



Effects of Irrigation Systems on Farming Practices: Evidence from Oluch-Kimira Scheme, Homa Bay County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. Author SMM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author EAB managed the analyses of the study. Author DKB managed the literature searches, analyses and reporting. All authors read and approved the final manuscript.

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ABSTRACT

Irrigation waters have vast benefits to the soils especially where they are installed. Some of the benefits of water includes: facilitating nutrient circulation within the soil profile, assist in nutrient uptake by various plants, enhance transpiration as well as enhances nutrient diffusion in the soil. But also irrigation systems have negative effects to soils mostly including environmental impacts. The current study wanted to investigate the effects of irrigation systems on farming practices in Oluch-Kimira. A survey methodology with an *Ex-post facto* research design was used with a sampling frame consisting of 340 small-scale farmers. A sample of 332 irrigation participants and 8 non irrigation participants were chosen for the study using random sampling. Primary data was collected through interview schedules administered to participants in irrigated agriculture and Non participants. It was revealed that before irrigation technology the level of embracing farming systems was at 3.96% ($R^2=0.0396$) while after introduction of irrigation technologies the embracing lever increased to 55.6% ($R^2=0.556$), a clear indication that the farming systems in the study areas

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improved due to presence of waters or humid environment brought about irrigation and water in general. The results also revealed that increased irrigation technologies have also improved the farming practices and eventually improved good agricultural practices.

Keywords: Farming practices; irrigation systems; irrigated agriculture; non-irrigated agriculture.

1. INTRODUCTION

The idea beyond the irrigation technology was due the world's ever growing of urbanization as well as changing climatic conditions, these among many other factors have led to an increased of the demands of water resources [1]. According to Kulecho & Weatherhead [2], rapid growing of urbanization and industrialization has also posed a challenge of increased demand for water thus bringing a competition with agricultural sector. It is evident that efficient utilization of water in irrigated agriculture is crucial for achieving sustainable farming systems [3]. In late 1970s water resource policies in most of the developing countries emphasized on supply augmentation, targeting to enhance irrigation potential and to guarantee a steady water supply to the consumers. A lot of capital was pooled together to invest in the construction of large dams, enhancing irrigation facilities and other irrigation related activities [4].

Irrigation waters have vast benefits to the soils where they are installed, some of the benefits includes: playing a critical role in facilitating nutrient movement within the soil profiles, assist in nutrient uptake by various plants, enhance transpiration and also enhances nutrient diffusion in the soil. But in equal measure irrigation systems has negative effects to farming systems this include environmental impacts. If irrigation waters are poorly managed it can cause irreversible damage to soil properties which can be either long term or short time. For instance, Soil erosion, ground water pollution and salinity are among the main long term effects of irrigation. In limited water supply, Salinity appears to be the most difficult factor to deal with in arid and semi-arid zones.

The existing literature on the positive effects of irrigation technologies in some Asian and African countries indicates that farmers who use irrigation systems have been found to be better off in terms of farming systems, food secure, nutritional status, income and better living standard than those who entirely rely on rainfed agriculture. Sing and Misra [5] made comparison between non-irrigating farmers and canal

irrigation systems and came up with the following observation according to FAO, [6] that, the total farm output per acre as a whole is 8.6% much higher in the irrigated agriculture than in rainfed agriculture; the crop production from the whole farm output is 5.5% more with irrigated agriculture compared to that from rainfed agriculture; that, the value of agricultural crop produce sold per acre is 48% more in the irrigated agriculture compared to that from rainfed agriculture; the gross inputs per acre stand at 3.7% higher in regards to quantity for irrigated agriculture than rainfed agriculture and finally, labour payment including permanent and casual labourer is about 21% higher in irrigated agriculture as compared to non-irrigated agriculture (rainfed). From the above study, it's evident that irrigated agriculture accrues more the benefits in regards to enhanced income generation; crop productivity and creation of job opportunities to many farmers in the community thus give better chance to guarantee household food security. According to FAO [7], they further reported that farmers' incomes from irrigated areas are significantly greater than those incomes from rainfed agriculture.

The initial stages of irrigation installation or construction come along with specific environmental problems mostly associated with environment such as loss of natural habitat and some of them have harmful effects beyond the construction phase. Water losses through percolation, seepage as well as unproductive evaporation have potentially triggered the problems of salinization and waterlogging which in one way or the other affect the farming systems. The greatest impact of the irrigation development or scheme to the residents is water related disease such as bilharzias and malaria. For instance, when the Karnataka Irrigation Project was initiated in 1978, the scheme was malaria free, despite there was massive vegetative which blocked the seepage and the drainage systems thus causing pools of stagnated water for mosquito breeding hence making farming difficult [4,8].

Farming system approach assumes that, the technology that suits the demands of the

particular group is not always sufficient and required to be invented locally. The purpose is to link the farmers with the research that is tailored towards farmer's interests and needs as per their farming system conditions. Achieving sustainable agricultural growth to support ever increasing population and to support emerging agricultural development project and overall transformation can be made possible through engaging demand driven commercial production, promoting farmers' friendly technology transfer and adoption, enhancing agricultural based infrastructure, expanding agricultural markets, setting functional agricultural strategies and policies [9]. Different approaches have been applied to transfer technology packages to small scale farmers these includes, improved certified seeds, fertilizer, water conservation, soil management, credit, and provision of extension services advisory [10]. However, there have been great steps in agriculture sector as crop productivity remains relative low [10].

The existing farming systems or practices before irrigation systems was characterized by low farming input and mixed farming in small scale farms with an average of 1.3 hectare. Despite the low utilization of the available inputs, land is intensively utilized with little fallow land and some smallholder farmers trying double cropping in the short and long rains. Maize, beans, groundnuts and sorghum are the major crops; however, majority of the households have set aside small seasonal vegetable gardens as well. Low yields and crop failure were frequent due to irregular and unreliable rainfall patterns. The cropping system was based on the productivity of horticultural crops and annual crops [12].

2. MATERIALS AND METHODS

2.1 The Study Site Description

This research was conducted in Homa Bay County precisely in Kimira and Oluch irrigation scheme in Kenya, as shown in Fig. 1. The scheme is situated at the latitudes and longitudes of 34° 30' E and 34° 39' E and 0° 20' S and 0° 30' S respectively along the shore side of Lake Victoria's Winam Gulf. In terms of agro-ecological zones, the county consist seven Agro-ecological Zones (AEZ) however, for the purpose of this study the focus was on Oluch and Kimira schemes in Homa Bay sub-county and Rachuonyo sub-county respectively. The two schemes i.e. Kimira and Oluch consist of two

AEZ namely: Lower Midland (LM2), also known as marginal sugar zone where they grow green millet, grams, tobacco, sorghum, sunflower, beans, sugarcane, groundnuts, pineapples and sisal and Lower midland (LM3), also called cotton zone which grow crops such as sorghum, maize, cow peas, beans, ground nuts, soya, sweet potatoes, simsim, sunflower, green grams, vegetables and rice. On the other hand, Kimira scheme in Rachuonyo sub-county consist of Lower Midland (LM4), also called marginal cotton zone where they grow cotton, rice, beans, ground nuts, soya, sweet potatoes, simsim, sunflower, green grams and vegetables.

2.2 Target Population, Sampling and Sample Size Determination

The study targeted both farmers with and without irrigation technologies. The estimated farmer in Oluch and Kimira was 1,308 and 1,616 respectively [13]. These farmers were then subjected for face to face interviews using a structured interview schedules for the two sub counties. Both qualitative and quantitative data were collected and analyzed both descriptively and inferentially.

Simple random and purposive sampling techniques were used where; Simple random sampling was used to select farmers with access to irrigation systems and those without access to irrigation systems. The irrigation participants were selected based on water utilization, here the researcher was guided into specific farmers' plots by following the secondary canals from the primary canals whereas the non-participants were selected using the same method however, here the researcher targeted farmers without irrigation channel in their plots despite having equal chances of access to water just like irrigation participant farmers. The study therefore applied fisher formula [14] to give a required sample size of 340 respondents which was distributed based on the area size as shown in Table 1.

3. RESULTS AND DISCUSSION

3.1 Irrigation Technologies in Oluch-Kimira

The existing irrigation technologies in the study area include; open gravity, water can, treadle pumps, flood irrigation, canal and pipe

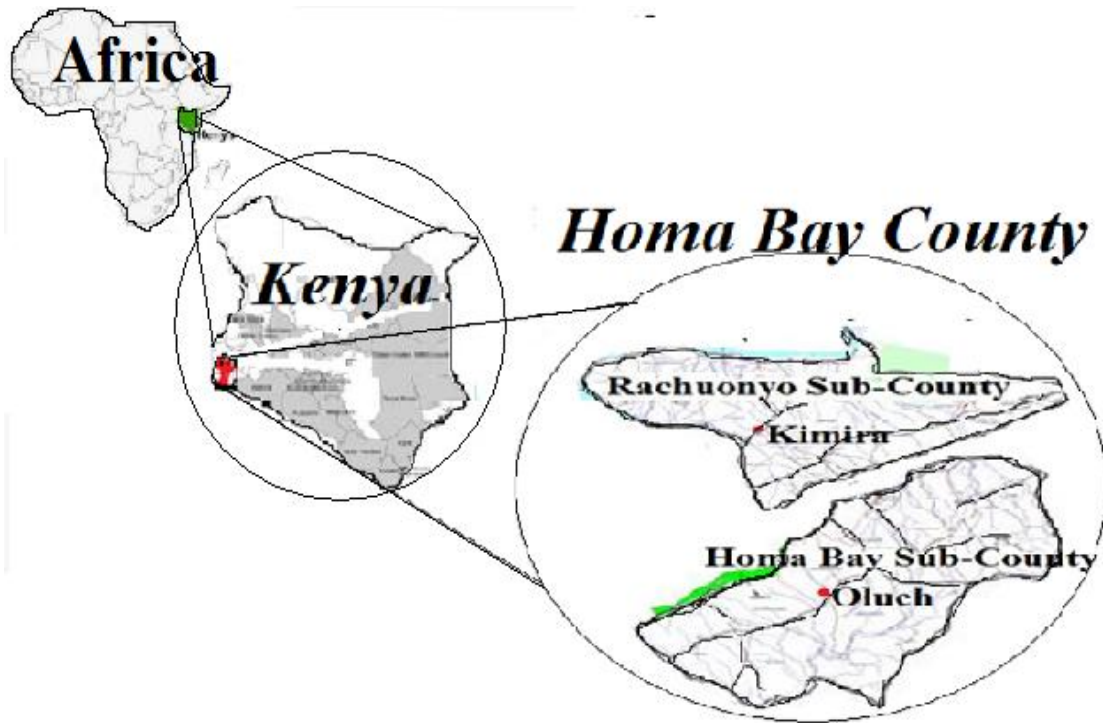


Fig. 1. Map of Kenya showing the study site, Oluch-Kimira schemes in Homa Bay County

Table 1. Sample size distribution in Oluch-Kimira irrigation scheme

Sub-counties	Total area (ha)	Total area under irrigation (ha)	Household beneficiaries	No. of divisions	Desired sample size ($\frac{x}{N} X n_f$)
Kimira scheme	1,790	808	1,616	4 (x)	227
Oluch scheme	1,308	666	1,334	2(x)	113
Totals	3,098	1474	2,950	6 (N)	340

Source; KNBS: (Where $n_f=340$)

conveyance system, sprinkle irrigation and motorized pump. However, the level of usage differs depending on the farmer's economic stability and availability of the resources. From the findings it was evident that, open gravity canal was mostly used technology at 63.5%. The contraction of Oluch-Kimira open canal system was funded by the African Development Bank (ADB) in order to reduce poverty and hunger among the residence in the region. The system has network of secondary and tertiary canal in order to take water to greater distance and covers a wider areas. However the tertiary is not fully complete which has attracted other technologies to be used. Along the canals, the construction took into consideration of the regulating structures as shown in Fig. 2 to control the flow of waters and the distribution of the required amount to avoid wastage. Also the

canal lining is properly designed to prevent water loss through seepage and erosion especially in sandy soils which is loss and unstable. Besides the construction and layout of the canal system, farmers were trained on the system by the extension officers as well as given advice about when and how much needed water required to be supplied to the particular crops. This was then followed by water can method at 46.8%, canal and pipe conveyance system was at 45.0% as indicated in Table 2. Even though sprinkle irrigation was introduced in the study area, its usage was low and 82.6% of the farmers never used the technology because of heavy investments in terms of installation and maintenance. The current study is consistent with FAO, [15] who found out that, utilization of irrigation technologies have tremendously effects on farming systems or practices consequently

improving productivity from 100 per cent and 400 per cent. Its estimates that irrigated cropland in developing countries will increase by 27% in the next 20 years, however, water amount expected to be available for agricultural production will only rise by a mere 12%. In developing countries such as Sub-Saharan Africa, only 4% of cropland is irrigated compared to 1.8% for Kenya.

3.2 Level of Embracement of Various Farming Practices on Crops and Livestock

The respondents were asked to indicate the level of embracing farming practices on various crops and livestock. From the findings it was observed that, mulching, use of disease resistance varieties and crop rotation was highly embraced at average percentage of 83.0%, 71.0% and 69.8% for maize, rice and Kale respectively while the use of local seeds (composite seeds) was lowly embraced at 54.7% as shown in Table 3. The importance of Crop rotations for

instance, it improves soil chemical, biological and physical characteristics [16]. To maintain all the three soil properties there must be water available which can be availed either by irrigation or mulching for chemical reaction to take place within the soil effectively. Tian et al. [17] argues that, rotating crop that include hay, sod or pasture crops helps to minimize bulk soil density, which affects rood penetrations and development as well as impede nutrient flow within the soils and plants. According to Bullock, [18], the effect of crop rotations on soil phosphorous (P), nitrogen (N), carbon (C) and potassium (K) is a complex one since it works well especially when including deep-rooted cover crops in rotations to helps in distributing potassium (K) and phosphorous (P) within the soil surface to the soil profile, where they can accessed by the plant roots [19,20]. The movement of nutrients in the soils can only work well where the soil humid is maintained either through irrigation or enhanced mulching.

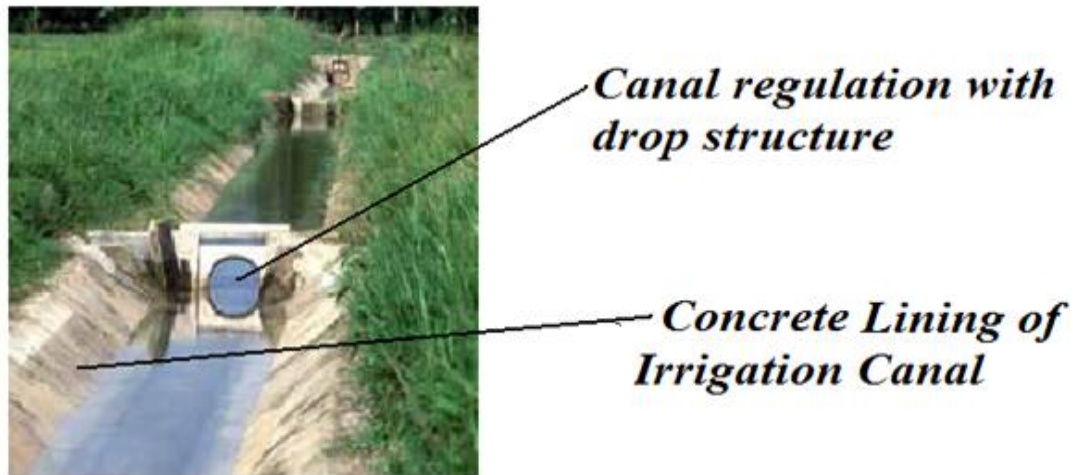


Fig. 2. Canal regulation with drop structure and concrete lining

Table 2. The existing irrigation technologies in Oluch-Kimira

Irrigation technologies	Level of Usage (%)				
	Never used	Rarely used	Moderately used	Sometimes used	Mostly used
Open gravity canal	14.4	11.2	3.5	7.4	63.5
Water can method	17.9	10.6	8.2	16.5	46.8
Canal and pipe conveyance	13.8	4.7	21.2	15.3	45.0
Motorized pump	31.2	12.4	2.9	35.0	18.5
Flood irrigation	26.8	42.4	12.9	-	17.9
Treadle pumps	21.2	5.9	36.2	34.6	2.1
Sprinkle irrigation	82.6	12.4	-	4.4	0.6

Table 3. Level of embracement of various farming practices on maize, rice and kales

Crop /management technologies	Level of embracement (%)								
	Very Low	Low	Undecided	High	Very High	Average for 4 & 5	Accumulative	Mean	Rank
	1	2	3	4	5				
Maize crop									
Mulching	8.3	12.0	1.2	50.3	28.2	78.5	248.9	83.0	1
Use of disease resistance varieties	12.0	21.2	8.0	10.7	48.2	58.9	213.0	71.0	2
Crop rotation	14.7	7.7	-	42.0	35.6	77.6	209.4	69.8	3
Use of drought resistance varieties	27.9	13.2	12.6	25.2	21.2	46.4	198.2	66.1	4
Use of faster maturity crops	1.2	9.5	31.0	14.4	43.9	58.3	187.6	62.5	5
Use of hybrid seeds (certified)	16.3	37.7	-	34.4	11.7	46.1	166.6	55.5	6
Use of composite seeds (Local seeds)	23.3	12.0	18.1	23.3	23.3	46.6	164.1	54.7	7
Rice crop									
Mulching	4.1	2.7	9.5	33.8	50.0	83.8			
Use of disease resistance varieties	-	2.7	8.1	18.9	70.3	89.2			
Crop rotation	2.7	2.7	17.6	32.4	44.6	77.0			
Use of drought resistance varieties	-	2.7	1.4	47.3	48.6	95.9			
Use of faster maturity crops	1.4	-	27.0	9.5	62.2	71.7			
Use of hybrid seeds (certified)	-	24.3	2.7	20.3	52.7	73.0			
Use of composite seeds (Local seeds)	24.3	-	17.6	23.0	35.1	58.1			
Kales									
Mulching	-	2.7	11.2	33.5	53.1	86.6			
Use of disease resistance varieties	11.7	8.9	14.5	29.1	35.8	64.9			
Crop rotation	-	43.0	-	4.5	50.3	54.8			
Use of drought resistance varieties	27.4	2.2	14.5	20.1	35.8	55.9			
Use of faster maturity crops	2.2	33.5	6.7	14.0	43.6	57.6			
Use of hybrid seeds (certified)	26.8	7.8	17.9	2.2	45.3	47.5			
Use of composite seeds (Local seeds)	6.3	20.1	14.3	34.4	25.0	59.4			

3.3 Comparison between Farming Practices before and After Irrigation Technologies

The preliminary findings on farming systems or practices existed before the introduction of irrigation systems (Rainfed agriculture) and after the introduction of irrigation system (Irrigated agriculture) were tabulated in Table 2. It was revealed that, farming system practiced before and after the introduction of the irrigation systems differ based on water availability. Water play a critical role in crop production, majority of the farmers engaged in multiple cropping to avoid risks of losing their crops due water stress. Farmers had to develop various methods to maintain soil temperature and humidity for the crop to grow optimally. Among the farming practices include: Crop rotation, Cover crop

farming, Contour farming, Organic farming, Minimum tillage, Frequent tillage, Monoculture, Mixed cropping, intercropping, Use of organic manure, Managing water utilization, Planting around the farm, Adopting agro-forestry practices and Use of integrated pest management. The findings further revealed that, before the introduction of irrigation technologies, contour farming was not embraced at 56.2% followed by use of organic manure application at 39.1%. However, monoculture and frequent tilling stood out as the common farming practice activity before the introduction of irrigation technologies at 40.9% and 38.8% respectively Table 4a. On the other hand, after the introduction of irrigation technologies, farmers' farming systems improved tremendously thus enabled them to diversify their crop productivity by introduce mixed cropping and intercropping of different types of crops

together with trees (Agro forestry). Also the findings revealed that, crop rotation; cover crop farming, contour farming, organic farming, frequent tillage and monoculture were very embraced at 39.1%, 50.9%, 57.5%, 67.4%, 67.4% and 57.9% respectively as shown in Table 4b.

Fig. 3 (A&B) shows bar graph presentation of farming practices before and after irrigation systems in percentage. The findings revealed that, before the introduction of irrigation systems, the farming practices were poorly embraced ranging from scale 1 to scale 3 where scale 1 is un-embraced, scale 2 somewhat embraced and scale 3-fairly embraced. On the other hand, (After the introduction of irrigation system, the farming practices were embraced at scale 4 and scale 5 where scale 4 was very much embraced and scale 5 represents fully embraced.

The findings in Fig. 3 (A & B) further revealed that, the $R^2=0.0396$ for farming systems before and $R^2=0.556$ for farming systems after introduction of irrigation systems respectively. This implied that, before irrigation technology the level of embracement of farming systems was at 3.96% while after introduction of irrigation technologies the embracement lever increased to 55.6%, a clear indication that the farming systems in the study areas has intensified due to the presence of waters or humid environment. This was also determined by sketching a linear graph for fully embraced scale 5 (as gauge meter) for both before and after irrigation and found that, before irrigation the graph showed downward trend (decline) while that of After irrigation showed upward trend (increasing). This also attributed to expansion of farm lands (as shown in Fig. 4) to accommodate farmers' demands in crop production. It was noted that,

Table 4. Level of embracement of farming practices before and after irrigation systems

Farming practices	Level of embracement (%)				
	Un-embraced	Somewhat embraced	Fairly embraced	Very embraced	Fully embraced
a) Farming practices before	1	2	3	4	5
Crop rotation	20.8	-	21.5	22.9	34.7
Cover crop farming	26.8	15.9	18.8	10.9	27.6
Contour farming	56.2	0.9	7.6	20.0	15.3
Organic farming	20.9	0.6	40.0	23.2	15.3
Minimum tillage	23.2	33.8	8.8	22.4	11.8
Frequent tillage	30.3	15.6	5.3	38.8	10.0
Monoculture	25.6	17.1	40.9	11.2	5.3
Mixed cropping	19.4	21.2	22.6	24.7	12.1
Intercropping	5.3	20.6	15.9	32.9	25.3
Use of organic manure	39.1	18.2	5.6	16.2	20.9
Managing water utilization	7.6	24.7	41.8	15.6	10.3
Planting around the farm	26.5	36.5	15.9	13.2	7.9
Adopting agro-forestry practices	23.8	28.5	35.6	9.7	2.4
Use of integrated pest management (IPM)	29.4	30.0	18.2	14.7	7.6
b) Farming system after	1	2	3	4	5
Crop rotation	-	5.3	4.1	39.1	15.5
Cover crop farming	10.0	11.2	12.1	50.9	15.9
Contour farming	17.9	4.1	12.4	57.5	14.1
Organic farming	9.1	12.1	8.2	67.4	16.2
Minimum tillage	2.4	12.1	25.3	23.2	37.1
Frequent tillage	-	8.2	8.2	67.4	16.2
Monoculture	-	3.7	11.8	57.9	26.8
Mixed cropping	9.7	5.0	31.8	26.8	26.8
Intercropping	-	5.6	27.4	36.2	30.9
Use of organic manure	1.2	20.3	9.1	31.5	37.9
Managing water utilization	5.3	11.5	3.5	37.4	42.4
Planting around the farm	16.2	5.9	31.8	27.4	18.8
Adopting agro-forestry practices	11.8	15.3	39.1	15.0	18.8
Use of integrated pest management (IPM)	11.2	7.9	3.5	34.1	11.8

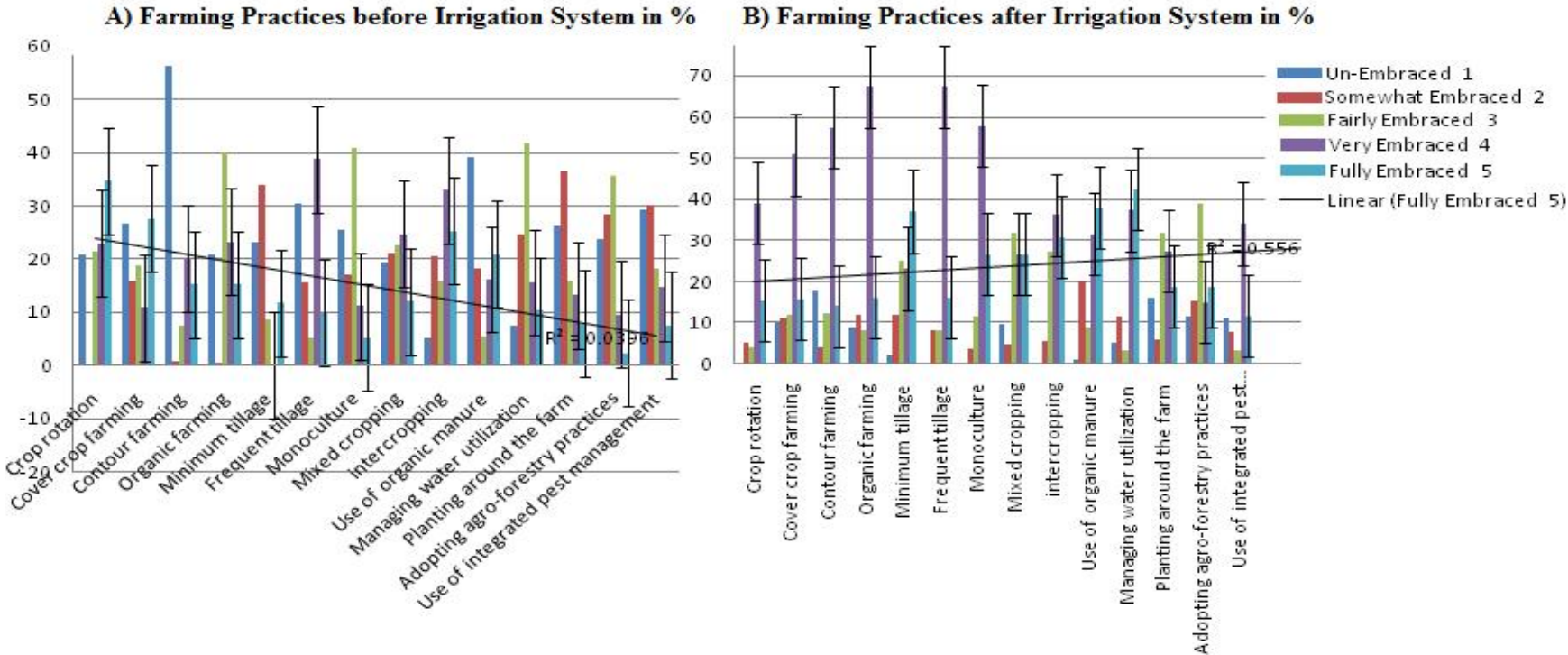


Fig. 3. Farming practices before and after irrigation system

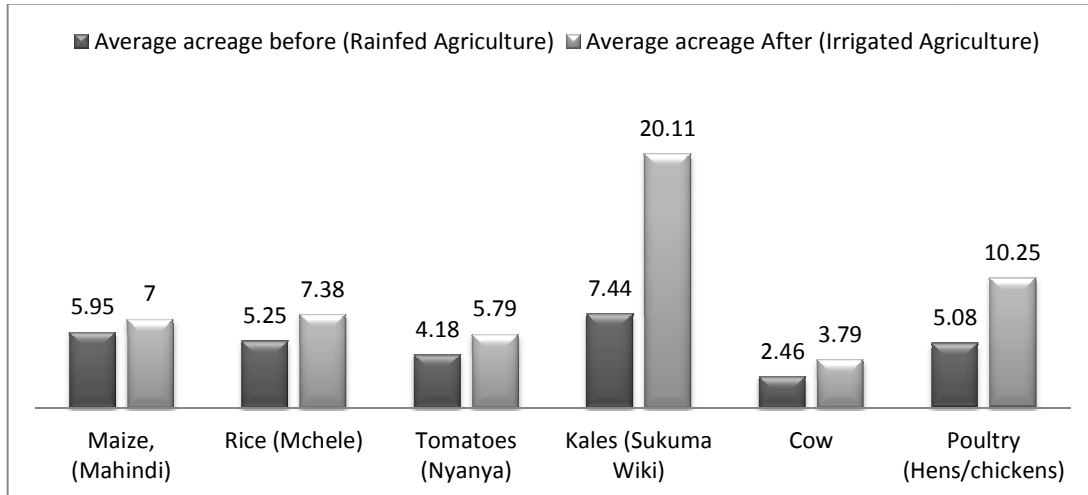


Fig. 4. Average production before and after the introduction of irrigation systems

an increase in water and irrigation increases farm lands and reduced labour requirements by decreases the time spent in providing water to a crops due to self managed water flow in the irrigation systems. This indirectly minimizes time spent on fertilizer application and weeding. In so doing, agricultural intensification in a rural setting seems to have been contributed to a decline in area deforestation to create more space for agricultural use thus causing land degradation according to Verma and Shekhawat [16].

4. CONCLUSION

Some of the conclusion drawn from this study include: water play a critical role in crop production and majority of the farmers engaged in multiple cropping to avoid risks of losing their crops due water stress. Farmers had to develop various methods to maintain soil temperature and humidity for the crop to grow optimally. Among these farming practices mechanisms include: Crop rotation, Cover crop farming, Contour farming, Organic farming, Minimum tillage, Frequent tillage, Monoculture, Mixed cropping, intercropping, Use of organic manure, Managing water utilization, Planting around the farm, Adopting agro-forestry practices and Use of integrated pest management which came as result of irrigation technologies in the study area. The findings further revealed that, before irrigation technology the level of embracing farming systems was at 3.96% ($R^2=0.0396$) while after introduction of irrigation technologies the embracing lever increased to 55.6% ($R^2=0.556$), a clear indication that the farming systems in the

study areas has intensified due to the presence of waters or humid environment brought about irrigation and water in general. It was also noted that, an increase in water and irrigation increases farm lands and reduced labour requirements by decreases the time spent in providing water to a crop area due to self managed water flow in the irrigation systems. This indirectly minimizes time spent on fertilizer application and weeding. In so doing, agricultural intensification in a rural setting seems to have been contributed to a decline in area deforestation to create more space for agricultural use thus causing land degradation according to Díaz-Alcaide et al. [21].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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