



REVIEW

Rice and Climate Change: It's Significance towards Achieving Food Security in Nigeria: A Review

Diagi B.E^{1*} Edokpa D.O² Suzan Ajiere³

1. Department of Environmental Management, Federal University of Technology, Owerri, Nigeria

2. Department of Geography and Environmental Management, Rivers State University, Port Harcourt, Nigeria

3. Department of Geography and Environmental Management, University of Port Harcourt, Nigeria

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ABSTRACT

Climate change is already impacting on every aspect of man life on earth especially in the agricultural sectors of developing nations. In Nigeria, and indeed the world over, seasons are shifting, temperatures are rising, landscapes are changing and sea levels are rising. Extreme weather events like drought and flood are becoming more frequent and pronounced.^[3] stressed on the fact that Agriculture will suffer from major damage caused by changes in climate especially in the African continent. Nigeria is one of the African country that is highly vulnerable to the adverse effects of climate change, as Nigeria is still practicing rain fed agriculture^[16]. The impact of climate change is experienced in form of extreme climatic events like flooding, severe heats, and droughts which has led to the degradation of soil and consequently low yield in crops. This will have consequences for rice cultivation in Nigeria, where the dominating climatic factor relied on by farmers in the choice of when to prepare the land for planting, the actual planting, the types of crop variety to plant and harvesting of crop is rainfall^[23, 24]. The implication of this will be interference with food security as rice is an essential food crop in Nigeria that is consumed by a large number of the population.^[26] has warned that hunger in Africa will be worsen by adverse effects of climate change, as it threatens the capacity of vulnerable countries like Nigeria to guarantee food security, eradicate poverty and actualize sustainable development in agriculture. The increasing rate of inadequacy in food supply in the world leading to different form of malnutrition is worrisome and more needs to be done in the areas of agriculture so as to guarantee food security to some extent and improve on nourishment, if a world without hunger is to be achieved by 2030.

1. Introduction

All over the world, adverse effects of climate change have become a national concern particularly in the agricul-

tural sector^[1]. This concern is due to the fact that climate change is creating unfavorable challenges in advancement of agriculture, food security and the general wellbeing of man^[2].^[3] asserted that agriculture will significantly be

**Corresponding Author:*

Diagi B.E,

Department of Environmental Management, Federal University of Technology, Owerri, Nigeria;

E-mail: edeoli@yahoo.com

affected by damage caused by changes in climate. Rice farming, particularly those dependent on rainfed, need certain acceptable climatic parameters to produce optimally and therefore are in danger due to climate change^[4] especially if it comes with unfavorable conditions^[1]. In Nigeria, production of crops and its yield is largely determined by variation in climatic factors mainly rainfall and temperature^[5-9].

Several studies have attributed the setback majorly encountered in rice production to climate change impacts;^[10-14] along with others factors. Evidence from these studies shows that variability in climate poses a danger to food security. It has been noticed that inconsistency in weather elements can lead to reduction in yield of crop and destruction especially at the onset of germination; hence to attain sufficiency in rice production in Nigeria, urgent steps must be taken to address the vagaries of these climatic elements. In Nigeria, the sector of agriculture is very important to its economy as it is the key engine that helps to stimulates growth and development. The agricultural sector still maintain a major position in the economy of Nigeria, as it contribute about 40% of the GDP and in the employment of about 70% of its youthful population that reside majorly in the rural area despite the revenue from the oil sector. Therefore, the changes presently experienced in climatic elements could pose a danger to the sustainability of agriculture if not checked^[15, 16] resulting to food scarcity and unemployment especially bearing in mind the rapid growing population. Presently in Nigeria, rice is a major food consumed in most homes and a major source of calories for families, unfortunately this demand has not been sustained by local production hence the dependence on foreign rice to compensate for the shortfall in local production to prevent rice shortage.

Rice is consumed in large quantity by both the rich and the poor.^[17] noticed that 70% of the entire populace of Nigeria feed on rice. In 2012, towards the end of the year it was observed that the total foreign debt and importation figures of rice added up to around one trillion of naira, causing importation of rice to have the highest figure of over 60% out of all import figures. But with the recent pronouncement and enforcement of the federal government, on the ban of imported rice more effort needs to be put in place to improve on local production to meet the large demand of rice in the country. Therefore, in order to avert food crises in Nigeria, which will be further complicated by an adverse climate condition necessary steps needs to be taken to improve on food crop production especially rice crop which is linked to food security of developing nation.

2. Effect of Changing Climate on Rice Production

Changes in climate resulting to increasing temperature can have a direct or indirect effect on rice farming, by influencing the capacity for its abundance or a dearth in its availability due to variability in pattern. The most important indicators in climate are temperature and rainfall, which is due to the role they play as both factors of climate as well as elements of climate as any changes in them have the ability to cause a change in the other element^[1]. A prolong increase in temperature that exceed the required threshold for growth will have impact on rice production. This impact can cause growing season to be reduced, hence maximal yield will not be attained and consequently there will be shortage in rice production to meet the ever increasing demand.

Climate has a direct impact on the physical development of all stages of rice formation and growth. Changes in climate could also affect yield as well as growth of rice as a result of temperature and carbon dioxide. Rice plant is also affected indirectly by climate change through the occurrences of crop pests and diseases which prevent grain yields. The climatic environment in which rice grows is very important for attaining food security all over the world. Additionally, other activities that could influence rice yield are availability of irrigation water, competition with animals, changes in the fertility of soil and erosion. Changes in climate is creating an increased demand on the food supply structure of the world. Climate change is anticipated to cause an increase of food grain yield in some areas at higher latitude and cause a decline in yield at lower latitude^[18]. The production of rice is faced with a lot of challenges resulting from global warming which has led to shortage of water and brought about other factor that incapacitate the ability of farmers to grow rice crop optimally. (e.g.,^[19-21])



Figure 1. Rice crop requires water at every stage of development

It is imperative to note that, even with improvement in seedling, and the use of irrigation support system, agriculture in Nigeria is still highly dependent on weather and climate for production and sustainability of food crops. [22] In a tropical environment like Nigeria, where rain-fed agriculture is practiced majorly, the start and end of raining season determine the culture adopted by farmers. This is because most farmers await the first rain of the year before preparing land for planting, selection of crop types, and time of harvest [23-24].

However, high rainfall and temperature with extreme weather conditions such as drought, flooding can affect and /prevent crops from growing, reduce crop production [15] and in other instances destroy crops. In Nigeria, in almost all the rice producing state flooding resulting from excessive rainfall is a major extreme climatic event that destroys rice farms leading to destruction of several hectares of rice farms and lose of billion of naira yearly. Evidences of such climate related extreme events is shown in Figures 2-6.



Figure 2. 280 hectares of Rice farm destroyed by flood in Iguomo in Ovia North-East of Edo state in 2018



Figure 3. 1000 hectares of rice farm destroyed by flood in Katsina State in 2018



Figure 4. 200 hectares of rice farm destroyed by flood in Anambra state in 2018



Figure 5. 5,000 hectares of rice farm destroyed by flood in Kano State in 2018



Figure 6. 4,000 hectares of rice farm submerged by flood in Maiduguri in 2018

Climate change threatens the capability of many nations, especially in Africa to guarantee global food security, poverty elimination and actualize sustainable development. Food security is a situation where all human beings, consistently have access to a reasonable amount of affordable, healthy food that is able to meets their dietary needs and the type of food they prefer for a functioning and healthy life [25]. [26] has warned that hunger in Africa is made worse by the effect created on agriculture by climate change. For example, the occurrence of drought is now a common happening in some part of the world,

and in some cases persist for a longer time than usual. In Africa, some countries have suffered the worst kind of drought in the last decade notable among these countries are Rwanda, Kenya, Somalia, Ethiopia amongst other. [27] stated that over 70 million humans around the world are faced with hunger due to drought which is a consequent of climate change. Over the years a consistent shift in the climatic and weather conditions in Nigeria and specifically in northern Nigeria has become evident. This could be as a result of the general variability in the global climatic conditions due to global warming. For example, the onset of the rainy season on the average is normally expected to start in Northern Nigeria between late March and April, but the recent weather condition shows a deviation from this trend. As a consequent of this change in the climatic condition of Northern Nigeria some part are now faced with drought. (Figure 7&8) this particularly has consequences for the Nigeria nation as the geographical northern region of the country is where majority of food crops are grown.



Figure 7. Drought affected rice farm in Northern Nigeria



Figure 8. Rice farm affected by drought

Therefore, the susceptibility of rice crop to global

warming has become of key concern with current reality of its importance to the society and the attainment of food security.

3. Climate Change Effect on Wetland Used for Rice Cultivation

All over the world, wetland performs a very important task in the cultivation of rice crop for mankind either for consumption or as source of livelihood. The commonest agro ecosystems wetlands are those used for rice farming. These wetlands are very beneficial to mankind, as they provide habitation to a large range of biodiversity such as fish, insect and amphibians. Wetlands also play a crucial role in conserving the population of water birds [28]. In Asia, several rice farmers also keep fish in their rice farm as an alternative source of income.

In Tanzania for example, rice farming as well as cattle grazing is done widely on wetlands: these wetlands also account for up to 98% of household food that is consumed [29-30]. While the threat to wetland caused by agriculture is recognized, it is also imperative in recognizing the significant of wetlands for agricultural purposes for the cultivation of crops like rice and the rearing of livestock and also fishing in developing countries of the world [30-31].

Wetlands contribute significantly to countries with higher income, for instance, in prairies of Canada, wetlands have been intensely turned to agricultural lands by many farmers for the cultivation of crop [32].

In Nigeria, wetland contributes very significantly to agriculture especially in rice cultivation. This is as a result of the limitation of upland production systems to provide sustainable food security to their population. [33] Studies have shown that the major determinant of the structure as well as the functioning of wetland ecosystem is the degree of change in temperature and the quantity of water available from precipitation. Water is an important driver of wetland ecosystem functions, including the yield from crop, as well as other services that is helpful in supporting mankind. It serves also as the most important source in boosting production of food crops. Although artificial source of water supply is a good method of meeting the gap in water shortage to improve crop yield in most nations of the world, its usage and practice in Nigeria is low compare to other nations. Rainfed agriculture remains the main practice for rice farming and other crop. This is as a result of the dominant method of subsistence agriculture in most parts of Nigeria. Crop output from rainfed farming is still low as a consequence of reduced soil nutrients, high incidence of pests and diseases which is made worse by climate change over time and also the period of minimal

or no precipitation at critical stages of growing when it is mostly needed. Water availability is key to gaining food productivity in wetlands as the functioning of wetlands is affected by changes in both temperature and rainfall. This is because, decomposition in wetlands are closely tied to variation in temperature and rainfall ^[34].

Wetland could become susceptible to climate change as a result of increased potential evapotranspiration due to increased temperature ^[35]. Consequently, these changes in climate variables will have impact on how wetland function and reduced the benefit derived from their usage by mankind for survival especially in the production of food crop like rice. Some ecosystems are more sensitive to climate change compared to others, but in most cases, their ability to withstand this climatic disturbances could be over stretch, which can led to irreversible losses and thereby affect the services its provide to mankind hence, the need to be proactive and provide adequate measures for mitigation should this happen. Changes in water quality and quantity can destroy the physical, chemical as well as biological properties of wetland ^[36-40]. Due to these changes, there will be shortage of water supply to the rivers, deficiency in groundwater, polluted water and sedimentation, brackish and salt water encroachment depletion of soil nutrient from soil erosion ^[41-42]. Since agriculture depend majorly on the hydrologic cycle, cultivation of food crops will be affected significantly by changes in rainfall, soil moisture content and evapotranspiration. Locally, the cultivation of agricultural food crops such as rice is likely to either increase or reduce depending on the climatic condition prevailing in the locality and other human factors. Wetlands in the tropics like Nigeria, depends directly on precipitation hence are likely to be influenced by climate change ^[43]. Therefore, with a hotter and drier climate, there could be a reduction in wetland size or a complete loss. It is necessary therefore, to build resilience to climate change as well as other disturbances when planning for any agricultural year so as not to miss the goal of achieving food security ^[44]. It is imperative that these factors are considered in early planning as change in wetlands affects those who depend on them for livelihood, especially the underprivileged that do not have any other means of survival ^[45].

4. Rice and Climate Change: Implication Food Security

Rice being a very important food grain is used to assess the level of food security in an increasing population of the world and Nigeria is one of these growing population .In Nigeria, rice is consumed by a large number of

the population as scarcity and changes in its price is felt in many homes as has been witnessed in recent times. It has acquired a staple food status as many now depend on it for their calories intake ^[46]. All over the world, rice is among the commonest food crop for mankind, as they feed on it than other crops ^[47]. Presently in Nigeria, different varieties of rice are grown; some are indigenous while others have been introduced into the country. Nigeria has a land area of 923,768 million square kilometres with a total of 71.2 million hectares of farmable land, an estimated 4.6 million hectares is useful for rice cultivation but only about 1.8 million hectares or 39% is presently used for rice cultivation ^[48]. On the Africa continent, Nigeria is the first in rank in the consumption of rice which is due to its large population, largest producer of rice and also the highest in the importation of rice after the Philippines (Figure 9) which is largely due to the importance of rice consumption in the country. The food condition in Nigeria is particularly worrisome as has been seen of recent with a major rise in the price of rice causing untold hardship on the populace. Nigerian farmers generate more income from rice farming than other cash crops. Currently Nigeria is the highest in the production of rice in West Africa, as it produces an average of 3.2 million tons of paddy (2 million tons of milled rice) ^[49]. Rice imported into Nigeria was close to 3 million metric tons in 2008 alone, including 800,000 estimated metric tons that is alleged to have come into the country through illegal route yearly. irrespective of the crude oil boom, agriculture still maintain a strong base in the economy of Nigeria, as its provide income for many Nigerians especially those in rural areas.



Figure 9. A local rice mill in Nigeria

The agricultural sector faces many challenges, ranging from the use of obsolete land tenure methods that deprive farmer from having access to adequate land (1.8 ha/farming household), less use of artificial source of water supply to make up for shortfall in rainfall, non implementation of research recommendation and obsolete machinery,

increase in cost of farm input due to high exchange rate of the Naira to other currency, lack of access to loans, ineffective method adopted in the purchase and distribution of fertilizers to farmers, non availability of adequate storage facilities for farm products and access to good road network connecting farm land to market which has contributed also to the low productivity in agricultural products (average of 1.2 metric tons of cereals/ha) combine with waste and losses suffered after harvest.

Rice produced in Nigeria comes from the middle belts area, States in southeast and also northern part of the country^[50]. Rice is an important food crop that is consumed globally; although it has the capacity to adjust to different climatic condition, but its ability to withstand extreme climatic events will depend on the degree of severity of such events. About 90% of the world’s rice is propagated in tropical, semitropical regions and eaten where they are produced by farmers who work on small scale especially in countries with low income^[51]. Rain-fed lowland rice is the most prevalent rice system practiced in Nigeria, with a sum of over 50% of the entire rice –developing regions in Nigeria; about 30% of rice produced comes from rain fed upland rice, and just about 16% comes from irrigation farming that is high in yield^[52]. In around 25 million hectares of land utilized for development in 2000, for a few food crops classifications, just a little extent of 6.37% was utilized for rice development. Within this period, the yield from national rice produced went up to an average of 1.47 tons for each hectare of land.

An appreciable advancement was made in 1990 with respect to the quantity of rice produced where output from rice production appreciated to 2 million tonnes on the areas where there was cultivation of rice as yield also increased to 550 thousand hectares and 1.98 tonnes for each hectares respectively^[53].

The primary aim of food security is to focus on the ability of every human being to have access to food that

is needed for nourishment and matters that relate to how agricultural policies are formulated, economic wellbeing and trade^[54]. Developing nations of the world like Nigeria are most often faced with malnourishment which is most times associated with not having access to quality food and the inability to effectively distribute available food. That food is available in a country does not necessarily mean that every one that needs it has enough of it. Food security at the level of the individual is when a person either have adequate income to purchase food or they have ability to produce their own food through subsistence cultivation. Food security exists when all individuals consistently have physical and economic admittance to protected and nutritious food which meets their dietary necessities and food inclinations for a functioning and solid life”^[25].

As indicated by^[55], food security is based on three pillars which are

- (1) Food accessibility: adequate amounts of food accessible on a reliable basis.
- (2) Food access: The ability to acquire enough resources to get the necessary food for a healthy nourishment
- (3) Food uses: proper use of food available based on our understanding of basic nourishment and care, in addition to sufficient water and good hygiene

Other effects of climate change on agriculture is that it has the potential to interfere with the economic progress of a nation thereby causing extreme hunger of the populace particularly changes that comes with unfavorable impacts.

5. Relationship between Climate Change and Hunger

Climate change has impact on all areas of the food system (i.e) productivity, availability, quality as well as food system stability. This impact is felt more in countries with high levels of hunger that are also highly vulnerable

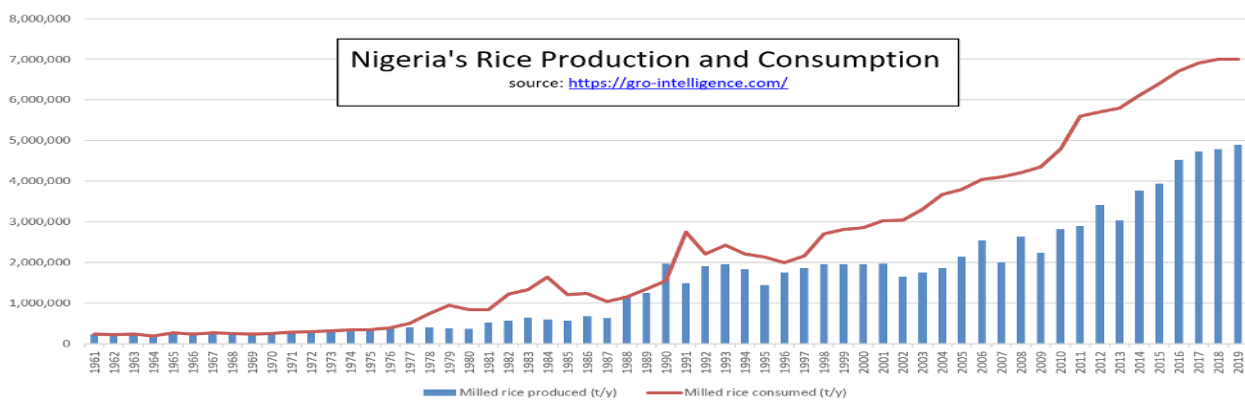


Figure 10. Nigeria’s rice production and consumption from 1961 to 2019

to adverse effects of climate change because they lack the ability to adapt. Climate change poses a danger to the high increase in the number of hungry and malnourished people. Climate models have predicted higher average temperature in most region of land and oceans, hotter extremes in many regions, excessive precipitation and the likely occurrences of drought in some regions which have all created extra threat in reducing hunger. In Nigeria, and indeed the world over, seasons are shifting, temperatures are rising, landscapes are changing and sea levels are rising. Extreme event like drought and flood are becoming more frequent and pronounced. Among the consequences of a changing climate is their impact on agriculture which has lead to the issues of food scarcity resulting to hunger and consequently a volatile population especially with a nation like Nigeria with a very active youth population that is increasing rapidly. In Nigeria, the population has been projected to increase by well over 50 percent in the next two decades^[56]. Within these 20 years, the population of the rural areas is projected to grow by over 25%, while the growth projected for the agricultural sector is expected to increase at a slightly lesser percentage, this is further modify by climate change and inadequate financing of the small scale farmers who form the bulk of farmers.^[57] stated that African countries will suffer the greatest threat occasioned by climate change to agriculture where agricultural yield and production of food per person has been on the decrease and growth of population will increase the need for more food and water in the next 30 years to come. Globally, more than 850 million people do not have adequate food^[58]. This condition is most likely going to be worsen in future as a consequent of climate change, as instability in food supply in many country including Nigeria will rise with just about 2°C increase in temperature (applicable to the 1990 basic standard). With a further increase in global warming of between 2-4°C, universally, agriculture is projected to decline in productivity in the tropics with more destructive effects as crops are most times near their best in the region^[59]. Changes in climate are already causing disruption in the production of major food crops like wheat, rice and maize in tropics and temperate regions and if climate resilience is not built, this condition will be worsen in the coming decades as temperature continue to rise and becomes severe. WHO study in 2018 shows that the number of unhealthy people have the tendency to be greater in countries where exposure to climate change is most severe. Malnutrition is also greater in these countries where exposure to extreme of climate change is high. This condition is also complicated when such population depends largely on agricultural methods that are highly susceptible to climate change. Tempera-

ture anomalies over agricultural lands used for farming has continued to be greater than the long term average throughout 2011-2016, bringing about more persistent spells of severe heat in the last five years. Rainfall pattern and duration is changing, giving rise to early start of raining season or late start and the irregular distribution of rainfall seasons which is a major requirement for farming in Nigeria. The harm from climate variability to agricultural productivity is contributing to the shortage experienced in food crops, and indirectly causing hikes in prices of food crops and losses in income that reduces people ability to get the required food for survival and resulting to food scarcity and consequently famine and undernourishment.

6. Conclusion

Climate change impacts have been linked to food insecurity, malnourishment and hunger. Climate change and its variability affect rainfall occurrences and distribution and consequently changes in agricultural Seasons. The key factor giving rise to hunger and undernourishment in developing countries is the severity of climate change happening in these countries resulting to frequent flooding and droughts. The increasing rate of food scarcity in the world leading to different form of malnutrition is worrisome and more needs to be done in the areas of agriculture to ensure food security and improve on nourishment if a world without hunger is to be achieved by 2030. Therefore, all hands must be on deck to hasten and strengthen the capacity of vulnerable nations like Nigeria to respond swiftly to climate change issues and extremes.

References

- [1] Diagi B.E, Nwagbara M.O. Perceived Impact of Climate Change on Swamp Rice Cultivation by Farmers in Ebonyi State, Southeastern Nigeria Archives of Current Research International, 2018.
DOI:10.9734/ACRI/2018/41176
- [2] Tologbonse EB, Auta SJ, Bidoli TD, Jaliya MM, Onu RO, Issa FO. Farmer's perception of the effects of climate change and coping strategies in three Agro-Ecological Zones of Nigeria. Journal of Agricultural Extension. 2010, 14(1):144-156.
- [3] FAO. Food Security and Agricultural Mitigation in Developing Countries: Options for capturing synergies, 2009.
- [4] Porter JR, Xie L, Challinor AJ, Cochrane K, Howden SM, Iqbal MM, Lobell DB, Travasso MI. Food security and food production systems. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova

- RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL editors. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part a: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press Cambridge, United Kingdom and New York, USA. 2014:485-533.
- [5] Tyubee, T.B. An Analysis of Food Crop Yield and Climate Relates in Benue State, Nigeria. *Journal of Nigerian Meteorological Society*, 2006, 6(1):13-22. DOI:<http://dx.doi.org/10.9790/0837-1314549>
- [6] Olanrewaju, R.M. Climate and Rice Production in a Part of the Niger River Basin Development Authority Area (NRBDA): A Case Study of Edu and Lafiagi Local Government Areas of Kwara State, Nigeria. *Journal of Meteorology and Climate Science*, 2010, 8(2):102-110. DOI:<http://dx.doi.org/10.4172/2157-7617.1000230>
- [7] Sawa, B.A., Adebayo, A.A. Relationship between Dry Spells and Crop Yield in Drought Prone Areas of Northern Nigeria NMets 2011 Conference Proceedings, 2011:502-525. DOI:[http:// dx.doi.org/10.1016/b978-0-444-88912-6.50011-6](http://dx.doi.org/10.1016/b978-0-444-88912-6.50011-6)
- [8] Mohammad, H. Akhadelor M.O., Isiaka, T.S. A Comparative Assessment of the Response of Quality Protein Maize Varieties to Rainfall and Soil in the Sudan and Guinea Savannah. NMets 2011 Conference Proceedings, 2011:444-454. DOI:<http://dx.doi.org/10.1016/j.fcr.2011.01.010>
- [9] Asikhia, M.O., Igbafen M.O. Food Security Implication of Climate Change and Loss of Biodiversity. Book of Proceeding of the 2012 Annual Conference of Nigerian Meteorological Society held at the Department Geography and Regional Planning, University of Benin City, Edo State, 2012:83-90. DOI:<http://dx.doi.org/10.15580/gjss.2012.1.gjss1204>
- [10] Auffhammer, M., Ramanathan, V., Vincent, J.R. Climate Change, the Monsoon, and Rice Yield in India, 2011. Available online at: www.ramanathan.ucsb.edu/files/pr186pdf. DOI:<http://dx.doi.org/10.1007/s10584-011-0208-4>
- [11] Ayinde, O.E., Ojehomon, V.E.T. Daramola, F.S., Falaki, A.A. Evaluation of the Effects of Climate Change on Rice Production in Niger State, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 6, 2013:763-773. DOI:<http://dx.doi.org/10.4314/ejesm.v6i6.7s>
- [12] Besir, K., Ceylan, M. Effect of Climate Change on Rice Production: The Case of Turkey. *Journal of Agricultural Research*, 2013, 8(23):2903-2910. DOI:<http://dx.doi.org/10.3923/ajar.2009.18.27>
- [13] Ugwu, C. Challenges of Rice Production in Nigeria: Punch, 2013, 4th 2014.
- [14] Scharticles. Effects of Climate Change on Rice Production: Project Materials, Term Papers, Thesis for Schools, 2014. Available online at: www.scharticles.com/effects-climate-changericeproduction. DOI:http://dx.doi.org/10.1007/978-3-642-40455-9_84-1
- [15] Chikezie C1, Ibekwe U. C, Ohajianya D. O, Orebiyi J. S, Ehirim N. C, Henri-Ukoha A, Nwaiwu I.U.O, Ajah E. A, Essien U. A, Anthony G., Oshaji I.O. Effect of climate change on food crop production in southeast, Nigeria: a co-integration model approach *International Journal of Weather, Climate Change and Conservation Research*, 2015, 2(1):47-56, March 2015 Published by European Centre for Research Training and Development UK (www.eajournals.org) 47.
- [16] Intergovernmental panel on climate change (IPCC) Impact, Adaptation and vulnerability. Contribution of Working Group 1 of the intergovernmental panel on climate change to the Third Assessment Report of IPCC. London : Cambridge University Press, 2007.
- [17] Uba, G. Nigeria: Investing in Rice Processing Project. This Day, 15th Jan, 2013. DOI:<http://dx.doi.org/10.1109/epe.2013.6634733>
- [18] IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 2014:151.
- [19] Horie, T., Centeno, H. G. S., Nakagawa, H., Matsui, T. Effect of elevated carbon dioxide and climate change on rice production in East and Southeast Asia. In Y. Oshima (Ed.), *Proceedings of the International Scientific Symposium on Asian Paddy Fields Saskatchewan: University of Saskatchewan*, 1997:59-58.
- [20] F. Tao, Yokozawa, M., Xu, Y., Hayashi, Y., Z. Zhang. Climate changes and trends in phenology and yields of field crops in China, 1981-2000. *Agricultural and Forest Meteorology*, 2006, 138, 82–92. <https://doi.org/10.1016/j.agrformet.2006.03.014>
- [21] S. Peng, et al. “Rice yields decline with higher night temperature from global warming”, *Proceedings of the National Academy of Sciences of the United States of America*, 2004, 101(27):9971-9975.
- [22] Suzan A. Diagi B.E, Peace N. Climate Change Anomalies and its prospects on Agriculture in Cross Rivers State. A Paper presented at the 32nd Annual international conference of the Nigerian Meteorological Society, Held at the Federal University of Tech-

- nology Akure, December 1-4, 2019.
- [23] Odekunle, T.O. Rainfall and length of the growing season in Nigeria. *International Journal of Climatology*, 2004, 24, 467-479.
- [24] Umar, A.T. Recent Trends and Variability in the Length of the Growing Season in Northern Nigeria. *Journal of Meteorology & Climate Science*, 2010, 8(1):40-52.
- [25] Global hunger and food security after the World Food Summit. ODI Briefing Paper. London: Overseas Development Institute, 1997, 1,
- [26] FAO, UNICEF, IFAD, WFP WHO. part of the tracking progress towards sustainable development goal 2-zero hunger, 2018.
- [27] Famine Early Warning Systems Network (FEWS NET). Retrieved from <http://www.fews.net/global/alert/January-25-2017>. accessed 29/6/2017
- [28] Matsuno, Y.; Ko, H.S.; Tan, C.H.; Barker, R.; Levine, G. Accounting of agricultural and nonagricultural impacts of irrigation and drainage systems: A study of multifunctionality in rice, 2002. IWMI working paper 43. Colombo, Sri Lanka: IWMI. 36p.
- [29] McCartney, M.P., van Koppen, B. Wetland contributions to livelihoods in United Republic of Tanzania. Food and Agriculture Organisation of the United Nations (FAO) Netherlands Partnership Programme: Sustainable Development and Management of Wetlands. Rome, 2004.
- [30] McCartney, M., Smakhtin, V. Water storage in an era of climate change: addressing the challenge of increasing rainfall variability. IWMI Blue Paper. Colombo: International Water Management Institute, 2010.
- [31] Wood, A., van Halsema, G.E. Scoping agriculture-wetland interactions. Towards a sustainable multiple response strategy. FAO Water reports 33. Rome: Food and Agriculture Organization of the United Nations, 2008. <http://www.fao.org/nr/water/docs/WaterReports33.pdf>
- [32] Canada's fourth national report to the CBD Canadian Wetland Inventory, (<http://www.ducks.ca/cwi/>)
- [33] FAO. Sustainability issues in agricultural and rural development policies. Trainer's Manual, Vol. 1. Rome: Food and Agriculture Organization of the United Nations, 1995.
- [34] Brinson, M.M., Logo, A.E., Brown, S. "Primary Productivity, Decomposition and Consumer Activity in Freshwater Wetlands." *Annual Review of Ecological Systematic*, 1981, 12, 123-161.
- [35] Bardeckil, M.J. Wetlands and Climate Change: A Speculative Review. *Canadian Water Resources Journal*, 1991, 16(1):9-22.
- [36] Alegria, H., Bidleman, T.F., Figueroa, M.S. Organochlorine pesticides in the ambient air of Chiapas, Mexico. *Environmental Pollution*, 2006, 140(3):483-491. <http://dx.doi.org/10.1016/j.envpol.2005.08.007>
- [37] T.H. Tuan, M.V. Xuan, Do Nam, Navrud, S. Valuing direct use values of wetlands: A case study of Tam Giang-Cau Hai lagoon wetland in Vietnam. *Ocean & Coastal Management*, 2009, 52(2):102-112. <http://dx.doi.org/10.1016/j.ocecoaman.2008.10.011>
- [38] Dong-Oh Cho. The evolution and resolution of conflicts on Saemangeum Reclamation Project. *Ocean & Coastal Management*, 2002, 50(11.12):930-944. <http://dx.doi.org/10.1016/j.ocecoaman.2007.02.005>
- [39] Gregory, P.J., Ingram, J.S.I., Andersson, R., Betts, R.A., Brovkin, V., Chase, T.N., Grace, P.R., Gray, A.J., Hamilton, N., Hardy, T.B., Howden, S.M., Jenkins, A., Meybeck, M., Olsson, M., Ortiz-Monasterio, I., Palm, C., Payn, T.W., Rummukainen, M., Schulze, R.E., Thiem, M., Valentin, C., Wilkinson, M.J. Environmental consequences of alternative practices for intensifying crop production. *Agriculture, Ecosystems & Environment*, 2002, 88(3):279-290. [http://dx.doi.org/10.1016/S0167-8809\(01\)00263-8](http://dx.doi.org/10.1016/S0167-8809(01)00263-8)
- [40] UNEP. People and forest: forest destruction fuels East Africa's drought .Nairobi: United Nations Environment Program, 2006b. <http://www.peopleandplanet.net/?lid=28180&topic=23§ion=32>
- [41] Dugan P, Sugunan V.V., Welcomme R.L., Bene C., Brummett R.E., Beveridge M.C.M. et al. Inland fisheries and aquaculture. In: CA. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Earthscan, London, and International Water Management Institute, Colombo, 2007, 459-483. <http://www.iwmi.cgiar.org/assessment/Publications/books.htm>
- [42] Atapattu, S.S., Kodituwakku, D.C. Agriculture in South Asia and its implications on downstream health and sustainability: A review. *Agricultural Water Management*, 2009, 96(3): 361-373. <http://dx.doi.org/10.1016/j.agwat.2008.09.028>
- [43] Haya, D., Brook, L., Aramde, F. Aspect of climate change and its associated impacts on wetland ecosystem functions. *Journal of American Science* 2012, 8(10).
- [44] FAO. Global Agriculture towards 2050. High Level Expert Forum- How to Feed the World in 2050. HLEF2050 Issues briefs, 2009b. <http://www.fao.org/wsfs/forum2050/wsfs-forum/en/>
- [45] Falkenmark, M. Finlayson, M., Gordon, L. Agriculture, water and ecosystems: avoiding the costs of going too far. In D. Molden (ed) *Water for Food, Water*

- for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute, 2007.
- [46] Akpokodje, G., Lancon, F., Erenstein, O. Nigerian rice Economy: State of the art the Nigerian rice economy in a competitive World: constraints opportunities and Strategies Choices. WARDA Bouake Cote d'ivoire, 2001.
- [47] Maclean JL, Dawe DC. Rice almanac: Source book for the most important economic activity on earth, CABI Publishing, UK, 2002.
- [48] Federal government of Nigeria national rice development strategy (NRDS) federal republic of Nigeria. Prepared for the Coalition for African Rice Development (CARD), 2009.
- [49] Damola, A.A. Sector strategies and policies related to rice development in Nigeria Mapping of Poverty Reduction Strategies Papers (PRSP), 2010.
- [50] Audu, S.I. "Analysis of cost and return of rice production in Ankpa Local Government Area of Kogi State, Nigeria." Proceedings of the 42nd Annual Conference of ASN, held at EBSU, Abakaliki, October 19-23rd, 2008, 768.
- [51] FAO/NRCB. Poster presented at the International Conference on Food Security and Environmental Change, 24 April 2008. Oxford, UK, 2008.
- [52] Rice Data System in Nigeria. This day live (2012). www.thisdaylive.com/articles/Nigeria, 2012.
- [53] Akande, T. "An overview of the Nigeria's Rice Economy." Nigerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria, 2002, 1-11.
- [54] Garwe, D Intellectual Property Rights and Food Security. Regional Status Report on Trade and Development, Agro biodiversity and Food Sovereignty. Harare. CTDI Publication, 2008, 26-50
- [55] UN-HLTF. Food and Nutrition Security for All through Sustainable Agriculture and Food Systems. 14 March 2012. WHO (forthcoming). Global Nutrition Policy Review. Forthcoming. Geneva. WHO online. Health Topics: Nutrition, 2012. Available at: <http://www.who.int/topics/nutrition/en/>
- [56] FAO. Farming systems and Poverty: Improving farmers' livelihoods in a Challenging world. FAO, Rome, Italy, 2001.
- [57] Davidson, O., Halsnaes, K., Huq, S., Kok, M., Metz, B., Sokona, Y., Verhagen, J. The development and climate nexus: the case of sub Saharan Africa, Climate Policy, 3S1: S97-S113, 2003.
- [58] German Advisory Council on Global Change (WBGU). World in Transition: Climate Change as a Security Risk. Berlin, Germany, WBGU, 2007, 13.
- [59] German Advisory Council on Global Change (WBGU). Climate Protection Strategies for the 21st Century: Kyoto and beyond. Special Report. Berlin, Germany, 2003.