Available online www.unicrossjournals.com

UNICROSS JOURNAL OF SCIENCE AND TECHNOLOGY, UJOST

RESEARCH ARTICLE VOL. 1(2) SEPTEMBER, 2022 ISSN:2814-2233

Date Accepted: 31st August, 2022 Pages 71 - 90

PILOT STUDIES OF THE EVAPOTRANSPIRATION AND RESERVOIR MANAGEMENT PROCESSES IN SELECTED FARMSTEADS IN THE CALABAR METROPOLIS CATCHMENT, SOUTHERN NIGERIA

Antigha[1], R.E.; Ogarekpe[1], N.M; Odey[2], S.O; Bassey[1], G.I; Egbe[1], J.G. and Ekeng[1], I.B

[1]Dept of Civil Engineering, CRUTECH, Nigeria and

[2]Dept of Wood Products Engineering, CRUTECH, Nigeria.

Corresponding Author: richard.antigha@crutechedu.ng

Abstract

Five selected arable land areas were selected within the Calabar Metropolis catchment for evapotranspiration studies. The selected farmsteads were sited at CRUTECH, Akai Efa, Marina, Ekorinim and Big Qua. 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. 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. There was however an inverse proportionality between temperature and rainfall in the catchment for the period studied. 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. With the existing relationship between rainfall, temperature, infiltration and evapotranspiration, the simple water balance model should be incorporated in any design which targets to investigate the rainfall-runoff relationship within the Calabar Metropolis catchment.

Keywords: Evapotranspiration, catchment, variability, infiltration, rainfall-runoff processes.

1.0. Introduction

The primary source of recharge for most reservoirs in the world is rainfall. The three main characteristics of rainfall are its depth, frequency and intensity, the values of which vary from place to place, month to month and year to year. Precise knowledge of these three main characteristics is essential for water resource planning in any given watershed, the Calabar Metropolis being one of such. Information on the amount, intensity and distribution of monthly and/or yearly rainfall in Calabar Metropolis were obtained from the Nigerian Meteorological Agency (NIMET), Margaret Ekpo International Airport.

Long term records of daily rainfall have been compiled for years; normal and standard deviations have been worked out; floods and droughts have been defined and climatic zones of potential evapotranspiration, less precipitation have also been mapped from rainfall pattern and reservoirs studies (Wiley, 2005). In spite of the voluminous data of weather, all is not yet known that should be known about rainfall, largely due to its variability.

The pathway of rainwater indicates the diverse factors that are needed to be considered. Before rain strikes the ground, there is some evaporation in the atmosphere. This amount is never measured, but it increases the air humidity, lowers the temperature and as a result, reduces evapotranspiration from life form on the surface. Vapour may also be blown away by the wind to the surrounding areas; this fraction is partially useful, but not necessarily taken into consideration in most computation.

Rain may be intercepted by vegetation. Some of it may be absorbed and retained by leaves, which is eventually lost as evaporation. Some may drip from the leaves unto the soil surface, the rate of vegetal interception being high at the beginning of a storm event, but reduces with time, which is measured in the total rainfall, and is useful in the reduction of transpiration and depletion of soil moisture. When showers are light, the entire rainfall may be intercepted by vegetation.

On striking the earth surface, some water infiltrates into the soil directly as interflow and later as baseflow (Antigha and Ogarekpe, 2013). Some may remain stationary on the earth surface, while some may spill over as runoff. Factors that influence infiltration and surface runoff are numerous and interrelated.

Rainwater lost by runoff may be pumped back and reused at the site where it was received, or it may be used elsewhere downstream. The water that stagnates on the earth surface is lost through infiltration and in due course, by evaporation. This infiltrated water is retained around the soil particles as a thin film and is thus stored in the root zone. A part of the water stored in the root zone may actually be utilized in raising crops. It may be useful for evapotranspiration and for reservoir recharge (Tamer &Fayez, 2010).

Water may be lost beyond the root zone by deep percolation to underground storage or streams. Though essential in arid and semi-arid regions for washing down the salts, if there is no sanitary problem, all water lost by deep percolation beyond the root zone is useful only through recharge of the underground reservoir. (Bowen, 2015)

Precipitation is derived from atmospheric water. Its form and quantity are influenced by climatic factors such as wind, temperature, and atmospheric pressure. There are different forms of moisture falling from the atmosphere to earth, example drizzle, rain, glaze, sleet, snow, snow pellets, hail etc. Precipitation is produced primarily when the water vapour in the atmosphere becomes saturated, condenses and increases in weight such that solid or liquid water can no longer be supported by air currents and fall to the earth surface (Bowen, 2015).

Prediction of reservoir inflows and other unregulated flows in a river basin often requires a computer model representing the key hydrologic processes occurring in the drainage basin. These models can range from very simple to very complex models. Most models applied in practice are fairly simple, due to limited data, and combined empirical methods with physically-based modeling (Ogarekpe, et al, 2021). The partitioning of precipitation into the components of infiltration, evapotranspiration, surface storage, and runoff depends on a number of factors. These include land use, land cover, soil type, slope, and climatic variables such as temperature, wind, and humidity (Wurbs and James, 2002).

The objectives of the research included obtaining evapotranspiration, infiltration, rainfall and temperature data from selected farmsteads in the Metropolis using acceptable approaches and subjecting the acquired data to statistical analyses; reviewing of several ways used in reservoir management as well as documenting the effect of rainfall, infiltration, runoff and evapotranspiration in reservoir management.

2.0: Literature Review

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 (Giuseppe, et al, 2012; Antigha, 2021).

Basically, 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. The horizontal movement of water is called Interflow (Antigha, 2019). The interflow joins streams, lakes and rivers without first becoming underground water. The vertical movement of water from deeper layers of soil is called percolation. The percolated water moves as Groundwater flow (Parlange, 1982). Infiltration is controlled by two forces: gravity and capillary action. While smaller pores offer greater resistance to gravity, very small pores pull water through capillary action in addition to and even against the force of gravity (Hendriks, 2010). Infiltration is measured in terms of depth of water lost in unit time. This is necessary as amount of infiltration varies with time. At a particular instant, infiltrated depth of water divided by time is called Instantaneous Infiltration Rate. If total infiltrated water depth is divided by total time, it is known as Average Infiltration Rate (Parlange, 1982).

Various researchers proposed formulae to calculate Rate of Infiltration for a given soil. One of these formulae which is most commonly used is 'Horton's Equation' as given below:

$f = f_c + (f_o - f_c) e^{-kt}$ Where,

f = infiltration rate at any time ‘t’

f_o = initial infiltration rate

fc = final infiltration rate

k = a constant having units of 1/t

Integration of above equation gives total infiltration as given below.

Total infiltration 'F' = [(fo - fc) / k] + f_{ct} (Horton, 1933)

Equally, Kostiakov's infiltration model suggests a formula which assumes that at time t = 0, the infiltration rate is infinite and at time t = α, the rate approaches zero (Kostiakov, 1938). The equation is given by:

$I = Ct^{\alpha}$

Where t is the time elapsed for the experiment.

I is the cumulative infiltration.

α, and c are empirical constants that are site specific and depend on soil conditions such as texture, moisture content, bulk density and other soil properties.

To determine the parameters α and C, the logs of both sides of (1) are taken. This gives

Log = log C + a log t

A plot of log I against log t gives a straight line whose slope gives the value of 'a' while log C gives the intercept (Heber & Ampt ,2009; Adindu, et al, 2014).

2.1: Description of Area of Study

Calabar Metropolis 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. The 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, 2015)

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, 2015; 2021).

The Metropolis occupies an area of about 223.325 sq.km. 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, 2015).

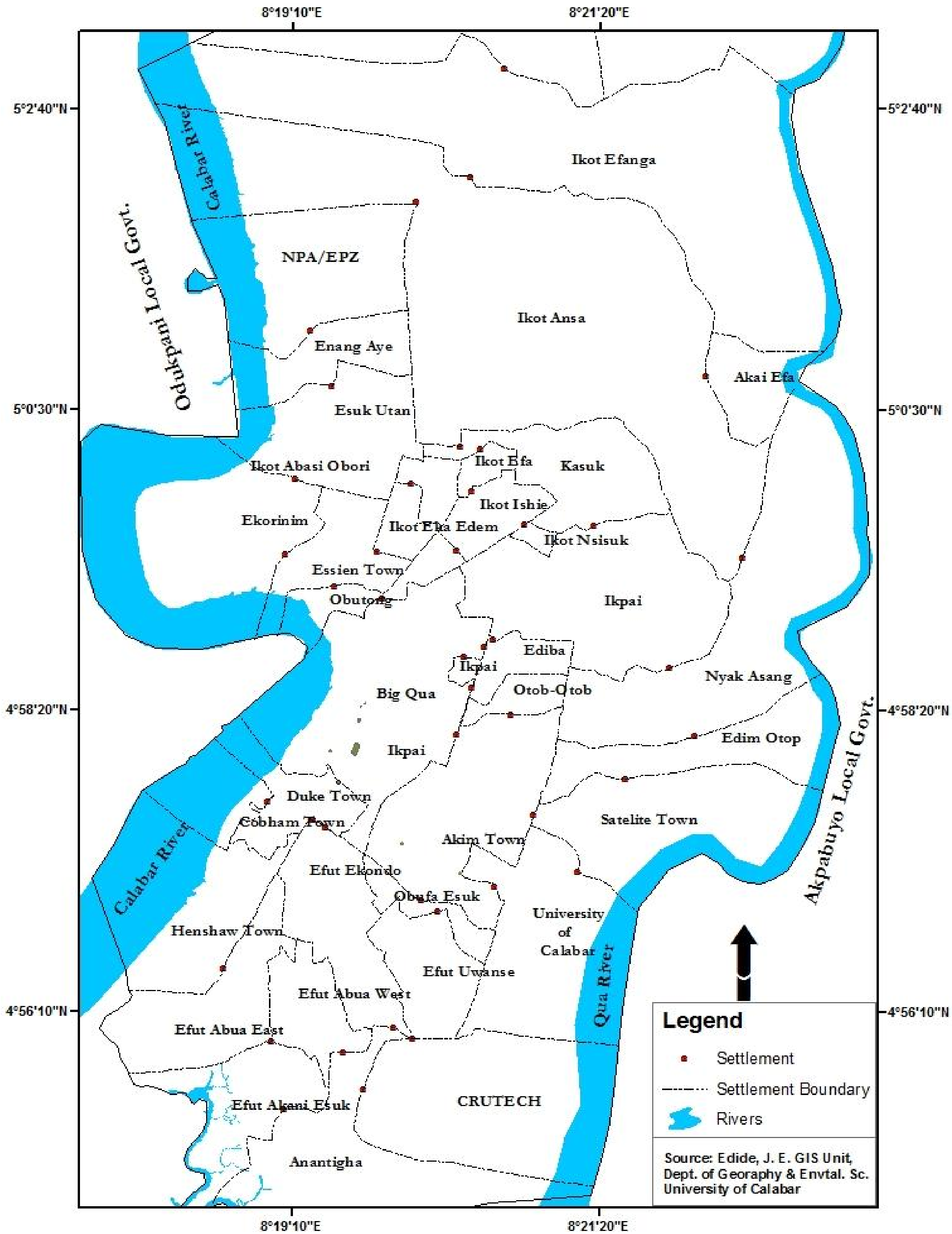


Fig. 1: Layout of Calabar Metropolis (Antigha, et al., 2014)

3.0: Materials and Methods

3.1: Infiltration Data

For this study, infiltration measurements were carried out using the cylinder infiltrometer. A metal tube was driven into the ground to a depth of 10cm with a hammer. Care was taken to prevent damage to soil structure in the process. A constant ponding level of 5cm was maintained in the metal tube (ring) throughout the experiment. With the aid of a stop watch, readings were taken at intervals. The readings continued until a steady state of equilibrium was reached.

3.2: Rainfall Data

For the rainfall data, the recording rain gauge installed at The Meteorological Centre of the Margaret Ekpo International Airport in Calabar was used. Results were read-off the screen recorded as depth, duration and intensity for different storm events.

3.3: Evapotranspiration Data

The evapotranspiration data were acquired with the use of a lysimeter instrument. A lysimeter is simply a tank filled with soil in which crops are grown, basically for experimental purposes. The combined presence of soil and plant in a lysimeter helped in the measurement of the combined process of evapotranspiration.

3.4: Temperature Data

For the temperature data, the installed mercury thermometer at The Meteorological Centre of the Margaret Ekpo International Airport in Calabar was used. Both minimum and maximum diurnal temperatures were recorded.

4.0: Results and Discussion

Evapotranspiration data were obtained from five sampling points (CRUTECH, Marina, Ekorinim, Akai Efa and Big Qua) within the area of study using the lysimeter instrument**.** The results obtained are as presented on tables 1 to 7 between January and July. Accordingly, the temperature and the rainfall for the corresponding months were also recorded at the Meteorological Centre of the Margaret Ekpo International Airport in Calabar to observe how the two parameters influence the evapotranspiration processes in the catchment. There was an observable positive correlation between rainfall, temperature and evapotranspiration with a stronger bond (0.41) existing between temperature and evapotranspiration, and a weaker bond (0.21) existing between evapotranspiration and rainfall. From the study, there was however an inverse proportionality between temperature and rainfall in the catchment.

The detrended p-p plots (fig. 2), showed higher values of deviation from the normal for the rainfall data while that for temperature gave a fairly even distribution. Generally, the horizontal line on a detrended plot represents what would be for that value if the data were normally distributed. Any value above or below depicts how much higher or lower the value is than would have been expected if the data were normally distributed. Figs 3a, b and c show the variability of the temperature, rainfall and the evapotranspiration processes in the catchment while figs. 4a, b, c and d show the various line plots for all variables studied.

The infiltration rate in the catchment ranged from as high as 0.66cm/s as recorded at Akai Efa to as low as 0.01cm/s as recorded at Ekorinim.

The lysimeter measurements yielded 1.1mm as the lowest and 14.0mm as the highest values of evapotranspiration from the catchment. The range between the minimum and maximum observable values for temperature, rainfall, infiltration and evapotranspiration was 12.1, 108.4, 0.69 and 14.0 with a standard deviation of 1.4, 26.46, 0.18 and 2.32 respectively. With an R^2 of 0.23, an adjusted R of 0.21, a multiple R of 0.48 and a standard error of 3.46 from 91 observations, 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. In all, the contributions of rainfall to the recharge of the catchment by the various approaches of direct precipitation, overland flow, interflow and base flow could be established.

Table 1: Calabar monthly record of meteorological observations (January,)

LATITUDE: 04°58'N
LONGITUDE: 08°2l'E
SITE LOCATED: 62.3m ABOVE M.S.L

	TEMPERATURE		RAINFALL	
DAY	**MAXIMUM**	**MINIMUM**		**ETP**
1	33.1	22.2	0.0	6.6
2	32.0	22.5	0.0	7.1
3	31.5	21.0	0.0	9.7
4	31.6	21.0	0.0	10.2
5	32.5	19.5	0.0	9.7
6	31.6	17.9	0.0	9.7
7	32.3	20.2	0.0	7.7
8	32.1	19.0	0.0	8.2
9	32.0	20.5	0.0	12.2
10	32.1	18.5	0.0	12.7
11	31.6	19.4	0.0	14.3
12	32.2	18.5	0.0	13.3
13	32.6	18.4	0.0	10.7
14	34.0	18.5	0.0	8.2
15	32.0	19.6	0.0	7.1
16	32.8	21.0	0.0	6.6
17	33.6	20.5	0.0	7.1
18	34.2	20.5	0.0	8.2
19	32.9	22.9	0.0	5.6
20	33.6	23.4	0.0	5.6
21	34.4	24.0	0.0	6.1
22	34.5	23.6	0.0	6.6
23	35.2	24.8	0.0	6.1
24	33.7	25.0	0.0	6.1
25	31.6	25.6	TR	5.6
26	33.9	23.5	0.0	5.6
27	33.4	22.5	0.0	6.1
28	33.6	25.3	0.0	6.6
29	34.5	22.4	0.0	7.1
30	34.9	23.5	0.0	7.1
31	34.7	24.0	0.0	7.7

SUM	**1025.7**	**669.2**	**TR**	**251.1**

Table 2: Calabar monthly record of Meteorological Observations (February)
LATITUDE: 04°58'N
LONGITUDE: 08°2l'E
SITE LOCATED : 62.3m ABOVE M.S.L

	TEMPERATURE		RAINFALL	
DAY	MAXIMUM	MINIMUM		ETP
1	34.4	24.0	0.0	6.6
2	35.2	25.1	0.0	7.1 -
3	34.2	25.0	4.8	6.8
4	35.0	24.4	0.0	7.1
5	35.4	25.0	0.0	7.7
6	35.4	23.5	0.0	8.2
7	34.5	23.5	0.0	7.7
8	32.6	25.2	0.0	6.1
9	34.3	23.0	1.6	8.2
10	34.6	23.0	0.0	8.2
11	34.0	25.5	0.0	7.7
12	34.6	24.5	0.0	9.2
13	32.6	23.6	0.0	7.1
14	34.0	26.0	0.0	7.1
15	33.6	23.6	0.0	6.6
16	33.6	24.0	0.0	7.1
17	32.2	24.0	10.6	5.5
18	31.0	21.5	2.4	3.9 .
19	33.0	21.0	0.0	7.1
20	34.5	23.2	26.5	8.6
21	33.0	22.0	0.0	7.7
22	31.7	24.5	44.6	4.6
23	33.0	21.0	1.3	5.1
24	31.5	24.2	0.0	4.6
25	33.5	24.5	2.0	5.1
26	29.7	23.0	2.8	4.8
27	30.2	23.8	0.0	4.5
28	31.9	21.8	0.0	3.6
SUM	**933.2**	**663.4**	**96.6**	**183.6**

Table 3: Calabar monthly record of Meteorological Observations (March)

LATITUDE: 04°58'N
LONGITUDE: 08°2l'E
SITE LOCATED: 62.3m ABOVE M.S.L

	TEMPERATURE		RAINFALL	
DAY	MAXIMUM	MINIMUM		ETP
1	33.5	23.5	0.0	7.7
2	34.5	24.0	0.0	7.7
3	33.2	23.6	0.0	6.6
4	33.0	23.7	0.0	7.1
5	34.0	23.6	0.0	7.7
6	34.2	24.7	0.0	7.1
7	32.7	24.8	0.0	7.7
8	32.5	24.5	0.0	6.6
9	31.5	23.0	0,0	3.6
10	32.0	23,3	2.7	5.7
11	33.5	23.5	25.2	5.3
12	33.8	20.0	0.0	6.6
13	33.2	22.1	0.0	6,1
14	33.5	22.5	0.0	7.7
15	34.0	25.2	0.0	8.2
16	33.0	24.3	0.0	7.1
17	27.0	23.6	15.2	2.5
18	33.5	22.5	0.0	7.7
19	33.0	24.5	0.0	7.1
20	32.5	24.1	0.0	5.6
21	27.0	24.9	41.8	2.0
22	30.5	23.0	0.0	3.1
23	34.0	23.7	0.0	7.1
24	27.8	25.3	1.8	3.1
25	29,2	22.0	20.2	1.8
26	32.8	22.3	6.6	4.6
27	26.6	23.3	1.6	0.6
28	31.9	22.5	0.0	5.6
29	30.8	24.0	0.0	3.1
30	30.5	22.2	0.0	3.6
31	31.7	22.3	0.0	6.1

SUM	990.9	726.4	143.1	172.1

Table 4: Calabar monthly record of Meteorological Observations (April)

LATITUDE: 04°58'N
LONGITUDE: 08°2l'e
SITE LOCATED : 62.3m ABOVE M.S.L

	TEMPERATURE		RAINFALL	
DAY	MAXIMUM	MINIMUM		ETP
1	32.2	24.3	0.0	5.1
2	33.4	23.0	0.0	6.6
3	33.0	24.0	0.0	6.1
4	32.0	23.4	35.2	5.2
5	28.5	21.5	0.0	3.1
6	32.6	22.6	9.6	5.5
7	30.0	24.0	1.2	3.7
8	32.7	23.4	0.0	7.1
9	31.7	24.1	3.4	4.4
10	32.6	23.5	1.6	5.2
11	29.5	22.5	0.6	3.1
12	31.8	23.2	12.3	4.3
l3	32.5	23.3	0.0	6.6
14	33.8	24.0	0.0	7.1
15	34.4	24.3	0.0	8.2
(16	34.0	23.8	0.0	8.2
17	33.0	23.5	0.0	7.1
18	34.4	24.4	0.0	7.7
19	33.0	25.0	0.0	7.7
20	32.7	24.3	0.0	7.7
21	33.6	25.5	0.0	8.2
22	33.5	25.0	6.2	4.2
23	31.0	23.0	0.0	5.1
1 24	32.6	22.0	2.5	8.1
25	32.5	25,0	TR	7.1
26	31.4	22.5	0.0	7.7
27	34.0	22.8	TR	7.7
28	33.0	21.5	0.4	7.0

29	33.0	32.8	0.0	6.6
30	33.0	23.0	27.2	7.1
SUM	**975.7**	**715.2**	**100.2**	**188.5**

Table 5: Calabar monthly record of Meteorological Observations (May)

LATITUDE: 04°58'N

LONGITUDE: 08°2l'e

SITE LOCATED: 62.3m ABOVE M.S.L

	TEMPERATURE		**RAINFALL**	
DAY	**MAXIMUM**	**MINIMUM**		**ETP**
1	31.5	21.9	0.0	6.1.
2	32.2	23.0	TR	6.6
3	33.0	24.5	0.0	7.1
4	34.2	24.3	0.0	8.2
5	27.4	24.2	28.4	1.9
6	34.0	20.8	0.0	7.1
7	32.5	24.0	31.2	4.7
8	32.5	21.0	0.0	6.6
9	33.0	24.2	0.6	7.1
10	32.0	24.0	0.0	6.6
11	33.2	23.2	3.2	7.3
12	32.5	23.1	26.0	4.1
13	33.1	22.0	0.0	7.1
14	29.0	24.4	2.2	3.6
15	33.7	23.0	0.0	6.1
16	30.6	23.6	0.0	5.6
17	32.0	25.5	16.5	4.8
18	28.4	21.3	2.5	5.0
19	33.2	23.0	48.3	5.0
20	31.2	22.0	0.0	5.6
21	29.7	24.5	TR	5.1
22	32.6	24.0	0.0	6.6
23	30.5	24.4	30.7	4.2
24	33.2	21.2	0.0	6.1
25	33.6	24.0	10.5	5.5
26	31.5	23.4	0.0	6.1
27	31.8	24.6	56.0	14
28	30.2	22.5	32.1	5.1
29	30.2	22.5	28.4	3.4
30	30.8	24.3	76.7	14

31	30.0	22.6	8.7	3.6
SUM	**985.1**	**721**	**401.0**	**161.9**

Table 6: Calabar monthly record of Meteorological Observations (June)

LATITUDE: 04°58'N

LONGITUDE: 08°2l'E

SITE LOCATED : 62.3m ABOVE M.S.L

	TEMPERATURE		**RAINFALL**	
DAY	**MAXIMUM**	**MINIMUM**		**ETP**
1	31.0	23.7	61.5	14
2	31.2	20.9	14.3	3.8
3	30.0	20.7	12.4	4.0
4	31.5	22.4	50.7	14
5	29.0	22.4	2.4	3.0
6	30.4	23.4	19.6	3.8
7	30.9	23.9	2.4	3.7
8	30.3	23.7	2.9	4.0
9	30.9	22.2	62.7	14
10	31.6	22.9	7.8	3.2
11	30.4	23.1	2.2	3.3
12	37.6	21.3	5.3	5.8
13	30.9	22.5	1.0	3.8
14	30.4	23.6	31.5	2.4
15	29.6	23.6	16.9	2.6
16	29.4	23.7	1.2	4.0
17	29.3	24.3	1.0	4.0
18	32.5	23.9	0.5	5.2
19	29.7	24.3	108.4	14
20	30.0	23.8	67.3	14
21	29.4	23.2	2.1	3.6
22	30.1	23.7	0.3	2.9
23	31.3	24.2	0.0	4.2
24	31.4	24.5	16.2	3.2
25	28.2	23.8	37.4	2.7
26	30.4	23.4	3.1	3.1
27	29.2	23.6	26.8	2.8
28	30.9	23.7	41.4	2.6
29	28.2	24.2	53.8	14

30	29.2	23.8	25.8	1.9
SUM	904.9	698.4	678.7	65.2

Table 7: Calabar monthly record of Meteorological Observations (July)

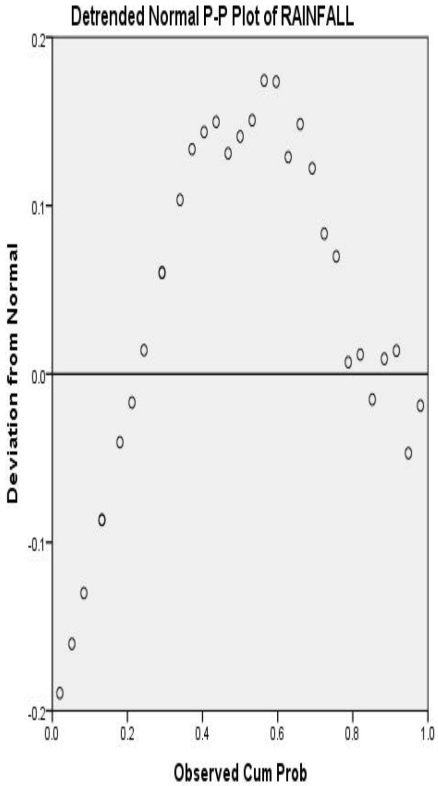
LATITUDE: 04°58'N

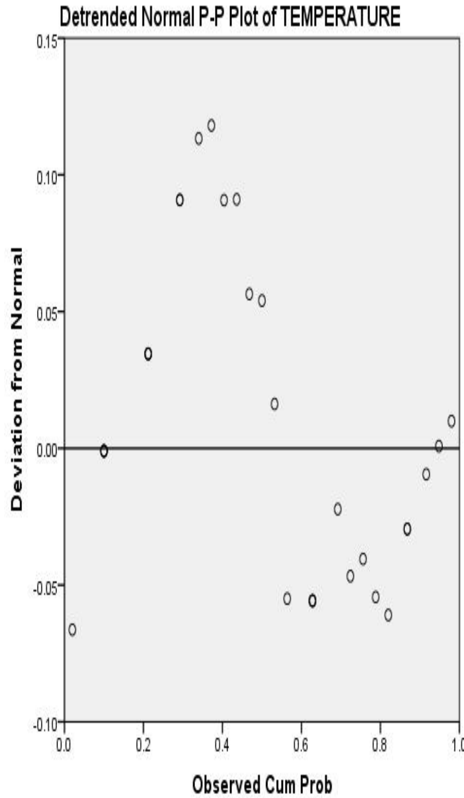
LONGITUDE: 08°2l'E

SITE LOCATED: 62.3m ABOVE M.S.L

	TEMPERATURE		**RAINFALL**	
DAY	**MAXIMUM**	**MINIMUM**		**ETP**
1	28.5	22.5	8.0	2.1
2	26.0	22.5	27.4	1.1
3	26.0	22.5	2.0	1.3
4	27.9	23.0	6.7	2.0
5	30.2	22.6	0.0	3.2
6	31.0	24.0	TR	4.0
7	30.5	23.6	0.0	3.8
8	31.5	24.3	1.6	4.0
9	31.5	24.2	0.0	4.2
10	28.5	24.6	13.1	2.4
11	30.5	22.0	20.1	3.2
12	30.7	21.2	6.3	3.8
13	27.0	23.0	38.6	1.3
14	28.9	23.5	18.0	2.1
15	26.0	22.5	49.4	14
16	29.0	22.5	0.8	3.4
17	29.6	23.1	0.3	2.9
18	25.6	23.8	14.9	1.9
19	25.5	22.9	14.4	1.5
20	27.1	22.4	11.6	2.1
21	27.6	22.1	TR	3.0
22	30.0	23.0	0.6	2.6
23	24.5	23.0	42.1	1.1
24	27.0	22.0	10.2	1.8
25	27.7	22.5	2.6	2.2
26	26.4	22.6	38.9	1.8
27	25.6	21.8	57.6	14
28	27.5	21.6	0.7	3.4
29	28.0	21.5	TR	2.8

30	28.0	23.1	0.7	2.7
31	29.5	23.0	0.0	2.8
SUM	**873.3**	**706.9**	**386.6**	**74.5**





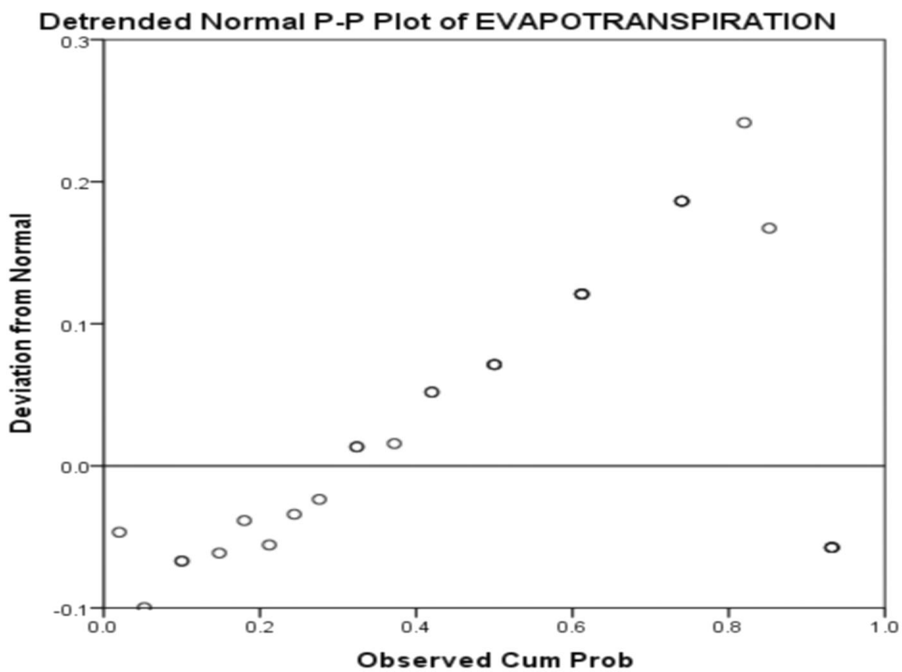


Fig 2: Detrended normal plots of rainfall, temperature and evapotranspiration

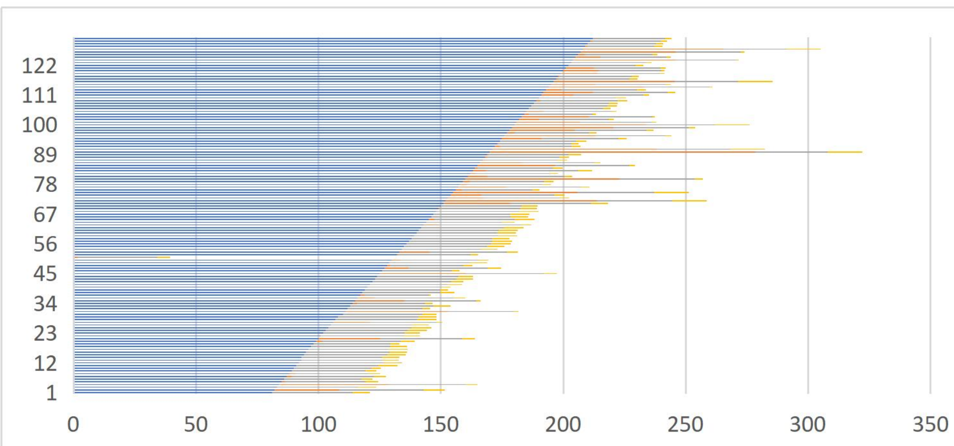


Fig 3a: Variability in evapotranspiration processes within the catchment

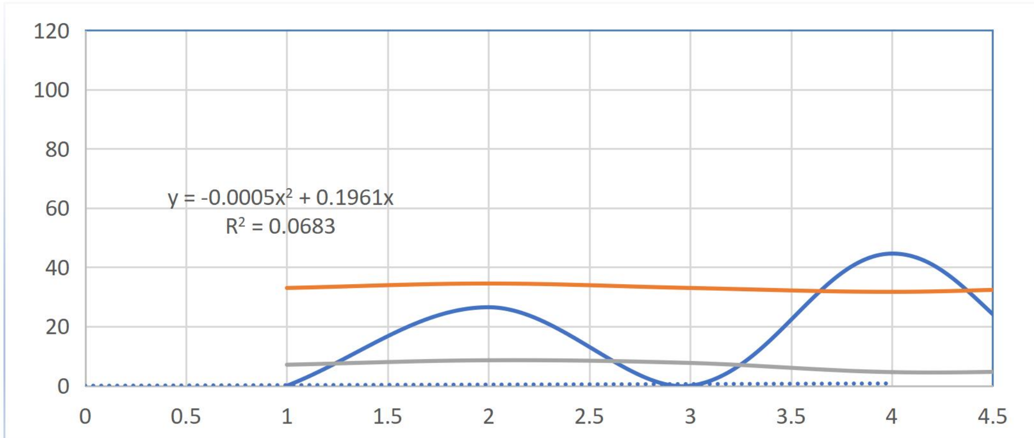


Fig 3b: Variability in temperature processes within the catchment

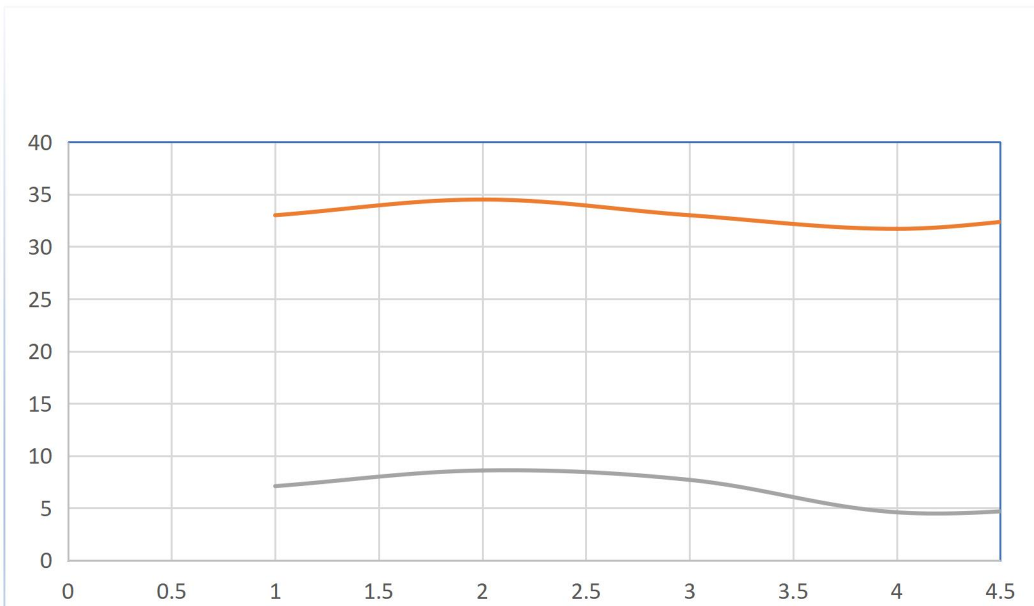


Fig 3c: Variability in rainfall processes within the catchment

Table 8: Infiltration rate (Hydraulic Head/Time)

	CRUTECH	MARINA	EKORINIM	AKAI EFA	BIG QUA
1	0.18	0.18	0.266	0.66	0.44
2	0.08	0.15	0.14	0.57	0.17
3	0.06	0.13	0.07	0.57	0.11
4	0.05	0.125	0.05	0.57	0.08
5	0.048	0.125	0.038	0.5	0.07
6	0.047	0.126	0.033	0.46	0.066
7	0.045	0.116	0.027	0.51	0.056

8	0.041	0.116	0.023	0.44	0.052
9	0.038	0.113	0.02	0.41	0.047
10	0.037	0.108	0.019	0.38	0.043

Table 9: Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
TEMP	91	12.10	20.70	32.80	23.3022	1.40246	1.967	22.628	.500
RAINFALL	91	108.40	.00	108.40	22.6388	26.46119	700.194	1.782	.500
INFILTRATION	91	.69	.11	.80	.4198	.18381	.034	-.804	.500
EVAPOTRANSPIRATION	91	14.00	.00	14.00	6.1385	2.31942	5.380	4.311	.500
Valid N (listwise)	91								

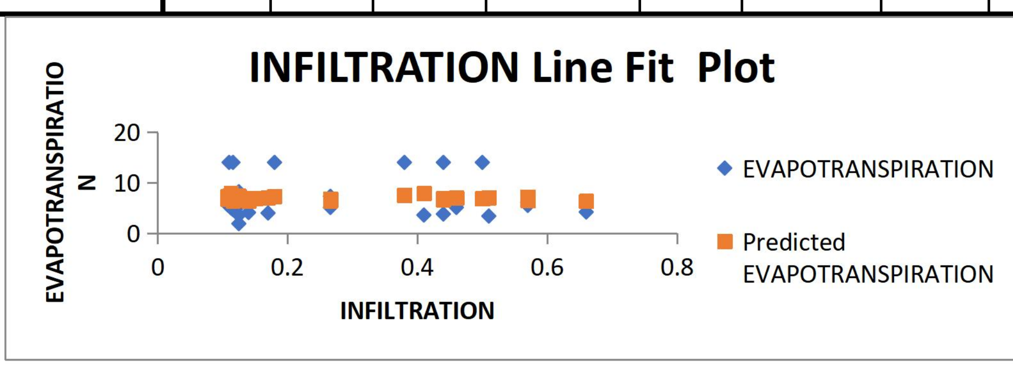


Fig.4a: Line Fit Plots of Infiltration

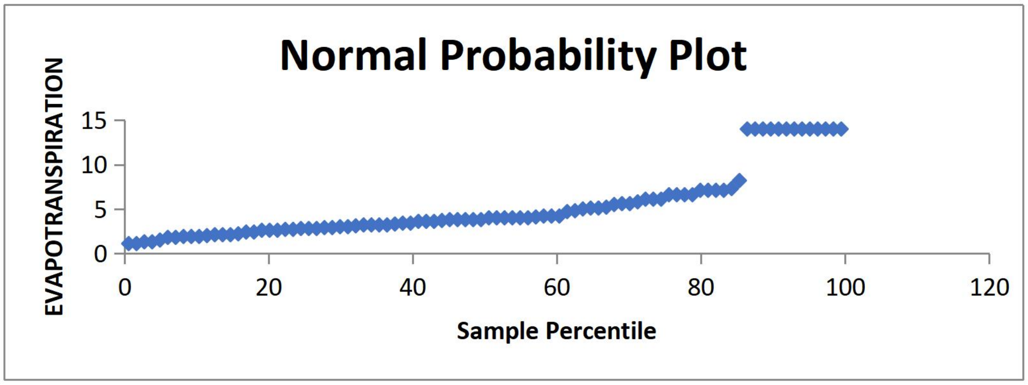


Fig.4b: Line Fit Plots of Evapotranspiration

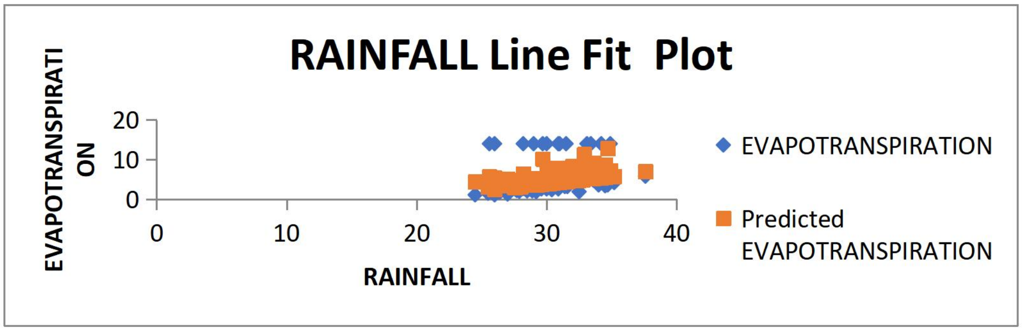


Fig.4c: Line Fit Plots of Rainfall

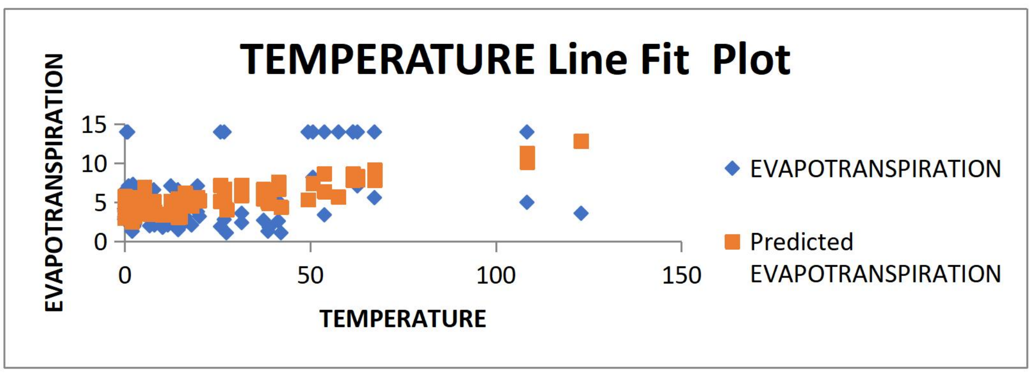


Fig.4d: Line Fit Plots of Temperature

5.0: Conclusion and recommendations

This study has confirmed that reservoirs are recharged mainly through rainfall after storm events with noticeable intensity, and this is largely aided by deep percolation of the water molecules. This is sufficiently affected by surface runoff, vegetation, temperature and evapotranspiration. All the processes mentioned above play pivotal roles in this regard. Temperature was observed to be directly proportional to Evapotranspiration and inversely proportional to Rainfall. The amount of water that falls as rain and recharges the basin is equal to the amount that leaves it through evapotranspiration, runoff and infiltration. This is the strength and principle of the simple water balance model, and it is recommended that the concept should be incorporated in any design which targets to investigate the rainfall- runoff processes, adequacy and application within Calabar catchment.

References

Adindu Ruth Uloma, Akoma Chigozie Samuel, Igbokwe Kelechi Kingsley (2014) *"Estimation of Kostiakov's Infiltration Model Parameters of Some Sandy Loam Soils'*

Antigha, R.E.E (2021). Regional Approach to the Modification of the Kostiakov Infiltration Constants for Irrigation Purposes for Calabar Metropolis, South-South, Nigeria. World Journal of Engineering Research and Technology, 7(6), 308-326

Antigha, R.E.E. (2019). Experimental Evaluation of the Permeability Coefficient of Soils around the Premises of the Federal Polytechnic, Bauchi, North-Eastern Nigeria. *IOSR Journal of Environmental Science, Toxicology & Food Technology 13*(6), 36- 47.

Antigha, R.E.E & Ogarekpe, N.M. (2013). Development of Intensity Duration Frequency Curves for Calabar Metropolis, South- South, Nigeria. *The International Journal of Engineering and Science 2*(3), 39 - 42.

Antigha, Richard E.E, Ayotamuno, M.J., Akor, A.J., Fubara-Manuel, I **&** Ogarekpe, N.M. (2014). Rainfall-Runoff Model for Calabar Metropolis using Multiple Regression: *Nigerian Journal of Technology,33*(4), 14-21

Horton, Robert E. (1933). "The role of infiltration in the hydrologic cycle".

Heber Green & Ampt, G. A. (2009). "Studies on Soil Physics". The journal of Agricultural Science.

Parlange, J. Y.; Lisle, I.; Braddock, R. D. & Smith, R. E. (1982). "*The Three Parameters of Infiltration Equation"*. Soil science 133 (6): 337

Ogarekpe, N.M; Nnaji, C.C & Antigha, R.E.(2022): *A Preliminary Case for Modification of the SCS-CN Hydrologic Model for Runoff Prediction in Imo River Sub-basin.* Arabian Journal of Geosciences (2022) 15: 786 https://doi.org/10.1007/s12517-022-09995-3

John Wiley and sons "water Resources Engineering", 2005 Edition.

Kostiakov, A. N.(1938) "*On the Dynamics of the coefficient of water-percolation in soils and on the necessity of studying it from a dynamic point of view for purposes of amelioration".* Transaction of 6th congress of International Soil Science Society. Moscow. Pp 17-21.

Hendriks, Martin R. (2010) "*Introduction to physical Hydrology*. Oxford University Press"

Bowen, Gabriel (2015). *"Hydrology: The Diversified Economics of Soil Water".* Nature *525(7567): 43-44*

Tamer A. AI-Assa'd & Fayez Ahmad Abdulla (2010) *"Artificial Groundwater Recharge to a Semi-Arid Basin: Case Study of Mujib Aquifer, Jordan"*

Giuseppe Ross, Enrica Caporali Luis Garrote (2012) *"Definition of Risk*

Indicators for Reservoirs Management Optimization " http://www.fao.org/docrep/x5560e/x5560e02.htm

Wurbs and James, 2002; Bedient et al., 2008 "Managing *Climate Risk in Water Supply Systems"*

https://www.google.com/search?q=class+a+pan&source=lnms&tbm=isch&sa=

X&ved=OahUKEwiUzNzNxbDLAhWGvRoKHTOpDAUQ_AUlBygB&biw=1366&bi h

Green and Ampt (1911) "Mathematical Models of Small Watershed Hydrology and Applications"