	0	0	0	0
5=Purchase	86.7	100	100	0	100	0
Beans and other pulses						

1=Own production	16.7	9.1	25	21.4	16.7	21.4
5=Purchase	93.3	90.9	75	78.6	83.3	78.6
Milk and other milk products						
1=Own production	34.3	10	30.4	25	40	25
5=Purchase	65.7	90	69.6	75	60	75
Oils and fats						
1=Own production	0	0	7.1	100	0	0
5=Purchase	100	100	92.9	0	100	100
Sugar and Honey						
5=Purchase	100	100	100	0	100	100
Miscellaneous						
Purchase	100	100	100	0	100	100

When asked if the past week was considered low, normal or peak on food availability, over 60% of all the respondents stated that it was a normal week. For 2018 data only, however, about 67% of respondents in Kake and 58% in Masimbani (those without irrigation), as well as 31% of those in Kwa Kyai (having irrigation) stated that it was a low week on food availability. Majority of respondents (59%) in Kwa Kyai said it was a normal week on food availability, a difference that was significant at 1% level. Indeed, irrigation moderates the effects of weather so that food is available all-year round. Details of the results disaggregated by gender are presented in Tables 24 and 25. It was only in Masimbani in 2014 and Kake in 2018 that the results showed significant differences between male and female-headed households at 10% level.

Table 23: Status of the week whose seven days were referenced in 2014

	Kwa Kyai			Masimbani			Kake		
	Household (%)		Statistical significance	Household (%)		Statistical significance	Household (%)		Statistical significance
Status of the week preceding the survey	**Male**	**Female**		**Male**	**Female**		**Male**	**Female**	
1=Low food season	27.3	31.6	$\chi2$ = 0.805 P= 0.668	7.1	30	$\chi2$ = 4.798 P=0.091	34.8	12.5	$\chi2$ = 4.482 P=0.118
2=Normal food season	63.6	50		64.3	30		52.2	50	
3=Peak food season	9.1	18.4		28.6	40		32.0	37.5	

Source: Survey results, 2019

Table 24: Status of the week whose seven days were referenced in 2018

Kwa Kyai	Masimbani	Kake

	Household (%)		Statistical significance (χ2)	Household (%)		Statistical significance (χ2)	Household (%)		Statistical significance (χ2)
Status of the week preceding the survey	Male	Female		Male	Female		Male	Female	
1=Low food season	31.6	27.3	χ2 = 1.939 P=0.379	53.6	70	χ2 =0.816 P=0.816	65.2	68.8	χ2 = 0.053 P= 0.366
2=Normal food season	55.3	72.7		46.4	30		34.8	31.2	
3=Peak food season	13.2	0		0	0		0	0	

Source: Survey results, 2019

Food availability in the last twelve months

Asked if they had experienced food shortage in the preceding 12 months, only 27% in Kwa Kyai, 37% in Masimbani and 15% in Kake responded in the affirmative. In Kwa Kyai, all the female-headed households were food insecure in March, August, September, and October. In Masimbani, they were all food insecure in July and August, whereas in Kake, they were all food insecure in June, July and August. There was no instance where all the male-headed household were food insecure for a given month (Table 26).

Table 25: Status of food availability in twelve months preceding the survey

		Kwa Kyai		Masimbani		Kake	
Percent of farmers who overall experienced food shortage within 12 months prior to the survey		26.5		36.8		15.4	
		Percent of households reporting shortage					
Percent of farmers (male and female) who experienced food shortage in various months	Months	Male	Female	Male	Female	Male	Female
	Jan	33.3	50	50	50	0	33.3
	Feb	33.3	50	58.3	0	0	33.3
	March	22.2	100	66.7	0	33.3	33.3
	April	33.3	75	33.3	0	33.3	33.3
	May	22.2	0	25	0	33.3	66.7
	June	33.3	0	50	0	66.7	100
	July	55.6	25	33.3	100	33.3	100

Aug	88.9	100	41.7	100	33.3	100
Sep	88.9	100	50	50	66.7	66.7
Oct	44.4	100	50	50	0	66.7
Nov	33.3	75	25	50	0	33.3
Dec	11.1	25	8.3	50	0	33.3

Food security in the last five years at the study sites

For majority of the households, the food security situation either decreased or remained the same in the five years preceding the survey for both male and female-headed households (Table 27). Overall, 55% of the respondents in Kwa Kyai, 45% in Masimbani and 47% in Kake said the food security situation had decreased or worsened, whereas 16% in Kwa Kyai, 34% in Masimbani, and 28% in Kake said it had increased. For the rest (29% in Kwa Kyai and in Masimbani and 25% in Kake) it had remained the same. Similar results were recorded for the consumption of protein-rich foods (Table 27).

Table 26: Status of food security and protein-rich foods in the last five years at the study sites

	Kwa Kyai			**Masimbani**			**Kake**		
	Household (count)		Statistical significance	Household (count)		Statistical significance	Household (count)		Statistical significance
	Male	Female		Male	Female		Male	Female	
Rated change in food security In the last 5 years									
1=decreased	23	4	X^2=0.365	13	4	X2=4.40	8	7	X^2=0.208
2=Increased	4	4	P=0.111	9	4	0	9	5	P=8.33
3=Remained the same	11	3		6	2	P=0.901	6	4	
Rated status of consumption of protein rich foods in the last 3 years									
1=Decreased	22	3	X^2=8.307	14	4	X^2=1.66	7	6	X^2=0.362
2=Increased	2	4	P =0.016	8	5	7	10	7	P =0.835
3=Remained the same	14	4		6	1	P =0.435	3	3	

Source: Survey data 2019

Reasons for changes in food security

The main reason given for the decrease in food security and consumption of protein-rich foods was climatic factors (Tables 28). The households for whom food security had improved said the reason comprised climatic factors and improved technology.

Table 27: Reasons for change in status of food security and consumption of protein-rich foods in the last five years at the study sites.

	Kwa Kyai Household (%)		Masimbani Household (%)		Kake Household (%)	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
If food security increased what are possible attributable factors						
1=Climatic factors	75	100	88.9	75	66.7	80
2-Security	0	0	0	0	11.1	0
3=Improved technologies	25	25	77.8	100	55.6	40
4=Income	50	0	33.3	0	7.1	0
5=Others	25	0	0	0	0	0
If food security decreased what are the possible attributable factors						
1=Climatic factors	100	100	100	100	100	100
2-insecurity	4.3	0	7.7	0	0	0
3=Lack of inputs	21.7	50	-	-	-	-
If protein consumption increased what are the possible attributable factors?						
1=Climatic factors	62.5	80	100	100	70	85.7
2-Security	-	-	50	-	-	-
3=Improved technologies	75	60	50	25	40	42.9
4=Income	37.5	0	50	0	40	14.3
If consumption of protein foods decreased what are the possible attributable factors?						
1=Climatic factors	95.5	100	92.9	100	100	88.3
2-insecurity	4.5	0	-	-	-	-
3=Lack of inputs	22.7	0	21.4	25	14.3	0

5=Others	4.5	33.5	21.4	0	0	33.3

Source: Survey data 2019

Socioeconomic evaluation of project

This section presents data and information on household perceptions on the impacts of the drip irrigation project on the farming households, as well as the profitability of the project.

Perceptions on the impacts of drip irrigation

The perceptions on the project impacts were sought on use of money received through the project, changes in gender roles, conflicts over use of water, access to agricultural services associated with irrigation water, employment creation, poverty, environmental conservation, and incidences of corruption.

a) Use of Income from irrigation

The major expenditure items in the three schemes were food and school fees. Households in Kwa Kyai scheme spent most money on food (80.4%) while those in Masimbani spent more on school fees (71.1%). The other expenditure items were at low levels; Kwa Kyai had unique expenditures on machinery and land (Figure 13).

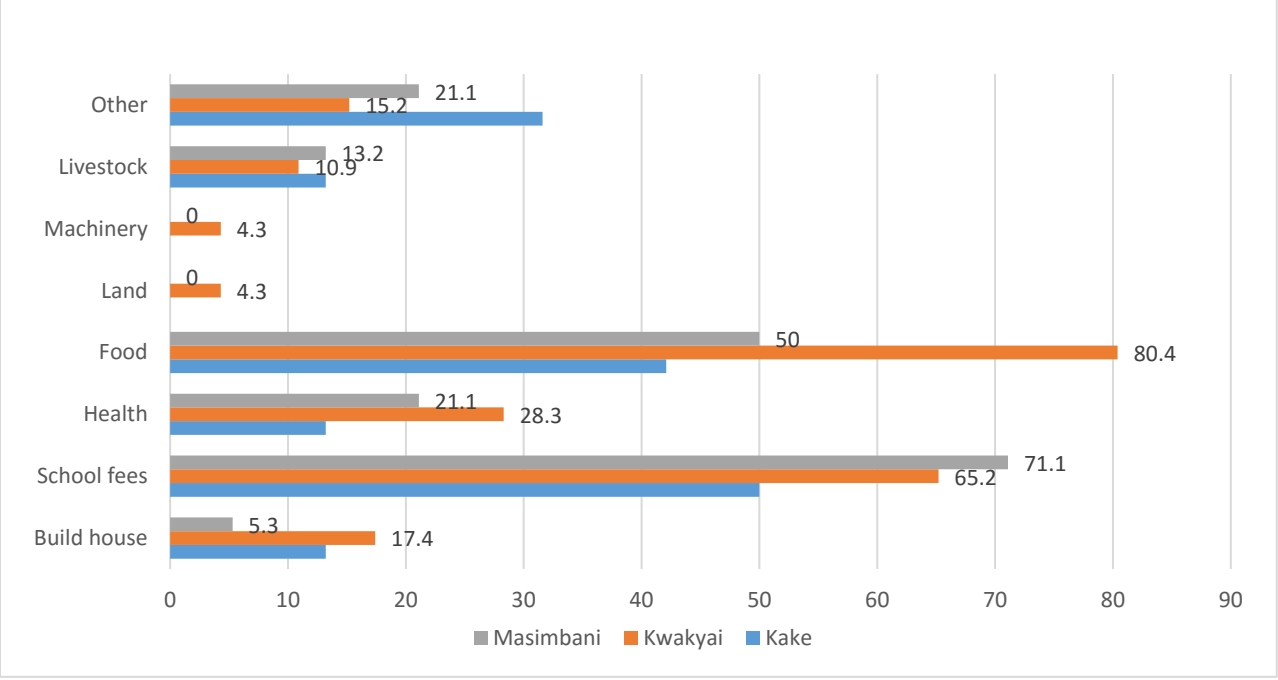

Figure 14: Use of irrigation money

b) Changes in gender roles

Irrigation was perceived to have greatly increased youth involvement in agriculture, women access to production resources, and participation in markets (Table 29). Increased youth involvement in agriculture was perceived more in Kake than the other two villages, while increased women access to production resources was higher in Masimbani than in the other two sites. Increased involvement of youth could be attributed to the cultivation and sale of high value horticultural crops; a situation that may also explain the increased involvement of women in markets and access to production resources.

Table 28: Perception of household heads on changes in gender roles in production and marketing activities

Impact	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Women participation in markets	11.5	9.8	11.5	32.8
Youth involvement in agriculture	23.0	20.5	15.6	59.0
Women access to production	9.8	9.8	14.8	34.4
Other	1.6	7.4	2.5	11.5
	30.3	38.5	31.1	100

c) Status of conflict

Table 30 shows the proportion of households reporting changes in status of conflicts. Irrigation was perceived to have led to a significant increase (p=0.003) in conflicts over resources, with more of the conflicts in Masimbani (72.7%) than Kake (67.6%) and Kwa Kyai (34%). Masimbani and Kake, which were downstream schemes, had no water before the project; hence, there was increase in intra scheme and inter-scheme conflict with Kwa Kyai residents who claimed that the other two villages introduced competition. The situation can perhaps be explained by the limited participation during the project implementation phase with respect to household responsibilities, roles and obligations.

Table 29: Perception of household heads on changes in status of conflicts

Trend	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Increased	67.6	34.0	72.7	55.3
Decreased	14.7	38.3	21.2	26.3

Remained same	17.6	27.7	6.1	18.4
X^2				16.153
p value				0.003***

*** significant at 1%

d) Access to agricultural services

Overall, access to agricultural services (extension, veterinary, credit, etc) was perceived to have remained the same over time by 39.3% of the respondents. This was more pronounced in Kwa Kyai (72.7%) and Kake (45.7%) than in Masimbani (39.4%) (Table 31). None of the respondents reported any increase in access to agricultural services.

Table 30: Perception of household heads on changes in access to agricultural services

Trend	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Remained same	45.7	72.7	39.4	39.3
Decreased	13.0	24.2	45.5	10.7
X^2				10.2
p value				0.037**

**Significant at 5%

e) Employment creation

Employment creation was perceived to have increased by 53.5% of the respondents, with a higher proportion of this being from Kake (67.6%) and Kwa Kyai (51.1%) (Table 32). In Kwa Kyai, 31.9% of the respondents perceived employment to have remained the same; in Masimbani, this was 24.2%.

Table 31: Perception of household heads on changes in employment creation

Trend	**Scheme**			**Mean**
	Kake	**Kwa Kyai**	**Masimbani**	
Increased	67.6	51.1	42.4	53.5
Remained same	11.8	31.9	24.2	23.7
Decreased	20.6	17.0	33.3	22.8
X^2				7.835
p value				0.098*

*significant at 10%

f) Impact of irrigation project on poverty reduction

Poverty was perceived to have decreased significantly by 57.1% (p=0.0248) due to irrigation activities, with the highest reduction being in Kake (70.6%), followed by Masimbani (59.4%) (Table 33).

Table 32: Perception of household heads on changes in poverty status

Trend	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Decreased	70.6	45.7	59.4	57.1
Remained same	20.6	43.5	31.3	33
Increased	8.8	10.9	9.4	9.8
X^2				5.403
p value				.0248**

***significant at 5%*

g) Environmental conservation

Environmental conservation effort was perceived to have remarkably increased due to irrigation activities by 54.9% of the respondents. Kake scheme respondents expressed this perception more than the other two schemes (Table 34).

Table 33: Perception of household heads on changes in environmental conservation

Trend	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Increased	58.8	54.3	51.5	54.9
Remained same	26.5	41.3	31.3	34.5
Decreased	14.7	4.3	15.2	10.6
X^2				4.309
p value				0.366

h) Pollution incidence

Pollution incidence was perceived to have remained the same by 38.7% of the respondents, but the perception was higher in Kwa Kyai (47.8%) than in other sites (Table 35). A further 37.8% of the respondents perceived that pollution had decreased significantly.

Table 34: Perception of household heads on changes in pollution incidence

Trend	Scheme			Mean
	Kake	Kwa Kyai	Masimbani	
Remained same	29.4	47.8	35.5	38.7
Decreased	44.1	34.8	35.5	37.8

Increased	26.5	17.4	29.0	23.4
X^2				3.608
p value				0.462

Perceptions on other impact areas

The respondents perceived that the irrigation project positively impacted on youth involvement in agriculture due to the rise in the production and marketing of high value crops, employment, and environmental conservation activities. They also perceived that the project negatively impact on incidences of conflict over the control of water resource. These conflicts occurred at the three sites of the project due to poor management.

Gross Margin Analysis

Gross margin analysis is used as a proxy for economic analysis. The gross margins (GMs) calculated using data from the farmers sampled had a mean of KES161,025.63. The GMs ranged from a minimum of KES5,300 for sorghum grown at Masimbani to a maximum of KES1,167,584 for tomatoes grown under irrigation at Kwa Kyai (Table 36).

Table 35: Gross margin per acre of various crops grown at Kwa Kyai, Masimbani and Kake

Schemes	Crop	Annual Harvest Per Acre	Revenue Per Acre	Production Cost Per Acre	Gross Margin Per Acre	Land Lease Per Acre	TFC	Total Cost (TC)
Kwa Kyai	Cassava	240	12,000	5,000	7,000	5,000	5,000	10,000
Kake	Cowpeas	1,685	52,416	18,432	33,984	5,000	5,000	23,432
Kwa Kyai	Cowpeas	941	14,118	2,329	11,788	5,000	5,000	7,329
Masimbani	Cowpeas	1,839	51,852	13,323	38,529	5,000	5,000	18,323
Kwa Kyai	Egg plant	13,928	278,560	71,306	207,254	40,000	40,000	111,306
Masimbani	Grass	450	22,500	2,250	20,250	5,000	5,000	7,250
Kake	Green grams	2,856	180,738	50,780	129,958	5,000	5,000	55,780
Kwa Kyai	Green grams	482	22,500	11,625	10,875	5,000	5,000	16,625
Masimbani	Green grams	3,349	217,664	49,416	168,248	5,000	5,000	54,416
Kake	Green maize	900	27,000	3,000	24,000	5,000	5,000	8,000
Kwa Kyai	Green maize	720	28,800	8,000	20,800	5,000	5,000	13,000
Kwa Kyai	Maize	18,046	422,795	213,791	209,004	40,000	40,000	253,791
Masimbani	Maize	750	21,750	5,600	16,150	5,000	5,000	10,600
Kwa Kyai	Managu	1,200	36,000	6,000	30,000	40,000	40,000	46,000
Kwa Kyai	Okra	2,662	133,105	28,555	104,551	40,000	40,000	68,555
Kwa Kyai	Sorghum	360	14,400	2,500	11,900	5,000	5,000	7,500
Masimbani	Sorghum	90	6,300	1,000	5,300	5,000	5,000	6,000
Kwa Kyai	Sukuma wiki	30,632	989,427	147,115	842,312	40,000	40,000	187,115
Kwa Kyai	Tomatoes	37,246	1,373,438	205,854	1,167,584	40,000	40,000	245,854
Minimum					**5,300.0**			
Maximum					**1,167,584.0**			
Mean					**161,025.6**			
Std. Error					**71,093.1**			

Field Survey 2019. 100 KES = 1 USD

Gross margin analysis and cost benefit analysis

Using data from the farmers sampled, gross margin cost ratio (GMR), profit cost ratio (PCR) and benefit cost ratio (BCR) were done on 11 crops grown under either rain-fed or furrow irrigation system (Table 37). It was found that the mean GMR was 0.75, with a minimum of 0.48 for green grams grown at Kwa Kyai and maximum of 0.9 for grass grown at Masimbani. A GMR of 0.75 for a particular implies that the farmers growing the crop met their costs and remained with some income of 75% to pay for fixed costs and extra income for household expenditure. PCR analysis showed a mean of 0.5, with a minimum of 0.18 for tomatoes grown at Kwa Kyai and sorghum. The maximum PCR of 1.28 was for managu grown at Kwa Kyai. The lower the PCR, the more profitable the crop. The BCR analysis showed a mean of 2.5, with a minimum of one (1) for cassava, green grams and managu grown at Kwa Kyai and the maximum of six (6) for tomatoes grown at Kwa Kyai. A BCR of 1 implies that farmers met their costs and remained with some income. The profit indicators for the crops grown by the sampled farmers were generally good, meaning that the enterprises were sustainable. A BCR must be greater than 1 and PCR should be less or equal to 0.65 for an enterprise to be sustainable.

Table 36: Gross margins and net tomato income in Kibwezi (Kwa Kyai) per acre

Schemes	Crop	Total Cost (TC)	Gross Margin Ratio (GMR)	Profit Cost Ratio (PCR)	Benefit Cost Ratio (BCR)
Kwa Kyai	Cassava	10,000	0.58	0.83	1
Kake	Cowpeas	23,432	0.65	0.45	2
Kwa Kyai	Cowpeas	7,329	0.84	0.52	2
Masimbani	Cowpeas	18,323	0.74	0.35	3
Kwa Kyai	Egg plant	111,306	0.74	0.40	3
Masimbani	Grass	7,250	0.90	0.32	3
Kake	Green grams	55,780	0.72	0.31	3
Kwa Kyai	Green grams	16,625	0.48	0.74	1
Masimbani	Green grams	54,416	0.77	0.25	4
Kake	Green maize	8,000	0.89	0.30	3
Kwa Kyai	Green maize	13,000	0.72	0.45	2
Kwa Kyai	Maize	253,791	0.49	0.60	2
Masimbani	Maize	10,600	0.74	0.49	2
Kwa Kyai	Managu	46,000	0.83	1.28	1
Kwa Kyai	Okra	68,555	0.79	0.52	2
Kwa Kyai	Sorghum	7,500	0.83	0.52	2
Masimbani	Sorghum	6,000	0.84	0.95	1
Kwa Kyai	Sukuma wiki	187,115	0.85	0.19	5
Kwa Kyai	Tomatoes	245,854	0.85	0.18	6
Minimum			**0.48**	**0.18**	**1**
Maximum			**0.9**	**1.28**	**6**
Mean			**0.75**	**0.5079**	**2.526**

Schemes	Crop	Total Cost (TC)	Gross Margin Ratio (GMR)	Profit Cost Ratio (PCR)	Benefit Cost Ratio (BCR)
Std. Error			0.02834	0.06386	0.3094

Conclusions

Although documented evidence on drip irrigation activities in Kibwezi was not exhaustive, it was clear from the beginning that farmers needed irrigation water to increase agricultural productivity. Thus, they requested the County and National Government leadership to install water irrigation and contribute fund to their agricultural activities, as observed during the conduct of Masimbani FGD. Farmers formed groups and were subsequently trained on agronomic practices and soil conservation, but there was minimal training on water use and management. They were then supported in line with the government's efforts to increase land under irrigation (ASGTS, 2018; Vision 2030).

In the short term, the Jain drip irrigation project brought immediate benefits which included increased crop and livestock production for food and income, as well as employment, especially for the youth and women. The cyclic annual dependence on relief food was eliminated, especially when implementation of the project was at its peak. The outcome of the project was improved livelihoods, health, security and housing. However, the benefits were short-lived, being only for one season, due mainly to rural-urban migration.

The benefits from the Jain drip irrigation project were short-lived also because there was minimum involvement of beneficiaries' right from the start of the project. The farmers were not properly sensitized or trained on the use of water (a public good) and there were weak management and leadership structures in place to manage the project. This resulted in what is termed as the "Tragedy of the Commons" (where a public good -water is used by all, but the benefits are entirely private); hence, the users were maximizing gains while mismanaging the facility. Politicians also interfered with the project by pitting the users against one another, thus the project rules were not followed, resulting in institutional failure. Farmers in Kwa Kyai (the water source) were not willing to share the water with those in Kake and Masimbani; at some points, they closed the water valves. There was also no maintenance of the drip lines, to the extent that there were leakages resulting in water losses. Drip lines were then vandalized and used for unintended purposes. Other partners who would have built capacity of the end users of the irrigation project were not involved. Thus, FGD participants of WRUA in Kibwezi said, "If we had been involved in the Jain irrigation project, we could have sensitized farm households and managers on watershed conservation, and also on how to organize small funds for maintenance". Failure of the irrigation project brought about conflicts among community members. After the project ended, deterioration set in for beneficiaries livelihoods; there was also reduced food security, incomes, and employment, thus exacerbating rural-urban migration.

Despite the failure of the irrigation project, the beneficiaries learnt the importance of collective action, good governance and management of a public good, to make it sustainable and beneficial to every stakeholder. The Kake FGD participants had stated that the project implementers should have run the project for at least for one year before handing it over to the end users. Perhaps if

WRUA had been involved in the project, it would have been better managed and more sustainable. Another aspect that could have increased sustainability of the irrigation project was improved marketing of farm produce; hence, increased commercialization of farming activities at the study sites. Sub-standard irrigation infrastructure also contributed to inefficiencies in water use.

Lessons Learnt and Recommendations

Lessons Learnt

In the course of analysing the project design and implementation, various lessons have been learnt.

Drip irrigation increased water use efficiency

This study has shown that the project introduced water use efficiency through the installation of drip irrigation system. The farmers all reported how they were able to use the system to increase production and income.

Additional area served through the drip irrigation system

The use of drip system allowed more farmers to be served by the same amount of water that initially was barely enough for one community. The furrow irrigation system that was used before the launch of the drip system only served Kwa Kyai; the drip system extended this service to Kake and Masimbani through the extra water that was saved.

Coordinated planning between different government offices/staff

There was effective coordination, planning and execution between the National Irrigation Board, local agricultural engineers, agricultural extension officers and contractors with regard to the irrigation design, including the offtake points, the reticulation and drip irrigation lines.

Successful launching of the project

The drip irrigation system was successfully launched and farmers' testimonies showed that they were trained on how to collectively grow and market various income-generating crops in production and marketing clusters.

Improved health and cohesion of families

Interviews with farmers at the three study sites indicated that in the period that the drip irrigation system was in operation, there was improvement in livelihoods of farmers, especially their health status. Adequate and diverse foods were available for the period that the project was in operation and families lived cohesively.

Involvement of local stakeholders is critical for success

The drip irrigation project was completely planned and executed by government actors; there was no effort to sensitize the local stakeholders, especially the targeted beneficiaries of the project. These included the local farmers, the local administrators, WRUAs and other grassroots leaders. This led to the lack of ownership, which is critical to sustainable development. One crucial factor of the project collapse was the sense of entitlement to irrigation water by Kwa Kyai

community, who were the original users of the scheme. The project team should have properly sensitized the farmers and involved other key players, such as WRUA and local leaders. Another option could have been to design the Kake and Masimbani drip irrigation schemes using intake points separate from those of Kwa Kyai.

Training of local maintenance personnel is key to sustainability of projects

The study also found that minimal efforts were made towards training local maintenance personnel. Such personnel, when properly trained, could have taken over this crucial function on handing over of the project to the community.

Lack of formal handing over of project to local stakeholders causes alienation

The community members interviewed complained about failure by the project implementers to hand over the project to them after the launch. They stated that the contractors and government technical staff unceremoniously left the project sites. A respondent stated, ”the project staff left as suddenly as they came, with no local persons trained on maintenance of the system” (FGD interview, Kwa Kyai).

Unexplained overhaul of existing facilities may cause resentment

For many years, farmers in Kwa Kyai were used to the furrow irrigation system. The system provided easy access to drinking water both to livestock and human use. The drip irrigation did not allow open access, since the water was piped. Although the project had planned to construct water kiosks and livestock watering points, the plan was not followed. Consequently, community members developed a negative perception and felt that water was being channelled to faraway areas at their expense. They thus resorted to destroying the irrigation facilities.

Lack of transparency gives room for speculations and innuendoes

Due to the lack of community sensitization, the local stakeholders began to speculate about the project budget; there were conclusions that the fund was squandered by the implementers. These speculations and innuendoes were mainly made by farmers who felt left out in the irrigation scheme. Those who paid for the irrigation system and did not get adequate water also added to the pool of misinformation. The misinformation was also fuelled by political interests. These were all as a result of the lack of transparency in the implementation of the project.

Vested political interests will negatively affect a people’s livelihood

The drip irrigation project was highly commendable for this water-deprived area, as is the case with all ASALs in Kenya. The technical specifications were based on sound engineering principles. However, vested political interests gradually crept into the project and created tension between communities who had earlier lived harmoniously side by side.

Recommendations

It is important for both national and county governments to revisit the issue of irrigation in Kibwezi with a view to increasing the water use efficiency of the available irrigation water among farmers. It is critical that such attempts sufficiently involve the local communities particularly those in Kwa Kyai, who are currently benefiting from the water under flood irrigation. A committee to manage water use should be put in place and should comprise all benefiting communities and government officials. The beneficiaries should be sufficiently trained on water management, modern production system and marketing of crops under irrigation. These should be coordinated by the Ministry of Agriculture, Livestock and Fisheries.

In all irrigation projects, there should be proper planning and organization to provide not only irrigation water but also water for domestic use, to avoid incidences of destruction of inlet valves and pipes.

There is need for a more holistic approach to irrigation management through a coordinated arrangement with stakeholders (including inputs dealers). Such an approach could include scheduled supply to the various schemes on designated days, establishment of water management bodies with representatives from the different schemes/ communities and organized payment of operations and maintenance funds.

Finally, there is need for more support for women/female-headed households, who constitute the larger percentage farmers in Kenya. Drip irrigation system should be designed in such a manner that ensures equity in water resource sharing.

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ANNEXES: Photo Gallery

	
Drip lines used for fencing	**Vandalized drip lines**
	
Using drip lines to tether goats	**Cattle drinking from furrow line**

Farrow Irrigation a Kwa Kyai

Abandoned Drip Irrigation Infrastructure at Masimbani and Kake

Conducting Focus Group and Individual Interviews at Study Sites