ASPECTS OF CLIMATE CHANGE AND RESOURCE CONFLICTS IN THE NIGERIAN SAVANNAH

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Abstract

This study analyses the pattern of rainfall anomalies and its relation with ecosystems changes and vulnerability of rural communities in the Nigeria Savannah. 60-year observed rainfall data for 22 stations over the Savannah was analyzed for spatial and temporal anomalies. Ecosystems change analysis was done using 19-year two-time landcover data. A simplified vulnerability index using multicriteria analysis was developed for about 750 communities using ecological zone, settlement status, administrative status, and the degree to which communities are tied to the land as candidate variables.

Results obtained showed that the 60-year long term annual mean and standard deviation for the Nigeria Savannah are 942mm and 270mm respectively. Correspondingly, the long term decadal mean and standard deviation are 976mm and 75mm respectively. The spatial pattern shows very high negative anomaly over the Sahel fringes and upper Sudan zones and high positive anomalies around the Guinea zones which reduce towards the lower Sudan zone. The influence of local perturbations is captured by the localized high positive anomaly around the highlands and very high negative anomalies around the inland basins. All the 4 stations in the Sahel zone and 6 in the upper Sudan zones recorded negative standardized rainfall. The temporal anomaly shows that the decades 1970s and 1980s are the driest in the Savannah over the last 60 years. Results from landcover and ecosystems changes indicate that general agricultural landuse increased by 20% between 1976 and 1995. In specifics, agricultural tree and crop production decreased by 30%, while rainfed arable crop production, extensive small holder rainfed agriculture with denuded areas, and extensive grazing areas increased by about 8000%, 129%, and 13% respectively. Water impoundments (reservoir and dams) increased by 115% and floodplain agriculture and irrigation agriculture increased by 110% and 572% respectively. Grassland increased by 121%, wood and shrublands decreased by about 37%, forest reduced by 17%, and aeolian sands and gullies increased about 428% and 15,000%. 231 of the sampled communities (23 in the Sahel zone and 208 in the Sudan zone) fall under the high vulnerability category. The spatial pattern of vulnerability of the communities to climate change and its effects clearly confirms that the trajectory of resource conflict in the Nigeria Savannah is towards the south of the Sudan zone. The paper also suggested necessary adaptation strategies to combat long-term implications of climate change in the Savannah.

1. INTRODUCTION AND STATEMENT OF PROBLEM

From the sophisticated megalopolis of the developed to the simple, poor, dotted villages and rural country sides of the less developed countries, the climate change story is becoming real by the day because of compelling evidences from its impacts. The risk of global climate change is associated with high probability of occurrence and well known damage potential, but with a time lag between trigger and consequence which often creates a fallacious impression of security (German Advisory Council on Global Change, 2000), and until recently, climate was generally taken for granted with little thought that the climate could be a problem with severe impacts (Ojo, 1987). The recently released summary for policy makers (SPM) of the Intergovernmental Panel of Climate Change Fourth Assessment Report (IPCC-AR4) by the Working Group 1 noted that "11 of the last 12 years (1995 -2006) rank among the 12 warmest years in the instrumental record of global surface temperature since 1850, the updated 100-year linear trend (1906–2005) of 0.74 [0.56 to0.92]°C is therefore larger than the corresponding trend of 0.6 [0.4 to 0.8]°C for 1901-2000 given in the Third Assessment Report(TAR). The linear warming trend over the last 50 years (0.13 [0.10 to 0.16]°C per decade) is nearly twice that for the last 100 years, and the total temperature increase from 1850 – 1899 to 2001 – 2005 is 0.76 [0.57 to 0.95]°C (www.ipcc.ch).

If these direct observation records and future projections from the various global and regional climate models are anything to go by, then more serious and focused attention must be paid to global climate and environmental change issues.

Africa is particularly vulnerable to the direct consequences of climate change because of poor preparedness for the effects of climate change poor and harsh socio-economic conditions on ground that have considerably diminished the resilience of the population. The Sahel region of Africa is highly vulnerable probably due to its proximity to the Sahara, large scale ocean changes and local desertification. Over the years, increased temperature and reduced rainfall has been the trend over the Sahel. A severe drought (which resulted in loss of many human lives, livelihoods, and livestock) was observed in the Sahel in the late 20th century (Ramaswamy, 2007; Adefolalu, 2006; Ojo, 1987). The Sahelian drought has not only created a difficult situation for the inhabitants of the region, but it has also thrown up new challenges in other ecological zones of Africa. The climatic-future appears very bleak because according to Ramaswamy (2007), results from the coupled models using estimates of historical forcings by scientists at Geophysical Fluid Dynamics Laboratory (GFDL) indicated that the Sahel gets drier in future scenarios.

Generally, rainfall is a prime factor of agriculture in Africa, and change in rainfall quantity and regime is a strong index of climate and climatic variability and a critical limiting factor to human survival in Africa. The effects of diminishing rainfall in the Sahel is leading to ecosystems perturbation, landuse pressure and land resource conflicts among social groups in the adjoining ecological zones such as currently being experienced in the Savannah region of Nigeria. In recent times, the certainty of climate change manifested in the different obvious ways in which both the urban and rural dwellers in the Savannah are being affected is making the people to exercise local adjustments and coping strategies. The herdsmen of the Sahel and upper Sudan zones appear to be moving permanently into the lower Sudan and Guinea Savannah zones (Fig1)

The rainforest zone of the south is increasingly being opened-up for tuber and cereal crop cultivation. The climatic limit of cultivation appears to be expanding for some crops and contracting for others. For example, the area of the southern rainforest zone devoted to cocoa cultivation (a major cash crop in Nigeria) appears to be

Fig 1: Herds roaming permanently in the Guinea Savannah

shrinking as some of the lands that used to be cocoa plantations are now devoted to yam and cassava cultivation. These are some of the observed impacts and evidences of climate change at regional, local and communal levels in Nigeria which in turn have implications for natural resource management, food security, and long-term economic development of the nation.

2. AIM AND OBJECTIVES

Although the regional climate models have improved our understanding of the dynamics and effects of the climatic forcings better than the global climate models, they have not been able to provide insights into the vulnerability of people to the climatic variability and the struggle to cope with the effects at local levels. The global chain-effects of macro and regional climate variability may not give clue to how climate and environmental change affects human livelihoods, human well-being, and the struggle for diminishing resources among social groups at local and communal levels. The anomalies in climatic elements, especially rainfall and temperature, and their resultant strong ecological perturbations have increased the risk and vulnerability of rural communities in the Savannah. The aim of this study is to analyze the pattern of rainfall anomaly and correlate this with ecosystems changes to determine the degree of vulnerability of some rural communities in the Savannah region of Nigeria to the effects of climate change.

The specific objectives are:

- To analyze the rainfall data over the Nigerian savannah and assess the rainfall anomaly over a 60-year period
- To conduct ecosystems change analysis over a 19 year period and correlate the pattern and magnitude of observed changes with the pattern of rainfall anomaly
- To conduct a simplified vulnerability assessment of some communities in the Savannah and correlate resulting vulnerability pattern with the pattern of rainfall anomaly and ecosystems change trajectory.

3. THE STUDY AREA

The Nigerian Savannah (roughly from Lat. $7^0 45^1$N to 14^0 N) straddles the entire longitudinal extent of Nigeria (Figure 2). The Savannah covers about 80% of Nigeria's landmass and is roughly divided into the Guinea, Sudan and Sahel ecologies with zonal transition following increasing latitude. The Guinea Savannah zone stretches from around Lat. $7^0 45^1$ N to 10^0N, the Sudan Savannah zone runs roughly between Lat. 10^0N to 12^0N, and the Sahel zone is found in areas above Lat. 12^0N.

Rainfall is perhaps the most important climatic characteristic which distinguishes the different zones of the Savannah. The onset and cessation of the rains in the Savannah, like in the other parts of Nigeria, is controlled by the movement of the inter-tropical convergence zone (ITCZ) over Nigeria. In the months April to September when the ITCZ moves across Nigeria into the Sahel (North of Lat. 15^0), the Savannah falls under the influence of the moist tropical maritime airmass (African monsoon wind) from the Atlantic and the region receives rainfall. As the ITCZ moves down south in October to February, the influence of the maritime air mass over the Savannah is replaced with that of the dry, dust-laden tropical continental air mass from the Sahara, and there is a progressive decrease in rainfall from the Sahel to the Guinea Savannah.

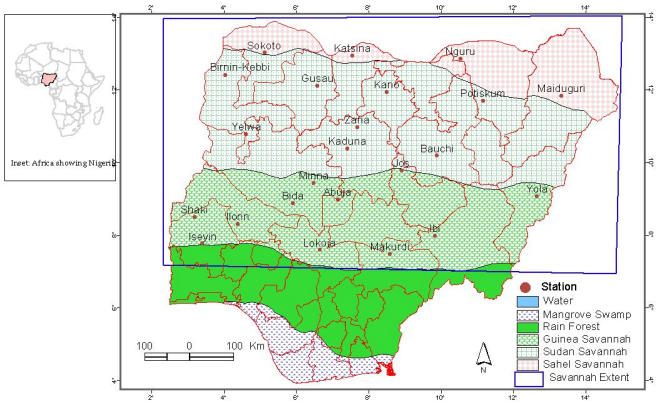


Figure 2: Generalized Ecological Regions of Nigeria

Generally, mean annual rainfall in the Savannah is between 700mm and 1500mm and it decreases with increase in latitude with exceptions in few areas with local orographic perturbations. The mean annual rainfall is between 1200mm and 1500mm in the Guinea zone, 760mm-1020mm in the Sudan zone, and 380mm-700mm in the Sahel. Mean daily relative humidity and number of rainy days also decreased from the Guinea to the Sahel. Mean annual temperature is around 27^0c to 29^0c with a general rise with increasing latitudes. The only exceptions are in some small areas with strong orographic influences where the temperature is considerably lower than the surrounding areas.

The Savannah region of Nigeria is densely populated. It is dotted with many administrative, commercial and service urban centers. However, a large percentage of the population lives in scattered rural settlements and villages. Inhabitants of these rural communities depend entirely on land resources from the Savannah for livelihood, and agriculture is the main human activity. The Guinea and lower Sudan zones of the Savannah represent the crop cultivation zone. Tubers and cereals are the main crops and the inhabitants are sedentary cultivators. Animal rearing in these zones is intensive and localized. The Guinea Savannah zone (which is a transition from the southern rainforest) is regarded as the food basket of the Nigeria. It is a zone of rainfed agriculture and extensive small holder crop cultivation. A large percentage of the root and tuber food crops transported into cities and urban centers all over Nigeria originate from this zone. The lower part of the Sudan zone also produces cereals in large quantity which is distributed to urban centers across the nation.

The upper Sudan and the Sahel zones represent the zone of extensive grazing. Crop cultivation is restricted mainly to the river val-

leys, alluvial flood plains, inland wetlands and depressions (Fadamas) and irrigated lands. Because the time between the onset and cessation of the rains is very short in this zone, long range transhumance is practiced. Prior to the sahel drought of the 1980s, the nomadic herdsmen set out towards the lower Sudan and Guinea zones of the Savannah for greener pastures for their herds as soon as the dry period sets-in in the Sahel. This trans-humance is completed by a return journey to the upper-Sudan and Sahel zones at the on-set of the rainy season. Things appeared to have changed now as so many nomadic herdsmen have relocated their animals permanently into the southern guinea savannah and rain forest ecologies. This has increased the struggle and strife for diminishing resources among the northern invading herdsmen and the sedentary cultivators of the guinea and rainforest zones with its attendant effects on human security, livelihoods and ecological degradation.

4. METHODOLOGY

Data for this study consists of historical monthly rainfall records obtained from the Nigerian Meteorological Agency and multi-temporal landcover data obtained from the archive of the Department of Geography, University of Lagos. Digital spatial-administrative data and limited socio-economic attributes of about 750 communities in the Savannah were collated from different sources. The characteristics of the data utilized are shown on Table 1.

Table 1: Data and data sources

S/n	Data	Year	Source
1	Monthly Rainfall data over 22 stations in the Savannah	1940-2000	Nigerian Meteorological Agency
2	Multi-temporal Landuse/Landcover data for the Savannah region	1976 &1995	Archive of the Department of Geography, University of Lagos
3	Spatial data and attribute data on communities		Topographic base maps, Nigerian abstracts of statistics, Department of Geography, literatures

Historical Monthly rainfall data for 60 years (1940-2000) for 22 stations over the Savannah was collated and summarized for long-term mean, monthly and decadal means, and standard deviation. Rainfall index (standardized rainfall values) was calculated for each station. The spatial and temporal long term rainfall anomaly was computed for each station and for the 6 decades. Using GIS, the computed values for long-term mean and long-term rainfall anomaly (for each station) were converted into rainfall surfaces using the tools of geographic information systems (GIS).

Multi-temporal ecological/landcover data for the years 1976 and 1995 were accessed and analyzed and within GIS to generate landcover changes. The result of the change analysis was cross-tabulated to produce the perspectives, extent, rate and trajectory of change in the light of changing climate scenarios.

To present the climate change, ecological change, resource conflicts and vulnerability perspectives, about 750 settlements across the Nigeria Savannah were digitized from existing base maps. Limited attributes including names, settlement status (urban, semi-urban, rural), administrative status (Federal/State capital, Local Government Area headquarters, others), ecological zones where a community is located, and the major occupation of inhabitants (service/commercial/government, mixed, and peasant agriculture) were generated and digitally attached to each settlement. A simple multi-criteria analysis was used to allocate weights/scores to the different attributes of communities (Table 2) to create a simplified vulnerability index to climate change and its diminishing land resources impacts for each of the community.

The maximum obtainable score is 65 and the minimum is 20 (difference of 45). It is considered that a score of 45 (and above) is classified as low vulnerability (which indicates that the livelihoods of the inhabitants are not directly tied to primary production or land resources). Correspondingly, 30-44 is categorized as medium vulnerability (inhabitants depends on secondary and tertiary sectors as well as primary production from land resources for livelihoods), and less than 30 is categorized as high vulnerability (livelihoods of inhabitants completely tied to the land).

Table 2: Candidate variables for constructing simplified vulnerability index for communities

Variables	Attributes	Total score	Score obtained
Ecology	Rainforest Guinea zone Sudan zone Sahel zone	50	20 15 10 5
Settlement status	Urban Semi-urban Rural	30	15 10 5
Administrative status	Federal/State Capitals LGA Headquarters No status	30	15 10 5
Major occupation	Tertiary and secondary - Government/service/commerce Mixed – primary & secondary Primary – agric and natural resource based	30	15 10 5

5. RESULTS AND DISCUSSIONS

5.1 Rainfall pattern and rainfall anomaly over the Savannah

5.1.1 Spatial anomaly of rainfall

The long term mean and standard deviation of rainfall values for the 22 stations over the 60-year period is 942mm and 270mm respectively. The long term decadal mean and the standard deviation over the 6 decades are 976mm and 75mm respectively. Figure 3 presents rainfall isohyets constructed from the mean rainfall for each station over the 60 year period and Figure 4 presents the spatial anomaly of rainfall over the Savannah.

The average rainfall values decrease from Guinea zone to the Sahel zone. The highest value (1200mm) is recorded around Iseyin and Lokoja in the Guinea zone while the lowest value (450mm) is recorded around Nguru in the Sahel. The effect of local orographic perturbations is also very clear in the areas around Jos plateau (in the lower Sudan zone) where the average rainfall (1200mm-1250mm) is the highest in the Savannah region of Nigeria. The inland basins around Sokoto, Katsina, Maiduguri and Nguru displays lower aver-

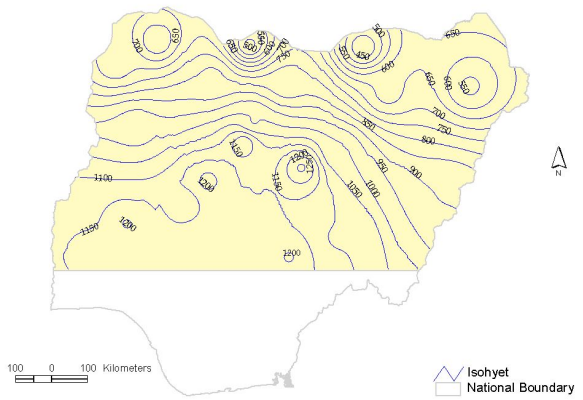


Fig 3: Rainfall isohyets

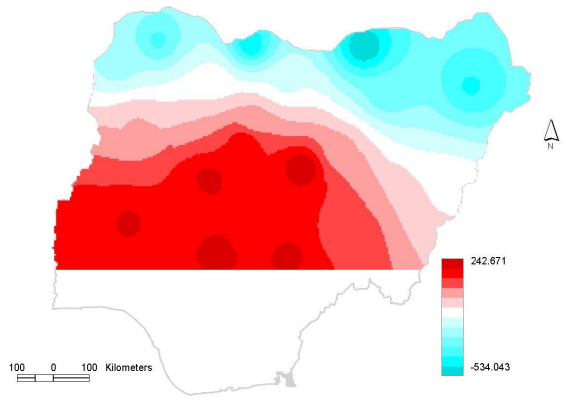


Fig 4: Spatial anomaly of rainfall over the Nigerian Savannah

age rainfall than the surroundings. This is also consistent with the constructed spatial anomaly of rainfall. Very high negative rainfall anomaly is recorded over the Sahel and upper Sudan zones. Correspondingly, high positive anomaly is recorded over the Guinea zone. The influence of local perturbations (highlands and inland basins) is once again captured by the localized high positive anomaly around the highlands and very high negative anomaly around the inland basins.

An insight into the magnitude of diminishing rainfall over the Savannah is presented on Table 3 and Fig 5 which show the long-term standardized rainfall values for each station. 10 stations recorded negative long-term standardized rainfall values. These include all the 4 stations in the Sahel zone (Sokoto, Katsina, Nguru and Maiduguri) and 6 other stations (Birni-Kebbi, Gusau, Kano, Yola, Potiskum and Gusau) which are located within the upper part of the Sudan zone. Judging from the magnitude of negative anomaly of the stations in the Sahel zone, it is clear that this zone is facing severe rainfall deficiency. This has indeed impacted seriously on the ecosystems, water resources, agricultural activities and other human activities within the regions as will be discussed in the next section. In all, no station in the Guinea and lower Sudan zones of the Savannah recorded negative index value, while Nguru, Katsina and Maiduguri in that order recorded the highest negative rainfall anomaly.

This suggests serious decline in the carrying capacity of the Sahel and the lower Sudan ecologies which calls to question the ability of these ecological zones to continue to support human and animal populations without necessary intervention and adaptation strategies.

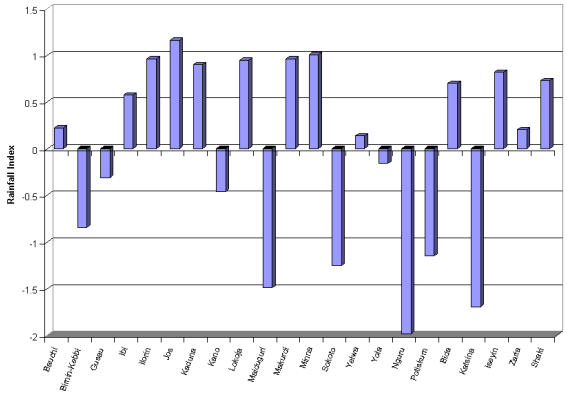


Fig 5: Standardized rainfall index for stations in the Nigeria Savannah

There is high uncertainty about how successful the local response and coping strategies have been and for how long the local dwellers can tenaciously carry-on. It is however obvious that some forms of climatic adaptation strategies which are lacking, at present, need to be urgently considered and introduced.

5.1.2 Temporal anomaly of rainfall

Figure 6 shows the calculated long-term standardized rainfall index (temporal anomaly) for the 6 decades 1940-2000.

The decades 1970s and 1980s are the two driest decades in the Savannah over the last 60 years. This is consistent with what has been observed and reported over the Africa Sahel zone (Ramaswamy, 2007. Desiccation of water sources, loss of lives, livelihoods and livestock, and other effects of the droughts of 1970s and 1980s in the Nigeria Savannah have been reported in literatures (Adefolalu, 2006; Ojo, 1987). Incidentally, the decade 1980s is the beginning of a marked variation in the behavioral pattern of transhumance by the Fulani herdsmen of the Sahel and upper Sudan zones. It also marked a positive increase in resource conflicts and agrarian landuse change in the Savannah. Although, the rainfall situation improved in the 1990s as shown on Figure 6, the increased rainfall was accompanied by rising temperature perhaps more than in any previous decades. Realities on ground, therefore, suggest that the increased rainfall of the 1990s has not been significant enough to reverse the permanent down-south shift of activities by the Sahel and lower Sudan nomads to the lower Sudan and Guinea zones of the Savannah which was set in motion by the drought of the previous decade.

Table 3: Standardized rainfall index for the Nigeria Savannah

S/n	Station	index value		S/n	Station	index value
1	Bauchi	0.22		12	Minna	1.01
2	Birnin-Kebbi	-0.84		13	Sokoto	-1.25
3	Gusau	-0.31		14	Yelwa	0.14
4	Ibi	0.57		15	Yola	-0.16
5	Ilorin	0.96		16	Nguru	-1.98
6	Jos	1.16		17	Potiskum	-1.15
7	Kaduna	0.90		18	Bida	0.70
8	Kano	-0.46		19	Katsina	-1.69
9	Lokoja	0.95		20	Iseyin	0.82
10	Maiduguri	-1.49		21	Zaria	0.21
11	Makurdi	0.96		22	Shaki	0.73

5.2 Ecosystems Perturbation and Change

Ecosystems are the most important resources of the Savannah on which the livelihoods of many of the rural inhabitants depend. Hence ecosystems change is perhaps the most visible effect of global climate change in the Nigeria Savannah. Its effects are all pervasive. Apart from the fact that ecosystems changes are central to global environmental change processes, they also significantly affect livelihoods of Savannah dwellers and thereby determine the spatial pattern of natural resources loss, trajectories of eco-migration, and land resource pressure and conflicts. The relationship between climate variability and human impacts, especially in the Savannah, is a vicious cycle. Decreased rainfall in the Savannah constrains human activities and thereby induces land degradation and loss of prime agricultural lands through synergistic effects of natural processes and human pressures on the land. This in turn exacerbates global climate change and its effects. Thus every year the intensity and effect of climate variability increases, pressure on available land resources increases, land degradation and resource loss increases, and the intensity of the forcings of climate variability also increases.

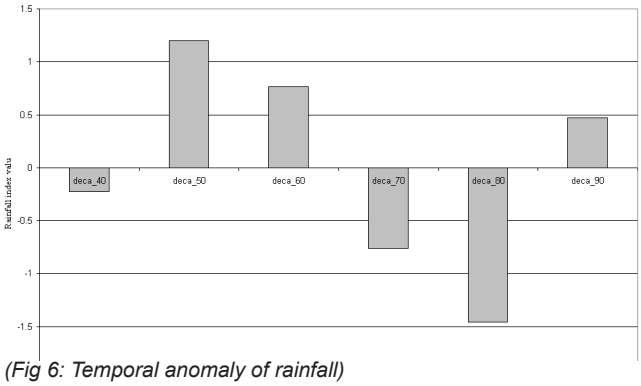
Table 4 summarizes the analysis of data on ecosystems change and ecological response to the impact of climate variability over the Savannah within a 19 year period (1976-1995).

The implications of climate change on ecosystems as well the implications of ecosystems changes on the environment and key human activities in the Savannah are summarized in the following discussions.

5.2.1 Agriculture

Agriculture is the major human activity in the Savannah, and it depends almost entirely on rainfall. Agriculture types and areas in the Savannah consist of agricultural tree and rainfed arable crop production of the Guinea Savannah, extensive small holder rainfed agriculture of the lower Sudan zone, intensive small holder rainfed agriculture with minor grazing of the upper Sudan zone, and extensive grazing with very little small-holder rainfed agriculture of the Sahel zone. Others include localized floodplain agriculture or Fadamas, irrigation projects or equipped wetlands and livestock projects.

Generally, between 1976 and 1995, the total area devoted to agriculture increased by about 20% which indicate about 1% annual growth. Specifically, while agricultural tree and crop production in the Guinea zone decreased by about 30%, rainfed arable crop production, extensive small holder rainfed agriculture with denuded areas, and extensive grazing areas increased by about 8000%, 129%, and 13% respectively. The decrease in the Guinea zone localized agriculture types which are balanced by the increase in Sudan and



(Fig 6: Temporal anomaly of rainfall)

Sahel agriculture types is a clear indication of extension of the Sahel and Sudan agriculture types to the Guinea zone. This clearly suggests effects of diminishing rainfall and by implication, effects of climate change and variability. The magnitude of influence exerted by population pressure on diminishing agricultural lands is indicated by the 117% increase in the area mapped as human settlements, which by extension led to 110% increase in floodplain agriculture (Fadamas) and 572% rise in irrigation agriculture.

5.2.2 Water resources and Wetlands

Water resource is a strong limiting factor of human habitation and livestock agriculture in the Savannah. Generally, within the period under review, areas mapped as water increased by about 47% over the 1976 extent. Specifically, the implication of climate change and human response to it is clear from the increase in the extent of water impoundments (reservoir and dams) which increased by 115% i.e. 6% per annum. This increase in water impoundment is also positively correlated with increase in Fadamas and irrigation agriculture. This shows human responses and adjustments to diminishing water resources in the Savannah. Increase in irrigation and floodplain agriculture as well as water impoundments is in turn leading to loss of natural wetlands. Within the period under review, natural wetlands decreased by about 52%. This is very significant because the biodiversity of these wetlands will be negatively impacted.

5.2.3 Grasslands and Woodlands

Green pastures and grasslands are important for livestock (animal) farming in the Savannah. Intensive fodders, feedlots and

Table 4: Ecosystems changes in the Savannah (1976-1995)

Sn	Ecological Classes	Coverage (km2) in 1976	Coverage (km2) in 1995	Change (km2) 1976-1995	Change (as % of 1976)	Change per annum (%)
1	Urban	1,250.03	2,724.40	1,474.37	117.95	6.21
2	Agriculture	403,870.26	483,739.62	79,869.36	19.78	1.04
3	Grassland	8,723.50	19,310.63	10,587.13	121.36	6.39
4	Woodlands/shrubs/tall grasses	277,635.71	175,212.50	-102,423.21	-36.89	-1.94
5	Forest/plantation	20,923.38	17,377.63	-3,545.75	-16.95	-0.89
6	Wetland	22,354.16	10,815.20	-11,538.96	-51.62	-2.72
7	Water	4,370.15	6,400.53	2,030.39	46.46	2.45
8	Sand/rock/gullies/mines	2,995.63	26,610.47	23,614.84	788.31	41.49

equipped grasslands are not available. Animals are moved from place to place in search of greener pastures virtually everyday. Generally, grassland increased by about 121% over the 19 year period. Although the increase in the area of grassland translates into increased grazing lands for animals, it also implies increased desiccation of former wood and shrub lands of the Guinea and lower Sudan zones of the Savannah. The implication is that the woodlands and shrublands of the southern Guinea forests are transiting to grassland at a rate of about 6% annually. This is a serious problem, because it is an indication of loss of resilience and stability by the Guinea zone ecosystems. This is also correlated with a 37% decrease in the extent of the wood and shrublands of the lower Sudan and Guinea zones. This strongly suggests that the lower zones of the savannah too are getting drier.

5.2.4 Forest and Plantation

Forests similar to those present in the southern rainforest zones are found in some parts of the lower Guinea zone of the Savannah. Galleria forests are found around wetlands and along river courses both in the Sudan and Sahel zones. Montane forests are also found in areas where local mountain perturbations produce orographic effects which significantly altered the vegetation. Forest plantations are mitigation responses to climate change effects. Trees are planted to act as shelter-belts and wind-breaks especially in the Sahel zone. In general, the area of forest reduced by about 17% (about 0.89% per annum) during the period under investigation. In specific terms, disturbed forests increased by 292%, undisturbed forests reduced by 90%, riparian and Montane forests reduced by 14% and 3% respectively, while forest plantation increased by about 213%.

5.2.5 Sand/rocks/gullies/mines

Another incontrovertible evidence of increased desiccation of the Sahel and by implication, the down-south march of the Sahara is the increase in areas covered by sand dunes. Reduced rainfall with its attendant pressure on land both for grazing and crop cultivation is also increasing the extent of exposed lands that are susceptible to soil degradation. In specific terms, area covered by Aeolian sand and gullies increased about 428% and 15,000% respectively, while fertile alluvial soils reduced by 41% during the period under review.

5.3 Climate change, human vulnerability and trajectory of resource conflicts

The discussions provided under rainfall anomaly have established strong signals of declining rainfall over the Savannah. Evidences from ecosystems change and diminishing natural resources have also established that the trajectory of landuse pressure and consequently, resource conflicts, is towards the lower Sudan and Guinea zones. If this trend of climatic variability and loss of natural resources is to be taken seriously, then existing adjustments and coping strategies of the rural communities in the Savannah may soon be outstripped. Hence, focused studies on climatic adaptation in the Savannah are urgently needed now to prevent future disaster.

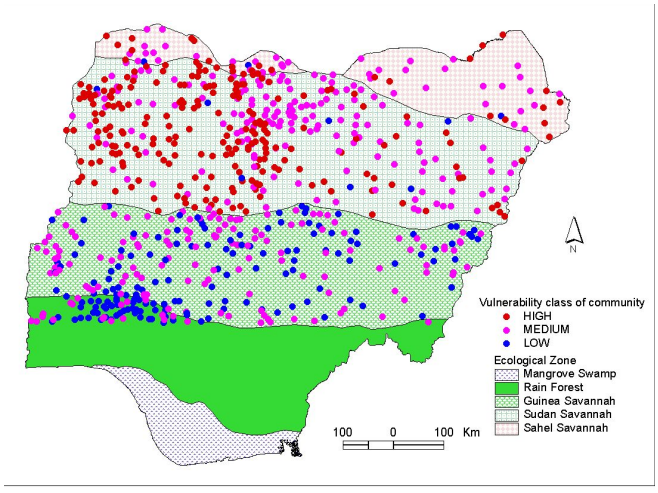
However, for climatic adaptation studies, specifics such as the location and degree of vulnerability of each community are required in order to develop community (or group of communities) specific adaptation strategy. As noted in the methodology, a simplified vulnerability index, which is exploratory, is developed for a group of about 750 communities in the Nigerian Savannah. The index was based on the ecological zone of the Savannah where a community is located, the community status (rural, semi-urban, urban), administrative status, the degree to which the inhabitants are tied to the land (major occupation of inhabitants), and the availability of alternative livelihood sources in the face of climate change and diminishing land resources. Figure 7 presents the spatial perspectives of the degree of vulnerability of these communities.

The degree of vulnerability of communities in the different ecological zones of the Savannah is summarized on Table 5.

A total of 231 (of the 746) communities are categorized as highly vulnerable to the effects of climate change. Of these, 23 are located within the Sahel zone while 208 are located within the Sudan zone. These highly vulnerable communities appear to cluster around the northwest of the of Sudan zone. 351 communities fall under the medium vulnerability category and these consist of 38 in the Sahel, 158 in the Sudan, 134 in the Guinea and 21 in the upper rainforest zone. Low vulnerability communities are found mainly in the Guinea Savannah and there are 164 of these, with only 3 located in the Sahel, 8 in the Sudan, 104 in the Guinea and 49 in the forested area of the Guinea zone/lower rainforest. The spatial pattern of vulnerability of the communities clearly confirms that the trajectory of resource conflict in the Savannah is towards the south of the Sudan zone (i.e. the guinea zone). Clashes between communities and social groups on land resources is now a regular occurrence in these zones (Fasona and Omojola, 2005), and given the analyzed trends, conflicts over natural resources is likely to be intensified, except a drastic breaking solution is found soon.

Table 5: vulnerability of communities in different zones of the Savannah

Vulnerability class	Sahel	Sudan	Guinea	Rainforest	Total
High	23	208	0	0	231
Medium	38	158	134	21	351
Low	3	8	104	49	164
Total	64	374	238	70	746



(Figure 7: Vulnerability of communities to climate change in the Sahel)

6. CONCLUSIONS AND RECOMMENDATIONS

The results presented a classical case of the implications of climate change at sub-regional and local levels which may be very difficult for the global and regional climate models to capture. From the discussion under rainfall anomaly, it is clear that diminishing rainfall is a strong climatic forcing that has far reaching consequences for both natural ecosystems and human activities in the Savannah. The long term spatial anomaly of rainfall shows that the stations in the Sahel recorded strongly negative anomaly, while those in the Guinea recorded positive anomaly. The analysis on ecosystems changes and natural resources loss also indicate that critical ecologies including wetlands, forests, and arable lands are being lost, and degraded lands including Aeolian sands and gullies are increasing in extent. The results from the simplified vulnerability assessments also show the preponderance of highly vulnerable communities in the Sahel and Sudan zones, the loss of arable lands in the Sahel and Sudan and the opening up of forest lands and woodlands in the Guinea zone and upper rainforest are indication that the trajectory of landuse change, and, by implication, resource conflicts is towards the Guinea zone. Evidences on ground also suggest that these zones are fast becoming critical flash points of climate change induced human insecurity in Nigeria.

Apart from lack of consistent and focused government policy on agriculture, the most important trigger of agricultural decline in Nigeria is climate change and variability. Present adjustments and coping strategies by the rural communities in the Nigerian Savannah are multifarious. For cereals and other arable crop cultivation, Fadamas (wetland agriculture) have been intensified. Irrigation and equipped wetland farming is also on the increase. The government and some international organizations have also intensified planting of trees to serve as shelter breaks. For animal farming, the long range transhumance to the south for greener pasture has been intensified. There are more temporary and permanent Fulani herdsmen settlements in the Guinea Savannah and rainforest zones now than in the past. However, how sustainable these mitigation and coping strategies are in the face of obvious increased climatic variability is yet to be determined. However, it is clear that adaptation strategies to climate change will be more sustainable than the present coping strategies.

Any efforts at redeeming the present trend should aim first towards cooperation rather than competition among all actors and stakeholders – especially communities in the Guinea zone and the invading nomadic herdsmen from the Sahel and Sudan. Confidence building and tolerance among social groups are necessary for an enabling environment to introduce climatic adaptation strategies. Secondly, such efforts should also aim at making more arable and grazing lands available through restoration of already degraded and impoverished lands. Elements of such adaptation strategy will include sustainable all year round fodders and pastures for animals which will stem transhumance and the attendant conflicts in other ecological zones. This can be achieved through equipped grasslands and grazing areas to ensure all-year-round feed for animals. There is also the need to intensify research on animal fodder systems in Nigeria to sustain animals on hay and silage and feedlots which will reduce the search for greener pastures. Finally, there is need for adaptation research to improve local agriculture. Large scale afforestation projects can also create local perturbations that can positively alter the local climate and improve agriculture in both the Sudan and the Sahel zones.

The effects of climate change which are manifesting now are results of long and continuous neglect of the basic climatic signals of the past and gross under-investment in mitigation and adaptation strategies. Present remedy (coping mechanisms and adjustments) may be not be able to cope with future trends and effects of climate change. Therefore, the time is now for teamwork and cooperation among scientists, governments, policy makers and communities to develop friendly and robust adaptation strategies to future challenges of climate change in the Savannah.

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