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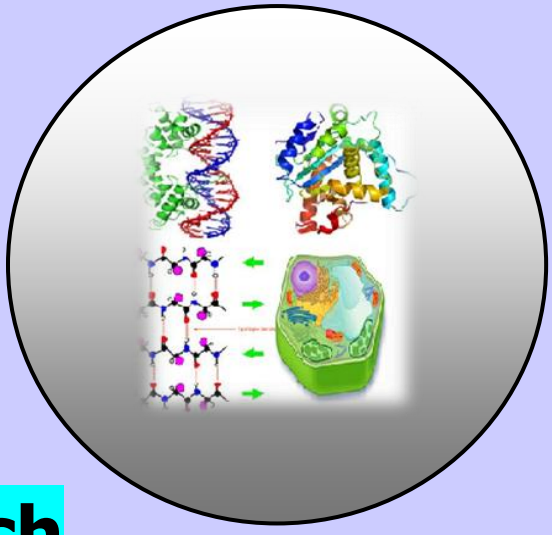

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Assessment of the Need and Water Potentials for Supplementary Irrigation in the Southern Guinea Savanna Zone of Nigeria

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ABSTRACT

Assessment of the need and water potentials for supplemental irrigation, quality of surface and sub surface water for irrigation in Makurdi and Lafia areas in the southern Guinea Savannah Zone of Nigeria was carried out. Climatic data on rainfall, daily temperature, and solar radiation were collected from Methorological station for the period of 33 years and was processed into their monthly mean values and the relevant portions were used to compute the monthly potential evapotranspiratiopn for the locations using the Hargreave's equation. Surface and sub-surface water, hand dug well/borehole water and rainfall water samples were collected from the study areas namely River Akei, Asu and Kpege, river keeleke, Bbaa-keeleke and Anwanger, river Fete, Orngu and Kpelajen in Makurid. River Bukansidi, Sabon Sidi and Kurkyo, river Shabu, Sabon Pegi and Baki Shabu, river Amba, Wajenlele and Korfankura, Boreholes and rainfall water in Lafia. Results of the study showed that there is need for supplemental irrigation and full irrigation. The water qualities in the study areas were found to be suitable for irrigation as the values of the parameters related to the general irrigation problems of salinity, permeability, toxicity and miscelanous fall within the tolerable limits. The SAR values of the study areas also fall within the acceptable limit.
Key Words: Irrigation, Supplementary, Assessment, Makurdi and Lafia.

INTRODUCTION

Most of the food in the world is produced under rain-fed agriculture, which plays a key role in poverty reduction. Majority of poor people in the world are dependent on rain-fed agriculture for food and income. In rain-fed agriculture, water is the key constraint for improving agriculture. Investments in rain-fed agriculture have shown large pay-offs in yield

improvements and poverty alleviation through income generation and environmental sustainability (FAO, 1994). Makurdi and lafia areas are bounded by longitude 08º31` 45”E and latitudes 07º44`25”N, 97m above sea level and longitude 08º31` 00”E and latitudes 08º29` 30”N and 175m above sea level respectively. They constitute major crop producing areas within the Southern Guinea savanna zone of Nigeria. The climate of the areas is that of a tropical sub-humid with distinct dry and rainy seasons. The annual rainfall is 1200m/annum and occurs from April to October with peaks in July – August while there is little or no rainfall during the dry season around November to March. Farmers in Makurdi and Lafia areas practice subsistence agriculture majorly because they depend on rainfall for their farming activities. Crops grown include cassava, maize, millet, sesame, yam, rice, melon, sorghum, groundnut, Sesame, vegetables and sugarcane. These are either grown sole or intercropped. Farming in these areas is mostly carried out during the raining season and so is done once a year, whereas some crops could be cultivated two to three times a year under irrigation. It is also likely that rainfall alone may not supply the needed water during the raining season required by some crops. It is therefore intended to assess whether rainfall alone could satisfies crop water need in these agroecological zone both during the dry and raining seasons and so discover the need or otherwise of supplementary or full irrigation. This study is therefore design to:

1. Assess the need for supplementary or full irrigation in Makurdi and Lafia.

2. Assess the quality of surface and sub surface water in the study areas for irrigation.

MATERIAL AND METHODS

Study Areas

The Research was carried out in three locations each in Makurdi and Lafia areas of Benue, and Nasarawa States in Makurdi, the study was carried out in three locations, these are: River Akpei along University of Agriculture Makurdi, Gbajimba road, River Keeleke, Yogbo Road after NASME and River Fete at Adaka. Makurdi is bounded by longitude 08º31` 45”E and latitudes 07º44`25”N. Height above sea level is 97m. **:** In Lafia, the study was carried at River Bukansidi, Jos Road, Lafia South, River Amba, Doma Road and River Sabon Pegi along Jos Road. Lafia is bounded by longitude 08º31` 00”E and latitudes 08º29` 30”N. Height above sea level is 175m. The climate of the study areas is that of a tropical sub-humid with distinct dry and rainy seasons. The annual rainfall is 1200m/annum and occurs from April to October with peaks in July – August while there is little or no rainfall during the dry season around November to March. The vegetation is guinea savannah and is wood and grass land which has given way to bush burning and farming activities given arise to open grass land in some places. The land is used majority for farming activities, pottery making and brick making (burnt brick), crops grown include cassava, maize, millet, sesame, yam, rice, melon, sorghum, groundnut, cassava, sesame, vegetables and sugar cane (Idoga and Ogbu, 2012).

Assessment of the Need for Supplementary Irrigation

Climatic data on rainfall, temperature and relative humidity were collected from the meteorological station of the Air force Base Makurdi for a period of thirty (33) years. The data collected were processed into their monthly mean values and the relevant portions used to compute the monthly potentials evapotranspiration values for the locations using the Hargreaves equation. This equation incorporates both temperature and solar radiation as given by (Hansen et al 1979).

The mean monthly differences between rainfall and potential evapotranspiration were then computed to check when there were deficiencies in the amount of water supplied by rainfall as compared to that required for evapotranspiration. This was then used as an indication as to when, and to what extent, if any, more water that was needed to supplement that supplied by rainfall to meet the evapotranspiration needs of the crops.

Assessment of Water Potentials for Irrigation

Surface water from streams/rivers and sub-surface water from hand dug wells/boreholes as well as rain water were collected in each of the three locations within Makurdi and Lafia.

In Makurdi study area, River Akpei, Keeleke and Fete were the main Rivers while, River Asu and River Kpege, River Gbaa-Keeleke and Angwanger as were as River Orngu and Kpelajen were the tributaries respectively. Well Water samples at Kpelajen and Rain Water samples in Makurdi were also collected.

In Lafia study area, River Bukansidi is the major river; River Sabon-Sidi and River Kurkyo are the tributaries. River Shabu is the major river while River Sabon Pegi and River Baki Shabu are the tributaries. River Amba is the major river while River Wajenelele and River Kofan Kura are the tributaries. Borehole water at Kurkyo and rain water in Lafia were also collected. All together, three water samples from three major rivers, six water samples from six tributaries, one rain water sample and one borehole water sample were collected given a total of 11 samples. The water samples collected were analyzed for their quality status in determining the suitability of the water for irrigation.

The pH of the water was determined using pH meter (Mclean, 1965). Mg^{2+}, Fe^{2-}, Ca^{2+} and Mn^{2-} were measured using Atomic Absorption Spectrometer. The concentration of Na^{+} and K^{+} were determined using flame photometer (IITA, 1979)). Concentration of Anions $Co_2^{2-}\ Wo_3^{-}\ So_4^{2-}\ and\ Cl^{-}$**:** were determined by the titremetric method (Landon 1971).Boron was determined by photometer. Electrical conductivity meter was used directly to determine the water electrical conductivity. The evaporation-drying method was used to determine total dissolved solids (IITA, 1979).Sodium Adsorption Ratio was determined according to Brady (1999**).** Bicarbonate was determined by the titrimetric method (Landon, 1971). The turbidity of the water was determined using Hach spectrophotometer BR/2000 model. Biological Oxygen Demand (BOD) was determined using Hach BOD meter. Tables 1 and 2 are standards for irrigation water suitability

Table 1. Water quality criteria for irrigation.

Parameter	Good	Poor (ppm)
Bicarbonate	200	800
Chloride	100	300
Nitrate	300	500
Sulphate	200	500
TDS	500	3000
Boron	0.3	0.5

Source: FAO (1994)

Table 2. Recommended Water for irrigation classification based on SAR.

SAR	Water Class
<10	Excellent
10 – 18	Good
18 – 26	Fair
>26	Poor

Source: FAO (1994).

RESULTS AND DISCUSSION

Assessment of the Need for Supplementary Irrigation

Results of average monthly rainfall, potential evapotranspiration and the differences in rainfall and potential evapotranspiration for Makurdi and Lafia are presented in Tables 3a – 3f. Results of the study show that the months of January, February, March, November and December, (Five months) rainfall does not meet evapotranspiration need out of the twelve months. Zero in-soil reserve was observed in April 1983 and 1987 and October 1983. The negative values indicate need for supplemental irrigation. From the results, it can be inferred that planting can commence effectively as from April under a complete rain-fed agriculture. Rainfall is usually at its peak between June and September. But from November to March every year, evapotranspiration rate is usually high; rainfall agriculture should therefore be augmented with irrigation between November and May because agricultural drought occurs within this period. The year 1983 had the highest drought periods of 7 months while 1987, 1988 and 1989 had 5 months, showing that rainwater alone cannot be relied upon for cropping during these month and so full and supplementary irrigation services are needed.

Assessment of Water Potentials for Irrigation

Results on quality status of surface and ground water sources are presented in Tables 4 and 5. The pH ranges from 6.5 – 7.5. The pH of the water samples in the study areas fall within the acceptable limits. Both pH values are good for irrigation. The electrical conductivity values in Makurdi ranged from 13.91 to 57.50%. The value, 57.50% was obtained from hand dug well water, indicating high EC value. This high EC value could be as a result of the concentration of total soluble salt content in the water (FAO 1994). The EC values of the water sample in the Lafia study areas ranged from 11.55 – 80.90% which is also high based on the FAO (1994) EC standard for irrigation water. This could also be as a result of the concentration of the total soluble salt content in the water (Bauda et al 2011). High turbidity values were also reported in river Wajenlele and river Kofankura. This high turbidity indicates pollutant from soil particles and other organic materials that may have found their way into the river thereby increasing the turbidity of the water (FAO, 1994).

The TDS of the water sample in both Makurdi and Lafia study areas could be classified as “fresh and good” for irrigation purposes with no permeability problems and clogging effects.

The DO values of Makurdi ranged from 6.80 to 7.80mg/l while that of Lafia ranged from 6.60 to 7.30mg/l and all fall within the tolerable limits though with an indication of presence of pollutants in appreciable quantities. BOD value in the two study areas shows that the Biological contaminant in the water samples is very high. This could be also as a result of surface contaminant and parent material

Table 3 a. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

Month/Variables			1980	1981	1982	1983	1984	1985
	-	MAR	0.00	0.57	0.00	0.00	0.00	0.60
JAN	-	PET	0.49	0.47	0.37	0.33	0.40	0.38
	-	DIFF	-0.49	0.10	-0.37	-0.33	-0.40	0.22
	-	MAR	0.00	0.00	0.00	0.00	0.00	0.00
FEB	-	PET	0.54	0.56	0.42	0.50	0.47	0.46
	-	DIFF	-0.54	-0.56	-0.42	-0.50	-0.47	-0.46
	-	MAR	1.93	0.00	0.60	0.04	1.67	1.95
MARCH	-	PET	0.53	0.51	0.47	0.52	0.46	0.39
	-	DIFF	1.40	-0.51	0.13	-0.52	1.21	1.56
	-	MAR	5.20	2.67	1.05	0.09	3.88	0.47
APRIL	-	PET	0.50	0.46	0.41	0.52	0.43	0.41
	-	DIFF	4.70	2.21	0.64	-0.43	3.45	0.06
	-	MAR	6.11	5.21	1.86	6.23	7.17	3.85
MAY	-	PET	0.44	0.39	0.33	0.41	0.39	0.38
	-	DIFF	5.67	4.82	1.53	5.82	6.78	3.47
	-	MAR	5.42	3.98	3.56	77.12	4.20	4.94
JUNE	-	PET	0.40	0.37	0.33	0.29	0.38	0.31
	-	DIFF	5.02	3.61	3.23	6.83	3.82	4.63
	-	MAR	7.33	10.20	10.10	7.50	10.14	9.34
JULY	-	PET	0.33	0.32	0.28	0.28	0.34	0.30
	-	DIFF	7.00	9.88	9.82	7.22	9.80	9.04
	-	MAR	11.35	9.28	2.77	5.10	14.62	4.35
AUGUST	-	PET	0.33	0.31	0.26	0.26	0.35	0.32
	-	DIFF	11.02	8.97	2.51	4.84	14.27	4.03
	-	MAR	7.42	6.52	5.46	4.27	5.84	6.18
SEPT	-	PET	0.36	0.31	0.28	0.33	0.33	0.33
	-	DIFF	7.06	6.21	5.18	3.94	5.51	5.85
	-	MAR	2.04	1.48	2.72	0.03	3.59	1.12
OCT	-	PET	0.37	0.39	0.34	0.37	0.36	0.39
	-	DIFF	1.67	1.09	2.38	-0.34	3.23	0.73
	-	MAR	0.00	0.11	0.00	0.00	0.00	0.00
NOV	-	PET	0.44	0.43	0.39	0.41	0.37	0.42
	-	DIFF	-0.44	-0.32	-0.39	-0.41	-0.37	-0.42
	-	MAR	0.00	0.00	0.00	0.00	0.04	0.00
DEC	-	PET	0.43	0.42	0.40	0.38	0.36	0.35
	-	DIFF	-0.43	-0.42	-0.40	-0.38	-0.32	-0.35

Table 3 b. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

Month/Variables			1986	1987	1988	1989	1991	1985
	-	MAR	0.00	0.00	0.30	0.00	0.00	0.00
JAN	-	PET	0.44	0.41	0.44	0.39	0.43	0.39
	-	DIFF	-0.44	-0.41	-0.14	-0.39	-0.43	-0.39
	-	MAR	0.13	0.11	0.00	0.00	0.00	0.00
FEB	-	PET	0.43	0.43	0.45	0.43	0.48	0.47
	-	DIFF	-0.3	-0.32	-0.45	-0.43	-0.48	-0.47
	-	MAR	1.04	0.77	0.03	0.05	0.00	1.48
MARCH	-	PET	0.44	0.41	0.38	0.47	0.47	0.47
	-	DIFF	0.60	0.36	-0.35	-0.42	-0.47	1.01
	-	MAR	2.02	0.41	2.003	1.96	3.66	3.46
APRIL	-	PET	0.40	0.46	0.40	0.43	0.41	0.40
	-	DIFF	1.62	-0.05	1.63	1.53	3.25	3.06
	-	MAR	5.47	5.22	3.28	6.19	2.57	5.91
MAY	-	PET	0.37	0.41	0.35	0.35	0.34	0.36
	-	DIFF	5.13	4.81	2.93	5.84	2.23	5.55
	-	MAR	5.76	2.70	2.29	6.77	4.74	2.76
JUNE	-	PET	0.28	0.33	0.33	0.29	0.27	0.35
	-	DIFF	5.48	2.37	1.96	6.48	4.47	2.41
	-	MAR	5.93	6.39	5.10	7.65	5.11	3.11
JULY	-	PET	0.30	0.33	0.24	0.29	0.26	0.31
	-	DIFF	5.62	6.06	4.86	7.36	4.85	2.80
	-	MAR	5.64	14.51	6.37	5.50	7.08	8.53
AUGUST	-	PET	0.33	0.30	0.30	0.27	0.32	0.29
	-	DIFF	5.31	14.21	6.07	5.23	6.76	8.24
	-	MAR	8.88	5.97	4.83	8.30	10.36	6.17
SEPT	-	PET	0.33	0.34	0.36	0.30	0.36	0.31
	-	DIFF	8.55	5.63	4.47	8.00	10.00	5.86
	-	MAR	3.65	3.17	2.95	4.25	2.62	5.20
OCT	-	PET	0.38	0.37	0.42	0.37	0.36	0.33
	-	DIFF	3.27	2.80	2.53	3.88	2.26	4.87
	-	MAR	1.05	0.00	0.00	0.00	0.05	0.00
NOV	-	PET	0.36	0.42	0.34	0.42	0.33	0.41
	-	DIFF	0.69	-0.42	-0.34	-0.42	-0.28	-0.41
	-	MAR	0.00	0.00	0.23	0.00	0.56	0.00
DEC	-	PET	0.35	0.39	0.35	0.38	0.40	0.37
	-	DIFF	-0.35	-0.39	-0.12	-0.38	0.16	-0.37

The Bio carbonate concentration in Makurdi study area ranged from 1.00 to 2.60 while that of Lafia ranged from 1.06 to 2.20mg/l. A permeability problem will not occur because the concentration of HCO_3 fall within the acceptable limit (<10mg/l) and is highly suitable for irrigation water.

The concentration of HCO_3 in the Lafia water samples also fall within the acceptable limit and showed no degree of restriction, high Biocarbonate values causes low infiltration rate and excessive white scale formation on leaves and fruits (Michael, 1985).

Table 3c. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

MONTH / VARIABLES			1992	1993	1994	1995	1996	1997
	-	MAR	0.14	0.00	0.87	0.00	0.00	0.00
JAN	-	PET	0.30	0.38	0.36	0.37	0.48	0.42
	-	DIFF	-0.24	-0.38	0.51	-0.37	-0.48	-0.42
	-	MAR	0.11	0.00	0.00	0.15	0.00	0.00
FEB	-	PET	0.49	0.49	0.43	0.49	0.48	0.48
	-	DIFF	-0.38	-0.49	-0.43	-0.34	-0.48	-0.48
	-	MAR	0.17	0.30	0.00	0.50	0.00	0.05
MARCH	-	PET	0.40	0.45	0.48	0.45	0.49	0.46
	-	DIFF	-0.23	-0.15	-0.48	0.05	-0.49	-0.41
	-	MAR	2.18	1.56	1.96	1.17	3.64	7.08
APRIL	-	PET	0.41	0.42	0.40	0.40	0.43	0.39
	-	DIFF	1.77	1.14	1.56	0.77	3.21	6.69
	-	MAR	2.42	1.71	4.85	2.74	4,37	3.20
MAY	-	PET	0.37	0.38	0.38	0.41	0.36	0.39
	-	DIFF	2.05	1.33	4.47	2.33	4.01	2.81
	-	MAR	2.81	8.94	3.61	11.80	8.03	5.38
JUNE	-	PET	0.30	0.32	0.34	0.30	0.35	0.34
	-	DIFF	2.51	8.62	3.27	11.50	7.68	5.04
	-	MAR	4.99	11.01	2.66	3.50	6.61	2.82
JULY	-	PET	0.28	0.30	0.29	0.27	0.29	0.28
	-	DIFF	4.71	10.71	2.37	3.23	6.32	2.65
	-	MAR	4.98	5.63	6.88	9.17	9.28	0.26
AUGUS	-	PET	0.27	0.29	0.26	0.31	0.31	4.78
T	-	DIFF	4.71	5.34	0.62	8.86	8.97	
	-	MAR	10.42	4.57	6.14	3.98	8.23	12.57
SEPT	-	PET	0.32	0.36	0.31	0.34	0.39	0.33
	-	DIFF	10.10	4.21	5.83	3.64	7.84	12.24
	-	MAR	2.61	6.03	4.81	4.97	3.18	6.88
OCT	-	PET	0.34	0.36	0.35	0.40	0.38	0.35
	-	DIFF	2.27	-0.36	4.46	4.57	2.80	6.50
	-	MAR	1.09	0.00	0.00	0.40	0.00	0.91
NOV	-	PET	0.41	0.36	0.43	0.39	0.43	0.45
	-	DIFF	0.68	-0.36	-0.43	0.01	-0.43	0.46
	-	MAR	0.00	0.00	0.00	0.00	0.00	0.00
DEC	-	PET	0.44	0.38	0.39	0.42	0.47	0.43
	-	DIFF	-0.44	-0.38	-0.39	-0.42	-0.47	-0.43

Table 3d. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

MONTH / VARIABLES			1998	1999	2000	2001	2002	2003
	-	MAR	0.00	0.03	0.00	0.00	0.00	0.00
JAN	-	PET	0.41	0.42	0.47	0.42	0.39	0.44
	-	DIFF	-0.41	-0.39	-0.47	-0.42	-0.39	-0.44
	-	MAR	0.00	0.00	0.00	0.00	0.00	0.00
FEB	-	PET	0.48	0.45	0.44	0.45	0.51	0.45
	-	DIFF	-0.48	-0.45	-0.44	-0.45	-0.51	-0.45
	-	MAR	0.00	1.36	0.00	0.00	1.37	0.00
MARCH	-	PET	0.49	0.47	0.45	0.48	0.45	0.48
	-	DIFF	-0.49	0.89	-0.45	-0.48	0.92	-0.48
	-	MAR	4.49	3.74	3.21	3.28	2.43	1.88
APRIL	-	PET	0.45	0.43	0.44	0.44	0.37	0.40
	-	DIFF	4.04	0.31	2.77	2.84	2.06	1.48
	-	MAR	5.04	4.99	3.68	4.41	3.55	0.99
MAY	-	PET	0.38	0.34	0.37	0.37	0.38	0.39
	-	DIFF	4.66	4.65	3.31	4.04	3.17	0.60
	-	MAR	11.29	10.15	7.59	8.02	5.70	6.67
JUNE	-	PET	0.36	0.37	0.28	0.36	0.40	0.29
	-	DIFF	10.93	9.87	7.31	7.66	5.30	6.38
	-	MAR	7.80	4.27	5.57	3.10	6.06	3.85
JULY	-	PET	0.30	0.28	0.26	0.30	0.30	0.31
	-	DIFF	7.50	3.99	5.31	2.80	5.76	3.54
	-	MAR	88.3	11.25	10.79	8.29	6.95	4.69
AUGUST	-	PET	0.29	0.29	0.31	0.29	0.29	0.30
	-	DIFF	8.54	10.96	10.48	8.00	11.48	4.39
	-	MAR	10.60	12.24	4.97	7.21	11.77	4.55
SEPT	-	PET	0.32		0.36	0.30	0.29	0.32
	-	DIFF	10.28		4.61	6.91	11.48	4.23
	-	MAR	3.02	5.00	2.55	1.19	3.50	1.28
OCT	-	PET	0.36	0.31	0.43	0.35	0.36	0.40
	-	DIFF	2.66	4.69	2.12	0.84	3.14	0.88
	-	MAR	0.00	0.00	0.00	0.00	0.65	1.12
NOV	-	PET	0.44	0.42	0.44	0.43	0.39	0.42
	-	DIFF	-0.44	-0.42	-0.44	-0.43	0.26	0.70
	-	MAR	0.00	0.00	0.00	0.00	0.00	0.00
DEC	-	PET	0.45	0.44	0.41	0.46	0.44	0.38
	-	DIFF	-0.45	-0.44	-0.41	-0.46	-0.44	-0.38

The HCO_3 of river Akpei and Asu in Makurdi study area had higher biocarbonate value of 2.60mg/l although still low. This indicates that the pH of the water sample decreased. This agrees with FAO (1994) findings that among the components of water, alkalinity, biocarbonates are normally the most significant concern.

The water samples in the Makurdi study area showed low concentration in Sodium exception of that which obtained from River Asu with the higher Sodium concentration of 3.50mg/l. Tthe other water samples values ranged from 0.00 to 2.30mg/l which falls within the acceptable limit as suggested by (FAo, 1994), the safe limit been < 3mg/l.

Table 3e. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

MONTH	/	VARIABLES	2004	2005	2006	2007	2008	2009
	-	MAR	0.00	0.00	1.51	0.00	0.10	0.07
JAN	-	PET	0.38	0.34	0.36	0.36	0.26	0.34
	-	DIFF	-0.38	-0.34	1.51	-0.36	-0.16	-0.27
	-	MAR	0.00	0.00	0.00	0.00	0.00	0.00
FEB	-	PET	0.48	0.42	0.38	0.43	0.41	0.43
	-	DIFF	-0.48	-0.42	-0.38	-0.43	-0.41	-0.43
	-	MAR	0.25	0.71	0.43	0.28	0.00	0.10
MARCH	-	PET	0.47	0.44	0.38	0.42	0.44	0.42
	-	DIFF	-0.22	-0.42	0.05	-0.14	-0.44	-0.32
	-	MAR	2.03	1.43	0.87	4.16	6.20	6.00
APRIL	-	PET	0.41	0.42	0.43	0.38	0.36	0.40
	-	DIFF	1.62	1.01	0.44	3.78	5.84	5.60
	-	MAR	2.36	2.92	8.91	5.50	4.75	6.14
MAY	-	PET	0.34	0.35	0.29	0.39	0.37	0.36
	-	DIFF	2.02	2.57	8.62	5.11	4.38	5.78
	-	MAR	5.48	6.99	3.66	7.00	6.20	7.99
JUNE	-	PET	0.32	0.28	0.31	0.30	0.32	0.34
	-	DIFF	5.16	6.71	3.35	6.70	5.90	7.65
	-	MAR	5.48	4.59	10.41	3.69	2..63	2.78
JULY	-	PET	0.30	0.26	0.26	0.26	0.27	0.28
	-	DIFF	5.18	4.33	10.15	3.43	2.36	2.50
	-	MAR	5.97	3.64	6.94	8.80	9.04	8.88
AUGUST	-	PET	0.26	0.26	0.23	0.22	0.24	0.28
	-	DIFF	5.71	3.38	6.71	8.58	8.80	8.60
	-	MAR	5.43	5.31	7.64	7.26	2.77	4.68
SEPT	-	PET	0.31	0.31	0.26	0.30	0.32	0.31
	-	DIFF	5..12	5.00	7.38	6.96	2.45	4.37
	-	MAR	4.76	2.95	3.34	7.07	2.63	9.16
OCT	-	PET	0.38	0.37	0.36	0.33	0.38	0.30
	-	DIFF	4.38	2.58	2.98	6.74	2.25	8.86
	-	MAR	0.02	0.00	0.00	0.05	0.00	0.04
NOV	-	PET	0.38	0.42	0.38	0.34	0.42	0.38
	-	DIFF	-0.36	-0.42	-0.38	-0.29	-0.42	-0.34
	-	MAR	0.00	0.00	0.00	0.00	0.05	0.00
DEC	-	PET	0.38	0.38	0.35	0.37	0.36	0.46
	-	DIFF	-0.38	-0.38	-0.35	-0.37	-0.31	-0.46

Table 3f. Average Monthly Rainfall Amount (mm) and Potential Evapotranspiration for Makurdi and Lafia.

Month/Variables		2010	2011	2012	
JAN	- MAR	0.00	0.00	0.00	
	- PET	0.43	0.38	0.35	
	- DIFF	-0.43	-0.38	-0.35	
FEB	- MAR	0.00	2.37	0.02	
	- PET	0.46	0.38	0.38	
	- DIFF	-0.46	1.99	-0.36	
MARCH	- MAR	0.41	0.00	0.00	
	- PET	0.46	0.44	0.40	
	- DIFF	-0.05	-0.44	-0.40	
APRIL	- MAR	1.05	2.60	4.77	
	- PET	0.42	3.80	0.35	
	- DIFF	0.63	2.22	4.42	
MAY	- MAR	4..35	4.61	4.68	
	- PET	0.34	0.33	0.32	
	- DIFF	4.01	4.28	4.36	
JUNE	- MAR	3.98	2.01	5.35	
	- PET	0.29	0.27	0.28	
	- DIFF	3.69	1.74	5.07	
JULY	- MAR	6.22	2.81	11.35	
	- PET	0.25	0.26	0.23	
	- DIFF	5.50	2.55	11.12	
AUGUST	- MAR	5.75	7.01	5.62	
	- PET	0.25	0.20	0.23	
	- DIFF	5.50	6.81	5.39	
SEPT	- MAR	10.19	9.07	5.62	
	- PET	0.28	0.26	0.23	
	- DIFF	9.91	8.81	5.39	
OCT	- MAR	3.89	9.46	6.42	MAR= monthly Average Rainfall
	- PET	0.33	0.29	0.34	
	- DIFF	3.56	9.17	6.08	
NOV	- MAR	0.80	0.00	0.91	PET = Potential Evapotranspiration
	- PET	0.38	0.40	0.37	
	- DIFF	0.42	-0.40	0.54	
DEC	MAR	0.00	0.00	0.00	DIFF = Difference between MAR and PET
	- PET	0.43	0.39	0.40	
	- DIFF	0.43	-0.39	-0.40	

Table 4. Physiochemical Properties of Water from Makurdi.

S/N	SAMPLE NAME	PH	EC (SCM^{-1})	TURBIDITY UNITS (NTU)	TDS (mg.1)	Dissolved Oxygen (mg/1)	BOD (mg/1)	HCO_3 (mg/1)	CO_2^- (mg/1)	CL^- (mg/1)	Na^{2+} (mg/1)	K^+	NO_3^- (mg/1)	Ca^{2+} (mg/1)	Mg^{2+} (mg/1)	Fe^{2+} (mg/1)	Mn^{2+} (mg/1)	Bo (mg/1)	SAR
1	R. AKPEI	5.70	13.91	5.0	0.80	6.90	74.00	2.60	6.13	0.55	2.30	0.50	0.0014	0.38	ND	1.15	ND	0.08	5.27
2	R. ASU	6.15	42.20	77.20	1.60	7.00	80.00	2.60	2.04	0.50	3.50	1.20	0.0007	ND	0.43	10.83	0.07	0.06	7.54
3	R. KPEGE	6.25	14.32	25.00	0.60	7.30	82.00	1.40	1.82	0.60	0.30	0.10	0.0024	1.29	ND	1.11	ND	0.02	0.37
4	R. KEELEKE	6.20	15.46	27.00	0.60	7.00	86.00	1.00	1.36	0.60	0.60	0.10	0.0017	1.22	ND	1.70	ND	0.14	0.76
5	R. GBAA-KEELEKE	6.00	16.32	8.00	0.20	6.80	72.00	2.60	5.22	0.65	0.30	0.20	0.0014	1.82	ND	0.58	ND	0.06	0.31
6	R.ANGWANGE	6.00	14.68	7.00	0.00	7.10	78.00	1.40	3.41	0.70	0.30	0.20	0.0021	2.09	ND	1.21	0.01	0.10	0.29
7	R. FETE	6.20	47.10	72.00	0.60	7.20	80.00	2.00	1.14	0.70	2.30	0.50	0.0024	2.91	0.57	6.20	ND	0.04	1.74
8	R. KPELAJEN	6.50	21.80	67.00	0.40	7.00	80.00	1.20	1.36	0.55	1.80	0.30	0.0024	0.52	ND	6.59	ND	0.05	3.53
9	R. ORNGU	6.55	22.80	58.00	0.40	7.00	84.40	1.80	1.36	0.65	1.30	0.10	0.0010	1.72	ND	5.06	ND	0.02	1.40
10	WELL WATER	6.45	57.50	13.00	0.60	7.80	92.00	2.00	1.36	0.80	2.30	0.40	0.0021	4.75	0.29	1.72	ND	0.07	1.02
11	RAIN WATER	6.55	21.50	1.00	0.20	7.00	16.00	1.40	0.91	0.70	0.00	0.10	0.0021	4.61	0.19	0.91	ND	0.00	0.00

Foot Note: ND equals Not Detected

Table 5. Physiochemical Properties of Water from Lafia.

S/N	SAMPLE NAME	PH	EC (SCM^{-1})	TURBIDITY UNITS (NTU)	TDS (mg.1)	Dissolved Oxygen (mg/1)	BOD (mg/1)	HCO_3 (mg/1)	CO_2^- (mg/1)	CL^- (mg/1)	Na^{2+} (mg/1)	K^+	NO_3^- (mg/1)	Ca^{2+} (mg/1)	Mg^{2+} (mg/1)	Fe^{2+} (mg/1)	Mn^{2+} (mg/1)	Bo (mg/1)	SAR
1	R. BUKANSIDI	6.50	37.30	23.00	0.60	6.90	48.00	1.40	1.14	0.75	1.80	1.10	0.0010	3.08	0.21	2.23	0.04	0.88	1.40
2	R. SABON SIDI	6.50	43.20	2.00	0.40	6.60	52.00	1.80	2.50	0.80	2.00	0.30	0.0028	3.15	0.54	1.39	ND	0.64	1.47
3	R. KURKYO	6.70	31.90	23.00	1.80	6.90	58.00	1.40	2.49	0.75	1.40	0.60	0.0010	2.97	0.12	2.05	ND	0.61	1.12
4	R. SHABU	6.80	23.40	2.00	0.00	7.30	66.00	1.60	1.14	0.80	1.00	0.20	0.0017	3.37	0.05	1.58	ND	0.68	0.58
5	R. SABON PEGI	6.60	46.60	5.00	1.00	6.70	54.00	2.00	2.72	0.85	2.30	1.10	0.0017	3.64	0.56	4.51	0.016	0.71	1.59
6	R. BAKISHAB	6.80	30.20	9.00	0.00	7.00	54.00	1.60	0.91	0.75	1.10	0.30	0.0024	3.53	0.04	3.95	0.04	0.54	0.56
7	R. AMBA	6.70	80.90	5.00	0.00	6.90	58.00	2.20	3.86	0.75	4.90	1.30	0.0017	3.55	1.58	1.21	ND	0.12	3.06
8	R. WAJENLEL	6.75	56.00	59.00	1.40	7.00	62.00	2.20	1.14	0.80	2.30	0.80	0.0021	3.97	2.07	10.95	0.14	0.14	1.32
9	R. KAFANKURA	6.75	56.10	80.00	1.00	6.90	62.00	2.00	2.04	0.85	2.50	0.80	0.0017	3.56	1.07	4.63	0.01	0.09	1.64
10	BOREHOLE	7.00	12.55	1.00	0.40	7.10	76.00	2.20	1.14	1.75	0.20	0.10	0.0010	3.82	ND	0.83	ND	0.05	0.14
11	RAIN WATER	6.95	11.55	0.00	0.20	6.90	18.00	1.00	0.68	1.00	1.40	0.70	0.0014	4.84	0.07	1.73	ND	0.00	0.89

Foot Note: ND equals Not Detected

The concentration of Sodium in the Lafia water samples ranged from 0.20 to 4.90mg/l, the highest Na^{2+} concentration value was obtained from River Amba with the value of 4.90mg/l. The Sodium concentration values falls within the recommended limit exception of that obtained from River Amba. Higher values of SAR were recorded in Makurdi water samples particularly river Asu with the value of 7.54mg/l and river Akpei with the value of 5.27mg/l. this could be as a result of high sodium concentration combined with calcium and magnesium (FAO, 1994).

The SAR concentration in the Lafia water samples ranges from 0.14 to 3.06mg/l and has a low Sodium content and is also recommended based on Landon (1991) and FAO (1994) standards.

CONCLUSION

The result of the climatic data from the metrological station computed using the Hargreaves equation showed that even though there is a high annual rainfall amount it does not necessary follow that irrigation may not be needed in such areas. The findings have shown that on the average there is sufficient water from rainfall to meet the evapotranspiration needs of crops during the rainy season. However, such water is not available during the dry season. It is observed that drought periods were prevalent to some months within the rainy season. This is a clear indication for the need for full and supplemental irrigation during the dry and rainy season respectively. The river, well and rain water in the two study areas were found to be suitable for irrigation as salinity, permeability, toxicity and miscellaneous quality related parameters fall within the tolerable limit as recommended by the FAO (1994).

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