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The Influence of Rainfall Variability in Land Degradation Problems in Northern Katsina State, Nigeria

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ABSTRACT
Rainfall variability in northern Katsina state and northern Nigeria in general have exacerbated the land degradation and the physical condition of the region. Some authors attributed the land degradation in the region to the anthropogenic activities while others linked it to climatic variability particularly unstable and unpredictable rainfall. Human activities such as agricultural expansion, overgrazing, fuel wood extraction and unsustainable land use as well as physical/climatic factors such as rainfall variability and atmosphere feedback mechanism were identified by different authors as important agents of land degradation in northern Katsina state and northern Nigeria in general. Remediation strategies such as practice of agroforestry, rain water harvesting, utilization of wetter sites, public participation in planning and implementation of amelioration measures and introduction of suitable seed well- suited to the climate condition were suggested to reduce the menace of the problem.
Keywords: Land degradation, Rainfall variability, Northern Katsina state, climatic factors, anthropogenic factors

1.0 INTRODUCTION

In the Sudano-Sahelian zone of Nigeria increasing, rainfall variability, land degradation and their impact on soil and vegetation productivity is the major concerns to the local people and the Nigerian government in general (Abubakar, 2006). Northern Katsina state where Nigeria borders Niger Republic is among the areas considered to be seriously affected by increasing rainfall variability and land degradation, hence described as ecologically fragile (Effeh, 2000). The area lies in drought prone location and located within the "ecological disaster zone, north of latitude 12^0 30' North (Effeh, 2000).

Northern Kasina state has an 'AW' type of climate as identified by Koppen's climatic classification. According to this classification, this climate is a tropical one with a clear wet and a dry season. The coolest month is normally experienced between December/January with temperature of less than 18^0C. The dominant climatic influence throughout the areas is the Inter- Tropical Convergence Zone (ITCZ), also known as the Inter Tropical Discontinuity (ITD). It is a mobile zone where two opposing air masses meet. This zone is noted to follow the apparent movement of the sun, North and South of the equator (Rowland, 1993).

. A year in the areas is divided into four seasons based on the prevalence of particular climatic elements at a particular time and the farming activities. These seasons are;

(a) Hot and dry season (Bazara)

It is a period before the rain starts. It is the hottest of the year and a transitional one between the harmattan and the wet seasons. The mid-day air temperature can be well over 40^0C.

(b) Rainy season (Damuna)

This is the rainy season proper and last between 4 to 5 months with single rainfall maximum in the month of August. There are variations in terms of the rainfall duration and intensity between the villages. The average temperature is warm. It is the period of intensive rain-fed cultivation, the most important season in the life of a farmer.

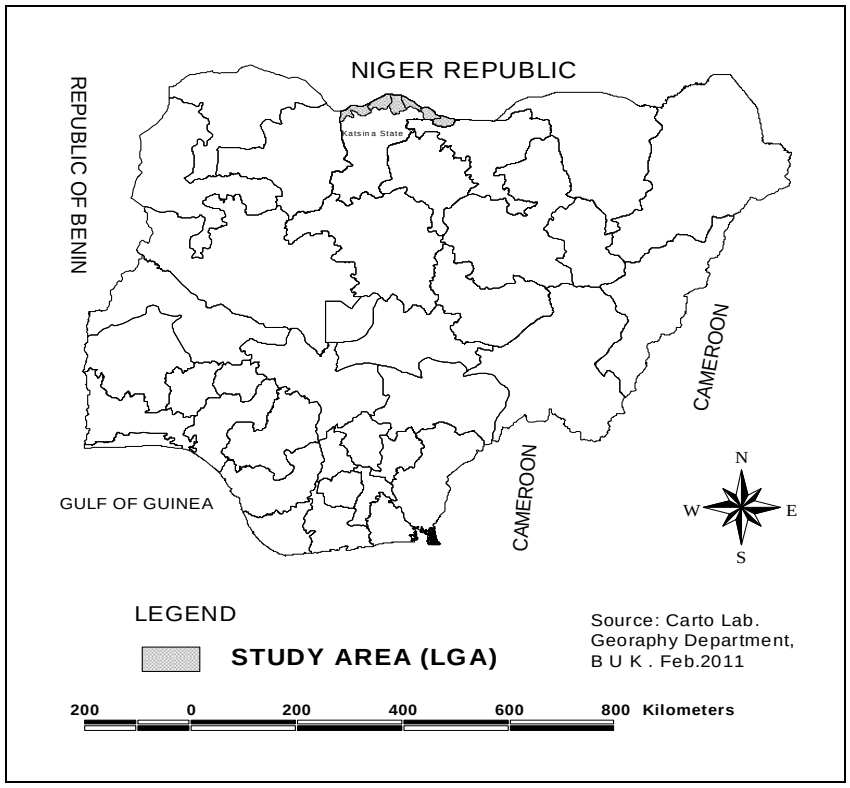
(c) Harvesting period (Kaka)

This is the period immediately after the rains. It is crop harvest season, a good period to farmers with a successful harvest. If the harvest is on millet, it is called 'kakar gero' meaning the season of millet. If it is on sorghum, it is called 'kakar dawa', the season arrival of new sorghum. This period coincides with the onset of cold, dusty and dry weather called the harmattan.

Dry season (Rani)

This is the dry season proper. It is a period with very less or no farming activities. Most farmers (especially between the ages of 15 to 50 years) travel to other places to source income to their families. This practice is called 'ci-rani' in Hausa (Mohammed, 2004).

The dominant wind in the dry season is the dry northerly known as the harmattan, which originates and moves across the Sahara, accompanied by marked diurnal temperature fluctuations. The harmattan erodes, transports and deposits fine silt and clay dust, which often impair visibility.



2.0 Pattern of Rainfall in Katsina State and Other Parts of Northern Nigeria

A very marked relationship between rainfall and latitude has been identified in the whole of West Africa (Kowal and Kassm, 1973). In the study area, Mortimore (1999) noted that the ITD advances steadily northwards until about August when it halts and begins to retreat southwards, while the humid maritime air mass advances northwards and increases in depth causing rainfall there also to increase. Thus, rain does not fall in any of the study areas until the ITD has moved north of it sufficiently for an established pattern to occur (Mohammed, 2004). The onset of the rains in the semi arid areas generally starts from March in the South to mid June in the extreme North. This season ranges from 60 to 200 days in length, ending around early September in the north and the end of October in the South (Mortimore, 1999).

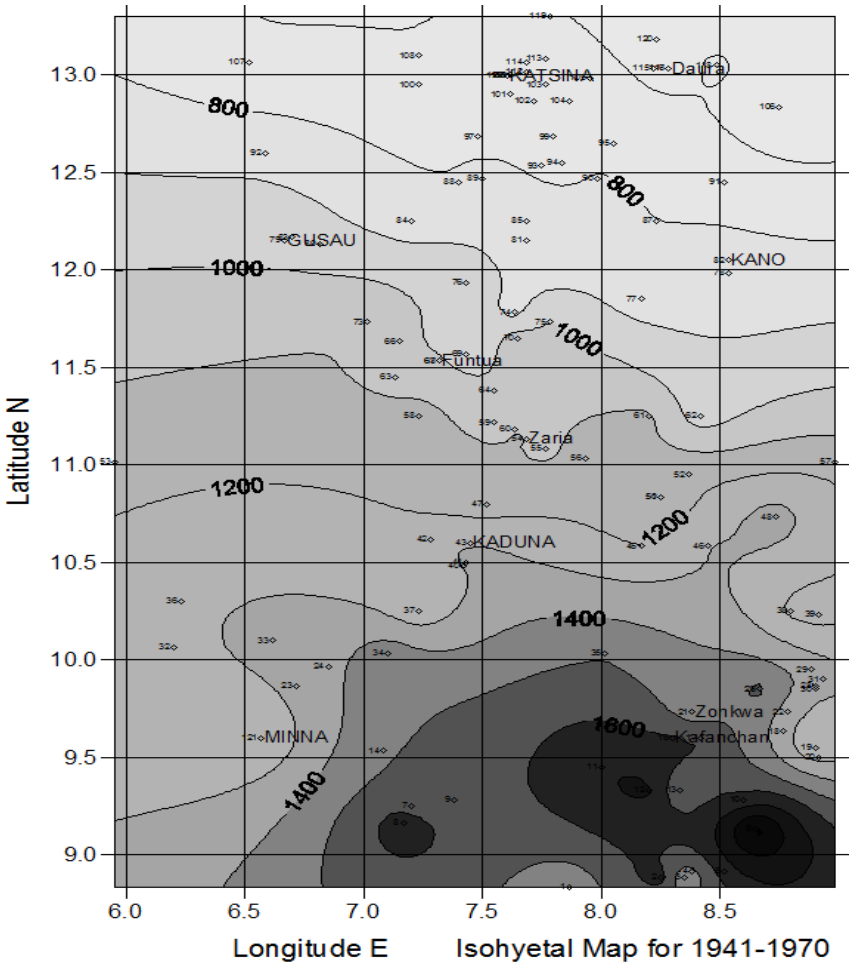
Kowal and Knabe (1972) noted that the rate at which the rain advances to the north is about 13 days per degree of latitude, i.e. 8km/day. Rowland (1993) added that the dry season in this area is between nine to ten months long (from October to July). Kowal and Knabe (1972:70-93) used data from over 50 rainfall stations throughout Nigeria. Their analysis showed that latitude correlates significantly with all major

parameters of rainfall and in higher latitudes rainfall deficit becomes more pronounced and the extent and aggravation of land degradation increases with latitude. In other words, as one move north ward, the amount of rainfall received decreases and its variability increases. Also the impacts of land degradation become more apparent. Lawal (2012) had reported increasing impact of water and wind erosion as a result of decrease and disappearance of woody, shrubs and grasses species in the northern Katsina.

Kowal and Kassam (1973) had also computed a higher negative correlation (r = 0.77) between rainfall and latitudinal position in northern Nigeria. This value signifies that the higher the latitude the less the rainfall. All the study area is located towards the northern extreme of Nigeria and by the values given above; they receive less rainfall compared to many places south of them.

3. 0 Relationship of rainfall and land degradation

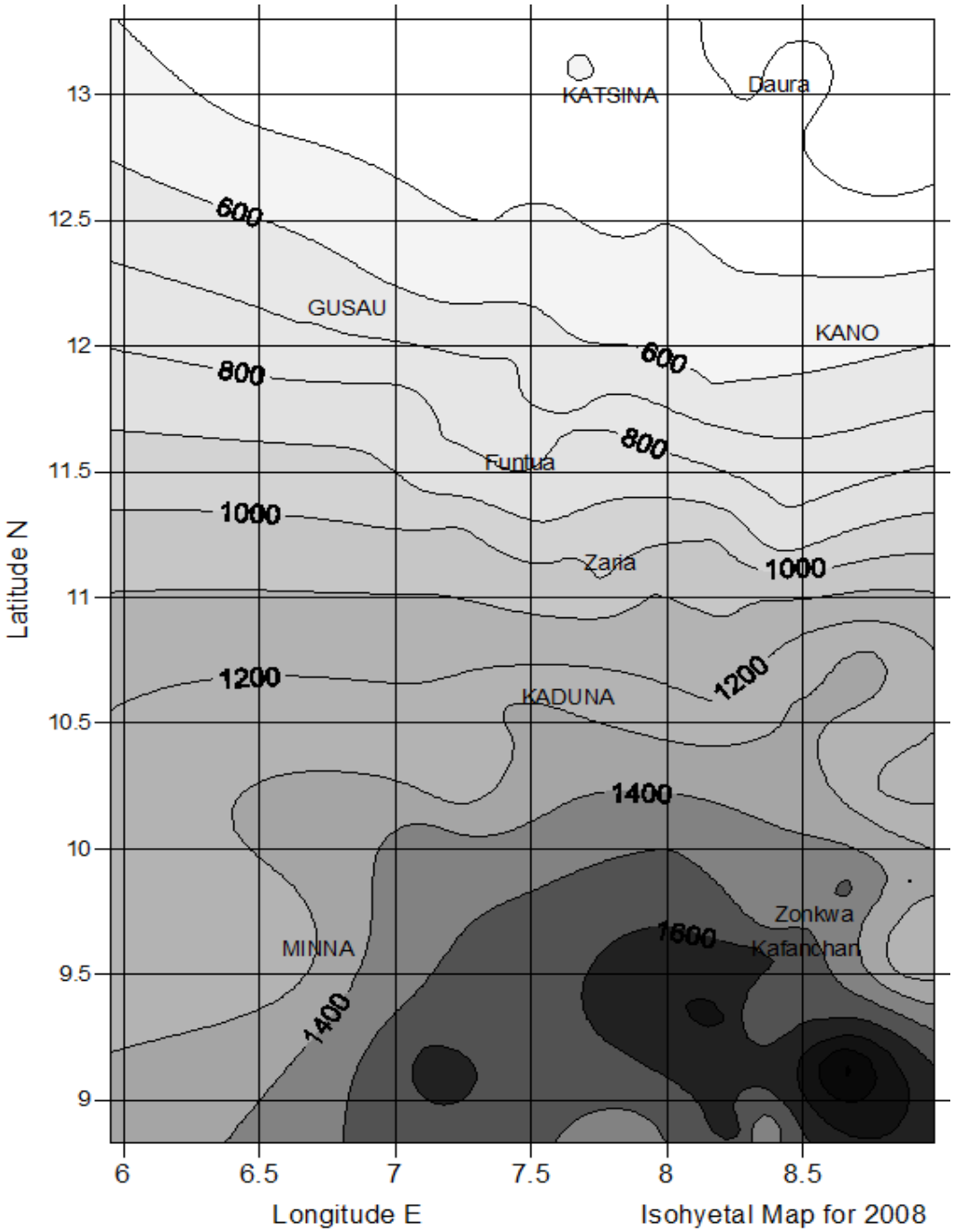
Rainfall records (1941-1970) analysed by Tomlinson (2010) from more than 120 stations extending between 9^o to 13.5^{o}N, 7^o to 8.5^{o}E in present Kaduna and Katsina states. The rainfall records are used for producing isohyets map for descriptive and planning purposes. The data indicated downward trend in the amount of rainfall recorded north of latitude 10^{o}N (see figure 1) suggesting the need for new isohyets mapping. The new isohyets map produced from the annual rainfall estimate for 2008 by regression indicates reduction in the amount of rainfall received in the study area from 700mm in 1970 to less than 600mm in 2008. (figure 1 and 2).



. **Source: Tomlison (2010)**

Figure. 1 : Annual rainfalls (mm) from 120 stations records (1941-1970)

Tomlinson (2010) predicted that if the downward trends persist, the reliability in the amount of rainfall in the study area will decrease to less than 400mm by the year 2030. (See figure 3)

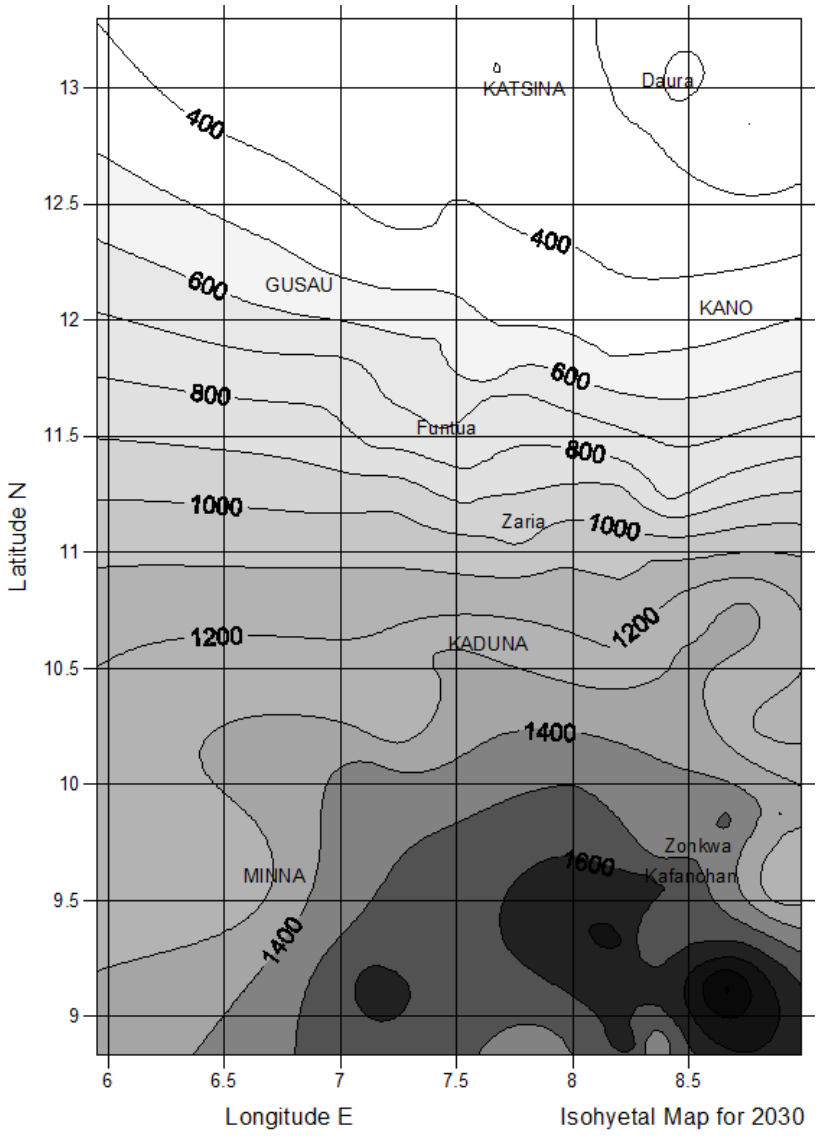


Source: Tomlinson (2010)

Figure 2: Annual rainfalls (mm) estimated for 2008 by regression

Tomlinson (2010) noted that "the trends observed in Katsina state over the last 50 years are in accordance with the result from climatic modeling of the Hadley Centre which has shown a reduction in

annual rainfalls of about 4mm/y over the next 100 years at the Nigerian edge of the Sahel'. Tomlinson (2010) further posited that the general effect of rainfall variability on the environment is "woodland becoming thorn shrub and savanna becoming desert, with sustain rain fed agriculture becoming unviable." Tomlinson (2010) further added that the condition in Katsina town up to Nigeria-Niger republic border is expected to be worst, which may compel people to migrate southward. .Tomlinson (2010) backed his findings with the report of Intergovernmental Panel on Climate Change (2007) which indicated that "'…..In West Africa, the long term decline in rainfall from the 1970s to the 1990s caused a 25-35 km southward shift of the Sahelian, Sudanese, and Guinean ecological zones in the second half of the 20th century."



Source: Tomlinson (2010)

Figure 3 Annual rainfalls (mm) estimated for 2030 by regression

4.0 Boserupian and Neo-Multhusian Perspectives on Land Degradation in Arid and Semi-arid Environment

Land degradation is the persistent decrease in the soil and vegetation productivity (Agnew and Warren 1996; Maigari 2002; Stocking 2004). In other words, a degraded land is that which ‘’due to natural processes or human activity is no longer able to sustain properly an economic function and/or the original natural ecological function” (Lestrelin and Giordano 2007).

In dry lands, land degradation processes, which have a more severe impact on land productivity, include, deforestation, water erosion, wind erosion salinization, alkalinization and soil compaction (UNEP 1992; Dregne 2002; Olofin 2006). These degradation processes take place in three interlocking stages with one stage leading to another. These are soil physical degradation, chemical degradation, and biological degradation (Maigari 2002).

In Sudano-Sahelian region, degradation is the eventual output or end product of desertification. As noted by Olofin (1993,) drought, deforestation and desertification have more in common than the letter “d”, as they are three devils that constitute an unending nightmare to environmentalists and conservationists. They merge to produce another dreaded “d” called degradation.

Globally, about 200,000 square kilometers of productive land is reduced by desertification every year to the point of yielding nothing. Some 15% of the land surfaces of the earth are subject to various degrees of degradation, and 32% of drylands are undergoing processes of land degradation (Abuhussain 2000).

Since the first United Nations (UN) Desertification Conference of 1977 in Nairobi, the 1992 UN Conference on Environment and Development, which held in Rio de Janeiro, and the 1994 Inter-governmental Convention to Combat Desertification which held in Paris, scientists has been playing a leading role in defining land degradation, as well as determining its extent and assessing its impact and offered a variety of alternatives to remedy the problem. (Stringer and Reed 2007). Despite all these and other efforts, the problem still persists (Le Houerou, 2003). Nigeria’s savanna region covers about 849,496km^2 or 86% of the country’s land area and contains 60% of the country’s population (Omijeh et al, 1989; Adegbehin, et al., 1990; Mijindadi and Adegbehin 1991). Between 11^0N and 14^0N where the Sudano-Sahelian agro-ecological zone lies, is about 40% of the country’s landmass that is very susceptible to land degradation than any other region of the country due to a variety of factors, including persistent rainfall variability, overgrazing, deforestation, wind erosion, soil depletion aggravated by continuous cropping, drought and bush fire (Adegbehin, 1990). The rate of land degradation in Nigeria appears to have extended below 11^0N because of uncontrolled human activities (Otegbeye, 2004). It has been estimated that Nigeria is losing 350,000m^2 to desertification every year and the Sahara desert is advancing at an estimated rate of 0.6km per year (Daily Trust, 16, June 2008, qouting Minister of Environment). But this assertion has been rejected by some researchers (e.g. Mortimore, 1989; 1993a; 1993b; 1998; 2003; Tiffen and Mortimore, 2002; Tiffen, 2004; Mortimore and Tiffen, 2004) who established that despite the claim of increasing desertification in the Sudano-Sahelien sub- region, there has been a substantial increase in food production that supports rapid population growth in the region.

The neo-Boserupian theory postulates that agricultural production increases with population growth due to the intensification of production. In other words, human induced land degradation can stimulate the innovation necessary to overcome resource scarcity and maintain sustainable livelihood (Zaal and Oostendrop, 2002). The Boserupian theory is a response to neo-Malthusian and vicious circle model proponents who believed that increasing population with high poverty leads to land degradation (Kasperson et al., 1999). Kirby et al. (2001) observed that since the emergence of modern environmental pressure groups in the 1960s and 1970s, many countries and international organizations, such as the World Bank, the UN etc were convinced by neo-Malthusian arguments, as shown in the report of the World Commission on Environment and Development (WCED, 1987), as cited in McNab (2004). The report linked large populations of impoverished people to environmental degradation. More specifically it stated that:

“Those who are poor and hungry will often destroy their immediate environment in order to survive: They will cut down forest; their livestock will over graze grassland; they will overuse marginal land; and

in a growing number they will crowd into congested cities. The cumulative effects of these changes are so far-reaching as to make the poverty of the self a global scourge'' (WCED, 1987 in: Mcnab 2004).

Neo-Boserupians rejected neo-Malthusian claims based on empirical studies in many African and Asian Countries. In Africa, Tiffen et al., (1994) study in Machakkos district, Kenya, where rural populations increase six-fold from 1930-1960. Adapted technology, growing market, secure land tenure, infrastructural development, increased management capacity and skill and self help group have led to an increase in agricultural production by nearly 400%. Mortimore (2005) found a similar "success story" in three dry land areas of West Africa; Kano State in Northern Nigeria; the Diourbel region of Senegal and the Maradi Department in Niger.

Also citing Mazzucato and Neimeijer (2000), Mortimore (2003) reported that eastern Burkin Faso experienced a low fertile soil, a quadrupling human population, a tripling of livestock numbers and declined average rainfall since the 1950s. Instead to witnessing land degradation, he found average food production increases rapidly and the area cultivated after 1980, an average yield increased by 400 kg ha^{-1} without any evidence of soil degradation. In Asia, Sherbinin et al.(2007) cite the findings of Turner and Shajaat (1996) in Bangladesh from analysis of time series data (1950-1986) they found support for the neo-Boserupian hypothesis, with yield largely keeping face with or exceeding population growth despite high population densities (783 person per km^2).

5.0 The Concept of Land Degradation

Desertification has been used as a synonym for land degradation in cultivable dryland (e.g. UNEP, 1994, Le Houerou, 1996; Dregne, 2002; Tiffen and Mortmore, 2002; Nielsen and Adriansen, 2005; Kiunsi and Meadows, 2007). In general terms, land degradation may be defined 'as undesirable change in the state of land from productive to unproductive due to natural or man-made factors' (Kiunsi and Meadows 2007). In dry land, land degradation is a complex and contentious issue because it involves physical, biological and socio-economic parameters. The term land degradation is used as defined in the International Convention to Combat Desertification (1994 as cited in Kiunsi and Meadows, 2007). According to this definition, land degradation involves the processes and end result of both vegetation and soil degradation as a result of various factors, including climatic variation and human activities.

The concept of land degradation in dry land (desertification) was first conceived by E.P. Stebbing in the 1930s during the colonial rule in West Africa, in response to what colonial administrators saw as unsustainable resource management by local farmers and herders, which could eventually lead to the Sahara desert advancing south wards into fertile land. (Dregne, 2002).

Stebbing's prognosis of 1930s on the "encroaching" Sahara desert has been maintained in many scientific reports of many international organizations, such as United Nation Agencies, the World Bank, NGO reports, etcetera particularly after the 1970s and 1980s drought in Africa (Mortimore, 1989).

5.1 The Causes, Factors and Process of Land Degradation in Dry lands

Even though land degradation is widely recognized as a global problem yet it is be devilled with highly contentious issues in determining its extent, definition, causes, distribution, means of assessment and its effects, e.g. Veron et al., (2006, reported in Glantz and Orlovskys, 1983) review of more than one hundred different definitions of land degradation. Lack of consensus is also depicted in other studies (e.g. Kasass, 1995; Lal, 1995; 2001; Agnew and Warren, 1996; Le Houerou, 1996; 2002; Thomas, 1997; Ayoub, 1998; Albaladeje et al., 1998; Fu, 2000; Dregne, 2002; Abuhussai, 2002; Herman and Hutchinson, 2005; Al-awdhi et al., 2005; Veron et al., 2006; Kiunsi and Meadow, 2006; Sivakumar, 2007; Wang et al., 2008).

The causes of land degradation in dryland can be divided into two, indirect and direct causes (Le Houerou, 1996, 2003 Lal, 2001, Abuhussain, 2002). Indirect causes are the human activities that reduce vegetation cover, thus, provoking development of direct causes (i.e. factors) of land degradation. Le Houerou (1996, 2003) attributed the direct causes of land degradation in dryland to the destruction or decrease of perennial plant biomass, which left the soil surface bare to become subject to various

processes, such as wind and water erosion, water logging, alkalinization and salinization due to soil campaction.

5.1.1 The Indirect Causes of Land Degradation in Dryland

The indirect causes of land degradation that trigger the direct causes can be summarized, as explained by Le Houerou (1996, 2003) and Abuhussain (2002):

- Population pressure
- Excessive firewood collection
- Over collection of medicinal plants
- Wild fire leaves the soil vulnerable to erosion
- Inadequate legislation and lack of enforcement of legislation on land use and erosion control.
- overgrazing
- inappropriate land ownership system
- poverty, lack of formal education, and insufficient extension services.

By comparing the combined effects of population pressure (PP) and resource utilization (RU) on the available resources (AR) and the carrying capacity (CC) and their resilience to regenerate (RR), Olofin (1993) argues that statistically there is no relationship between population and land degradation He represents it quantitatively as follows:

PP + RU/AR + RR = 1 = CC i.e. environment balance
PP + RU/AR + RR > 1 > CC i.e. land degradation
PP + RU/AR + RR < 1 < CC i.e. environmental renewal

Population pressure represents all population dynamics
Resource utilization connotes both appropriate and inappropriate use of resources.
Conservation measures are subsumed under resources regeneration.

Olofin (1993) concluded that it may be difficult to ascertain the actual cause of degradation due to natural changes or the human misuse of resources, or what is reversible or what is not. However, he conceded the misuse of resources through a complicated interaction of political, socio-economic and environmental factors.

5.1.2 The Direct Causes of Land Degradation

The destruction of perennial plant covers result in the degradation chain:

- reduction in the organic content of the soil due to a lower permanent biomass and increased production litter
- decreased organic matter reduces the stability of soil aggregates and thus renders soil moisture more fragile and prime to destruction
- unstable soil structure results in soil compaction, lower porosity, lower permeability to air and water intake, lower water storage and reduced oxygenation
- lower permeability, water intake and storage result in increased run off and erosion, consequently a diner environment developed and increased edaphic aridity.
- decreased organic matter and unstable soil structure leads to increased run- off and erosion.
- reduction in the organic matter content of the solid leads to lower biological activity from micro, moseo and macroflora and fauna, causing reduced fertility and therefore productivity.
- lower water and nutrient availability cause lower fertility and productivity, hence lower biomass production and plant cover.
- the clearing or destruction of permanent vegetation cover, particularly shrubs and trees and/or perennial grasses, reduces the shading of the solid surface and
  increases its temperature, hence more potential evapo-transpiration, as soil surface temperature rises and increases oxidizing soil organic matter and faster depletion of water reserves.

- the reduction or destruction of perennial plant cover also decrease the rugosity of the landscape, resulting in higher wind speed at the soil surface and hence higher rate of evaporation and increased aridity.
- wind erosion (creeping, suspension, corrosion) results in the development of desert pavements.

6.0 CONCLUSION AND RECOMMENDATION

Farmers and herders in the study area are experiencing the scarcity of many species of trees, which provide food, fuelwood, medicine and other sources of livelihood as reported by Lawal (2012). In planning action to address these problems, local farmers and herders should be contacted on their plant/tree species preference for shelter belt/windbreak and for agro forestry. Since most of the farmers knew the effect of agro-forestry in increasing the output of food crops from a given land area, and its positive effect in the prevention of soil degradation through the control of erosion and the replenishment of soil nutrients through litter droppings, farmers should be encouraged to plant more trees instead of relying on those that have been naturally growing in their farmland.

Most of the people in the villages of the study area kept livestock such as goats, sheep cattle, etc to get cash to supplement income from crops production. Many farmers/herders acknowledge the problem of overgrazing due to the increasing number of livestock in the area. It is a known fact that "every ecosystem has a finite carrying capacity, and when that capacity is exceeded, degredation of the ecosystem occurs" (Cao, 2008). Hence the key strategies to combat land degradation in the study area is better to understand the natural carrying capacaity of each ecosystem and to use the ecosystem resources sustainably to avoid damaging the ecosystem beyond its ability to repair itself.There is the need to devised ways of providing alternative income generating activities to reduce dependence on livestock and to enhance the quality of communal grazing area by finding the most resilient and palatable form of fodder grasses that may help to reduce erosion and improve the capacity of the soil to retain moisture.

Local empowerment and sustainable livelihood will be achieved only when greater control of natural resources is given to the local communities. The first step could be in gaining the government respect for customary form of management by identifying the areas of its success in the sustainable use of natural resources. To do this, there is the need for the government to establish clear rules on access, ownership and the use of these resources.

Government employees are the main link between villagers and the local, state and federal governments. Despite their limited number and limited ability to reach all the villages, they are pillars in not only conveying new ideas and innovations but also in communicating farmers' need to the appropriate authority. Hence in the training of personnel, authorities should consider using experienced local farmers and herders as resources person to give detailed accounts of their perception on environmental changes in their localities. The local perspectives could be used as a starting point for understanding farmers' belief and grievances by the extension workers.

The education system in Nigeria is still largely based on a colonial structure. Formal education considers traditional or indigenous knowledge as inferior to western philosophies. Many aspects of Western teaching are irrelevant to the live and progress of most of our students. Hence, emphasis should be concentrated on issues that are important and relevant to student progress, such as teaching the medicinal knowledge of plant species and how to use trees in a farm help in improving crop yield (agro forestry).

Majority of the farmers in the rural areas have access to radio. Radio as a medium to disseminate farmers' innovation and experience could be used as a tool. As the majority of farmers could not read the western alphabet, the radio could be an important medium to disseminate local farmers' experience, innovation and perspectives on different environmental challenges.

Government community development initiatives rarely seek out who owns what, and who has access to what type of information. Understanding the social interaction in a community setting is necessary to understand how knowledge is generated, transmitted and transferred by different people. This will increase the chances of people participation in the development initiative.

Control of technology has traditionally been determined by colonial and post colonial government agencies in Nigeria, even though farmers are not completely passive in accepting this technology. They

should be given the right to direct the development process and actively take part in the creation of new practices and techniques, e.g in government forestry or shelter belt/wind break lots or agricultural research stations.

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