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Building Resilience for Adaptation to Climate Change among Downstream Communities in Nigeria through Climate Smart Agriculture

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Abstract – **Rainfall and river flow are highly variable in space and time. The variability affects agricultural production in a number of ways including reduction in crop production. North central region in Nigeria holds significant agricultural importance in the country particularly Niger State in terms of Agricultural productivity. Although, the influence of rainfall variability has been widely recognised, the seasonal rainfall and rivers Niger and Kaduna discharge pattern and the relationship between them have not been quantitatively established in Niger State. The purpose of this research is to fill up the gap and adopt climate-smart agricultural practices that are suitable for the study area to reduce the impact of climate change especially flooding. Data on rainfall, river discharge and flood occurrences were obtained from Nigerian Meteorological Agency, Lagos, Federal Ministry of Water Resources and Dartmouth Flood Observatory Archive respectively. The rainfall and river flow pattern were determined by calculating the monthly average for 31 years [1982-2012], while the relationship between them was calculated using correlation coefficient and regression. The results show that r=0.79; r^2 = 0.63. The significance of the regression equation was also tested using student 't' test and H_o is rejected. Therefore, there is a significant relationship between rainfall pattern and rivers Niger and Kaduna discharge pattern in Niger State. Moreover, about 75% of the annual rainfall total accumulates in the four heaviest rainy months of June, July, August and September and the peak occurs in August. However, the mean monthly discharge of River Niger at Kainji reservoir reaches its peak in September, whereas the highest mean monthly discharge of river Kaduna at Shiroro reach its peak in August. Consequently, the results also show that floods usually occur in the study area between the months of August and September. Therefore, climate smart agricultural practices suitable for the down-stream communities in Niger State should include the use of irrigation system, cultivation of upland rice and use of improved crop varieties (i.e. early maturing and drought resistant crops) to reduce the impact of floods on crop production. Discouragement of transhumance agriculture and establishment of aquaculture can also drastically reduce the impact of flood on agriculture.**

Keywords – **Climate-Smart Agriculture, Floods, Floodplain, Rainfall Variability, River Flow Variability.**

I. Introduction

Climate change is expected to impact on the agricultural sector in multiple ways, among others through increased variability with regard to temperature, rain, frequency and intensity of extreme weather events, changes in rain patterns and in water availability and through perturbations in ecosystems (FAO/OECD, 2012). The main effects on agricultural production are expected to be an increased variability of production, decrease of production in certain areas and changes in the geography of production (ADF, 2010). One way to cope with the challenges comprised by climate change is to build resilience for adaptation in the agriculture sector (Eze, 2008). The OECD and the FAO are working together on an analytical report that focuses on building resilience in agricultural production systems in the context of climate change (FAO/OECD, 2012).

Climate change therefore, has brought to bear the need to dialogue on several aspect of the environment, for instance agriculture, food security, water etc. This is to ensure sustainability and man's survival (Eze, 2008). In water resources, particularly in the science of hydrology, two hydrological extreme events are recognized. They are flood and drought. While the former represents abundance, the latter depicts scarcity of water. Scientific studies and human experiences have shown that both extremes have their impacts on water resources availability particularly dam reservoir operation and management for agricultural purpose. Flood, which is the main concern of this study, is a natural hydrological extreme event affecting the flow regime of all rivers particularly during the rainy season. All rivers are subject to flooding in the hydrological sense of inundation of riparian areas by stream flow that exceeds bank-full capacity (Deyer, 1988). Therefore, Man is left with the option of seeking out and assembling scientific knowledge, generation of wide spread awareness, identification of policy and management option that build capacity to cope and make the knowledge of climate change available to different community and decision makers (Dialogue on water and climate change, 2008; Madu and Ayogu, 2010). The inevitability of changes cannot be queried even in climate sector. Changes in the earth's climate and its adverse effects are a common concern of human kind. This research therefore intend to achieve the following: examines the pattern of rainfall and river flow/discharge into Kainji, Shiroro and Jebba reservoir in Niger State; examines the relationship between the rainfall pattern and the river flow pattern in the study area; and adopt climate-smart agriculture that is suitable for the community in order to cope with the effects of recurrent flooding.

Climate-Smart Agriculture is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. This can be achieved by; sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; reducing and/or removing greenhouse gases emissions, where possible (FAO, 2013). Resilience can be described as the capacity of systems, communities, households or individuals to prevent, mitigate or cope with risk and recover from shocks (FAO, 2013). A system is resilient when it is less vulnerable to shocks across time and can recover from them (Adger, et al, 2004).

II. Materials and Methods

2.1 Study area

This research was carried out in in Niger State, Nigeria. Niger State is located between latitude 8º 22'N and 11º 30'N and Longitude 3º 30'E and 7º 20'E in Nigeria, The region experiences two distinct seasons, the dry and wet seasons, with annual rainfall varying from 1,100mm in the northern part to 1,600mm in the southern parts (Garnier, 1967). Mean maximum temperature remains relatively high throughout the year, averaging about 32°C, particularly in March and June. The lowest minimum temperature occurs usually between December and January (Iloeje, 1982). Generally, the fertile soil and hydrology of the State permit the cultivation of most of Nigeria's staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development.

Niger State shares boundaries with Kaduna State and Federal Capital Territory, in the East and South-East respectively, Kebbi and Zamfara in the North, Kwara and Kogi States in the South and Benin Republic in the West. The landscape consists mostly of wooded savannas and includes the floodplains of the Rivers Niger and Kaduna (Iloeje, 1982). Niger State has an area of 29,484 square miles (76,363 square km). Generally, agricultural activities form the mainstay of the people's economy and engage directly or indirectly more than 80 percent of the population.

2.2 Data collection and analyses

The data for the research (Rainfall, River flow, flood occurrences) were obtained from three sources namely Meteorological Agency Oshodi, Lagos, Ministry of Water Resources Abuja and Dartmouth Flood Observatory archives. The data collected were analysed using descriptive (mean) correlation coefficient and regression analysis. The correlation coefficient and regression analysis were performed using XLSTAT software 7.5. Rainfall and river flow pattern were analysed by calculating the mean monthly rainfall (mm) for in 31 years (1982-2012). The results are represented graphically to display the seasonal pattern of rainfall in Niger State.

III. Results and Discussion

3.1 Rainfall Pattern in Niger State

The result of rainfall analysis shows that rainfall generally begins in April, increases till the month of August and decreases thereafter until cessation takes place almost completely in November (table 1). Therefore, the study area has single peak of rainfall which occur in the month of August. About 75% of the annual rainfall total accumulates in the four heaviest rainy months of June, July, August and September. (Fig.1). The month of August usually records the highest amount of Rainfall, while the month of December usually records the lowest amount of rainfall. Ayoade (1988) states that the times of the start, duration, and end of the rainy season control agricultural activities in the tropics. The result of the analysis shows that farming activities in Niger State start in May, with land preparation and planting of such crops like melon, ground nut and guinea corn because of their higher levels of drought resistance. Results also indicate that rice and late maize, often planted on the Fadama (wetland/ floodplan) are more vulnerable to flood. High incidence of death and disease condition among livestock and extinction of fish species are among prominent setbacks caused by flood on agriculture.

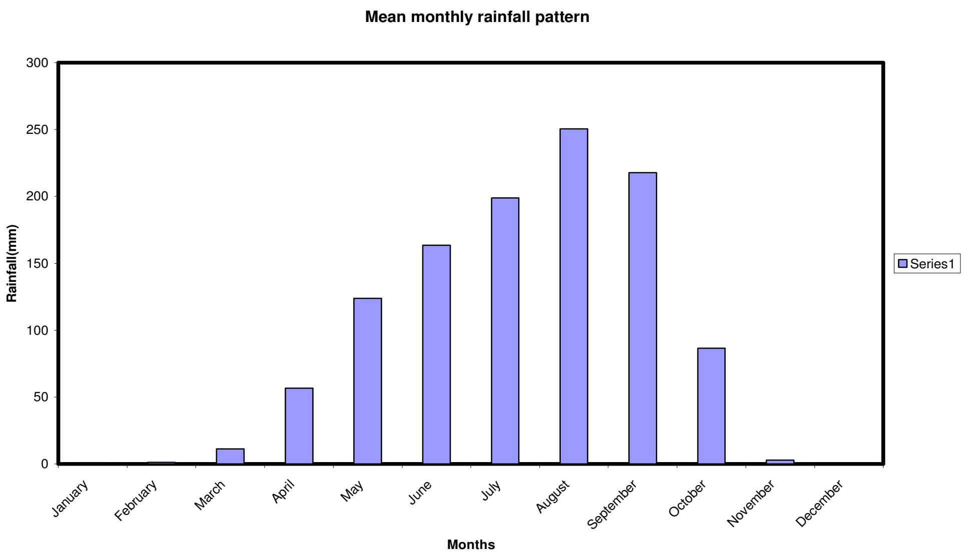

Fig.1. Mean monthly rainfall pattern over River Niger catchment areas

Table 1: Mean monthly rainfall (mm) in Niger State for 31 years (1982-2012)

Rainfall Stations	Kaduna South	Minna	Bida	Yelwa	Kainji	Average
January	0.62	0.54	3.10	0.1	1.00	1.072
February	0.00	0.40	4.00	0	1.20	1.12
March	10.66	9.20	17.70	9.3	9.50	11.272
April	66.42	71.20	66.00	34.6	45.00	56.644
May	105.16	153.20	137.00	93.3	130.30	123.792
June	167.84	177	178.00	137.4	157.80	163.608
July	213.00	189.40	208.00	208.5	176.10	199
August	304.60	253.90	219.00	249.1	226.60	250.64
September	288.40	223.20	206.00	185.9	185.80	217.86
October	53.38	173	82.40	54.7	69.30	86.556
November	6.90	4.40	2.30	0.5	0.70	2.96
December	0.00	0.00	0.00	0.1	0.00	0.02

Source: NiMet Oshodi (Lagos)

Climate change will affect agriculture through more variable rainfall and extreme climate events such as heat waves, floods and droughts (FAO, 2013). Many impact studies point to severe crop yield reductions in the next decades without strong adaptation measures particularly in Sub-Saharan Africa where rural households are highly dependent on agriculture (Cline, 2007; Eze, 2007; Lamhauge et al, 2011; Jones and Thornton, 2013). Therefore, there is need to adopt specific climate-smart agricultural practices among the down-stream communities in Niger State, Nigeria.

3.2 Monthly Discharge of Rivers Niger and Kaduna into Kainji, and Shiroro reservoirs

The mean monthly discharges of rivers Niger and Kaduna for 31 years have been computed to obtain the pattern of seasonal variability of discharge in Niger State (Table 2). The results of the data analysed show that there are variability in the peak discharge of rivers Niger and Kaduna. The mean monthly discharge of River Niger at Kainji reservoir reaches its peak in September (Table 2), whereas the mean monthly discharge of river Kaduna at Shiroro reach its peak in August (Table 2).

Table 2: Mean Monthly River Flow (m^3 /sec approximated) into Kainji and Shiroro reservoir for 31 years (1982-2012)

Month	Kainji	Shiroro	Average
Jan	482	627	554.5
Feb	339	506	422.5
mar	98	201	149.5
Apr	165	268	216.5
May	792	956	874
Jun	1194	1370	1282
Jul	1612	1770	1691
Aug	1757	2326	2041.5
Sept	1907	1942	1924.5
Oct	1293	1486	1389.5
Nov	1114	1329	1221.5
Dec	1010	1158	1084

Source: Federal Ministry of Water Resources, Abuja

The flood-peak inflow into Kainji immediately following accumulated peak rainfall period may be attributed to the time lag factor between rainfall and peak flow. Moreover, at both rivers Kaduna and Niger, the minimum average discharge occurs in the month of March. On the average, however, the peak flow of rivers Niger and Kaduna occur in August (Fig.2).

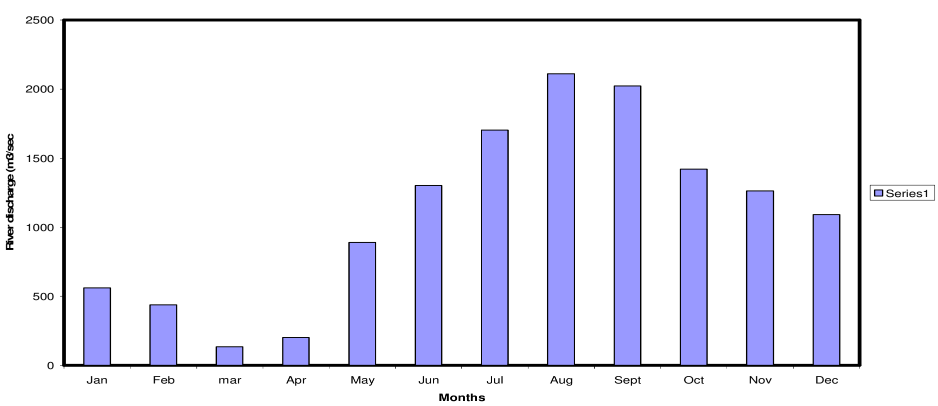

Fig.2. Mean monthly water discharge (m^3/sec) of the Rivers Niger and Kaduna into Kainji and Shiroro reservoir

About 54% of the annual discharge is received at Kainji and Shiroro reservoirs during the flood season of July to October and the remainder is distributed over the rest of the year. The seasonal flow pattern has shown that July, August, September and October are the months with highest chances of flood occurrence in downstream communities along Rivers Niger and Kaduna in Niger State

3.3 The relationship between rainfall pattern and Rivers Niger and Kaduna flow/discharge pattern

The result of the regression analyses shows that there is a strong positive relationship between rainfall pattern and river flow/discharge pattern in Niger State. The equation of the model writes:

River Discharge = 574.49 + 5.34*Rainfall

The linear relationship between river discharge and rainfall indicates that the base constant which is the fixed amount of discharge that will occur before the influence of rainfall duration will begin to make an input is 574.49. Moreover, the regression coefficient or slope of the regression line is 5.34. This means that a unit increase in rainfall amount will lead to a 5.34 increase in river discharge other factors being constant (Fig.3).

The correlation coefficient (r) between rainfall and river discharge pattern in the study area is 0.79 (Table 3). Therefore, a unit increase in rainfall amount leads to a unit increase in river discharge in Niger State. Moreover, 0.63 or 63% of the variations in rainfall amount are determined by variations in river discharge in the study area (Table 3). This implies that (100-63) = 37% of the variations in river discharge in Niger State are due to other causes or reasons.

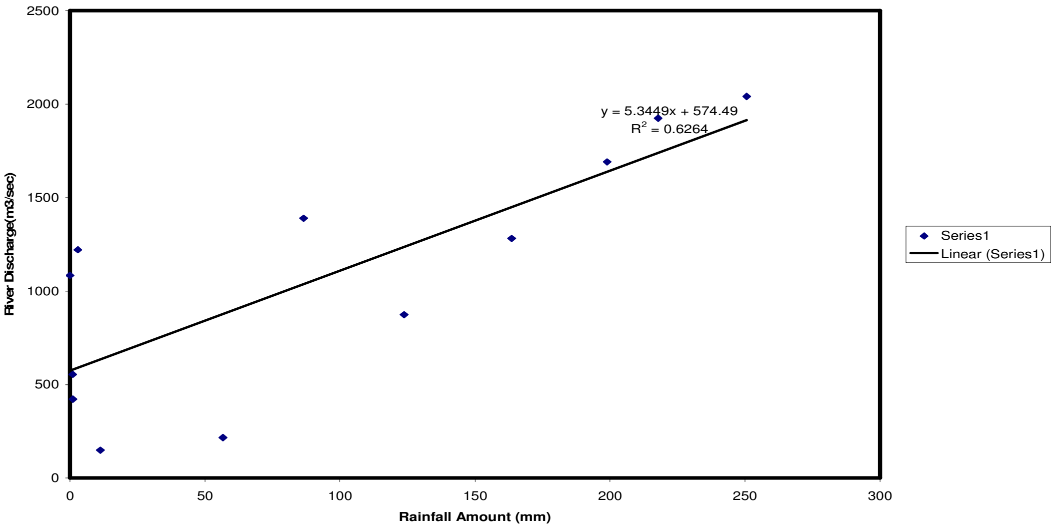

Fig.3. Regression of stream discharge on rainfall amount

The significance of the regression equation was also tested using student ‘t’ test. Degree of freedom (DF) = n-2 = 10 (Table 4). The critical value of ‘t’ at 95% confidence is 1.81. However, ‘H_o’ states that there is no significant relationship between rainfall amount and river discharge in Niger State at 0.05 level of significance. Therefore, since our calculated value 4.09 > 1.81 (Table 5), the H_o is rejected. So there is a significant relationship and the regression equation is significant at 95% level of confidence.

Table 3: Goodness of fit coefficients:

R (coefficient of correlation)	0.791
R² (coefficient of determination)	0.626
R²adj. (adjusted coefficient of determination)	0.589
SSR	1692198.636

Table 4: Evaluating the information brought by the variables (H0 = Y=Moy(Y)):

Source	DF	Sum of squares	Mean square	Fisher's F	Pr > F
Model	1	2836782.280	2836782.280	16.764	0.002
Residuals	10	1692198.636	169219.864		
Total	11	4528980.917			

Table 5: Model parameters:

Parameter	Value	Standard deviation	Student's t	Pr > t	Lower bound 95 %	Upper bound 95 %
Intercept	574.485	169.713	3.385	0.007	196.341	952.630
Rainfall	5.345	1.305	4.094	0.002	2.436	8.254

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3.4 Flood Occurrences Downstream communities in Niger State

The flood data from Dartmouth Flood Observatory (Table 6) shows major flood events that have occurred along rivers Kaduna and Niger in Niger State from the year 1988, to 2012. The least flood flow duration lasted for 13 days, while the highest flood flow duration lasted for 54 days. The data also show that flood occurrences in the study area were caused mainly by heavy rainfall. Moreover, the flooding usually begins in the month of August or September and usually ends in October (Table 6). This also corresponds with the peak of rainfall and River discharge recorded in the study area (Fig. 1 & 2).

Moreover, there is a striking resemblance to the seasonal rainfall induced floods with a distinct peak. The highest peak, which ranges from 2041.5m3/sec to 1389.5m3/sec, that is August to October (Table 2) corresponds to the floods generated during the peak of wet season experienced from July to September (Fig. 1).

Consequently, the data from Dartmouth flood archive, rainfall and river discharge pattern show that downstream communities in Niger State are likely to experience flooding between the months of August and October. Therefore, there is need to build agricultural resilience among the farming communities along rivers Niger and Kaduna in Niger State.

Table 6: Flood data for Kaduna river from 1988-2012 (severe floods)

Location	River	Began/ended	Duration	Main cause(s)
Niger State	Niger/Kaduna	Sept.14 - 26, 1988	13 days	Heavy rainfall
Niger State	Niger/Kaduna	Sept. 15 - Oct.11, 1999	27 days	Heavy rainfall
Niger State	Niger/Kaduna	Aug. 25 - Oct.17, 2003	54 days	Heavy rainfall
Niger State	Niger/Kaduna	Aug 7 - Sept 16, 2005	53 days	Heavy rainfall
Niger State	Niger/Kaduna	Aug.19,- Oct 10, 2007	18 days	Heavy rainfall
Niger State	Niger/Kaduna	Sept 13 - Sept 30 2010	45 days	Heavy rainfall
Niger State	Niger/Kaduna	Aug 23 - Oct.7 2012	41 days	Heavy rainfall

Source: Dartmouth Flood Observatory (www.dartmouth.edu).

Recent catastrophic floods all over the world have raised new questions as to traditional approaches in dealing with such extreme events (Blaikie, et al., 1994; Vlachos, 1995; Pelling and Uitto, 2001). Many societies have accepted floods as inevitable natural phenomena to be endured. The increasing flood frequency and its impacts on agriculture have greatly reduced food production among the community dwellers on the floodplain, hence, increasing their vulnerability to food insecurity and malnutrition (Devereux and Edwards, 2004, Eze, 2007). However, advancement in science and technology have enhanced human society in manipulating the physical environment (Blaikie, et al., 1994).

3.5 Recommendations

To address the impact of climate change on Agriculture, food systems have to become, at the same time, more efficient and resilient, at every scale from the farm to the global level. They have to become more efficient in resource use (use less land, water, and inputs to produce more food sustainably) and become more resilient to changes and shocks. It is precisely to articulate these changes that FAO has forged the concept of climate-smart agriculture (CSA) as a way forward for food security in a changing climate. CSA aims to improve food security, help communities adapt to climate change and contribute to climate change mitigation by adopting appropriate practices, developing enabling policies and institutions and mobilizing needed finances.

In this paper therefore, we recommend the short term and long term measures to protect crop production against the disaster and problems of climate change through climate-smart agricultural practices. The strategies are:

(i). Establishment of irrigation system. Irrigation system will help farmers cultivate and harvest crops during flood free months such as November till May. Hussain and Hanjra (2004), state that irrigation enhances higher yields, lower risks of crop failure, and all year round farm and non-farm employment. Moreover, irrigation enables smallholders to diversify cropping patterns, and to switch from low-value subsistence production to high-value market-oriented production (Hagos et al. 2013). Irrigation in Africa is often highly valued by its users. Investigations by Chancellor & Hide (1997) at 12 small schemes in Kenya and Zimbabwe, where the average holding size varied between 0.5ha and 1.0 ha, showed that irrigation generally contributed 25–80% of total family income. The annual net income from irrigation per family farm was generally between $150 and $1000. Farmers appeared to have a reasonable standard of living and were able to cover the cost of school expenditures and health needs

(ii). Adoption of upland rice. The study area is predominantly lowland/floodplain rice farmers, which are usually inundated before harvesting. Therefore adopting upland rice will eliminate crop destruction by floods. Upland rice is easier to cultivate compared to traditional varieties that mainly grow in paddies, and responds well to low rainfall as long as it is well distributed during growing phase (ARC, 2009, Oonyu, 2011). Uganda produces mainly three varieties of the New Rice for Africa (NERICA), namely NERICA 1, 4 and 10. NERICA 4 is popularly known as Upland rice. A variety known as NARIC 3 which is not only high yielding, producing yields of 1,250 to 1,500 kg/acre but also early maturing (90 to 110 days) has been developed by local breeders. Normally, local varieties take more than 120 days to mature with yields hardly about 800 kg/acre. In addition, NARIC 3 which has an attractive aroma, is less susceptible to birds, and yields heavier grains (MAAIF, 2008). The wastage is also less than 25% compared to 40% for the local varieties. As a result of the upsurge in Upland rice growing, Uganda's total area under rice cultivation is now threefold (180,000 ha) of what it was 10 years ago (60,000 ha).

(iii). Use of improved crop varieties (i.e. early maturing and drought resistant crops). Early maturing crops will enable farmer plant crops and harvest them before the possible period of flooding. Moreover, drought resistant crops will enable farmers cultivate as early as March/April during the unset of rainy season. With the little amount of rain in March/April, drought resistant crops should be able to survive and grow very well. The new improved crop varieties enhance the reduction of climate change impacts on farmers. The use improved crop varieties are designed with the objective of improving food security, increasing incomes and reducing poverty especially at household farm-level performance (Norton, 2004).

(iv). Irrigated rangelands should be established by the government: - This will aid in controlling the transhumance nature of our herdsmen, which will in turn reduce the high concentration of cattle along the river banks.

(v) Practicing aquaculture: - Aquaculture is a means of bringing aquatic lives closer to the people. This will go a long way in increasing fish production thereby enhancing preservation of species. Asante et al., (2004) also argue that the adoption of climate-smart agriculture is expected to enhance productivity and consequently increase incomes, reduce impact of climate change on farmers and consequently ensure equity among beneficiaries. The above mentioned climate-smart agricultural practices will make the communities resilient to flood hazards and increase crop production.

IV. Conclusion

As a result of climate variability and extreme events, flooding has become the most common natural disasters among the communities on the rivers Niger and Kaduna floodplain, especially the communities downstream in Niger State. Flood hazard, which is associated with climate variability and changes affect agriculture in the study area. Rivers Niger and Kaduna discharge pattern, Dartmouth Flood Observatory archive and rainfall pattern have shown that flooding are most likely to occur between the months of August and October. Therefore, climate smart agricultural measures should be adopted such as use of irrigation system, upland farming and improved crop varieties (i.e. early maturing and drought resistant crops) to reduce the impact of floods on crop production.

Since the timing of seasonal flooding is predictable, early maize, rice and other crops that can tolerate the effects of reduced moisture supply around flowering could reduce farmers' risk in flood-affected ecologies. Farmers grow early maturing varieties not only to provide an early harvest to bridge the "hungry-season" before harvest of a full-season crop, but also ideal for off-season plantings in floodplain. Early varieties are ideal for intercropping by providing less competition for moisture, light, and nutrients than later maturing varieties. They also offer flexibility in planting dates, which enables: (i) multiple plantings in a season to spread risk of losing a single crop to floods (ii) late plantings during delayed onset of rainfall, and (iii) avoidance of known terminal flood periods during the cropping season.

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References

[1] Adger, W.N., Brooks, N, Bentham, G, Agnew, M and Eriksen, S., (2004): *New Indicators of Vulnerability and*
[2] *Adaptive Capacity*. Tyndall Centre for Climate Change Research Technical Report 7, 1-46.
[3] African Development Forum (ADF). (2010): Acting on Climate Change for Sustainable Development in Africa.
[4] Climate Risk Management: Monitoring, Assessment, Early Warning and Response. Issues Paper 4. Seventh African Development Forum. 10–15 October 2010, Addis Ababa.
[5] Africa Rice Centre (WARD) (2009). The Growing NERICA Boom in Uganda. WARDA Publications: Cotonou, Benin.
[6] Anyadike, R.N.C (1993): "Seasonal and Annual Rainfall Variations over Nigeria". *International Journal of Climatology*, *13*, 567–580.
[7] Asante E.G., Appiah M.R., Ofori-Frimpong, K., and Afrifa A.A. (2004): The Economics of Fertilizer use on some
[8] Peasant Cocoa Farms in Ghana. Ghana Journal of Agricultural Science 33: 183–190.
[9] Ayoade, J.O., (1988): Introduction to Climatology for the Tropics. Spectrum Books Limited.
[10] Bello, O. B., Azeez M. A., Mahmud, J., Afolabi, M. S., Ige, S. A. and Abdulmaliq, S. Y. (2012): Evaluation of Grain
[11] Yield and Agronomic Characteristics in Drought-tolerant Maize Varieties Belonging to two Maturing groups. Scholarly Journal of Agricultural Science Vol. 2(4), pp. 70-74.
[12] Blaikie, P., Cannon, T., Davies, I and B. Wisner, B (1994): At Risk; Natural Hazard, People's Vulnerability and
[13] Disasters. London: Routledge. pp 284.
[14] CIMMYT (International Maize and Wheat Improvement Center). 1993. The Adoption of Agricultural Technology: A
[15] Guide for Survey Design. Mexico: International Maize and Wheat Improvement Center
[16] Chancellor F & J Hide (1997) Smallholder irrigation: Ways forward. Volumes 1 & 2, Report No. OD 136, HR Wallingford, UK.
[17] Cline, W. (2007): Global Warming and Agriculture: Impact Estimates by Country. Centre for Global Development. Washington DC, USA. 250 pp
[18] Devereux, S and Edwards, J., (2004): Climate Change and Food Security, IDS III Bulletin. Institute of Development Studies, volume 35 number 3.
[19] Deyer, J. L. (1988): Human Responses to Floods. In: *Perspective in Water Uses and buses* Speidel, D. H. and others (Eds) Oxford University Press pp 286-295).
[20] Dialogue on water and climate change (2008): "Climate Changes the Water Rules", [Online], Available: www.water And climate.org [19 Sept 2008]

[21] Eze, J.N. (2007): Impacts of Floods on Shiroro Communities in Niger State. *Journal of Environmental Research and Policies*, Volume 2, Number 1. pp 46-53.

[22] Eze, J.N., (2008): Coping with Global Environmental Change: The Role of Adaptation in Niger State. Journal of Environmental Research and Policies, Volume 3, Number 1. pp 126-132

[23] Food and Agriculture Organisation of the United Nations (FAO) (2013): *Climate-Smart Agriculture Sourcebook (www.fao.org/ publications)*

[24] Food and Agriculture Organization of the United Nations Organisation for Economic Co-operation and Development,

[25] (FAO/OECD) (2012): Building Resilience for Adaptation to Climate Change in the Agriculture Sector. Edited by Alexandre Meybeck, Jussi Lankoski, Suzanne Redfern, Nadine Azzu and Vincent Gitz Proceedings of a Joint FAO/OECD Workshop 23–24 April 2012.

[26] Garnier, B.J., (1967): Weather Conditions in Nigeria. *Climatological Research Series,No.2*. McGill University, Montreal, Canada.

[27] Hagos, F.; Makombe, G.; Namara, R. E.; Awulachew. S. B. (2012): Does Access to Small Scale Irrigation Promote

[28] Market Oriented Production in Ethiopia? Scholarly Journal of Agricultural Science Vol. 2(4), pp. 21-32

[29] Hussain I.; Hanjra, A. (2004): Irrigation and Poverty Alleviation: Review of the Empirical Evidence. Irrigation and Drainage 53: 1-15.

[30] Iloeje, N.P., (1982): *A New Geography of Nigeria. Lagos*, Longman, Nigeria Limited

[31] Jones, P.G., Thornton, P.K., (2013): Generating Downscaled Weather Data from a Suite of Climate Models for Agricultural Modelling Applications. *Agricultural Systems* vol. 114 pp1-5

[32] Lamhauge, N., Lanzi, E. & Agrawala, S. (2011): *Monitoring and Evaluation for Adaptation: Lessons from Development Co-operation Agencies.* OECD Environment Working Paper No. 38. OECD.

[33] Madu. I.A. and Ayogu, C.N. (2010): *The Effects of Rainfall Variability on Crop Productivity in Northern Nigeria*. In Anyadike, R.N.C, Madu, I.A, and Ajero, C.K. (Ed) Climate Change and the Nigerian Environment *135-143*.

[34] Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Ministry of Finance, Planning and Economic Development, (MOFPED) (2002): Plan for Modernisation of Agriculture, MAAIF/MFPED: Kampala, Uganda).

[35] Norton, D.R. (2004): Agricultural Development Policy: Concepts and expectations. John Wiley & Sons, Chichester, UK. 528 p.

[36] Oonyu, J., (2011): Upland Rice Growing: A Potential Solution to Declining Crop Yields and the Degradation of the Doho wetlands, Butaleja district-Uganda. African Journal of Agricultural Research Vol. 6(12), pp. 2774-2783.

[37] Pelling, M and Uitto,J.I (2001): Small Island Developing States: Natural Disaster Vulnerability and Global Change, *Environmental Hazards*, 3, pp 49-62

[38] Vlachos, E (1995): Socio- Economic Impacts and Consequences of Extreme floods; Vdrometeorology, Impacts and Management of Extreme Floods. US-Italy Research workshop. pp 5-12

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