XVIIth World Congress of the International Commission of Agricultural Engineering (CIGR)
Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

FOSTERING IRRIGATION PRACTICES IN THE HUMID TROPICS OF (SOUTHWESTERN) NIGERIA TO SUSTAIN LIFE AND DEVELOPMENT

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CSBE100901 – Presented at Section I: Land and Water Engineering Conference

ABSTRACT The rain fed agriculture which was about the only common means by which farmers in the humid tropics raised their crops had limited their earning capacity for quite some time. Also, the abundant land and water resources that had long remained untapped and unharnessed were not even noticed. Thus, there was the need to create awareness as well as embarking on a study whose findings could have an impact on the large farming populace in the southwestern part of Nigeria. The objectives of the study were to highlight the enormous land and water resources available for all year round farming as well as applying the modern methods to cultivated lands for massive crop production by irrigation practices. Five major sub-basins of the Osun river basin were considered and one of them, (Apoje sub-basin) was modeled for crop production using Hill's hydro-salinity crop yield model. 19 years of stream flow data for the Apoje sub-basin was obtained and subjected to statistical analysis using the Normal, Log-Normal and Log-Pearson Type II distributions. The experimental plots were planted with maize (DMR-LSR yellow) and irrigation water was delivered through an overhead line-source sprinkler irrigation system consisting of 4 single nozzle sprinklers, each with an effective wetting diameter of 24 m spaced 6.1 m apart along an irrigation pipe of 24 m long. Results obtained show that over 800,000 hectares of land was left unused while a minimum volume of water of about 60.24 x 10^9 m^3 remained unharnessed. The values of maize grain yield ranged between 1 and 5 ton/ha when irrigated.

Keywords: Sub-basin, Land and water resources, Hill's hydro-salinity crop yield model, statistical distributions, line-source sprinkler irrigation.

1.0 Introduction

The untapped land and water resources in most parts of Nigeria have long been waiting for proper harnessing for socio-economy development of the citizenry.

A study conducted by Alatise (1995) Alatise and Fapohunda, (1999) and Alatise and Adeboye (2005) to evaluate the untapped land and water resources that abound in most of Nigerian river basins particularly in Owena and Osun basins that are domiciled in the Western part reveal a huge amount in quantity and quality.

For instance in Osun rive basin in which five sub-basins were modeled for crop production using Hill's hydro salinity crop yield model shows that about 800,000 hectares of cultivable farm lands remain untouched while a minimum annual volume of water of about 60.24 x $10^6$$m^3$ remain unused Hill et al, (1973) and Alatise and Adeboye, 2005). It is a well known fact that man needs food to survive and sustain life. And according to the report given by World Food Summit, (1996); life will be meaningful, when all people at all times, have physical and economic access to enough, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life style. Thus, for any socio-economic, and industrial development to take place, food must be available, affordable and properly utilized so that people can grow, develop normally, meet their energy needs and avoid disease.

It is true that food production requires massive amounts of water. It takes one cubic metre of water (1000 litres) of water to produce one kilogram of wheat and 3,000 of rice. Therefore, producing sufficient food is directly related to having sufficient water. Irrigation can ensure adequate and reliable supply of water which increases yields of most crops by 100% to 400%. And this is why irrigation practices need to be encouraged and boosted in Nigeria. Therefore, the objectives of this paper are to (1) highlight the abundance of land and water resources available for irrigation practices in Nigeria, (2) facilitate irrigation practices for massive food production to satisfy domestic, commercial and industrial demands and (3) sustain development as well as for healthy lifestyle.

2.0 Material and Methods

2.1 <u>Determining Land and Water Resources in the Basins</u>.

Five major sub-basins namely Ilase, Iwo, Ede, Asejire and Apoje in Osun river basin were considered. The common crops grown by the local farmers were identified and the soil properties were determined in order to ascertain the most suitable crops that would thrive in the soil of the sub-basins'

Also, a 19-year streamflow records of river Osun at Apoje gauging station was obtained and subjected to statistical analysis using the normal, Log-normal and Log-Pearson type III distributions (Alatise and Adeboye 2005). Also, the daily discharges were computed to determine the annual volume at Apoje sub-basin. The maximum-recorded stream flow of each year was selected and ranked in descending order of magnitude as recommended by Ray, *et-al* (1988).

2.22 <u>Proposed Irrigation Methods for the Study Area</u>

The field experiments were conducted for two dry seasons in the first instance: November 1999 to March 2000 and November 2000 to March 2001 consecutively. The same experiments were later repeated for another two dry seasons: November 2003 to March 2004 and November 2003 to March 2005. The soil textural class, other physical and chemical properties of the experimental site was determined.

The experimental design was a randomized Complete Block Design (RCBD) with three treatments and three replicates. The experimental plots were planted with maize (DMR. LSR, yellow) and irrigation water was delivered through an overhead line-source sprinkler irrigation system consisting of 4 single nozzle sprinklers, each with an effective wetting diameter of 24 m and spaced 6.1 m apart from along an irrigation pipe 24 m long (Hanks, 1974). Preplanting irrigation was applied to the plots to bring the root zone to field capacity so as to promote germination and early crop establishment. Subsequently, plots were irrigated under low wind conditions (< 1.0 m/s) in the evenings for two hours each day. It had been established during the preliminary trials that the overhead sprinkler system, on the average delivered 20 mm of irrigation water in two hours. An irrigation frequency of 3 days was maintained on the plots throughout the growing season based on design calculation. Maize (Zea Mays, L) was spaced 30 cm by 90 cm and fertilizer was applied twice at the rate of 45 kg N, 456 kg P and 45kg K per ha by broadcasting at planting and secondly at the sixth week of planting at the same rate.

Standard cultural practices were followed during the growing season for weed and disease control. There were three treatments based on thr level of water application. These treatments were typified by their distances away from the line-source of the sprinkler irrigation system. The first treatment (high level irrigation) which was the highest level of water application was 2.5 m from the line-source; the second treatment (medium level irrigation) was 6.5 m and the third treatment (low level irrigation) was upheld at the symmetric counterpart on the other side of the lateral.

A characteristic feature of the line-source sprinkler system is that it permitted the application of water at the maximum rate nearest to the line-source; the width of the experimental plots was limited 24 m by the wetted diameter of the sprinklers. Each side of the line-source was divided into three irrigation levels each of which received nearly the same irrigation water; as did its symmetric counterpart on the other side. During irrigation, the amount of water received by every irrigation level plot was measured with a catch can-can placed at the center of that plot.

3.0 Results and Discussion

3.1 Cultivable Farm lands at Apoje: the cultivable farm lands that were found available at the study area amounted to over 800,000 ha. Its deep sand sandy clay loamy soil favour mostly tuber and cereal crops. Of the abundant farmland at apoje, there is a clear and very distinct relationship between the topography, which affects drainage conditions and the soil, as well as vegetation and existing agriculture. On the better drained upland, the forests have been cleared to make way for shifting cultivation while the water logged lands being used for sugar cane and rice production.

Annual water yield at Apoje Sub basin

Table 1 gives the estimated maximum discharges by the three distributions used in the analysis while Table 2 gives the statistical parameters used in determining annual discharges estimated by the distributions. The coefficient of variation (cv) of 0.34 indicates a high reliability of the estimated volume of water at the Apoje sub-basin. There is a substantial volume of water that can be harnessed for irrigated agriculture, fish farming, water supply and for hydro-eletric power generation purposes.

3.20 Grain and Biomass Yield of Maize

The values of grain yield and biomass in tons per ha are as given in Table 3. The values of grain yield, biomass yield and total yield of grains and biomass were highest in treatment I (TRT 1) and lowest in Treatment 3 (TRT 3). There was no significant difference among replicates as shown in table 4. The variation in yield per treatment might be said to have been caused by the amount of water received which decreased with lateral distance away from the line-source.

Similarly, Table 5 shows that there is a difference in biomass yield between the treatments and none between the replicates. The difference in both the grain and biomass yields between the treatments confirmed the water distribution pattern and water use under the limited water supply condition. When the grain and biomass yields were combined as shown in table 5, there is a significant difference between the treatments at the level of 5 % level of significance but between the replicates, the difference is not significant at the 5 % level of significance.

Table: 1: Estimated flood by normal, Lognormal and LogPearson type III at Apoje Sub-Station

Systematic annual maximal $Q(m^3s^{-1})$	Ranks	Probability of non exceedence (%)	Return periods Tr (Years)	Frequency factors Z	Predicted floods using normal distribution $Q(m^3s^{-1})$	Predicted floods using log-normal distribution $Q(m^3s^{-1})$	Frequency factors Kt	Predicted floods using log-person type III distribution $Q(m^3s^{-1})$
400	1	96.73	30.80	1.8461	443.19	531.91	1.2319	423.67
372	2	91.56	11.85	1.3762	402.63	446.92	1.0795	400.40
372	2	91.56	11.85	1.3762	402.63	446.92	1.0795	400.40
372	2	91.56	11.85	1.3762	402.63	446.92	1.0795	400.40
363	3	86.36	7.33	1.0969	378.51	402.98	0.9591	382.94
360	4	81.17	5.31	0.8840	360.14	372.42	0.8507	367.85
354	5	75.97	4.16	0.7052	344.69	348.55	0.7475	354.05
337	6	70.78	3.42	0.5466	331.00	328.66	0.6462	341.01
306	7	65.58	2.91	0.4000	318.41	311.37	0.5446	328.41
299	8	60.39	2.52	0.2630	306.53	295.88	0.4409	316.04
273	9	55.19	2.23	0.1303	295.07	281.69	0.3335	303.71
255	10	50.00	2.00	0.0000	283.82	268.41	0.2208	291.29
236.50	11	44.80	1.81	-0.1303	272.59	255.76	-0.1018	278.72
227.50	12	39.61	1.66	-0.2630	261.12	243.48	-0.0279	265.66
209.50	13	34.42	1.52	-0.4000	249.23	231.38	-0.1711	251.92
200	14	29.22	1.41	-0.5466	236.64	219.20	-0.3329	237.27
195	15	24.03	1.32	.-0.7052	222.95	206.69	-0.5210	221.29
169	16	18.83	1.23	-0.8840	207.51	193.45	-0.7488	203.39
92	17	13.64	1.16	-1.0969	189.14	178.77	-1.0424	182.43

Table 2:**Statistical parameters used in determining annual volume and discharges at Apoje sub-basin**

Statistical parameters	Normal distribution m^3/s	Log-normal distribution m^3/s	Log-pearson type III distribution m^3/s
Total annual discharges	5877.52	5999.36	5851.83
mean	309.34	315.76	308.00
Standard deviation	8.63	0.16	0.16
Coefficient of variation (cv)	0.30	0.10	0.10
nt of skewness	0	0	-1.40

Coefficient of variation (cv) for the discharges on the sub-basin is 0.34

Table 3: Grain and biomass and total yield of maize in the 2000/2001 experiment

sn	Plot number	Grain yield (ton/ha)	Biomass (ton/ha)	Total yield (ton/ha)
1	RA1	3.15	10.51	13.66
2	RA2	3.61	13.32	16.93
3	RA3	5.04	11.05	16.09
4	RA4	1.95	4.66	6.61
5	RB1	2.47	4.65	7.12
6	RB2	2.21	5.9	9.11
7	RB3	1.24	2.67	3.91
8	RB4	1.08	3.69	4.77
9	RC1	2.32	3.87	6.19
10	RC2	2.10	3.81	5.91
11	RC3	1.77	2.82	4.59
12	RC4	1.14	2.67	3.81
13	LA1	3.45	6.22	9.67
14	LA2	4.48	8.18	12.66
15	LA3	2.98	5.05	8.03
16	LA4	1.58	4.59	6.17
17	LB1	1.33	2.87	4.25
18	LB2	1.25	4.36	5.61
19	LB3	1.08	3.69	4.77
20	LB4	1.98	3.11	5.09
21	LC1	0.00	1.08	1.08
22	LC2	0.00	1.54	1.54
23	LC3	0.00	1.65	1.65
24	LC4	1.83	3.16	4.99

Table 4: ANOVA table for biomass yield in 2000/2001 experiment

SUMMARY	TRT1	TRT2	TRT3	TOTAL
BLK1				
Count	2	2	2	6
Sum	16.73	7.52	4.65	29.2
Average	8.365	3.76	2.475	4.8667
Variance	9.202	1.5842	3.8921	10.609
BLK2				
Count	2	2	2	6
Sum	21.5	11.26	5.36	38.11
Average	10.75	5.63	2.675	6.3517
Variance	13.21	3.2258	2.5765	17.156
BLK3				
Count	2	2	2	6
Sum	16.1	6.36	4.47	26.93
Average	8.05	3.18	2.235	4.4885
Variance	18	0.5202	0.6845	11.631
BLK4				
Count	2	2	2	6
Sum	9.25	6.8	5.83	21.88
Average	4.925	3.4	2.915	3.6467
Variance	0.0024	0.1682	0.12	0.6795
Total				
Count	8	8	8	
Sum	63.58	31.94	20.6	
Average	7.9475	3.9925	2.575	
Variance	11.224	1.656	1.1108	

ANOVA

Source of variation	ss	df	ms	f	p-value	F crit
Sample	23.001	3	7.6671	1.7299	0.214	3.490299605
Column	124.04	2	62.02	13.993	0.0007	3.885290312
Interaction	23.15	6	3.8584	0.8705	0.5435	2.996117132
Within	53.186	12	4.4321			
Total	223.38	23				

Table 5: ANOVA- table for total yield (Grain and Biomass) in 2000/2001 experiment

SUMMARY	TRT1	TRT2	TRT3	TOTAL
BLK1				
Count	2	2	2	6
Sum	23.32	11.367	11.367	46.062
Average	11.664	5.6835	5.6835	7.677
Variance	7.9441	4.1041	4.1041	12.768
BLK2				
Count	2	2	2	6
Sum	29.583	14.724	14.724	59.031
Average	14.792	7.362	7.362	9.8385
Variance	9.1207	6.139	6.139	18.999
BLK3				
Count	2	2	2	6
Sum	24.118	8.676	8.676	41.47
Average	12.059	4.338	4.338	6.9117
Variance	32.514	0.375	0.375	22.55
BLK4				
Count	2	2	2	6
Sum	12.778	9.863	9.863	32.504
Average	6.389	4.9315	4.9315	5.4173
Variance	0.0968	0.0515	0.0515	0.6064
Total				
Count	8	8	8	
Sum	89.807	44.63	44.63	
Average	11.226	5.5788	5.5788	
Variance	17.667	2.9955	2.9955	

ANOVA

Source of variation	ss	df	ms	f	p-value	F crit
Sample	61.065	3	20.355	3.4396	0.0519	3.4903
Column	170.08	2	85.04	14.37	0.0007	3.8853
Interaction	33.523	6	5.5871	0.9441	0.4996	2.9961
Within	71.015	12	5.9179			
Total	335.68	23				

4.0 Conclusion

A study of abundance of land water resources was conducted in some of the river basins located in the humid tropics of Nigeria to ascertain basically their potentials for agricultural production that could sustain socio-economic developments. Five of such major sub-basins of the Osun river basins were considered and modeled for crop production using Hill's hydro-salinity crop yield model. Also stream flow records for upward of 19 years were obtained and subjected to statistical analysis using the Normal, Log-Normal and Log-Pearson type III distributions. As land and water resources abound in the study area, irrigation methods were proposed namely sprinkler irrigation system mainly for the cereal crops and surface irrigation system for deep rooted crops mostly especially crops with high water requirements like rice and sugar cane.

The massive production of these suggested crops has given rise to the establishment of small and medium scale industries, and large scale industries are being proposed in the study area.

Thus the socio-economic activities are on the increase and employments for the rural and urban populace are also being generated.

References

Alatise, M.O. (1995): An integrated development of water resources for allocation to domestic (Municipal), Industrial and Agricultural sectors is a must in water planning. Nigerian Society of engineers(NSE) Technical Transactions Vol 30; pp 6-12

Alatise, M.O. and Fapohunda, H.O. (1999): A study of Osun River basin Hydro-salinity flow systems for optimal crop yield. Journal of applied sciences Vol 2 no 2 pp 539-555.

Alatise, M.O. and Adeboye, B.O. (2005): Utilizing land and water resources at Apoje sub-basin (South-Western Nigeria) on Osun river for Agricultural production. Journal of Applied sciences, Engineering and Technology, vol 5, no 1 and 2. pp 75-79

Hanks, R.J. (1994): Model for predicting plant yield as influenced by water use. Agron. J. 66. Pp 660-665.

Hill, R.W.; Israelsoen, E.K; and Rilley, J.P. (1973): Computer simulation of the hydrologic and salinity flow system within the Bear River Basin. UWRL report No PRWC 104-1, Utah water research laboratory., Utah state University, Logan, Utah.

Ray, L; Max A.K. and Joseph, L.H. (1988): Hydrogeology for Engineers. International Edition, McGraw Hill inc. pp 1-3.

Food and Agricultural Organisation (FAO) (2006): The state of food insecurity. The world summit. http/www.fao.org. pp1-7.