Chemical Science Review and Letters ISSN 2278-6783

Research Article

A Study of the Operational performance of the Irrigation Network in Eljumoeia Agricultural Scheme

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Abstract

This study was conducted to outline the different operation conditions and aspects related to the irrigation practices and irrigation management in Eljumoeia scheme during seasons (2008-2009), (2009-2010). Determination of the overall efficiency was carried out by estimation of pumping, conveyance, distribution and application efficiencies The study showed a pumping efficiency of 76.5%, conveyance efficiency of 79.6%, water distribution efficiency of 73.88%, and water application efficiency of 57.14%.to give an overall low irrigation efficiency of 25.6% Analysis of variance showed no significant difference between Major One and Major Two in Conveyance efficiency (E_c %). Distribution efficiency average was found to be 75.99%. The statistical analysis shows no significant difference between canals in distribution efficiency (E_d %). Analysis of variance shows no significant difference between Major One and Major Two in application efficiency. However a significant difference between farms in application efficiency within Major One and Major Two.

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Introduction

Surface irrigation is the most widely used irrigation method in the world. In Sudan almost all irrigated areas use surface methods. Traditional surface methods are labor intensive and described to have poor uniformity of application, and excessive water losses, Irrigation Efficiency is used to evaluate effectively the available water supply for crop production. Irrigation efficiency declines as losses increase. A high efficiency of an irrigation project is always desirable The efficiency may be estimated for various operations beginning from diversion of water to its actual use by crops, Uniformity in its distribution in the root zone (Majumdar, 2006). The efficiency of surface irrigation is a function of the field design, and the irrigation management practices. Good management of the system is reflected in proper irrigation practices in all agricultural aspects starting at the point of water lifting from its source till its application to the field. Sometimes, farmers apply more water than required by the crop. Crops differ in their water requirement, while the same crop may have different water requirements at different places in the same country, depending on the climate, type of soil, method of cultivation and effective rainfall. In other cases, more water than required by crops is pumped but is wasted as runoff or canals breaks.

Eljumoeia Scheme is one of the subsistence agricultural schemes, which was erected to help the locality. Effectively it began 1974 using pumps to lift water from the White Nile to the fields. Eljumoeia scheme is one of the projects that suffered from low productivity.

A questionnaire revealed that (77%) of farmers believe that condition of irrigation canals and irrigation control structures are not satisfactory due to lack of rehabilitation programs and lack periodical maintenance. Farmers have no belief in the dependability of the irrigation Network performance as shown in the table below.

The pumps in Eljumoeia scheme works for (16) hours starting at (7am), until (6 pm) and resumes work from(11pm) until (4 am). Actual Irrigation at fields commences after (12) noon and continues throughout the night. the irrigation frequency ranges between eight to fourteen days depending on the crop. The majority of the farmers need to use small lift pumps to convey water from major to the (AbuXX) ditch or to the Hawasha directly throughout the season. Irrigation process is money time and consuming. One feddan requires (24-48) hours or more to be irrigated by a lift pump in Eljumoeia Scheme.

One of the reasons behind low productivity is believed to be the low irrigation efficiency. Furthermore the high irrigation cost is one of the problems associated to low performance of the scheme. The main objective of this work was to study the performance of irrigation net work in Eljumoeia scheme through achieving the following specific objectives:

- Determination of pumping efficiency (E_p %).
- Determination of water conveyance efficiency (E_c %).
- Determination of canals distribution efficiency (E_d %).
- Determination of water application efficiency (E_a %).
- Determination of overall irrigation efficiency(E_0%).

Materials and Methods

The study site

The study was conducted during seasons (2008-2009) at Eljumoeia scheme, 30 kilometers south of Omdurman on the West bank of the White Nile. The scheme lies between longitudes 32^o – 33^o E, at latitude ^{o} 15 36 N and extends over an area of about 7300 feddans. The climate of the area is considered as semi desert which is characterized by a short rainy season and abundant sun shine that ranges between 10 to 12 hours. The mean maximum temperature ranges from 41.7 C^o to 43.1 C^o. The mean minimum temperature ranges between 17.4 C^o to18.7. Relative humidity increases during rainy season with maximum of about 60% in August (Meteorological Authority2009). The main crops are vegetables and (Abu 70) as a fodder crop.

Irrigation net work of Eljumoeia Scheme

Eljumoeia scheme is under the management of the State Ministry of Agriculture (Khartoum State)S. Intake canal (450m) in length drawing water from the White Nile to the pumping plant. Pumping plant was composed of two pumps of the same pumping capacity (two cubic meters per second), total head (11.75m), motor power (44.2 Hp) and pump speed is (740 r.p.m).Discharge basin was constructed from rocks and cement. Main canal (2.5Km) extends from East to West then branches into two Majors. Major one runs from South to North (16Km), Major two (9Km) runs to West and then turns North.

Irrigation efficiencies

To evaluate the overall efficiency(E_0%) irrigation efficiencies such as pumping(E_p%), conveyance (E_c%), distribution (E_d%) and application efficiency(E_a%) have to be determined. These efficiencies are determined through relevant methods and calculated using equations described below:

Determination of pumping capacity

To determine the pumping capacity the discharge basin volume was calculated as follows:

$$V= L*W*D \qquad (1)$$

Where: V: Volume capacity of the basin (m^3), L: Length of the basin (m), W: Width of the basin (m), D: Depth of the basin (m).

The pump was operated for (15) minutes to reach a steady pump discharge while basin outlet was open. Then basin outlet was closed till basin is full. The time for basin filling was recorded using a stop watch. The process was repeated five times and the average time was calculated. Then the average pump discharge (Q) was finally calculated as follows:

$$Q = V_c/T \qquad (2)$$

Where: Q: Discharge (m^3 / sec), V_C: Basin volumetric capacity (m^3), T: time (sec).

Pumping efficiency ($E_{p\,\%}$)

Pumping Efficiency ($E_{p\,\%}$) was calculated as follow

$$E_p = (Q_{actual} / Q_{rated})*100 \qquad (3)$$

Where: E_p: Pumping Efficiency (%), Q_{actual}: actual measured pump discharge (m^3/ sec), Q_{rated}: rated pump discharge (m^3/ sec).

Water conveyance efficiency (E_c %)

Water conveyance efficiency (E_c %) was determined for both Major One and Major Two, five sections were selected from Major one and so Major two, the length of each section was (200m), cross sectional areas shape was trapezoidal, each cross- sectional area was calculated in square meters, using a measuring tape and staff.. Water conveyance efficiency (E_c %) was calculated using the formula:-

$$E_c = [(Q_1/ Q_2]*100 \qquad (4)$$

Where: E_c: Water conveyance efficiency (%), Q_1: Water discharge in section (1) (m^3/sec), Q_2: Water discharge in section (2) (m^3/sec).

Water flow measurement

Water discharge in each section was determined using the formula:-

$$Q = A*V_{av} \qquad (5)$$

Where: Q: Water flow in (m3/sec), A: Cross section area in (m2), Vav: Average water velocity in (m3/sec).

Cross sectional area calculations

Cross sectional area of Trapezoidal canal was determined using the formula

$$A = [(b+ w)/2] *d \qquad (6)$$

Where: A: cross sectional area (m^2), b: bed width (m), w: water surface width (m), d: water depth in the canal (m).

The average velocity measurements

The velocity was estimated by the float method descrided by (Michael, 1978). Using a straight section of the canal of (200) meters length for majors and (100) meters for minor canals with a fairly uniform cross section. The float (half water filled bottle) was placed in the canal, a short distance upstream from the start point. The float travel time from the start point to the end point was recorded using a stop watch. Time records were taken from the two sides and the middle of each canal section, nine replicates were taken and the average time of travel was determined. The average velocity of water for each section was determined as follow:

$$V_{av} = (L/T)*c \qquad (7)$$

$$V_{av} = \sum_{i-1}^{n} v/n$$

Where: V_{av}: The average velocity of water at the canal (m/sec), L: length of the trial section (m), T: average time taken by the float (sec), C: Flow coefficient = (0.85).

Water distribution efficiency(E_d %)

Four canals were taken from each major, the length of each selected canal was (100m), for which the cross sectional areas was calculated. The average velocity measurements were estimated using equation (7), then Water distribution efficiency(E_d %) was determined using equation (4).

Water application efficiency (E_a %)

Nine farms were taken from each major, five furrows were selected from each farm. Length and width of each furrow were measured and tabulated. Water discharges into to furrows were measured using Parshal flume. Discharges entering furrow and time needed to fill furrow were record and tabulated. Water application efficiency (E_a %) was calculated using the following formula (Merriam1980).

$$E_a\% = (w_s/w_f)*100 \qquad (8)$$

E_a%: Water application efficiency (%), W_s: The average infiltrated water depth in the root zone (cm), W_f: The average applied water depth to the farm (cm),.

For determining application efficiency soil moisture content, soil bulk density must be estimated.

Determination of soil moisture content (smc %)

Soil moisture content was determined gravimetrically. Soil samples were augured from succession of stations along the furrows. The soil samples were taken at 0.2 m increments from the soil surface to a depth of 0.8 m before irrigation and three days after irrigation. Samples were oven dried at 105 ^{0}C for 24 hours, then weighed to determined moisture content as percentage ratio on dry oven basis as flows:

$$\theta_m\% = [(M_w - M_{d)}/M_d] *100 \qquad (9)$$

Where: θ_m: Moisture content on dry basis (%), M_w: weight of wet sample (gm), M_d: weight of dry sample (gm), (Majumdar, 2006).

Determination of soil bulk density (sbd)

Soil bulk density was determined using the paraffin (clod) method described by ***Black (1965)***. An area of one meter was dug to 0.8 m depth. Four soil clods each approximately 5cm in diameter were taken at increments of 0.2 m from surface down to 0.8m depth. A mean value for each depth was calculated to give the bulk density of the soil in g/cm^3. This was done in three randomly selected sites and in each site three such pits were dug. Finally the paraffin wax method was followed to calculate soil bulk density

Determination of average infiltrated water depth (W_s)

Average infiltrated water depth or stored in the root zone was calculated by converting soil moisture content on dry mass basis as percentage to depth basis (cm /m depth) the corresponding bulk density was multiplied by moisture content on mass basis.

$$\theta_d \text{ cm/m depth} = \theta_m\% *\rho \qquad (10)$$

Where: θ_d= Moisture content (cm/m) depth of soil, θ_v = Moisture content on volume basis (%), ρ = Bulk density (g/cm^3).

Determination of applied water depth (W_f) to the farm

Parshal flume 2 inch throat was used to determine inflow applied to the field in liters per second also the time of water application were recorded and the furrow lengths, furrow spacing were measured in meters. Depths of water applied to the furrows in (cm) were calculated using formula below:-

$$D = \frac{Q * T * 60 * 1000}{W * L} \quad (11)$$

Where: D= Depth of water applied to the farm in (cm), Q= stream size (l/sec), T= irrigation period (minute), W= furrow spacing (cm), L= furrow length (cm).
The experiment was replicated three times and results were tabulate (Elsheikh, 2002).

Determination of overall efficiency (E_0 %)

Overall irrigation efficiency is calculated by multiplying the efficiencies of the components. For a system which includes reservoir storage, water conveyance, and water application, the overall irrigation efficiency (Haman, 2005).Overall efficiency was calculated using the formula below:

$$E_0 = E_p * E_c * E_d * E_a \quad (12)$$

Where: E_0: Overall efficiency (%), E_P: Pumping Efficiency (%), E_c: Water conveyance efficiency (%), E_d: Water distribution efficiency (%), E_a: Application efficiency (%).

Questionnaire

A questionnaire was designed to reveal the main irrigation problems in the study area. It was conducted using personal contacts. The questionnaire data were collected from (100) farmer samples that were selected randomly. The questionnaire model appendix (A) was used to collect information about the irrigation system problems, scheme management problems and scheme -farmer relations.
The data was analyzed using the analysis of variance of the statistical package for social sciences (SPSS) version 14.

Results and Discussion

Pumping efficiency

The pumping efficiency average was found to be76.5%.This agrees with Nebraska (1970s) results which ranged between 76% - 78.8%. Also Leon (1989) found Pumping efficiency range of (75%-82%) for centrifugal pumps. **Table 1** shows that the average Conveyance efficiency for the scheme irrigation system is 79.6%. The Conveyance efficiency average for Major One and Major Two was found to be 80.8% and 78.4% respectively. Average Conveyance efficiency for open canals in clay soils is around 80 % according to FAO (1989). The 20.4% water losses are reasonable due to the partial maintenance carried out recently.

The ANOVA **Table 2** shows no significant difference between Major One and Major Two in Conveyance efficiency (E_c %). **Table 3** shows that the average Canals distribution efficiency (E_d %) was founded to be 73.88%. Where the maximum Distribution efficiency average was found to be 75.99% and lowest one was 71.75%.

Table 1 Conveyance efficiency (E_c %) for Major One (M_1) and Major Two (M_2)

MAJOR	E_c% (1)	E_c% (2)	E_c% (3)	E_c% (4)	E_c% (mean)
M_1	88.59	75.05	79.70	79.95	80.8
M_2	87.52	76.4	72.6	76.96	78.4
Average	88.055	75.725	76.15	78.455	79.6

Table 2 Analysis of variance for conveyance efficiency (E_c %) in Major One (M_1) and Major Two (M_2)

Independent Samples Test						
		Levine's Test for Equality of Variances		**T-test for Equality of Means**		
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Conveyance efficiency (E_c%)	Equal variances assumed	.077	.791	.575	6	.586
	Equal variances not assumed			.575	5.908	.587

Table 3 Canals Distribution efficiency (E_d %)

Canal in Majors	E_d% (1)	E_d% (2)	E_d% (3)	E_d% (4)	E_d%(mean)
M_1-1	72.32	70.08	78.25	73.14	73.45
M_1-2	76.35	65.13	78.58	80.79	75.21
M_1-3	86.63	74.7	72.7	68.64	75.51
M_1-4	76.33	67.11	63.63	81.74	72.74
M_2-1	70.67	67.71	69.57	82.11	72.52
M_2-2	74.18	71.08	85.78	72.93	75.99
M_2-3	72.62	66.94	79.64	76.2	73.85
M_2-4	72.96	68.42	64.6	81.02	71.75
Average	75.26	68.9	74.09	77.07	73.88

The ANOVA **Table 4** above shows no significant difference between canals in distribution efficiency (E_d %). **Table 5** shows that the average of application efficiency for the scheme (57.14%). According F.AO. Publications (1989). Average scheme application efficiency for surface irrigation systems was found about 60% which is 2.86% higher than our average. The ANOVA **Table 6** above shows significant difference between Major One and Major Two in application efficiency.

Table 4 Analysis of variance (ANOVA) for Canals distribution efficiency (E_d %)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	75.261	7	10.752	.242	.970
Within Groups	1065.632	24	44.401		
Total	1140.893	31			

Table 5 Average farm water Application efficiency (E_a%) (Major one (M_1) and Major two (M2)

Major	Farms									
	Farm$_1$	Farm$_2$	Farm$_3$	Farm$_4$	Farm$_5$	Farm$_6$	Farm$_7$	Farm$_8$	Farm$_9$	Mean
M_1	74.53	73.48	70.49	64.74	61.09	48.27	43.91	46.4	46.3	58.81
M_2	71.95	66.12	56.79	63.60	59.74	47.88	43.34	45.15	44.75	55.48
Average	73.24	69.8	63.64	64.17	60.42	48.08	43.62	45.78	45.53	57.140

Table 6 Analysis of variance for Major One and Major Two in application efficiency (E_a %)

Independent Samples Test						
		Levine's Test for Equality of Variances		T-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Conveyance efficiency (E_a%)	Equal variances assumed	4.005	.048	1.357	88	.178
	Equal variances not assumed			1.357	85.110	.179

The ANOVA **Table 7** shows significant difference between farms in application efficiency within Major (M1). The ANOVA **Table 8** above shows significant difference between farms in application efficiency within Major Two (M_2). The significant differences between farms in application efficiency for both Majors One and Two can be attributed to improper land leveling and grading. differences between farms for both (M_1) and (M_2) in application efficiency respectively.

Table 7 Comparison between farms within Major One (M_1) in application efficiency

ANOVA					
Application efficiency (Ea %) for Major one					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	6417.789	8	802.224	47.072	.000
Within Groups	613.530	36	17.042		
Total	7031.318	44			

Table 8 Comparison between farms within Major Two (M_2) in application efficiency

ANOVA					
Application efficiency (Ea %) for Major two					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	4487.107	8	560.888	56.683	.000
Within Groups	356.227	36	9.895		
Total	4843.334	44			

The ANOVA table above shows significant difference between farms in application efficiency within Major Two (M_2). The significant differences between farms in application efficiency for both Majors One and Two can be attributed to improper land leveling and grading. differences between farms for both (M_1) and (M_2) in application efficiency respectively.

Multiple Comparisons between farms in application efficiency (Ea %) Major one (M_1)

LSD Major One (M_1)						
(I) Farms	**(J) Farms**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Farm(1)	Farm(2)	1.04282	2.61094	.692	-4.2524	6.3381
	Farm(3)	4.03746	2.61094	.131	-1.2578	9.3327
	Farm(4)	9.78806(*)	2.61094	.001	4.4928	15.0833
	Farm(5)	13.43955(*)	2.61094	.000	8.1443	18.7348
	Farm(6)	26.25684(*)	2.61094	.000	20.9616	31.5521
	Farm(7)	30.62573(*)	2.61094	.000	25.3305	35.9210
	Farm(8)	28.12819(*)	2.61094	.000	22.8330	33.4234
	Farm(9)	28.24923(*)	2.61094	.000	22.9540	33.5445
Farm(2)	Farm(1)	-1.04282	2.61094	.692	-6.3381	4.2524
	Farm(3)	2.99464	2.61094	.259	-2.3006	8.2899
	Farm(4)	8.74524(*)	2.61094	.002	3.4500	14.0405
	Farm(5)	12.39672(*)	2.61094	.000	7.1015	17.6919
	Farm(6)	25.21402(*)	2.61094	.000	19.9188	30.5092
	Farm(7)	29.58291(*)	2.61094	.000	24.2877	34.8781
	Farm(8)	27.08537(*)	2.61094	.000	21.7901	32.3806
	Farm(9)	27.20641(*)	2.61094	.000	21.9112	32.5016
Farm(3)	Farm(1)	-4.03746	2.61094	.131	-9.3327	1.2578
	Farm(2)	-2.99464	2.61094	.259	-8.2899	2.3006
	Farm(4)	5.75060(*)	2.61094	.034	.4554	11.0458
	Farm(5)	9.40208(*)	2.61094	.001	4.1069	14.6973
	Farm(6)	22.21938(*)	2.61094	.000	16.9242	27.5146
	Farm(7)	26.58827(*)	2.61094	.000	21.2930	31.8835
	Farm(8)	24.09073(*)	2.61094	.000	18.7955	29.3860
	Farm(9)	24.21177(*)	2.61094	.000	18.9165	29.5070
Farm(4)	Farm(1)	-9.78806(*)	2.61094	.001	-15.0833	-4.4928
	Farm(2)	-8.74524(*)	2.61094	.002	-14.0405	-3.4500
	Farm(3)	-5.75060(*)	2.61094	.034	-11.0458	-.4554
	Farm(5)	3.65148	2.61094	.171	-1.6437	8.9467
	Farm(6)	16.46878(*)	2.61094	.000	11.1736	21.7640
	Farm(7)	20.83767(*)	2.61094	.000	15.5424	26.1329
	Farm(8)	18.34013(*)	2.61094	.000	13.0449	23.6354
	Farm(9)	18.46117(*)	2.61094	.000	13.1659	23.7564
Farm(5)	Farm(1)	-13.43955(*)	2.61094	.000	-18.7348	-8.1443
	Farm(2)	-12.39672(*)	2.61094	.000	-17.6919	-7.1015
	Farm(3)	-9.40208(*)	2.61094	.001	-14.6973	-4.1069
	Farm(4)	-3.65148	2.61094	.171	-8.9467	1.6437
	Farm(6)	12.81730(*)	2.61094	.000	7.5221	18.1125

	Farm(7)	17.18618(*)	2.61094	.000	11.8910	22.4814
	Farm(8)	14.68865(*)	2.61094	.000	9.3934	19.9839
	Farm(9)	14.80968(*)	2.61094	.000	9.5145	20.1049
Farm(6)	Farm(1)	-26.25684(*)	2.61094	.000	-31.5521	-20.9616
	Farm(2)	-25.21402(*)	2.61094	.000	-30.5092	-19.9188
	Farm(3)	-22.21938(*)	2.61094	.000	-27.5146	-16.9242
	Farm(4)	-16.46878(*)	2.61094	.000	-21.7640	-11.1736
	Farm(5)	-12.81730(*)	2.61094	.000	-18.1125	-7.5221
	Farm(7)	4.36889	2.61094	.103	-.9263	9.6641
	Farm(8)	1.87135	2.61094	.478	-3.4239	7.1666
	Farm(9)	1.99239	2.61094	.450	-3.3028	7.2876
Farm(7)	Farm(1)	-30.62573(*)	2.61094	.000	-35.9210	-25.3305
	Farm(2)	-29.58291(*)	2.61094	.000	-34.8781	-24.2877
	Farm(3)	-26.58827(*)	2.61094	.000	-31.8835	-21.2930
	Farm(4)	-20.83767(*)	2.61094	.000	-26.1329	-15.5424
	Farm(5)	-17.18618(*)	2.61094	.000	-22.4814	-11.8910
	Farm(6)	-4.36889	2.61094	.103	-9.6641	.9263
	Farm(8)	-2.49754	2.61094	.345	-7.7928	2.7977
	Farm(9)	-2.37650	2.61094	.369	-7.6717	2.9187
Farm(8)	Farm(1)	-28.12819(*)	2.61094	.000	-33.4234	-22.8330
	Farm(2)	-27.08537(*)	2.61094	.000	-32.3806	-21.7901
	Farm(3)	-24.09073(*)	2.61094	.000	-29.3860	-18.7955
	Farm(4)	-18.34013(*)	2.61094	.000	-23.6354	-13.0449
	Farm(5)	-14.68865(*)	2.61094	.000	-19.9839	-9.3934
	Farm(6)	-1.87135	2.61094	.478	-7.1666	3.4239
	Farm(7)	2.49754	2.61094	.345	-2.7977	7.7928
	Farm(9)	.12104	2.61094	.963	-5.1742	5.4163
Farm(9)	Farm(1)	-28.24923(*)	2.61094	.000	-33.5445	-22.9540
	Farm(2)	-27.20641(*)	2.61094	.000	-32.5016	-21.9112
	Farm(3)	-24.21177(*)	2.61094	.000	-29.5070	-18.9165
	Farm(4)	-18.46117(*)	2.61094	.000	-23.7564	-13.1659
	Farm(5)	-14.80968(*)	2.61094	.000	-20.1049	-9.5145
	Farm(6)	-1.99239	2.61094	.450	-7.2876	3.3028
	Farm(7)	2.37650	2.61094	.369	-2.9187	7.6717
	Farm(8)	-.12104	2.61094	.963	-5.4163	5.1742

* The mean difference is significant at the. 05 level.

Multiple Comparisons between farms application efficiency (Ea %)

LSD

(I) Farms	**(J) Farms**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Farm(1)	Farm(2)	5.82620(*)	1.98949	.006	1.7913	9.8611
	Farm(3)	15.16072(*)	1.98949	.000	11.1258	19.1956
	Farm(4)	8.35320(*)	1.98949	.000	4.3183	12.3881
	Farm(5)	12.21349(*)	1.98949	.000	8.1786	16.2484
	Farm(6)	24.06918(*)	1.98949	.000	20.0343	28.1041
	Farm(7)	28.61350(*)	1.98949	.000	24.5786	32.6484
	Farm(8)	26.79975(*)	1.98949	.000	22.7649	30.8346
	Farm(9)	27.20498(*)	1.98949	.000	23.1701	31.2399
Farm(2)	Farm(1)	-5.82620(*)	1.98949	.006	-9.8611	-1.7913
	Farm(3)	9.33452(*)	1.98949	.000	5.2996	13.3694
	Farm(4)	2.52701	1.98949	.212	-1.5079	6.5619
	Farm(5)	6.38729(*)	1.98949	.003	2.3524	10.4222

	Farm(6)	18.24298(*)	1.98949	.000	14.2081	22.2779
	Farm(7)	22.78730(*)	1.98949	.000	18.7524	26.8222
	Farm(8)	20.97356(*)	1.98949	.000	16.9387	25.0084
	Farm(9)	21.37878(*)	1.98949	.000	17.3439	25.4137
Farm(3)	Farm(1)	-15.16072(*)	1.98949	.000	-19.1956	-11.1258
	Farm(2)	-9.33452(*)	1.98949	.000	-13.3694	-5.2996
	Farm(4)	-6.80751(*)	1.98949	.002	-10.8424	-2.7726
	Farm(5)	-2.94723	1.98949	.147	-6.9821	1.0876
	Farm(6)	8.90846(*)	1.98949	.000	4.8736	12.9433
	Farm(7)	13.45278(*)	1.98949	.000	9.4179	17.4877
	Farm(8)	11.63903(*)	1.98949	.000	7.6042	15.6739
	Farm(9)	12.04426(*)	1.98949	.000	8.0094	16.0791
Farm(4)	Farm(1)	-8.35320(*)	1.98949	.000	-12.3881	-4.3183
	Farm(2)	-2.52701	1.98949	.212	-6.5619	1.5079
	Farm(3)	6.80751(*)	1.98949	.002	2.7726	10.8424
	Farm(5)	3.86028	1.98949	.060	-.1746	7.8952
	Farm(6)	15.71597(*)	1.98949	.000	11.6811	19.7509
	Farm(7)	20.26029(*)	1.98949	.000	16.2254	24.2952
	Farm(8)	18.44655(*)	1.98949	.000	14.4117	22.4814
	Farm(9)	18.85177(*)	1.98949	.000	14.8169	22.8867
Farm(5)	Farm(1)	-12.21349(*)	1.98949	.000	-16.2484	-8.1786
	Farm(2)	-6.38729(*)	1.98949	.003	-10.4222	-2.3524
	Farm(3)	2.94723	1.98949	.147	-1.0876	6.9821
	Farm(4)	-3.86028	1.98949	.060	-7.8952	.1746
	Farm(6)	11.85569(*)	1.98949	.000	7.8208	15.8906
	Farm(7)	16.40001(*)	1.98949	.000	12.3651	20.4349
	Farm(8)	14.58626(*)	1.98949	.000	10.5514	18.6211
	Farm(9)	14.99149(*)	1.98949	.000	10.9566	19.0264
Farm(6)	Farm(1)	-24.06918(*)	1.98949	.000	-28.1041	-20.0343
	Farm(2)	-18.24298(*)	1.98949	.000	-22.2779	-14.2081
	Farm(3)	-8.90846(*)	1.98949	.000	-12.9433	-4.8736
	Farm(4)	-15.71597(*)	1.98949	.000	-19.7509	-11.6811
	Farm(5)	-11.85569(*)	1.98949	.000	-15.8906	-7.8208
	Farm(7)	4.54432(*)	1.98949	.028	.5094	8.5792
	Farm(8)	2.73057	1.98949	.178	-1.3043	6.7655
	Farm(9)	3.13580	1.98949	.124	-.8991	7.1707
Farm(7)	Farm(1)	-28.61350(*)	1.98949	.000	-32.6484	-24.5786
	Farm(2)	-22.78730(*)	1.98949	.000	-26.8222	-18.7524
	Farm(3)	-13.45278(*)	1.98949	.000	-17.4877	-9.4179
	Farm(4)	-20.26029(*)	1.98949	.000	-24.2952	-16.2254
	Farm(5)	-16.40001(*)	1.98949	.000	-20.4349	-12.3651
	Farm(6)	-4.54432(*)	1.98949	.028	-8.5792	-.5094
	Farm(8)	-1.81374	1.98949	.368	-5.8486	2.2211
	Farm(9)	-1.40852	1.98949	.484	-5.4434	2.6264
Farm(8)	Farm(1)	-26.79975(*)	1.98949	.000	-30.8346	-22.7649
	Farm(2)	-20.97356(*)	1.98949	.000	-25.0084	-16.9387
	Farm(3)	-11.63903(*)	1.98949	.000	-15.6739	-7.6042
	Farm(4)	-18.44655(*)	1.98949	.000	-22.4814	-14.4117
	Farm(5)	-14.58626(*)	1.98949	.000	-18.6211	-10.5514
	Farm(6)	-2.73057	1.98949	.178	-6.7655	1.3043

	Farm(7)	1.81374	1.98949	.368	-2.2211	5.8486
	Farm(9)	.40523	1.98949	.840	-3.6297	4.4401
Farm(9)	Farm(1)	-27.20498(*)	1.98949	.000	-31.2399	-23.1701
	Farm(2)	-21.37878(*)	1.98949	.000	-25.4137	-17.3439
	Farm(3)	-12.04426(*)	1.98949	.000	-16.0791	-8.0094
	Farm(4)	-18.85177(*)	1.98949	.000	-22.8867	-14.8169
	Farm(5)	-14.99149(*)	1.98949	.000	-19.0264	-10.9566
	Farm(6)	-3.13580	1.98949	.124	-7.1707	.8991
	Farm(7)	1.40852	1.98949	.484	-2.6264	5.4434
	Farm(8)	-.40523	1.98949	.840	-4.4401	3.6297

* The mean difference is significant at the. 05 level.

The **Table 9** shows that the average overall efficiency for the scheme is 25.6%.according to ***FAO (1989)*** a scheme irrigation efficiency of 50% -60% is good,40% reasonable while a scheme irrigation efficiency of 20% -30% is poor. The overall efficiency of Eljumoeia scheme is within the poor level.

Table 9 Overall efficiency (E_0 %)

Major	**Sector Number**				
	Sector$_1$ E_0%	**Sector$_2$ E_0%**	**Sector$_3$ E_0%**	**Sector$_4$ E_0%**	**Mean**
M_1	33.07	33.07	19.38	20.78	26.58
M_2	28.17	28.10	20.91	20.97	24.54
Average	30.62	30.59	20.15	20.88	25.56

Small lift pumps mobility

Table 10 shows that majority of lift pumps used are fixed and owned by the farmers (78%), mobile lift pumps represent (22%). mobile lift pumps are either hired or shared.

Table 10 Type of site of small lift pumps

Total number of respondents(100)	**Fixed site**	**Mobile site**
Percent	78 %	22 %

Time (hrs) needed to irrigate one feddan using small lift pump

Table 11 shows that (18%) of the lift pumps under study irrigate one feddan in less than (24) hours whereas (80%) of the lift pumps irrigate one feddan in (24-48) hours depending on pump capacity, only (2%) of the lift pumps irrigate one feddan in more than (48) hours. It is clear that the extended application time may be attributed to one or more of the following reasons:

- Low lift pumps efficiencies due to wear.
- Cracked heavy clay soil.
- Unattended pump operation

Table 11 Time (hr) needed to irrigate one feddan by using small pump

Total number of respondents(100)	**> (24)hr**	**(24-48)hr**	**> (48) hr**
Percent	18.0 %	80.0 %	2.0 %

Cost of irrigation by small pump (SDG/Feddan/irrigation

Table 12 shows the cost of irrigating one feddan was (20-35), (36-50), (51-65) and (66-80) SDG when using small pump. Variation in costs is reasonable, due mainly the fact that part of the farmers under study own small pumps and the others rent small pump. Some of the farmer rent labor during irrigation process.

Table 12 Cost of irrigation by small pump (SDG/Feddan)

Total number of respondents(100)	**(20-35)**	**(36-50)**	**(51-65)**	**(66-80)**
Percent	14.0 %	12.0 %	70.0 %	4.0 %

From **Table 14** it is clear that the additional cost for the different season crops ranges from (91.1%) to (71.8%) which are extremely high. This emphasis of necessity of structural and management rehabilitation efforts for the scheme irrigation system.

Table 13 Average Cost of lift irrigation in SDG/ Feddan /Season (winter vegetables, autumn vegetables, summer fodders)

Season	**Crop**	**Number of irrigations**	**Average cost for one irrigation**				**Average cost**
			(20-35) (av. 27.5)	**(36-50) (av.43)**	**(56-65) (av.60.5)**	**(66-80) (av.73)**	
Winter	Tomato	20	550	860	1210	1460	1020
Autumn	Okra	15	412.5	645	907.5	1095	765
Summer	Fodders	5	137.5	215	302.5	365	255

Table 14 shows the percent total cost of irrigation compared to the scheme water tariff

Season	**Winter vegetables (twenty irrigations)**	**Autumn vegetables (fifteen irrigations)**	**Summer fodders (five irrigations)**
Cost of irrigation by small lift pump	1020	765	255
Irrigation water tariff	100	100	100
Total cost of irrigation	1120	865	355
Percent increase	91.1%	88. 4 %	71. 8 %

Conclusions and Recommendations

The results obtained during this study reveals the following conclusions:

- Pumping plant composed of two centrifugal pumps, one of them is out of service and the other has 76.5% pumping efficiency. Out service pump should be put to service.
- Conveyance efficiency ($_{Ec}$%) and canal distribution efficiency ($_{Ed}$%) are considered satisfactory and agree with FAO results obtained for clay soils and water losses are reasonable due to the partial maintenance carried out recently.
- The average scheme water application efficiency (E_a%) was obtained (57.14%) is less than the average of water application efficiency (E_a%) recommended by FAO (60%)for clay soils more over there are some farms records low water application efficiency ranged between 43%-48% this seems to be attributed to improper land leveling and grading.
- The overall poor irrigation efficiency25.6% is resulted due to low water application efficiency.
- Irrigation process in Eljumoeia scheme consume a lot of time because the farmers use small lift pumps throughout the seasons to convey water from Majors to (Abu xx) or to the Hawasha directly.
- There are extremely high additional irrigation costs for the different season crops ranges from (91.1%) to (71.8%).
- There is no operation contract governing the relation between the farmers and scheme management body other than irrigation water tariff and consequently no penalties are enforced on water misuse. More over no compensations are given to farmers for irrigation failure this mean the full risk burden falls upon the farmers. It recommended to legalized this area.

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Publication History
Received 28th Feb 2017
Revised 10th Mar 2017
Accepted 20th Mar 2017
Online 30th Mar 2017