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INITIAL STUDIES OF WATER RESOURCES ADVANCEMENT IN RELATION TO IRRIGATIONAL REQUIREMENTS IN A NOMINATED GRANGE IN CALABAR, SOUTHERN NIGERIA

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ABSTRACT

A nominated farmstead in the southern part of Nigeria was selected for water resources advancement studies. The objectives of the study were to obtain the available moisture contentof the arable land area; obtain the rainfall data of the catchment by direct measurement with non-recording rain gauges; obtain the infiltration data from the catchment by the use of the double ring infiltrometer; parcellate the arable land area into plots to obtain measurable irrigated portions and finally, to subject all data obtained into statistical analyses using SPSS The model summary showed an adjusted R of 0.171 with a standard error of 0.0506 from 16 observations. The multiple R was 0.58 while the R^2 was 0.337. Since the R^2 is the measure of the strength of the relationship between the model and the dependent variable, the model was adjudged a poor one as approximately only 34% of the irrigational activities of the farm couldbe accounted for by the model. The final model for the irrigational processes in the area was given as, **Y = -0.0179 +0.000006X1 + 0.015X2 – 0.00012X3.** It was therefore recommended that every apparatus of the hydrological cycle, and the influence of human activities on it, needto be understood and quantified to proficiently and sustainably develop and protect our water resources.

KEYWORDS: Nominated, grange, water resources, irrigational, infiltration.

1.0 : INTRODUCTION

1.1 Background of study

"Water is life" is a concept which life has completely accepted without any allowance for reservation. This is because water is one product without which life cannot exist on earth. Principally, it is not only because it is essential for the actual living process, but also because it is necessary for supporting man's material activities which lead to his material development(Smith and Melone, 1993). With increasing human population and its attendant increased anthropoid activities, coupled with reduction in natural resources, the need for water for survival has presently added new dimensions in the recent past. Progressive pollution of fresh water supplies by accelerated human activity has made an already critical problem even moreperilous (Ifeanyi, et.al, 2012).

As opined by Getachew et.al 2019, water resources development and its management remain at the heart of the struggle for sustainable development, growth and poverty reduction. Unless progress in water management is made, sustainable growth and discount in poverty cannot be achieved (Daniel, 2011).

In countries with limited water resources, an all-inclusive, radical and articulated water resources development is an obligatory condition for optimal social and economic growth. (Jain & Singh,2003). Vis-a-vis projects to improve water use efficiency in agriculture (such as introduction of micro irrigation technologies) to achieve the desired and required results, they must be based on the concept of field level water saving requirement. This may be accomplished through the use of those technologies which help minimize the deep percolation of water applied in the fields (Antigha, et al, 2022). But in many situations, the deep percolation "losses" resulting from inefficient irrigation practice is available for reuse by well irrigation in the same catchment, and micro irrigation technologies only reduce this beneficial, non-consumptive use. Hence, using such concept can lead to overestimation of water saving benefits (Allen et. al, 1980). Therefore, to determine the 'real water saving', the basin manager should be concerned with reduction in the amount of water depleted (Kumar, 2013).

Basically, water resources development may be categorized into: surface storage; reservoirs, natural lakes with artificial control of outflows; channelization; irrigation canals, navigation canals, drainage works, dykes for flood protection and erosion control measures; diversion of water; inter basin water transfer projects; waste treatment and assimilation and ground water extraction as well as artificial catchment recharge.

Giuseppe, et al, (2012) in his study, reported that infiltration is a complex process and depends on many factors like soil moisture content, condition of soil, presence of vegetation, type of soil, storm event, temperature, properties of water and the storage capacity of the soil. Essentially, infiltration is the process by which precipitation water is abstracted by seeping into the soil below the land surface. It is also taken as water lost due to absorption of water by the ground surface. The infiltrated water may move horizontally, vertically or in both directions.

Kumar (2013) asserted that the horizontal movement of water is called interflow. Irrigation, on the order hand, is the precise application of water to arable lands in order to bring the land to field capacity for crop production. Its primary objective is to create an optimal soil moisture regime for maximizing crop production and quality while at the same time curtailing the conservational dilapidation intrinsic in irrigation of agrarian lands (Garder & Hillel, 1970; Charbenau & Asgian, 1991).

Antigha, et. al, (2022) undertook a pilot studies of the evapotranspiration and reservoir management processes in selected farmsteads in the calabar metropolis catchment, southern Nigeria. Five selected arable land areas were selected within the Calabar Metropolis catchment for evapotranspiration studies. The lysimeter was employed in obtaining the evapotranspiration data, cylinder infiltrometer was used for infiltration data, while rainfall and temperature data were obtained from Meteorological Centre of the Margaret Ekpo International Airport in Calabar between the months of January and July. This was done to observe how the three parameters influenced the evapotranspiration processes in the catchment. They reported that there was an observable positive correlation between rainfall, temperature and evapotranspiration with a seeming stronger bond (0.41) existing between temperature and evapotranspiration, and a recorded weaker bond (0.21) existing between evapotranspiration and rainfall. With an R^2 of 0.23 and an adjusted R of 0.21, the evapotranspiration processes in the catchment was adjudged to be far more complicated than the three predictor variables could explain as they only could account for less than 24% of the evapotranspiration processes in the catchment.

The objectives of this work were to obtain the available moisture content of an existing arable land area; obtain the rainfall data of the catchment by direct measurement with non-recording rain gauges; obtain the infiltration data from the catchment by the use of the double ring infiltrometer; parcellate the arable land area into plots to obtain measurable irrigated portions and finally, to subject all data obtained into statistical analyses using SPSS (2021).

2.0 : MATERIALS AND METHOD

2.1 : Description of Area of Study

The Royal Farm International is a privately owned farm in the Calabar Metropolis. The Metropolis itself lies between latitudes 04° 45' 30" North and 05° 08'30" North of the Equator and longitudes 8 ° 11' 21" and 8°27'00" East of the Meridian (fig. 1), while the farm is located approximately on latitude 05° 01' 41" North and longitude 8°22'25" East of the Meridian (fig.2). The Metropolis, as a town, is flanked on its eastern and western borders by two large perennial streams viz: the Great Kwa River and the Calabar River respectively. These are aside from the numerous ephemeral channels which receive water after storm events to drain the area of study as shown in figure 1 (Antigha, et al, 2014; Antigha, et.al, 2022).

The Calabar River is about 7.58 metres deep at its two major bands. The city lies in a peninsular between the two rivers, 56km up the Calabar River away from the sea. Calabar has been described as an inter-fluvial settlement (Antigha, et al, 2014; 2021).

The Metropolis occupies an area of about 223.325 sq.km, while the Royal International Farm sits on an areal land space of 5.6 ha of arable land. As a coastal town in Nigeria, Calabar Metropolis has a high relative humidity, usually between 80% and 100%. Relative humidity drops with the rise in temperature to about 70% in the afternoon during the dry season (Antigha, et al, 2014).

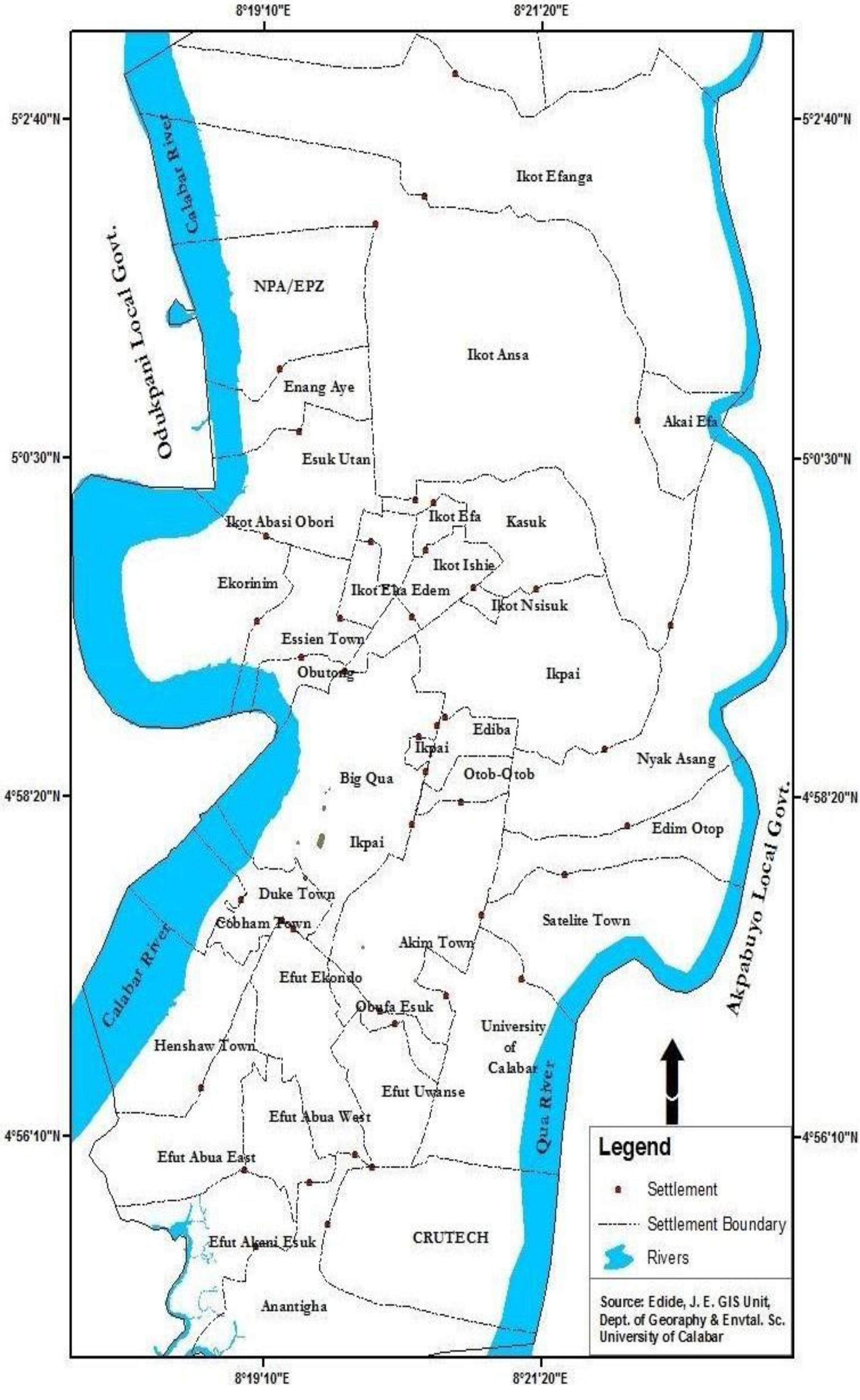


Fig. 1: Layout of Calabar Metropolis (Source: Antigha, et al., 2014).

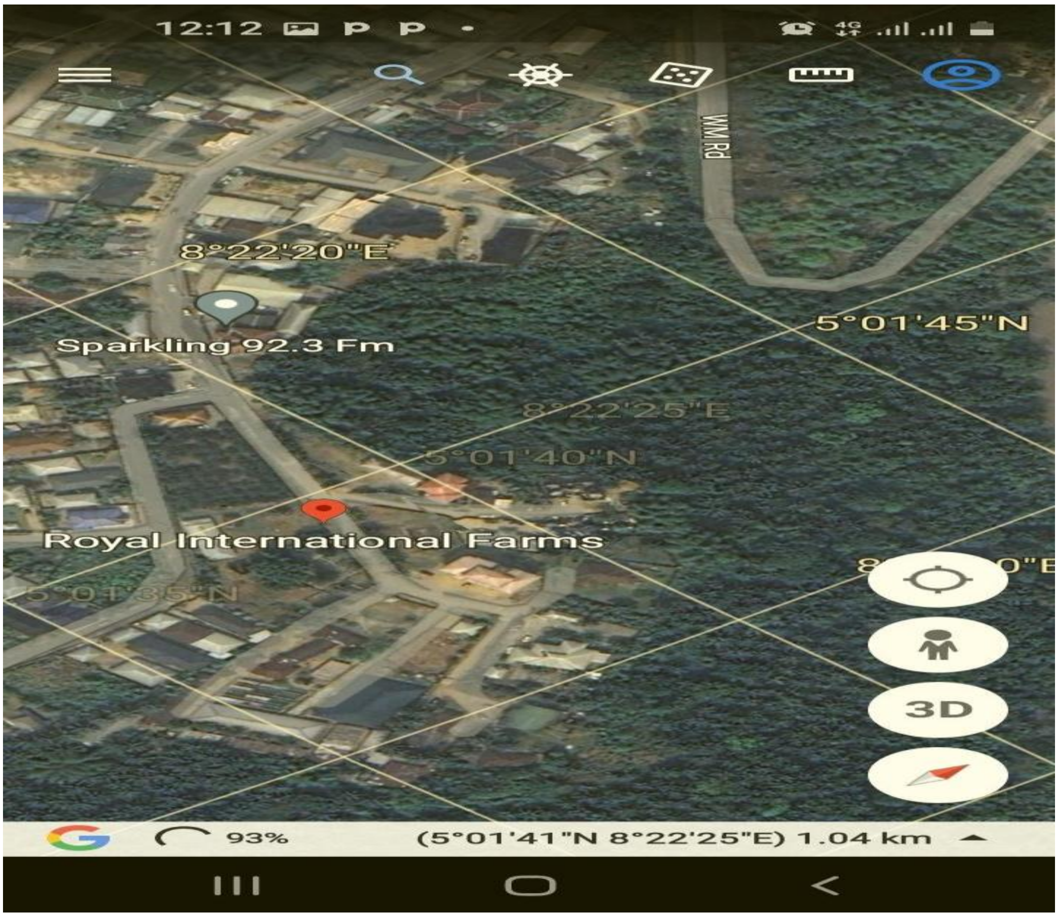


Figure 2: Google Earth Imagery of the Study Location (Source: Google Earth, 2022 App).

2.2 : Sample Collection

Soil samples were collected from (16) sampling points at different sections of the farm at average depth of 0.5m. The collected samples were taken to the laboratory for analysis.

2.3 : Sample Preparation

Collected sample were arranged and named alphabetically for proper identification in the laboratory for moisture content analysis.

2.4 : Test Procedures

2.4.1 : Moisture Content Test

The soil was excavated at an average depth of 0.5m beneath the ground using the soil auger after five days antecedent precipitation was determined. Soil samples were collected into a cellophane bag. This exercise was repeated for all the sampling points and samples collected were taken to the Soil Laboratory for analysis which involved weighing and recording the masses of wet soils, containers as well as the dried soils. Soil Moisture Content was obtained by subtracting the dry weight from the wet weight etc.

2.4.2 : Sieve Analysis Test

The collected wet soil samples from each sampling point were oven dried at a temperature of 105^{0}c. The samples were then removed and 500g of dried sample measured and placed in the. sieve machine and vibrated for 60 seconds. The results of percent passing were plotted.

2.4.3 : Field Measurement of Infiltration

Infiltration measurement was carried out using the double ring infiltration.

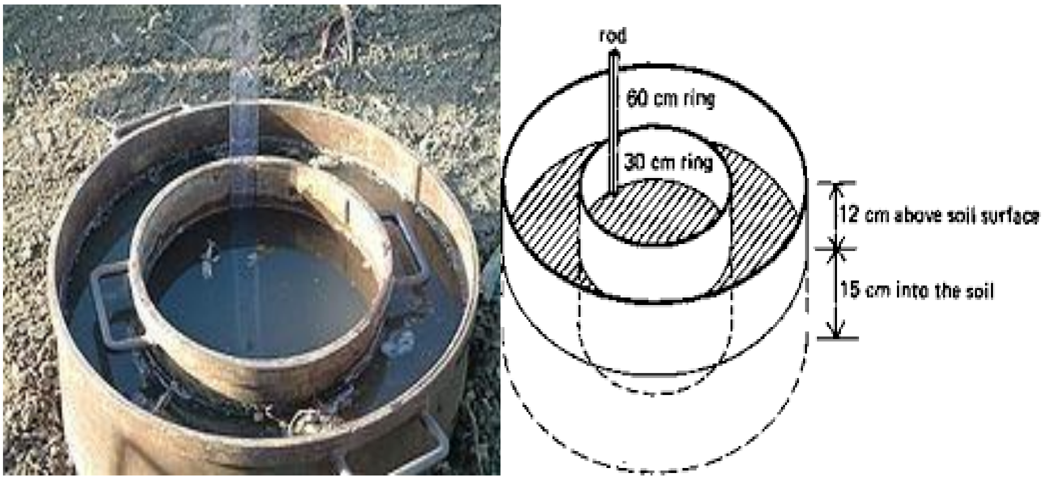


Figure 3: Pictorial view of a Double Ring Infiltrometer.

A metal tube was driven into the ground to a depth of 10cm with a sledge hammer to avoid lateral flow of water. Care was taken to prevent damage to soil structure. A constant ponding level of 5cm was maintained in the metal tube ring throughout the experiment. With the aid of a stopwatch, reading was taken at intervals of 5mins, 10mins, 15mins up to 40mins. The reading continued until a steady state of equilibrium was reached (Adindu et. al, 2014, Kostiakov, 1938).

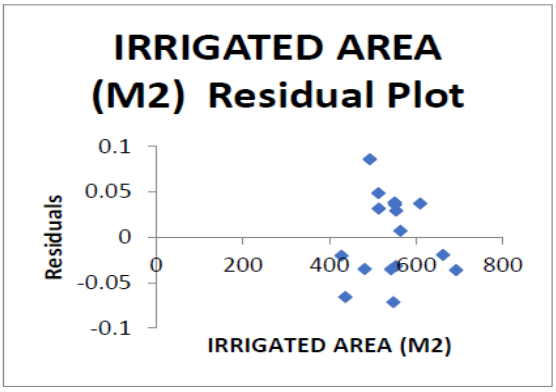
3.0: RESULTS AND DISCUSSIONS

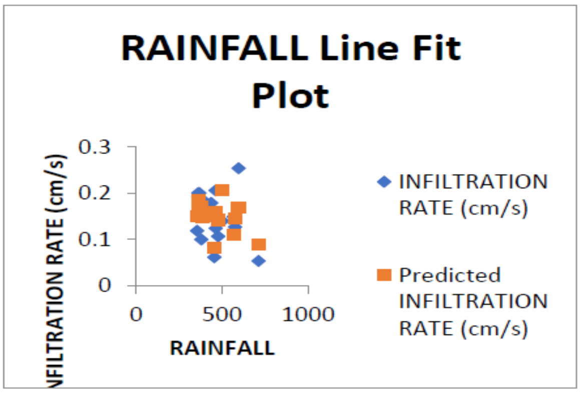
3.1: Results

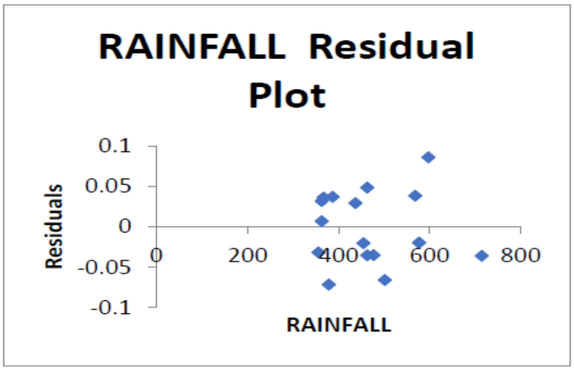
The modification of water resources development in relation to irrigation involved obtaining infiltration for the catchment from (16) sampling point for cumulative time intake for 5,10,15,20,30,35,40 minutes respectively. Soil samples were collected from each sampling point and the results obtained are presented in table 1 below.

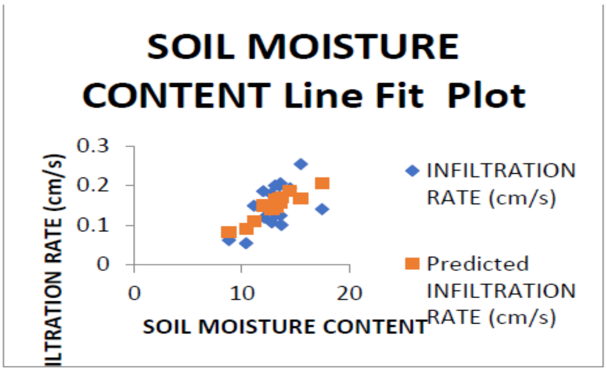
Table 1: Values of All Parameters for All Locations.

Location	Infiltration Rate (cm/s)	Irrigated Area (M^2)	Soil Moisture Content	Rainfall
PLOT 1	0.054	691.72	10.4	714.4
PLOT 2	0.186	609.06	12	386.6
PLOT 3	0.062	427.4	8.8	454.6
PLOT 4	0.179	553.55	12.7	437.2
PLOT 5	0.149	550.22	11.15	568.5
PLOT 6	0.127	661.85	13.2	576.8
PLOT 7	0.2	513.43	13.5	363
PLOT 8	0.14	436.26	17.5	501.5
PLOT 9	0.107	480.69	12.8	477.3
PLOT 10	0.193	563.55	14.5	363.3
PLOT 11	0.119	553.14	12.1	356
PLOT 12	0.124	541.85	13.6	462.7
PLOT 13	0.206	512.41	13.6	462.8
PLOT 14	0.254	492.47	15.5	597.4
PLOT 15	0.2	550.93	13.1	367.5
PLOT 16	0.1	547.26	13.7	378.6









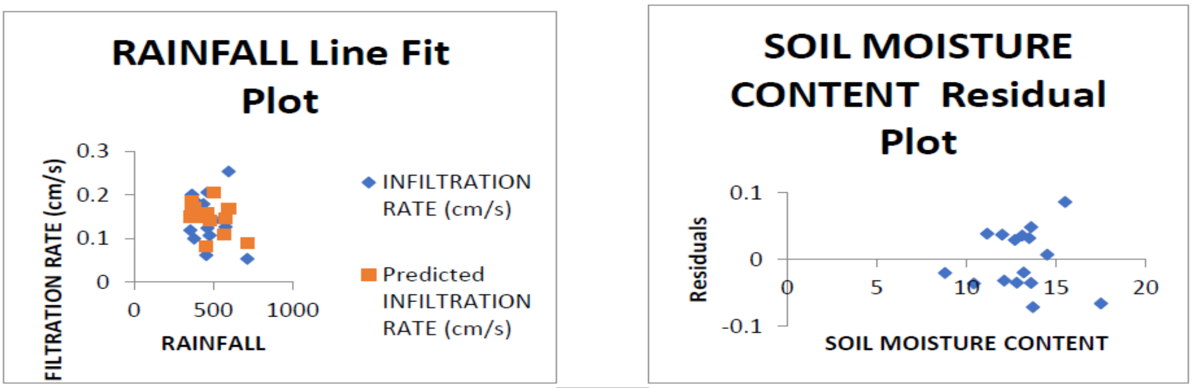


Figure 4a – f: Various Plots for All Variables.

Figure 5a – f: Plots for All Variables for Locations 1- 6.

Figure 6a – f: Plots for All Variables for Locations 7 – 12.

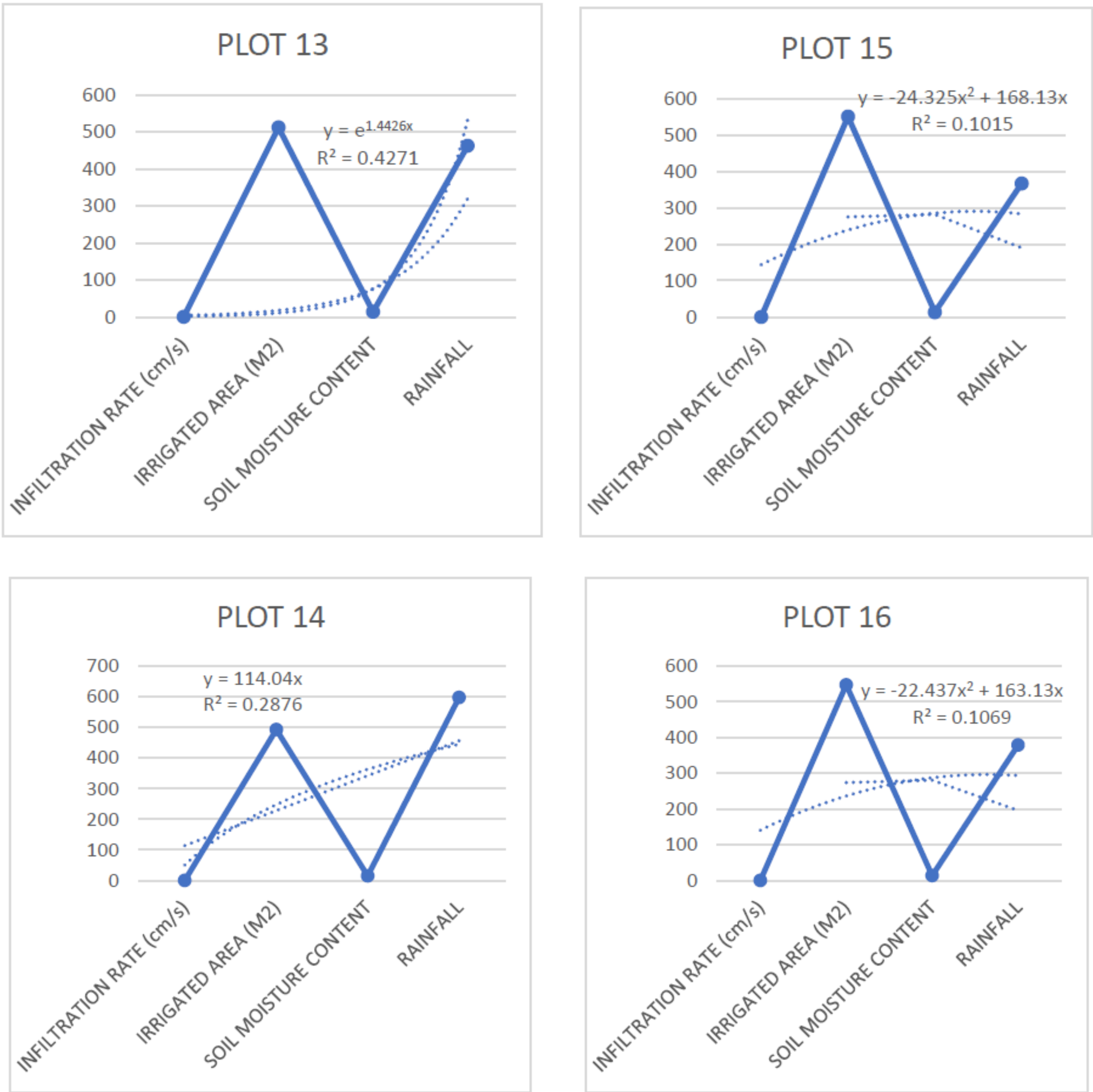


Figure 7a – d: Plots for All Variables for Locations 13 – 16.

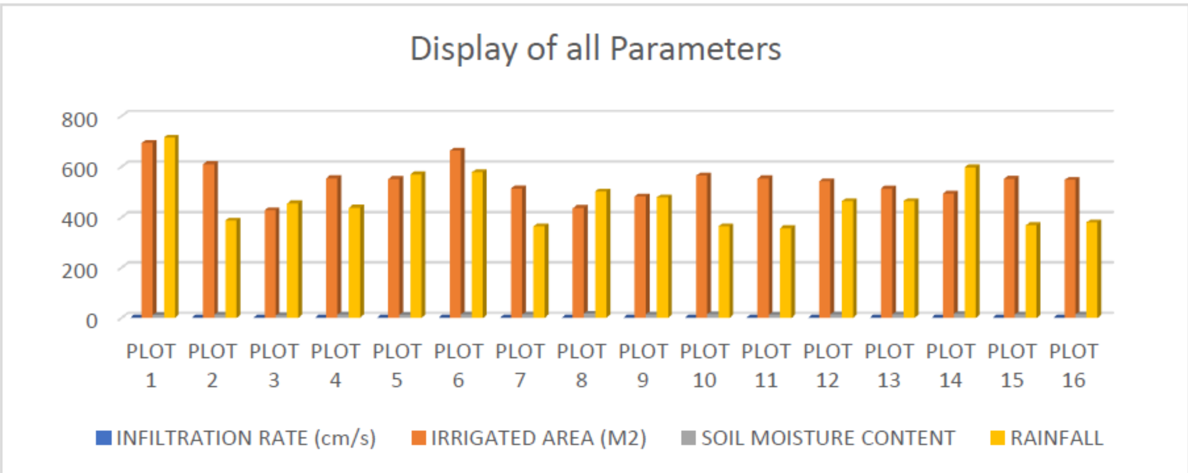


Figure 8: Display of All Parameters for Locations 1 – 16.

Table 2: Correlation Matrix of the Variables.

	INFILTRATION RATE (cm/s)	*IRRIGATED AREA (M2)*	*SOIL MOISTURE CONTENT*	*RAINFALL*
Infiltratizon Rzate (cm/s)	1			
IRRIGATED AREA (M2)	-0.137339042	1		
SOIL MOISTURE CONTENT	0.539089005	-0.26621658	1	
RAINFALL	-0.267705864	0.313027001	-0.119981715	1

3.3: DISCUSSIONS

Table 1 shows the result of the various data of all parameters analyzed in the catchment. Table 2 shows the correlation matrix obtained in the area of study. Figures 4 – 8 show the various plots and display of all the parameters obtained in the course of the study. There was a positive correlation of infiltration with soil moisture content (0.54) as well as for rainfall and the irrigated area (0.31).

The highest rainfall value for the study was recorded at plot 1(714.4mm depth) with an areal extent of 691.72m^2, while the lowest rainfall was recorded at plot 11 (356mm depth) with an areal extent of 553.14m^2. The highest soil moisture content of 17.5 was obtained at point 8, while the least value of 8.8 was recorded at point 3.

The plots of the trendline for all locations showed an R^2 of 0.63 as the highest at point 8 while the lowest value of 0.033 was observed at point 11.

The model summary showed an adjusted R of 0.171 with a standard error of 0.0506 from 16 observations. The multiple R was 0.58 while the R^2 was 0.337. Since the R^2 is the measure of the strength of the relationship between the model and the dependent variable, the model was adjudged a poor one as approximately only 34% of the irrigational activities of the farm couldbe accounted for by the model.

An exploratory factor analysis was done so as to report in quantitative terms, the relative influence of each variable in the model and as such, factor out any of the variables with minimal influence on the model. Again, a rotated factor analysis was also conducted but a poor f-value was obtained. Since an f-value (test) of the overall significance is the hypothesis test for the relationship, it follows therefore that if the overall f-test is significant, it could be inferred that the correlation between the model and the dependent variable is statistically significant. Additionally, a standard error of 72.277 was recorded in a rotated factor analysis, depicting that the adopted model, with a standard error of 0.051 was a better model, because, the smaller the standard error, the better the measure of the discrepancy in the sample estimate.

The final model for the irrigational processes in the area was therefore given as

Y = -0.0179 +0.000006X1 + 0.015X2 – 0.00012X3

Where Y is the infiltrated water into the soil for irrigational purpose X1 is the irrigated land area

X2 is the soil moisture content and, X3 is the rainfall.

CONCLUSION AND RECOMMENDATIONS

In recent times, climate change, both spatial and temporal, is having a momentous influence on weather patterns, precipitation and the hydrological cycle, affecting surface water accessibility as well as soil moisture accretion and groundwater recharge, especially through the baseflow (dry-weather flow) component.

It should be noted that the available water resources are irregularly distributed in intergalactic period. This therefore makes them to be constantly under pressure due to major population revolution and amplified request. Access to reliable data on the availability, quality and quantity of water, and its variability, form the necessary foundation for sound management of water resources. The diverse possibilities for augmentation inflate the boundaries of the water resource in a conventional sense, thus helping to match demand with supply.

It is therefore recommended that every apparatus of the hydrological cycle, and the influence of human activities on it, need to be understood and quantified to proficiently and sustainably develop and protect our water resources.

Again, as rising uncertainty of surface water obtainability and growing levels of water pollution and diversions threaten to dislocate social and economic growth in many areas as well as the health of ecosystems, there is a dire need to study the water resource as a system comprehensively in order to manage all forms of emerging precariousness.

Many outmoded practices are being refined (e.g. rainwater harvesting), while more recent advances (e.g. artificial recharge, detoxication, desalination and water reuse) are being developed further. This should be strongly encouraged by the various stake holders. A lot more backing needs to be given to policy opportunities, such as demand management, which emphasis is on more efficient and sustainable use of the available water resources.

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