

Review

Land degradation in Northern Nigeria: The impacts and implications of human-related and climatic factors

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Northern Nigeria despite its promising agricultural potential, is currently not enjoying economic bloom like its Southern counterpart as a result of political, religious, ethnic and socio-economic factors. The degradation of land and its resulting impact on other agricultural resources may have further exacerbated the economic and social conditions of the region. The perceived encroachment of Nigeria's Savannah into its rainforest zone indicated possible land degradation. Some authors attributed this degradation to anthropogenic sources whilst others reported climatic variability (which is nature-driven) as the singular culprit. Therefore, this study reviews the impacts and implications of both human-related and climatic factors on land degradation in Northern Nigeria. Human-related activities such as agricultural/pastoral expansion, agricultural intensification and fuel-wood extraction as well as climatic/physical factors such as rainfall variability and land-atmosphere feedback mechanisms were suggested by various authors as agents of land degradation in Northern Nigeria. The remediation strategies to reduce the impacts of anthropogenic factors include the practice of agroforestry, rainwater harvesting, local irrigation techniques, utilization of wetter sites, contour ridging and terracing to conserve nutrient and water run-off, cautionary expansion of cultivated sites, and the maintenance of a viable seed stock well-suited to variable climatic conditions. The recommendations made on the resulting conflict between crop farmers and pastoralists include a federal government-assisted water project to build more waterpoints at strategic areas in the region and the practice of agropastoralism. However, the controversy over the cause of land degradation in Africa has led to a number of research questions itemised in this paper on the main cause of land degradation, the elements of climate inducing the dryness and wetness of the region, and the extent of land recovery when wet seasons return.

Key words: Land degradation, impacts and implications, human-related factors, climatic factors, northern Nigeria.

INTRODUCTION

Nigeria, a West African country located in the tropical zone of the world has a land area of about 923,769 km² with the Northern region covering about 79% of the entire

land mass (FOS, 1989; Salako, 2003; Aregheore, 2005). The country comprises about five broad ecological zones: Swamp forest, Tropical rainforest, Guinea Savannah,

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Sudan Savannah and Sahel (Okpara et al., 2013). Of the five zones, Northern region is made up of three: Guinea Savannah, Sudan Savannah and the Sahel. Northern Nigeria is composed of 19 of the country's 36 states. It is inhabited by over 50% of the country's 167 million people (Pate and Dauda, 2013) sparsely distributed across 79% of the country's total land mass. It is home to over two-third of the country's 250 ethnic groups (Pate and Dauda, 2013).

According to Cleaver and Shreiber (1994), the surface area of Nigeria is about 91.07 million hectares and 57% of this land surface is suggested to be used for crops and pasture production (commonly practiced in Northern Nigeria) whilst the remaining 43% is divided amongst forests, water bodies and other uses such as construction and human settlements (Aregheore, 2005). Iortim (2012) also reported that agriculture contributes about 42% of the country's GDP and the Northern part of the country is responsible for most of these; yet the region is suffering from both economic and infrastructural deficiency as indicted by the country's Human Development Index (UNDP, 2010).

There are six geo-political zones in Nigeria: the South-South, South-West, South-East, North Central, North-West and North-East. Of the six geopolitical zones in Nigeria, the most developed in the North, is the North Central, possessing economically-viable cities like Kano (the centre for commerce in the North) and Abuja (the Federal Capital Territory) whilst other northern geopolitical zones appear to be economically less-attractive. The north-west and north-east, according to the 2012 National Bureau of Statistics (NBS) data, have the highest poverty rates of about 77.7 and 76.3% respectively (UNESCO, 2010); and alarming illiteracy levels of about 86% each in the country (UNESCO, 2010). The North also has the least annual per capita income, below the national average of twenty thousand naira (approximately \$127). The industrial deficiency in the North has increased the unemployment levels and youth restiveness in the region (Pate and Dauda, 2013). The region thus, experiences more violence than other parts of the country as a result of the poor management of its diverse resources (Pate and Dauda, 2013). The violence could manifest in the form of religious, ethnic, economic, political or value-based crisis, which makes the region "increasingly stigmatised as a theatre of violent clashes and as a parasite that cannot survive without monthly federal allocations" (Pate and Dauda, 2013). As a result of the socio-economic structure of the region, most families practice subsistent farming and/or nomadic, pastoralism for economic sustenance.

Northern Nigeria (as one advances north-ward) is characterised by low rainfall and drought-like conditions (Xue and Shukla, 1993). Despite the perceived harsh weather conditions of this region, many plant species such as *Acacia* species, baobab tree, mango, orange and *Moringa* species, with soils suitable for the production of crops such as cereals (millet, rice, corn, sorghum and

maize) and legumes (soybeans and cowpea) inhabit the area. The vast 'fertile' land of this region has the potential for agricultural revolution, however, most farming practices are not mechanised (Pate and Dauda, 2013) probably because the states in the north are not economically-fit to commercialise agriculture.

Human activities such as agricultural expansion/intensification, pastoralism and fuel-wood extraction, and climatic/physical factors such as rainfall variability and land-atmosphere feedbacks have been reported by many authors to have a significant impact on land degradation. Therefore, this study intends to review the impact of the aforementioned human-related and climatic factors on land quality in northern Nigeria, including the underlying implications and possible misconceptions and debates. The knowledge would improve the understanding of how land and other agricultural resources can be properly managed so that the potential of the region to lead the 'green revolution' crusade in the country can be actualised.

HUMAN-RELATED IMPACTS AND IMPLICATIONS ON LAND DEGRADATION IN NORTHERN NIGERIA

According to the WRI (1992) and Barbier (1999), land degradation and conversion in Africa is mostly caused by agricultural activities. Land uses such as tree felling for fuel-wood and timber production, crop and pastoral land expansion and agricultural intensification have been suggested to be part of the causes of land degradation in Africa (including Nigeria). The possible loss of natural vegetation cover due to changes in land use, influenced by man, could expose the soil surface and render it vulnerable to the elements of weather such as rain and wind. Lanly (1982) and Skoupy (1987) reported that for the past 30 years, changes in human activities have resulted in the continuing loss of vegetation cover and soil fertility in West Africa. Land use change has been suggested to impact the northern ecosystems of the country over the years leading to a perceived creeping of the savannah into the tropical rain forest zone (Badejo, 1998). Changes in crop and livestock production methods and increasing demand for forest products (such as fuel-wood and timber) will accelerate the rate of land degradation which if not checked, would have a negative implication on food and livestock quality and yield.

The total annual rainfall in the ecological zones of Northern Nigeria is lowest in the Sahel and increases southward. This variation in rainfall distribution greatly affects the soil type and biodiversity in each ecological zone in the country. The Northern region is also characterised by high intensity solar radiation in the area (Hekstra, 1985). Evapo-transpiration is therefore, higher in the Northern part of the country than in the South. Despite the increased temperature and decreased precipitation in Northern Nigeria, many vegetation species (generalists with a broad ecological niche) have

Table 1. The soil types in the ecological zones of Nigeria.

Ecological zone	Major soil types (FAO classification)
Humid forest	Ferralsols, nitosols and gleysols.
Derived savannah	Ferralsols, luvisols, lithosols, arenosols, nitosols and acrisols.
Guinea savannah	Luvisols, acrisols, ferrasols and lithosols.
Sudan savannah	Luvisols, ferrasols.
Sahel	Ferralsols and nitosols

Source: Salako (2003).

been found to survive and thrive in the area as a result of their resilience and ability to grow on a variety of soil types. In spite of the low precipitation in the Northern region, the soil types mostly iron-rich (Table 1) are well-suited for crop production under the right application of fertiliser and soil management practices.

About 80% of the inhabitants of the Northern region are involved in crop production, pastoral farming and nomadic pastoralism (Schaefer, 1998). These agricultural activities require the use of land, which if not managed properly may lead to the over-exploitation of the natural resource and consequently, degradation. Barbier (2000) reported that many poor pastoralists and farmers in Africa (including Nigeria) often respond to declining land fertility by moving on to a new piece of land for cultivation and grazing. There are cases when farmers and pastoralists will seek new lands for the purpose of expansion and not as a result of declining soil fertility. This practice is known as agricultural/pastoral land expansion.

Agricultural expansion takes place when uncultivated or unused lands are utilized for crop production. The aggressive acquisition of unused or virgin lands could mean the indiscriminate destruction of forest lands. Therefore, land fallowing is suggested by some authors as a means of reducing the incessant need by farmers and pastoralists to occupy virgin lands. Taylor et al. (2002) reported that if used land is abandoned for a period of 20 years, the land will replenish itself. However, farmers in the North have started reducing the fallow periods of used lands due to the rising demand on food crops in order to meet natural population growth and this may affect crop quality and production rate over time. For example, the reduction of fallow period from 6 to 2 years led to a decline in cassava yield from 11 to 2 tonnes/ha whilst maize yield reduced from 3 to 0.7 tonnes/ha in sub-Saharan Africa (Sanginga et al., 1995). Honlonkou (1999) suggested the use of inorganic fertilisers to restore degraded farmlands, although noted that it might be too expensive for farmers in Northern Nigeria to afford. However, Mortimore and Adam (2001) discouraged the incessant application of chemical fertilisers for environmental and health reasons whilst Tiffen et al. (1994) suggested that the local farmers be encouraged to maximize agricultural output using the resources at their disposal.

Both agricultural and pastoral land expansion may lead to severe conflicts between farmers and pastoralists in Northern Nigeria. This is because two or more interdependent resource users, in this case, between crop farmers and pastoralists, are very likely to have a clash over common environmental resources such as land, pasture, crop-residue, livestock routes and waterpoints (Ime, 2013). Farm encroachment, that is, crop damage caused by animal belonging to herdsman as a result of cattle routes or waterpoints on farmlands (Gefu and Gills, 1990) and even the straying of livestock into the grazing land of other pastoralists are possible sources of conflict (Traore, 1996). For example, Amzat (2013) reported the violent clashes between the Fulani herdsman and the Berom natives of Jos in Plateau State, Northern Nigeria. Pastoralists engage in seasonal rotation; migrating to southern Nigeria (which is usually moist) during the dry season in search of pasture and waterpoints, and returning to their major base in the north during the wet season (Shettima and Tar, 2008). This means that a possible face-off with pastoralists is not confined to the North as cases of bloody clashes have been recorded in southern states such as Enugu, Osun and Delta (Amzat, 2013).

The Nigerian Senate discussed a bill in 2012 seeking for the establishment of a National Grazing Reserves Commission, which will possess the authority to cease or/and acquire land that will serve as grazing reserves and routes for herdsman in any part of the country. However, the majority of the senators expressed their dissatisfaction with the bill, pointing out that it negates the Land Use Act and the concept of federalism. It was then decided that the matter be handled by the State House of Assembly in each of the 36 states of the country (Odebode et al., 2012). Currently, the matter is yet to be addressed by the State House of Assemblies.

Taylor et al. (2002) measured the percentage land use of areas in Northern Nigeria using the Sahelian Land use Model (SALU) and selecting three representative years (1961, 1996 and 2015) which span through a 54 year period (Table 2). The result indicated a continuous decrease in the percentage of forest areas but showed a continuous increase in the percentages of land area used for pasture and cropland. This inverse relationship suggests the direct impact of agricultural/cropland

Table 2. The percentage land use of areas in Northern Nigeria using the SALU for 1961, 1996 and 2015.

Land	1961	1996	2015
Forest	72	40	35
Pasture	14	16	17
Cropland	5	14	22
Fallow	9	16	15
Unused	0	13	11

Source: Taylor et al. (2002).

expansion (and probably fuel-wood demand) on forest resources which may likely have grave environmental/climatic consequences over time. Forest components such as trees act as nutrient pumps in ecosystems (Kang, 1993); provide shade; and preserve the little soil water available in the case of a low rainfall.

Trees also make the soil less-susceptible to erosion. Therefore, the roles of forest resources in the preservation of land quality cannot be overemphasized. However, Mortimore and Adams (2001) presented a contrasting idea that indigenous intensification has the potential to promote the stability of high densities of multi-purpose trees on farmlands. They considered agricultural expansion into virgin forested land as an adaptive strategy of the local farmers and pastoralists to climate variation.

In the Sahel and Savannah, nutrient deficiency due to the absence of vegetation cover poses a more serious threat to crop/pastoral productivity than insufficient water supply (Badejo, 1998). An study by Bremen and De wit (1983) revealed that the problem of insufficient soil nutrients in the Sahel and Savannah is a serious limitation to crop productivity as compared to low rainfall. The application of fertiliser in the right proportion was observed to promote vegetation growth in the area. They also added that water is the limiting resource in the desert but in the semi-arid ecosystems (such as the Sahel and Savannahs found in northern Nigeria), nutrient is a more limiting resource. The need to increase fertiliser inputs has led to agricultural intensification.

Agricultural intensification refers to the application of very high amounts of fertilisers, pesticides and other agricultural products, even including labour inputs, with the sole aim of maximizing crop production. Krogh (1997) reported that agricultural intensification may improve soil performance in sites intensely cultivated, however, there may be a net loss of soil fertility and quality in the surrounding extensive land areas. A better approach of restoring soil fertility is to combine nutrient amendments with fertiliser application. Pieri (1989) reported that the use of fertilisers alone has often, in the long run, had negative impacts on soil productivity. The choice of nutrient amendment depends on soil organic matter, phosphorus availability and the pH of the soil (Bremen et al., 2001).

Agricultural intensification may increase crop production to a break-even point where incessant nutrient additions will have little or no impact on soil quality and fertility. This is because the soils in Northern Nigeria generally comprise coarse-textured aggregates which bind loosely and therefore do not retain sufficient water and nutrients. This implies that even in the midst of sufficient nutrients, if the soil physical condition is not managed, soil productivity might still be low. Therefore, the addition of organic matter like animal dungs or crop residues may be required to safe-guard nutrient or water run-off/-leaching, thereby, restoring the soil's fertility and quality. According to Batterbury and Warren (2001) agricultural intensification is an improvised means by which local farmers cope with the changing climatic conditions of the region as successfully practised in Northern Nigeria (precisely Kano), but stated that the underlying challenges can be managed effectively by adopting an environmentally-healthy indigenous land restoration methods such as rainwater harvesting, local irrigation techniques, utilization of wetter sites, contour ridging and terracing to conserve nutrient and water run-off, cautionary expansion of cultivated sites, and the maintenance of a viable seed stock well-suited to variable climatic conditions.

CLIMATIC FACTORS INFLUENCING LAND DEGRADATION IN NORTHERN NIGERIA

A study in 1998 by Badejo (1998) showed that the savannah is creeping into the rainforest in Nigeria. Similarly, a study by Nobre et al. (1991) predicted that climate change due to deforestation may cause tropical savannahs to creep into tropical rainforests stretching 500 to 1000 km into the zone whilst the savannah will in turn be encroached by the sahara. Many authors termed this 'southward creep' as desertification.

Desertification has been identified to be one of the processes that degrades land, however, there has been an unending debate about the use of the concept to describe the environmental changes occurring in the African terrain. The process of desertification was described by the UN as human-induced with climatic factors increasing susceptibility (Nicholson, 2001). One of the definitions of desertification is 'the expansion of desert-like conditions and landscapes to areas where they should not occur climatically' (Graetz, 1991). The UN later modified their definition to 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climate variations and human activities' (Puigdefabregas, 1995; Warren, 1996). The concept of the 'advancement of the desert' was first proposed by Lamprey (1975) using maps of 1950s and aerial surveys of 1975. He concluded that between 1958 and 1975, the Sahara desert had advanced southward into Western Sudan by 90 to 100 km (a desert expansion of about 5.5 km per year). Similarly, in 1983, Skoupy

(1987) reported that about 4.125 million km² of land area in Africa's Savannah was affected by desertification. However, in 1984, a field study by Hellden (1984) at the same location found no proof to support Lamprey's claims.

A 10 year study by Tucker et al. (1991) from 1980 to 1990 using satellite-derived vegetation index to determine the annual variations in rainfall and the rate of expansion or retraction of the Saharan-Sahelian boundary, found that there was a progressive decrease in rainfall between 1980 and 1984. However, a steady improvement in rainfall was observed between 1985 and 1990, which led to the restoration of the native vegetation of the Saharan-Sahelian boundary. This variation in rainfall was found to determine the direction of movement of the boundary. Between 1980 and 1984 (during the drought), there was an overall southward movement of the Saharan-Sahelian boundary (the expansion of the desert) whilst between 1985 and 1990 (during the wet season), there was an overall northward movement of the boundary (the retreat of the desert). This study revealed that the average estimation of the overall direction of movement for the 10 year study period was southward (130 km) but most importantly, it should be noted that the movement is not progressive but fluctuating based on rainfall patterns in the region. This discovery rendered the desertification estimates problematic because Lamprey and Skoupy did not put into consideration the rainfall decline of about 50% that occurred during the period of assessment (Nicholson, 1990). Thus, while 'desertification' itself was defined as anthropogenic, evidence shows that such land degradations could have been a product of climatic variability.

In a similar vein, a group of scientists from the University of Lund, Sweden, carried out studies in Sudan in 2001 and revealed through a combination of satellite images and field work that there was neither a systematic advancement of the desert or other vegetation zones, nor a reduction or disappearance of vegetation cover, although the replacement of forage with woody species was observed which indicated declining soil quality (Nicholson, 2001). They reported no evidence of widespread removal of vegetation cover in the villages. However, the study revealed that vegetation changes was as a result of drought and noted that there was a full recovery of the land as soon as the drought ended. Therefore, the researchers added that the perceived 'advances of the desert' was as a result of fluctuations in rainfall pattern in the Sahelian region with no large-scale reduction or disappearance of biological entities in the region (Prince et al., 1998) which is in support of Tucker et al (1991) propositions. In other words, it might be technically wrong to refer to the environmental changes in the Sahelian as a product of desertification since these changes are not irreversible neither do they lead to the sterility of land. A better term could be 'land degradation' which explains the replacement of diverse and nutrient-

rich plant species by vegetation of poorer quality (Nicholson, 2001) due to reduced soil quality caused by drought.

Many studies (Bonan et al., 1992; Xue and Shukla, 1993; Zhang et al., 1996) have shown that the climate is altered when deforestation (mostly caused by human activities) occurs, due to land-atmosphere feedbacks. Charney (1975) and Garratt (1993) reported that rainfall over a semi-arid region may be affected if there is a change in the surface albedo (the reflectivity of solar radiation). Charney (1975) argued that bare soils have a higher albedo than vegetation surfaces, therefore, a decline in rainfall following increased deforestation is a possibility. This is because an increase in albedo can reduce the heat flux within the troposphere (atmosphere closest to the Earth's surface) thereby, weakening convection mechanisms and limiting cloud formation and precipitation (Hoffmann and Jackson, 2000). As a result, an increase in albedo may promote a positive feedback mechanism leading to a drier environment, unable to sustain natural vegetation recovery and may consequently cause prolonged drought (Wang and Eltahir, 2000). Similarly, Woodward (1987), Zeng et al. (1999) and Taylor et al. (2002) reported that land-atmosphere interactions may cause inter-decadal climate variability in the semi-arid regions of the world.

Zheng and Eltahir (1997) reported that the West African monsoon which fed rain to the Sahel regions of Africa is sensitive to vegetation removal. They added that changes in land use such as the overgrazing, agricultural expansion and increased fuel-wood extraction may collectively alter the behaviour of the West African monsoon over time. Clark et al. (2001) pointed out that the climate in semi-arid regions is very sensitive to land degradation whilst Nicholson et al. (1998) referred to the region as the most "ecologically unstable" in the world. The ecological instability of the Sahel and Savannah regions was explained by Zeng and Neelin (2000) who revealed that these "grassland ecosystems" try to smoothen out the large climatic variability between the desert and the rainforest, thus creating a state of unsteadiness in-between. Nevertheless, human population in the region is doubling every 20 years which has caused a proportional increase in demand for agroforestry resources (Taylor et al., 2002), therefore an accelerated loss of vegetation cover from anthropogenic sources may increase the albedo of the area, thus exacerbate climatic conditions. However, Taylor et al. (2002) argued that rainfall conditions have been generally poor since the 1960s and this would have caused the loss of vegetation cover by biophysical feedbacks even without changes in land use which are not large enough to cause the persistently low rainfall observed in the region over the decades. Taylor et al. (2002) argument may not hold water because it was reported that there was persistent drought between the 1950s and 1970s (Nicholson, 2001) but rainfall improved in the late 1980s

(Tucker et al., 1991) restoring the native vegetation of the region. Therefore, there should not be a progressive loss of vegetation as a result of a temporary drought that occurred many decades ago.

CONCLUSION AND RECOMMENDATIONS

This study reviewed the human-related and climatic factors inducing land degradation in northern Nigeria. Some authors believe that the human-related activities such as agricultural/pastoral expansion and agricultural intensification are localised adaptation measures by the natives of northern Nigeria in response to the changing climatic condition of the area, an idea referred to as the 'optimists view'. Others believe that the so-called adaptation measures are further destroying the integrity of the ecosystem, an idea referred to as the 'pessimists view' (Batterbury and Warren, 2001). Various studies in literature show that neither the optimists view nor the pessimists view can be totally discarded. Only when the uncertainties in the arguments presented by both parties are well-clarified with supporting evidences, will a common ground be found.

Conflicts between pastoralists and crop farmers may be reduced by the siting of more boreholes or waterpoints in the region by granting Northern states experiencing such crisis, a special federal-supported water project fund as a result of the political structure of the country and the financial limitations of most Northern states. Ime (2013) recommended 'agro-pastoralism' (a form of farming that combines the growing of crops with the rearing of livestock) as a way of managing pasture lands more effectively, thereby, reducing pastoral expansion and face-off with crop farmers.

Owing to the various debates on the cause of land degradation in Africa, it would be imperative for further studies to be carried out. The following controversial questions are to be further researched for the purpose of clarity of knowledge and a better understanding of land degradation in Nigeria and West Africa:

1. Is the perceived creeping of the Savannah in Nigeria, a result of either climatic variations which could be reversed during better weather conditions or human-related activities which some authors claimed are insufficient to cause large-scale land degradation?
2. It has been suggested that the African Monsoon and the InterTropical Convergence Zone (ITCZ) may be responsible for the rainfall variability in West Africa (Nicholson, 2001), therefore, what are the elements in these meteorological entities forcing the dryness and wetness of the region?
3. What is the extent of land recovery (whether total or partial) of the West African region each time rain is restored?

It is important for the inter-decadal measurement of the current Savannah-Rainforest boundary as well as the

current Saharan-Sahelian boundary to be carried out as this would help project a possible expansion or retreat of Nigeria's Savannah. The proper management of land and its resources including the full understanding of the climatic forces at work, may go a long way to help Northern Nigeria reach its full potential as a pace-setter for agricultural revolution in the country. The State Governments in Northern states are advised to utilize the potentials in agriculture as a reliable route to economic emancipation.

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