Original Research Article

Evaluation of Itoikin Irrigation Scheme Using performance Indicator

ABSTRACT

Irrigation is of major importance in many countries. It is important in terms of agricultural production and food supply, the incomes of rural people, public investment for rural development, and often recurrent public expenditures for the agricultural sector. Nigeria's irrigation system is confronted with many challenges which included a widening gap between demand for food and domestic supply as a result of population growth and changing patterns of consumption. The evaluation study was carried out at the Itoikin Irrigation Scheme using performance indices. The site is one of the irrigation projects under the Ogun-Osun River Basin Development Authority (O-ORBDA) located in the Epe Local Government Area of Lagos State. The potency and vulnerability of Itoikin Irrigation Scheme were evaluated. The physico-chemical properties of soil, soil and water inventory were used to carryout the evaluation. Soil samples were collected at different depth and taken to the laboratory for measurement and Analysis. Soil and water inventory, Crop water requirement and evapotranspiration, Irrigation scheduling for maize and rice at the scheme and Analysis of moisture content were assessed. The range of electrical conductivity (EC) is measured and the values range from 102.8 ms cm^{-1} to 308 ms cm^{-1}. The lowest electrical conductivity is 102.8 ms cm^{-1} at F4, depth 30-45 cm while the highest is 308 ms cm^{-1} at F3, depth 15-30 cm. The hydraulic conductivity (k) ranges from 3.75×10^{-4} to 8.99×10^{-4} cm s^{-1}. The lowest of the hydraulic conductivity was in F3 at depth of 25-50 cm in silt clay loam, while the highest was in F2 at depth of 25-50, in silt clay. The (EC) is too high and needs to be reduced. Root development will not pose as a problem as the bulk density will not restrict the development of the root, while the soil pH will allow the cultivation of maize, rice and vegetables. The minimum temperature ranged between 21.8 ^{0}C and 24.1 ^{0}C while the maximum temperature ranged from 28.2 ^{0}C to 33.2 ^{0}C. The average minimum and maximum temperatures are 22.8 ^{0}C and 30.8 ^{0}C respectively. The highest humidity was recorded on June (100%). The wind speed ranged between 156 km day and 207 km day and the values does not pose any adverse effect on the productivity of the crops. The evapotranspiration (ET) ranged between 2.5 mm day^{-1} and 4.22 mm day^{-1} with an average of 3.44 mm day^{-1}. High values of evapotranspiration (ET) recorded in the months of February, March and April indicates that more water is loss during this period. The (ET_{crop}) and crop water requirement for maize at the scheme varied from 1.36 to 6.35 mm day^{-1} and 5.1 to 63.5 mm dec^{-1} respectively. The total amount of water consumed by the crop is 398.2 mm dec^{-1}, while the effective rainfall was 212.2 mm dec^{-1} during the farming season. The total evapotranspiration is 494 mm dec^{-1}. The crop evapotranspiration (ET_{crop}) and crop water requirement for rice at the scheme varied from 0.35 to 4.30 mm day^{-1} and 1.0 to 47.1 mm dec^{-1} respectively. The total amount of water consumed by the crop is 494.3 mm dec^{-1}, while the effective rainfall was 250.3 mm dec^{-1} during the farming season. The total evapotranspiration is 491.9 mm dec^{-1}. The soil moisture contents were investigated to the depth of 45 cm. The minimum and maximum values are 20.6 mm and 34.66 mm on plot 6 were recorded. Down the profile, there is an increasing trend which posed the water at the scheme to be lost by deep percolation than runoff and evaporations.

Keyword: Irrigation, physico-chemical properties, hydraulic properties, crop water requirement and evapotranspiration.

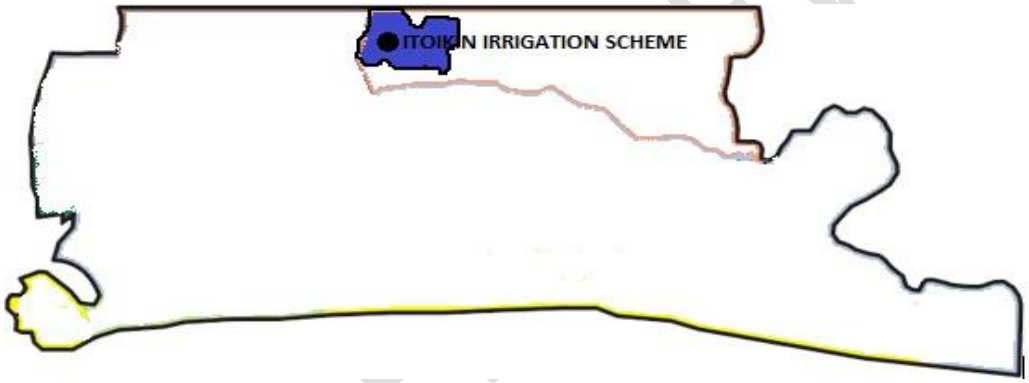
1.0 INTRODUCTION

Irrigation has allowed the world to overcome the potential food-supply problems associated with population growth. Water management in irrigation or efficient utilization of the water will increase crop intensity and productivity and suitable crop pattern (Sen and Das, 1986). The basic objective of irrigation is to supplement the natural supply of water to land so as to obtain an optimum crop yield. In order to achieve this, an irrigation system must be developed which involves planning, designing, construction, operation and maintenance of various irrigation structures required to bring water from the watershed to the agricultural field (Arora, 2009). At the outset it is important to recognize that while rain fed production accounts for the bulk of Nigeria's agricultural production, rain fed systems are ultimately limited by drought. Rain fed production is prone to volatility but measures to stabilize rain fed production can be very cost-effective. Where conjunctive use of surface and easily mobilized groundwater is possible, *Fadama* production can address local food requirements with less vulnerability to inter-annual variations in rainfall. However, *Fadama* production cannot address the scale or quality of production needed to supply urban populations. Formal 'precision irrigated production and post-harvest processing of food staples and high value cash crops can offer more stability in farm income and rural employment. Modern large scale irrigation can start to reduce the gap between demands and supply (National Irrigation Policy and Strategy for Nigeria, 2004). Sener *et al*. (2007) stated that the performance of many irrigation systems is significantly lower compared with their potential. This is due to a number of shortcomings, such as poor design, construction and operation and maintenance. Head tail problems, leaky canals and malfunctioning structures because of delayed maintenance, leading to low water use efficiency and low yields, are some of the commonly expressed problems. In recent years, improving irrigation systems performance is more preferable than developing new irrigation area due to the fact that investment in irrigation has failed to produce the expected result in many countries (Sener *et al.,* 2007) and in view of the enormous resources spent over the years on irrigation projects, it has become imperative to access the irrigation projects in the country. Process indicators and comparative performance indicators are two commonest methods of evaluating irrigation scheme. Process indicators uses indicator like the water use efficiencies, while comparative performance indicators examine indicators like agronomic, environmental, economic, financial and hydrological performances of irrigation systems (Yusuf, 2004). Itoikin Irrigation Scheme primarily served rice farmers, though other grains and crops are cultivated. Rice is also cultivated in other irrigation schemes and different parts of the country. The bulk of rice consumed in the country is been imported and there have been renewed efforts to encourage rice production in order to reduce the dependence on imported rice. Despite the rise in domestic production, the demand of rice far exceeds local production, precipitating an increase in the rice importation bill to as high as 160 million USA dollars in 2003 (FAO, 2003). According to Bitici *et al.,* 1997 Performance assessment is an essential component of performance management and the system is seen as the information system which enables the performance process to function effectively and efficiently. Performance assessment enables verification of the degree to which targets and objectives are being realized. It also provides different stakeholders (system managers, farmers, and policy makers) with a better understanding of how a system operates. It can help determine problems and identify ways and means of improving system performance (Cakmak *et al.,* 2004). In this respect, an irrigation water management system requires forms of performance measurement that reflect the different needs and expectations of the stakeholders involved (Behcet *et al*., 2014). Performance assessment provides the information needed to assess extend to which an organization delivers value and achieve excellence (Moullin, 2007). Therefore this research is considered very important and necessary. This study evaluated the performance of Itoikin Irrigation Scheme using irrigation performance indices. The main objective is to evaluate Itoikin Irrigation Scheme and to determine the physico-chemical and hydraulic properties of the soil at Itoikin Irrigation Scheme.

2.0 MATERIAL AND METHODS / EXPERIMENTAL DETAILS

2.1 Site description and environmental condition of the study area

The Itoikin Irrigation Project is one of the irrigation projects under the Ogun-Osun River Basin Development Authority (O-ORBDA) located in the Epe Local Government Area of Lagos State (Lat.6.39^{0}N, Long. 3.48^{0}E, at an altitude of 43 m above the mean sea level). It covers an estimated land area of 141 ha, though the actual cropped area is 70 ha (Figure 1). The land at Itoikin irrigation project is characterized by plain land of gentle slope suitable for surface irrigation. Based on the climatic data of Nigerian Meteorological Agency (NIMET), Lagos which covered Itoikin Irrigation Project, the monthly rainfall between May and July averages over 400 mm, while in August and September is down to 200 mm and in December the mean monthly rainfall is 25 mm. The main dry season is accompanied by harmattan winds from the Sahara Desert which in December and February can be quite strong. Itoikin Irrigation Project sources its water from Ogun River and abstraction is by pumping using 3 electric pumps. Each farmer is allocated a plot size of one hectare costing ₦2500 per hectare. Tractorisation and water access are also paid for by the farmers. The main crops grown in the irrigation project are maize, rice and vegetables planted twice in a year-during the dry and rainy seasons (National Irrigation Policy and Strategy for Nigeria (NIPSN), 2004).



<u>Image:</u> Map showing study location in Nigeria

<u>2.1.1 Collection of Data</u>

The data collection from irrigation projects was carried out in two phases: preliminary and main survey. During the preliminary survey, O-ORBDA, Agricultural Development offices, IITA, Irrigation Engineers, and some farmers were consulted to ascertain the reliability of the methodology and research instrument adopted for the study. Both primary and secondary data collection methods were used. Farmers' fields were selected at random from the head, middle and tail of the irrigation project.

<u>2.1.2 Primary data</u>

The primary field data collection activities are:

i. Field observations to determine and investigate the method of water applications, and practices related to water management techniques adopted by the farmers.
ii. Measurements of canal water flow and pump discharge.
iii. Determination of moisture contents of the soils of the selected irrigation fields before and after irrigations at different depths of the profiles during the dry season using the gravimetric method.
iv. Stratified random sampling technique was adopted to select four farms within Itoikin Irrigation Scheme.

v. Soil samples collected were at the four farms at different depths which represent the root zone of the plants (0-15 cm, 15-30 cm and 30-45 cm, 0-25 cm, 25-50 cm) to determine the pH, electrical conductivity, exchangeable cations, bulk density as reported by Adesigbin and Fasinmirin, (2011).

vi. Questionnaire was used to determine the water and soil inventory (water infrastructure and delivery and soil usage).

vii. The Velocity-area method was used to measure flow-rates in canals periodically.

viii. Crop water demands were estimated using FAO Cropwat 8.0 (FAO, 1998).

2.1.3 Secondary data

Secondary data on irrigation projects and farming activities from O-ORBDA, National Bureau of Statistics and CBN reports were consulted and summarized into social, economic and financial performance indicators. Climatic data (2014-2015) was sourced from Nigerian Meteorological Agency (NIMET), Oshodi-Lagos and was analysed using Cropwat 8.0.

2.1.4 Laboratory analyses

The seventy-two soil samples collected from the field were analysed to determine the soil parameters such as: bulk densities (BD), textures, pH, electrical conductivity, exchangeable cations and field capacity (FC). The physico-chemical properties data generated from the soil samples was analysed using descriptive and inferential statistics (Statistical Analysis Software).

2.1.5 Inventory

The irrigation network is designed to last long and is perhaps the costly part of an irrigation scheme. However, the original construction and design began to deteriorate soon after few years of construction. Malfunction structures, weed infestation, silt deposition and other undesirable situations make it practically impossible to control flow in canals. This led to the system unable to distribute water equitably. In this work, questionnaire was used to assess the water and soil resources in scheme and formal interviewed were conducted. The soil and water inventory were assessed considering the following parameters Weather parameters and evapotranspiration, Rainfall, Soil, Crop, Water Source and Abstraction, Canal System, Drainage System, Water Distribution System, Analysis of Moisture Content

2.1.6 Crop Water Requirements

The crop water and irrigation requirement were estimated using CROPWAT 8.0. CROPWAT 8.0 window is a computer program for calculating of crop water requirement and irrigation requirement base on soil, climate and crop data. . In addition, CROPWAT 8.0 can also be used to evaluate farmers' irrigation practices and to estimate crop performance under rain fed and irrigated conditions. Calculations of the crop water requirements and irrigation requirements are carried out with inputs of climatic, crop and soil data. For the estimation of crop water requirement (CWR) the model require:

i. Reference Crop Evapotranspiration (ET_0) values measured or calculated using the Food and Agricultural organization (FAO) Penman-Montieth equation based on decade/monthly climatic data: minimum and maximum, air temperature, relative humidity, sunshine duration and wind speed.

ii. Rainfall data (daily/decade/monthly data): monthly rainfall was divided into a number of rain storms each month.

iii. A cropping pattern consist of the planting date, crop coefficient data files (including k_c values, stage days, root depth, depletion fraction) and the area planted (0-100% of the total area); a set of typical crop coefficient data files are provided in the program. In addition, for irrigation scheduling the model requires information on soil type, total available soil moisture, maximum rooting depths, initial soil moisture depletion (FAO, 1998).

3.0 RESULTS AND DISCUSSION

3.1 Physico-Chemical Properties of the Soil at Itoikin Irrigation Scheme

The result of soil pH, electrical conductivity, bulk density, exchangeable cations and soil texture classification is presented in Table 1.

3.1.1 Bulk density

The bulk density of the soil was analysed by collecting samples from different farms and at different depths. As shown in Table 1, the bulk density varies among the farms in Itoikin Irrigation Scheme. It ranges from 1.25 to 1.57 g cm^{-3} with the highest in farm 3 at depth of 30-45 cm and the lowest in farm 1 at depth of 15-30 cm. The critical value of bulk density for restricting root growth varies with the soil type (Hunt and Gilkes, 1992) but in general bulk densities greater than 1.6 g cm^{-3} tend to restrict root (Mckenzie *et al*, 2004). Itoikin soil encourages root growth, effective aeration and water movement through the soil. Cresswell and Hamilton (2002) reported that bulk density increases with compaction at depth and very compact subsoil or strongly indurated horizons may exceed 2.0 g cm^{-3}. The bulk densities of the Itoikin were not significantly different ($p \leq 0.05$).

3.1.2 Soil Ph

The pH of the samples was measured by collecting soil at different depths of 0 to 15 cm, 15 cm to 30 cm and 30 cm to 45 cm and thereafter taken to the laboratory for measurement. The soils were slightly acidic as the pH values varied from 5.0 to 6.5. The lowest pH of 5.0 was observed on Farm 3 at 0-15 cm, while the highest pH of 6.5 was observed Farm 2 at 30-45 cm. According to Ed Hume Seed Handbook, 2012 the preferred pH for the main crops planted at Itoikin (maize, rice and vegetables) are maize (5.8 – 6.5), rice (5.6 - 6.5). Therefore, the soil at Itoikin favours the cultivation of maize, rice and vegetables. There was no significant different ($p \leq 0.05$) in the pH at different depths.

Table 1: Physico-chemical properties of soil sample at Itoikin Irrigation Scheme

Farm	Depth (cm)	Bulk Density (g cm^{-3})	pH ($CaCl_2$)	Electrical Conductivity (ms cm^{-1})	Moisture Content at Field Capacity (%)	Exchangeable Cations (cmol kg^{-1})			
						K^+	Mg^{2+}	Na^+	Ca^{2+}
F1	0 – 15	1.27	4.8	142.3	28.40	1.87	2.38	1.05	36.7
	15 -30	1.25	4.4	126.1	28.35	2.33	2.52	0.92	43.25
	30 -45	1.35	4.3	134.5	31.02	2.11	2.42	0.99	37.85
F2	0 -15	1.50	5.1	156.6	26.44	1.41	2.01	0.94	31.95
	15 -30	1.45	5.0	209	27.02	1.38.	2.23	1.15	32.85
	30 -45	1.38	5.2	261	28.13	1.33	2.21	0.94	33.85
F3	0 -15	1.55	5.0	275	32.40	1.59	2.26	0.81	34.3
	15 -30	1.48	5.6	308	31.02	1.06	2.13	1.11	29.8
	30 -45	1.57	5.4	219	30.15	1.58	2.16	0.81	32.6
F4	0 -15	1.33	4.6	152.1	27.85	1.64	2.25	0.81	35.7
	15 -30	1.40	4.6	143.5	29.60	1.65	2.24	0.94	34.5
	30 -45	1.51	4.6	102.8	31.40	2.04	1.94	1.01	36

3.2 Electrical conductivity of the soil

Soil samples were collected at different depth of 0 to 15 cm, 15 cm to 30 cm and 30 cm to 45 cm and thereafter taken to the laboratory for measurement. The range of electrical conductivity is from 102.8 ms cm^{-1} to 308 ms cm^{-1} as shown in Table 1. The lowest electrical conductivity is 102.8 ms cm^{-1} at Farm 4,

depth 30-45 cm while the highest is 308 ms cm^{-1} at Farm 3, depth 15-30 cm. The differences in electrical conductivity according to depth may have been due different rate of leaching of irrigation water. From the Table 1, it shows that the soil at Itoikin Irrigation Scheme have high salinity level. FAO recommended that salinity value of 16 ms cm^{-1} is considered high salinity and therefore there is need to reduce salinity at Itoikin Irrigation Scheme by permitting 10-20% of the irrigation water to leach the soil, be drained and discharged through an appropriate drainage system so that crop at the scheme will produce better yield. The EC of soil in Itoikin Irrigation Scheme were not significantly different ($p \leq 0.05$).

3.3 Exchangeable cations

From Table 1 the exchangeable K^+ ranges from 1.06 cmol kg^{-1} in F3 at depth of 15-30 cm to 2.33 cmol kg^{-1} in F1 at depth of 15-30 cm , the exchangeable Mg^{2+} ranges from 1.94 cmol kg^{-1} in F4 at depth of 30-45 cm to 2.52 cmol kg^{-1} in F1 at depth of 15-30 cm , the exchangeable Na^+ varies from 0.81 cmol kg^{-1} in F3 at depth of 0-15 cm to 1.15 cmol kg^{-1} in F2 at depth of 15-30 cm and the exchangeable Ca^+ content of the soil at Itoikin Irrigation Scheme ranges from 29.8 cmol kg^{-1} in F3 at depth 15-30 cm to 43.25 cmol kg^{-1} in F3 at depth of 15-30 cm. Cation exchange capacity is classified as low (< 6 cmol kg^{-1}), medium (6-12 cmol kg^{-1}) and high (> 12 cmol kg^{-1}) (Ezeaku, 2015). Based on these limits, the amounts of CEC across all Farms and depths are generally low except for Ca^{2+} which is high. These high nutrient deficiencies may be due to intense leaching and erosion due to rainfall or excessive irrigation. The proportion of K^+, Mg^{2+}, Na^+ and Ca^{2+} were not significantly different ($p \leq 0.05$).

3.4 Hydraulic Conductivity (k)

The result of the hydraulic conductivity (k) using the mini disc infiltrometer is shown in Table 2. The hydraulic conductivity (k) ranges from 3.75×10^{-4} to 8.99×10^{-4} cm s^{-1}. The lowest of the hydraulic conductivity was in F3 at depth of 25-50 cm in silt clay loam, while the highest was in F2 at depth of 25-50, in silt clay. The result is in line with the findings of Adesigbin and Fasinmirin 2011 who confirmed that hydraulic conductivity (k) of a soil profile can be highly variable from place to place and also vary at different depths. This shows that different soil layers have different hydraulic conductivities and the values of the hydraulic conductivity correspond to that of Bear (1972) for clayed soil. The variation in the values of the hydraulic conductivity does not affect the productivity of the farms as the crops produced optimally and the variation could have been as a result of the particle size distribution and the relative amount of fluid present in the soil matrix. The hydraulic conductivity was not significant difference ($p \leq 0.005$).

Table 2: Hydraulic Conductivity (k) of soil samples at Itoikin Irrigation Scheme

Farm	Soil depth (cm)	Hydraulic Conductivity $K \times 10^{-4}$(c ms^{-1})	USDA Textural Class
F1	0-25	5.85	Silt clay loam
F1	25-50	7.86	Silt clay loam
F2	0-25	4.94	Silt clay
F2	25-50	8.99	Silt clay
F3	0-25	6.01	Silt clay loam
F3	25-50	3.75	Silt clay loam
F4	0-25	6.51	Silt clay loam
F4	25-50	6.51	Silt clay loam

3.5 Soil and Water Inventories

The soil and water inventory were assessed considering the following parameters:

3.5.1 Weather parameters and evapotranspiration

Table 3 showed the temperature, humidity, wind, sun, radiation and evapotranspiration. The minimum temperature ranged between 21.8 ^{0}C and 24.1 ^{0}C while the maximum temperature ranged from 28.2 ^{0}C to 33.2 ^{0}C. The average minimum and maximum temperatures are 22.8 ^{0}C and 30.8 ^{0}C respectively. The

highest humidity was recorded on June (100%). The wind speed ranged between 156 km day and 207 km day and the values does not poses have any adverse effect of the productivity of the crops. The evapotranspiration ranged between 2.5 mm day^{-1} and 4.22 mm day^{-1} with an average of 3.44 mm day^{-1}. The months of February, March and April recorded high evapotranspiration. This indicates that more water is loss during this period. ET is next to rainfall the second largest component of the water balance. The growth of plants and the water cycle, including the relationship between the ET rate and runoff generation, are intrinsically linked (Hutjes *et al.*, 1998; Arora, 2002; Gerten *et al.,* 2004). The water balance is a fundamental constraint on the productivity (Clark, *et al*., 2001) and distribution (Stephenson, 1990) of terrestrial vegetation. The evapotranspiration does not pose any adverse effect on the crop due to the fact that the value is not high and the ranges were close (Table 3). According to Baille, *et al,* (1994) **t**he process of evapotranspiration obviously depends on both the outside weather regime and the internal state of the crop and top soil.

3.5.2 Crop water requirement and evapotranspiration

Water is the most important factor in sustainable crop production. Therefore, appropriate increase in water supply is important for increase productivity. The crop evapotranspiration (ET_{crop}) and crop water requirement for maize at the scheme varied from 1.36 to 6.35 mm day^{-1} and 5.1 to 63.5 mm dec^{-1} respectively (Table 4). The total amount of water consumed by the crop is 398.2 mm dec^{-1}, while the effective rainfall was 212.2 mm dec^{-1} during the farming season. The total evapotranspiration is 494 mm dec^{-1} (Table 4). The crop water requirement increases steadily from the month of September till the month of December, when it starts to decline. This shows that the amount of water for be supplied to compensate for evapotranspiration loss from the cropped field was less at the initial stage of growth of the crop. The crop coefficient at the initial stage of plantation is 0.3, development stage (0.43-0.91), mid (1.1) and late (1.04-0.38), this show that the rate at which the crop uses water increases steadily until the late season in January where it starts to declines. The effective rainfall ranges from 0 to 56.8, starting at 54.8 in September and ending at 0 in January. The crop evapotranspiration (ET_{crop}) and crop water requirement for rice at the scheme varied from 0.35 to 4.30 mm day^{-1} and 1.0 to 47.1 mm dec^{-1} respectively (Table 4). The total amount of water consumed by the crop is 494.3 mm dec^{-1}, while the effective rainfall was 250.3 mm dec^{-1} during the farming season. The total evapotranspiration is 491.9 mm dec^{-1} (Table 4). The crop water requirement increases steadily from the month of September till the first decade of November and start to increase again until the first decade of January. The crop coefficient at the nursery stage ranges from 1.20 to 1.06, initial stage of plantation is between 1.08 to 1.10, development stage (1.10.-1.14), mid (1.16) and late (1.15-1.11), this indicate that the rate at which the crop uses water was fluctuating until it remained constant at the mid- season and increase again at the late-season. The effective rainfall ranges from 3.1 to 41.5, it started at 11.6 in the first decade of September increasing until it started to decline in the third decade of October, reducing to 3.1 in the last decade of January. From these results there is an indication that the water was not a constraint at the scheme as the water needed by the crop for its physiological activities were available.

3.5.3 Irrigation scheduling for maize and rice at the scheme

Figures 1 show the soil moisture retention level of the maize farm in Itoikin irrigation scheme generated from Cropwat 8.0. The figures showed that the irrigation scheme was sufficient enough to conveniently supply water required for the growth of maize. The maximum depletion has a rate of 280 mm and it occurred on day 107 after planting (Figure 1). The rate of depletion of water increases with increase in days after planting (maturity stage of plant). However, the depletion of water from the maize farm did not exceed the threshold of readily available moisture indicating zero moisture stress for maize in the scheme. The readily available moisture at this stage is sufficient enough for the growth of the crop. For rice, more water is needed for adequate growth of the crop as depletion is higher (-10 mm and -100 mm) as shown in

Figure 2. The Total Available Moisture and Readily Available Moisture at the root zone are 80 mm and 18 mm respectively. This implies that there is need for adequate and constant irrigation of the farm for high productivity.

Table 3: Climatic parameters and evapotranspiration of Itoikin Irrigation Scheme

Month	Air temperature (^{0}C) Maximum	Air temperature (^{0}C) Minimum	Humidity (%)	Wind speed (Km day^{-1})	Sunshine (hr)	Radiation (MJ m^{-2}day^{-1})	ET_o (mm day^{-1})
Jan	22.4	32.2	86	173	5.8	16.7	3.67
Feb	23.7	33.2	86	199	6.6	18.8	4.22
Mar	24.1	32.9	88	207	6.3	19.2	4.21
Apr	23.7	32.2	91	199	6.3	19.2	4.05
May	23.2	30.9	94	181	5.6	17.6	3.56
June	21.9	29.3	100	190	4.3	15.2	2.77
July	22.3	28.2	99	207	3.4	13.9	2.5
Aug	21.8	28.3	92	199	3.4	14.4	2.89
Sept	22.1	28.9	94	173	3.6	14.8	2.93
Oct	22.4	30.3	95	156	5.1	16.6	3.25
Nov	23	31.4	93	156	6.4	17.7	3.54
Dec	22.5	31.8	86	164	6.4	17.2	3.69
Aver	22.8	30.8	92	184	5.3	16.8	3.44

Source: Cropwat 8.0

Table 4: Evapotranspiration and irrigation requirement for Maize farm at the scheme

Month	Decade	Stage	Kc Coeff	ET_c mm day^{-1}	ET_c mm dec^{-1}	Eff rain mm dec^{-1}	Irr. Req. mm dec^{-1}
Sep	3	Initial	0.3	1.36	13.6	54.8	0
Oct	1	Initial	0.3	1.48	14.8	55	0
Oct	2	Development	0.43	2.24	22.4	56.8	0
Oct	3	Development	0.67	3.45	37.9	38.6	0
Nov	1	Development	0.91	4.57	45.7	6.8	38.9
Nov	2	Mid-season	1.09	5.42	54.2	0	54.2
Nov	3	Mid-season	1.1	5.7	57	0	57
Dec	1	Mid-season	1.1	6.06	60.6	0.1	60.5
Dec	2	Mid-season	1.1	6.35	63.5	0	63.5
Dec	3	Late-season	1.04	5.51	60.6	0	60.6
Jan	1	Late-season	0.79	3.62	36.2	0	36.2
Jan	2	Late-season	0.54	2.21	22.1	0	22.1
Jan	3	Late-season	0.38	1.73	5.2	0	5.2

Month	Decade	Stage	Kc	ET_c	ET_c	Eff rain	Irr. Req.
Total				**494**	**212.2**	**398.2**	

Source: Cropwat 8.0

Where, K_c = Crop coefficient, ET_C = Evapotranspiration (mm day^{-1}), E_r = Effective rainfall (mm) I_r = Irrigation Requirement (mm dec^{-1})

Table 5: Evapotranspiration and irrigation requirement for Rice farm at the scheme

			Coeff	mm day^{-1}	mm dec^{-1}	mm dec^{-1}	mm dec^{-1}
Sep	1	Nur	1.20	0.35	1.0	11.6	1.0
Sep	2	Nurs/LPr	1.16	1.18	11.8	41.5	24.6
Sep	3	Nurs/LPr	1.06	3.23	32.3	38.8	0.0
Oct	1	Initial	1.08	3.38	33.8	36.8	177.4
Oct	2	Initial	1.10	3.58	35.8	35.4	0.4
Oct	3	Development	1.10	3.69	40.6	27.7	12.9
Nov	1	Development	1.12	3.86	38.6	18.1	20.5
Nov	2	Development	1.14	4.04	40.4	10.5	29.9
Nov	3	Mid-season	1.16	4.17	41.7	8.6	33.0
Dec	1	Mid-season	1.16	4.2	42.4	6.7	35.7
Dec	2	Mid-season	1.16	4.30	43.1	3.9	39.1
Dec	3	Mid-season	1.16	4.29	47.1	4.0	43.1
Jan	1	Late-season	1.15	4.25	42.5	3.6	38.9
Jan	2	Late-season	1.11	4.08	40.8	3.1	37.8
Total					**491.9**	**250.3**	**494.3**

3.5.4 Rainfall and effective rainfall

The effective rainfall for Itoikin irrigation scheme ranged between 14.4 mm and 156 mm, the value of the effective rainfall starts to decline from November (37.2mm) thus affecting the productivity of the crops planted negatively during this period. From Table 5 it was observed that the crops need irrigation as from November to March of every planting season. The average rainfall and effective rainfall are 1506.6 mm and 1046.5 mm respectively. According to Mulat *et al.,* (2004), the quantum of rainfall during crop growing season and temporal distribution of rainfall is a crucial factor deciding inter-annual fluctuations in crop production security. The rainfall analysis has shown (Table 5) that dry spells occurred from November through March. The lowest rainfall was recorded in January (13.2 mm). The implication of this dry spell is that the crops planted at this period will therefore experience severe water stress (deficit). Therefore, there is need for irrigation at a regular interval during this critical period. Wet spells are predominant from the month of April. Highest rainfall was recorded in June.

3.5.5 Soil

Itoikin irrigation scheme has a command area of 141 ha and the soils are predominantly silt- clay- loam. The highest bulk density recorded was 1.57 g cm^{-3}. The pH value of the soils ranged from 5.5 to 6.5, this indicates that the soil is slightly acidic and can support plant growth Ed Hume Seed Handbook (2012). The soil does not need any lime for neutralizing the soil. However, the electrical conductivity of the scheme ranged from 102.8 ms cm^{-1} to 308 ms cm^{-1}. There is indication that the salt content at the scheme is on high side. The high electrical conductivity could have resulted from periodic salt water intrusion from Lagos-Lagoon into Ogun River, which supplies Itoikin Irrigation Scheme The land allocated for Itoikin irrigation scheme project was demarcated into irrigable plots and these plots were allocated (User

allocation) to interested farmers usually on seasonal or annual basis at a rate of ₦2500 per ha per season. The average farm holding ranged between 0.25ha and 1ha. Efficient land utilization and management practices ensure achievement of farm level objectives in term of economic viability, food security and risk aversion (Udoh *et al,* 2002). The accessibility of most agricultural lands especially in the southern part of the country depends largely on land tenure system and the extent of competition by non-agricultural land uses (Udoh, 2000).

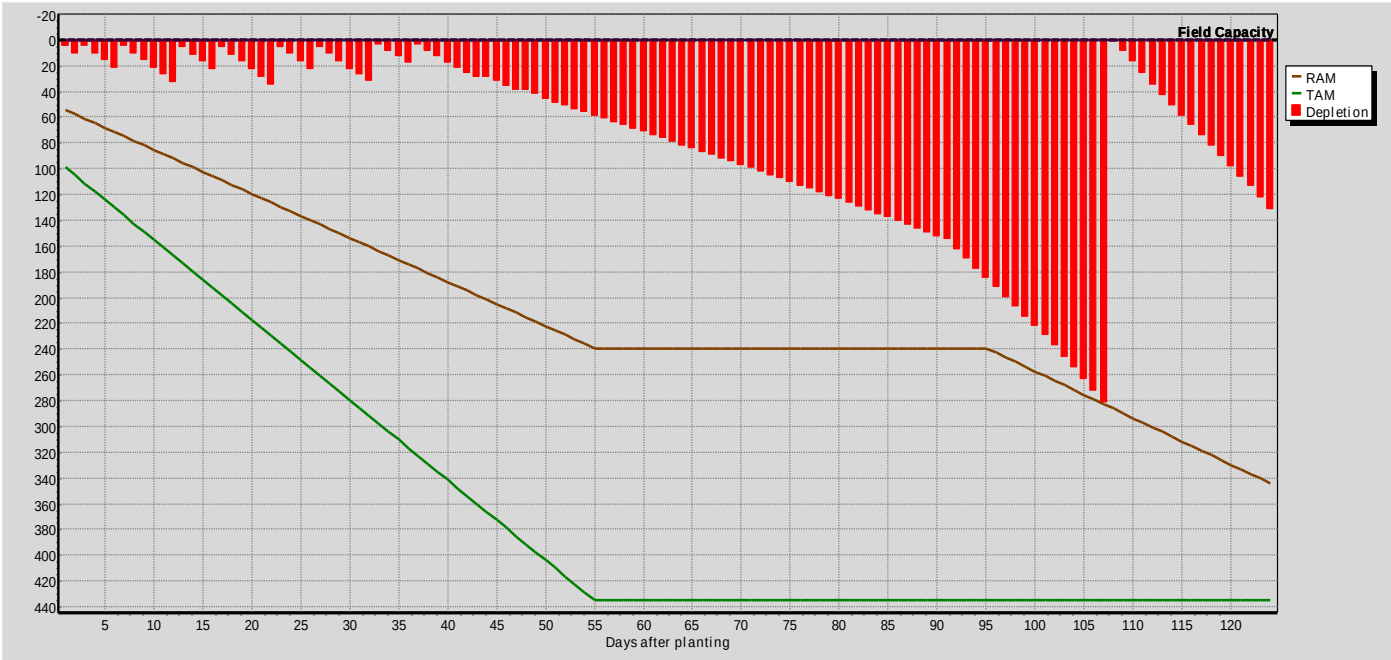


Figure 1: Irrigation scheduling for maize at the scheme generated from CROPWAT 8.0

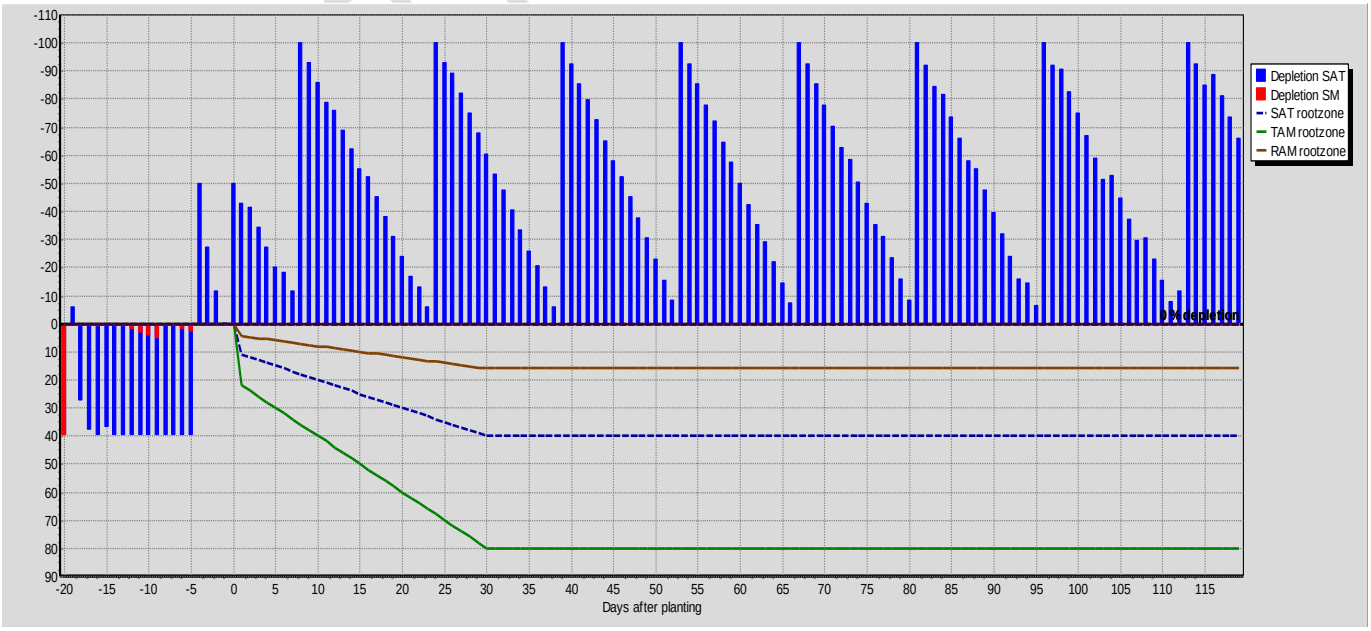


Figure 2: Irrigation scheduling for rice at the scheme generated from CROPWAT 8.0

3.6 Crop

Maize, rice and vegetables are the predominant crops. The scheme was originally designed for rice cultivation, but due to salt intrusion which leads to reduction in yield of rice, most farmers are now planting maize and vegetable. Plants growing in silt-clay loam need more water. Plate 4.0 shows the maize farm at Itoikin Irrigation Scheme (IIS). The relative flat field of Itoikin Irrigation Scheme allows water to spread naturally as it enters the field. Much of the water is wasted as3there is little or no control over the distribution of water in the field thus allowing over-supply of water. Weeding is done manually using hoe or cutlass by the farmers within three weeks of planting to enable the seedling to have a good start. Second time weeding is done when the plants are about 50 cm high.

3.7 Source of water and abstraction

Water flow from Ogun River into Itoikin Irrigation Scheme and abstraction is by using electric pumps with an average discharge of 85 liters per second. The pumping system consists of the Pump house, electric motors and transformer. The main problems affecting pumping of water in Itoikin Irrigation Scheme are lack of spare parts, high cost of replacement, high energy consumption and erosion around the intake structures. Plate 2 shows the pump house which comprises of three centrifugal pumps. The pumps are powered by electricity or diesel fuel using centrifugal force imparted to the fluid by one or more rotating elements (called impellers) to increase the kinetic and pressure of the fluid. Chemical injection and irrigation pumping are both perform by the both the pumps. The pumps have some problems which are wearing of the impeller, corrosion inside the pump, overheating due to low flow and leakage along rotating shaft. Plate 3 shows one of the two 550KVA diesel- powered generators in the power house at Itoikin Irrigation Scheme (IIS). The electric power generators supply standby power during a power failure. The generators worked most of the time as Itoikin Irrigation Scheme experienced frequent. Fuel for the generators was provided by the Ogun Osun River Basin Development Authority.

Table 6: Rainfall and effective rainfall

Months	Rainfall (mm)	Effective rainfall (mm)
January	13.2	12.9
February	40.6	38
March	84.3	72.9
April	146.3	112.1
May	202.4	136.9
June	315.5	156.6
July	243	148.5
August	121.7	98
September	160	119
October	125.1	100.1
November	39.7	37.2
December	14.8	14.4
Total	1506.6	1046.5

Generated from Cropwat 8.0

3.8 Canal system

The canal in Itoikin Irrigation Scheme is divided into main canals, sub main/ secondary canals and tertiary system/field channels. The total length of the main canals is 5 km and 20 % of the main canals are lined. The total length of the sub main canal is 140 m and the canals are not lined. The tertiary system is unlined. The canals were not lined because inadequate fund. The silt level in the concrete canal is generally low, while the silt level in the unlined canal is relatively high. Weed infestation is relatively low in the lined canal, while is high in unlined canals. The removal of the silt and weed is carried out by manually thus raising the cost of maintenance of the unlined canal.

Plate 1: Maize farms at the scheme

Plates 2 and 3 show the first part of canal that is lined which is made of cement concrete. The lined canal reduces seepage through the walls of the canal and thus reduces the potential for drainage problems, water losses caused by burrowing animals and maintenance costs are generally less. The canals are placed in a straight line across the upper edge of the field being irrigated to convey water to the field. There are cracks in the lined canal probably due to temperature changes and shrinkage and repair have not been effected because of inadequate fund.

Plate 2: First section of the lined Canal which convey water to the Scheme

Plate 3: A section of the lined canal which convey water to the scheme

3.9 Drainage system and Water distribution system

The length of the principal drains in Itoikin Irrigation Scheme is 1.20 km, but the drains are silted and overgrown with weeds. The drainage system is trapezoidal, but as result of erosion and poor maintenance, they now have irregular shapes, wider channel and much shallower. The irrigation water pumped from the river is discharged to main canal and subsequently to small reservoir that is used to dissipate the energy. Then 230 meter length concrete made primary canal carries the water to secondary canals. The secondary canals having a total length of 1800 meters runs longitudinally and with the help of several turnouts along the canal distributes the water to tertiary canals laterally. Individual farmers, according to their need, construct the tertiary canals to divert water into their fields. Farmers are diverting the water through their preferred direction as long as it is suitable to provide available head to irrigate their field.

3.10 Analysis of moisture content

Table 5 shows the soil moisture content before and 2 days after irrigation. The minimum value of 20.6 mm on plot 6 and the maximum value of 34.66 mm on plot 6 were recorded. The soil moisture contents was investigated to the depth of 45 cm and the moisture contents of the soil down the profile has an increasing trend (Table 5). It is therefore, suggested that the water at the scheme was lost by deep percolation than runoff and evaporations.

Table 7: Average soil moisture content before and two days after irrigation, % dry weight

Farmer's Plot	Time of sampling	Soil moisture contents of dry weight (%)		
		0-15 cm	15-30 cm	30-45 cm
Plot 1	Before irrigation	26.53	30.42	30.70
	After irrigation	33.26	34.16	32.43
Plot 2	Before irrigation	21.60	25.51	25.17
	After irrigation	25.43	27.48	29.93
Plot 3	Before irrigation	21.60	24.26	28.33
	After irrigation	28.30	30.32	30.27
Plot 4	Before irrigation	28.51	26.52	29.61
	After irrigation	33.16	32.23	32.18
Plot 5	Before irrigation	23.40	24.60	24.62
	After irrigation	29.74	28.83	28.76
Plot 6	Before irrigation	20.60	25.60	29.60
	After irrigation	27.66	28.66	34.66

3.11 Evaluation of the Scheme

The irrigation scheme was evaluated based on Irrigated Agricultural Output, Relative Water Supply (RWS), Relative Irrigation Supply (RIS) and the Water Delivery Capacity (WDC).

3.12 Indicators of irrigated agricultural output

The total output in naira (production) for the main crops planted at Itoikin Irrigation Scheme is shown in Figure 4. The scheme performance was evaluated based on irrigated Agricultural Output which comprises of the Output per cropped area, Output per unit Command area, output per irrigation supply and output per unit water consumed. For the period of analysis (2014-2015), the output per cropped area was ₦168, 116.22 per ha and output per unit command area was ₦236, 342.24 per ha. The output per unit irrigation supply was ₦183.31 per m^3 and output per unit water consumed was ₦3.29. The result of the agricultural performance indicators were higher than that of Oke Odan and Sepeteri except output per unit water consumed, output per cropped area- ₦152, 096.56/ha and ₦84, 021.88/ha, output per unit command- ₦216, 315.11/ha and ₦134, 435.00/ha, output per unit irrigation supply- ₦163.31/m^3 and ₦145.00/m^3, and output per unit water consumed- ₦4.29/m^3 and ₦28.70/m^3 (Ali, 2013). This indicated that higher unit of water was consumed by the scheme and may be attributed to the higher supply of water to the scheme. The cost of supplying water to the scheme is a bit higher. This is due to high maintenance of the machine.

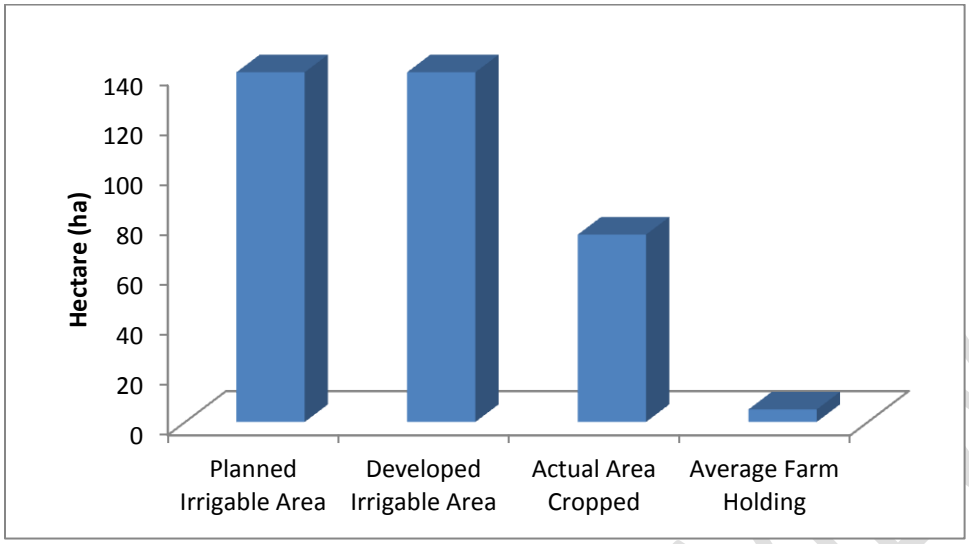


Figure 3: Planned irrigable area and actual area cropped

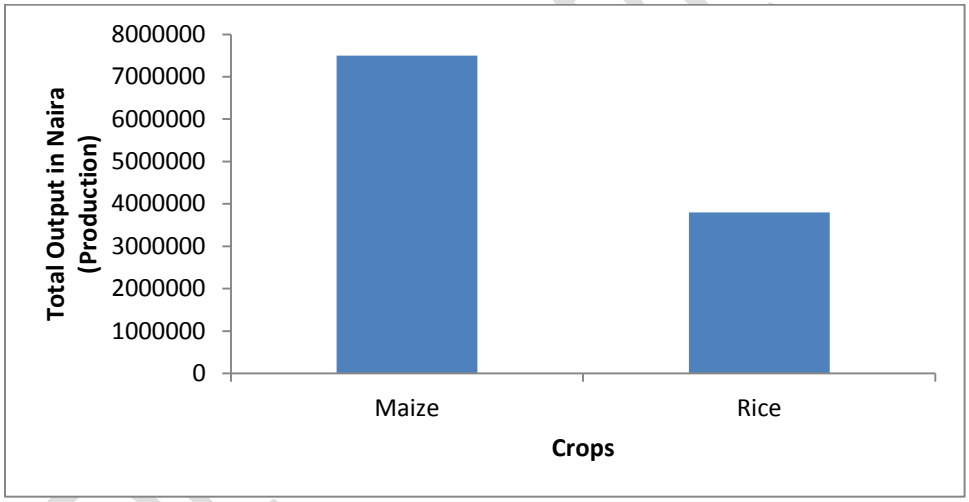


Figure 4: Crop Production in Naira (2014-2015 cropping season)

Table 8: Cost of Basic Agricultural Performance Indicators

Output per cropped area, (₦/ha)	Output per unit command, (₦/ha)	Output per unit irrigation supply, (₦/m^3)	Output per unit water consumed, (₦/m^3)
168,116.22	236,342.24	183.31	3.29

3.13 Basic water supply indicators

Figure 5 shows the basic water supply indicators at the scheme. These indicators are Relative Water Supply (RWS), Relative Irrigation Supply (RIS) and the Water Delivery Capacity (WDC). The RWS and RIS ratio for the scheme are 3.68 and 3.12 respectively; this could be considerably high and good where compared with FAO standard. Any value that is higher than 2 implies that there was a generous supply of

irrigation water in scheme during the period of analysis. It conformed to the work of Behailu, *et al*., (2002) and FAO (2003) which stated that RWS higher than 2 indicated generous supply of water. However, Yusuf (2004) argued that whenever the RIS ratio is higher than 2 there is indication that the water supplied was sufficient for the scheme and water supplied was solely for irrigation. The WDC at the Itoikin irrigation scheme was 1.92 (Figure 5) which shows that the scheme has the ability to discharge water sufficiently. It also shown that reservoir capacity is not a constraint in meeting water demand especially during peak time of crop demand. The basic water supply indicators were higher than that of Oke Odan and Sepeteri except WDC for Oke Odan, Relative Water Supply- 3.28 and 2.61 , Relative Irrigation Supply- 3.06 and 2.08 Water Delivery Capacity- 1.73 and 3.26 (Ali, 2013).

3.14 Financial indicators

The Gross Return on Investment of the irrigation project as presented in Figure 5 is (9.02%). The return on investment is fair when compared with FAO standard. The GRI is been affected by non-utilization of all the irrigable area at the scheme, this showed that the scheme is under-utilized. There is the need for the management of Itoikin irrigation scheme to increase the size of actual irrigable land so as to improve and increase GRI. The GRI was higher than that of Oke Odan and Sepeteri 6.54% and 0.028% (Ali, 2013).

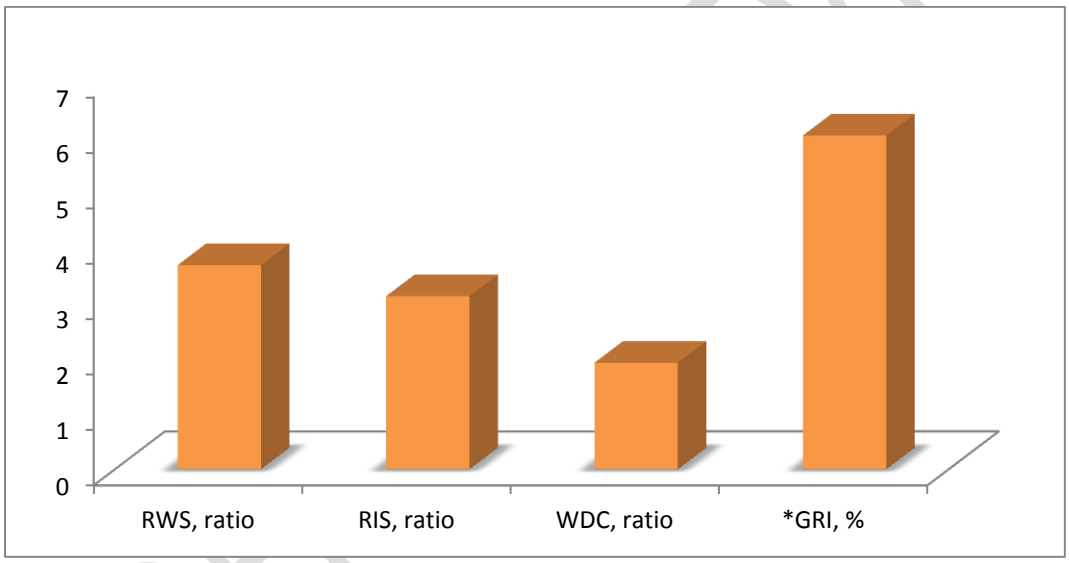


Figure 5: Basic water supply indicator

Conclusion

The strengths and weaknesses of Itoikin Irrigation Scheme were revealed in this study, which will be helpful in making managerial and technical decision. The physico-chemical properties of soil, soil and water inventory were used in carryout the evaluation. Site accessibility, availability of secondary data and organizational set up were the criteria used in selecting Itoikin Irrigation Scheme for the evaluation. Root development in Itoikin Irrigation Scheme will not pose as a problem as the bulk density will not restrict the development of the root, while the soil pH will allow the cultivation of maize, rice and vegetables. The electrical conductivity at Itoikin Irrigation Scheme is on the high thus posing a danger to the crops planted at the scheme if not reduced, while the high nutrient deficiencies of the exchangeable cations pose a danger to the productivity of the crops planted at the scheme. The different soil layers at Itoikin Irrigation Scheme do not hinder the movement of water as the hydraulic conductivity corresponds to that of the soils in the scheme. The climatic parameters of temperature, humidity, wind speed, sunshine, radiation and evapotranspiration does not pose any adverse effect on the crop plant at the scheme. Crops planted at Itoikin Irrigation Scheme required less water at initial stage of growth, but required more at the later stage

of growth to compensate for evapotranspiration loss. This implies that more water was needed at this stage of growth of the crops as the rainfall and effective rainfall have reduced. The soil in Itoikin Irrigation Scheme is suitable for the types of crops planted and the tenure system at the scheme make land easily available for intending farmers because there are no competitions by non- agricultural land users. Weed infestation and silt affected the discharge in the canal system. From the result of irrigated agricultural output, output per cropped area was ₦168, 111.22 per ha, indicating that the irrigation practice is good. Output per unit command area was ₦236, 342 per ha, showing that there is enough rainfall to fill the reservoir at the scheme. Output per irrigation supply was N183.31 per m^3 and output per unit water consumed was 3.29, indicating that there was proper utilization of water. The result of the analysis pointed that Relative Water Supply (RWS), Relative Irrigation Supply (RIS) and Water Delivery Capacity (WDC) were 3.68, 3.12 and 1.92 respectively, this show that the return per irrigation water was good. The Gross Return on Investment (GRI) was 9.02%, showing that there was good return on investment at the scheme. The values of the indicators can be said to be fair compared with Food and Agricultural Organization (FAO) standard.

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