

# **EROSION AND DESERTIFICATION VULNERABILITY IN AFRICA: FRAMEWORK FOR DEVELOPING INDICATORS FOR LAND DEGRADATION**

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## **Abstract**

Soil erosion is a great cause of land degradation and is one of the greatest challenges to natural resources management and a threat to food security in Africa. In the last decades, development organizations have been concerned with the vulnerability of the African countries, especially the Sahelian countries to resource base deterioration resulting from a combination of natural and human-induced causes. Previous studies using mainly climatic data have not adequately addressed the extent of the vulnerability of the Sahelian ecosystem to desertification as a result of erosion and other aspects of land degradation. A more appropriate approach is to combine the natural climatic effects and human-induced causes of land degradation in the monitoring and the evaluation of desertification vulnerability.

This paper presents first, an overview of the soils and climatic conditions affecting desertification vulnerability of the African Sahelian ecosystem. Second, historical trends of human and livestock population in these countries are used to assess the impact of human activities on the resource base and on resource use. The results of the climatic impact are represented as climatic desertification vulnerability classes. Under current level of resource management, the livestock and human population dynamics suggest from a land use perspective that the Sahelian ecosystem is collapsing and is not resilient to recurring droughts.

A framework that combines field level characteristics, including topographic, social, and economic factors, with the climatic vulnerability classes, is presented in an attempt to develop indicators for monitoring and evaluating the consequences of land degradation, especially in desertification vulnerability.

**Key Words:** Soil erosion, land degradation, desertification vulnerability, Livestock-person ratio, livestock stocking density, cattle (sheep + goat + camel) ratio land quality indicators,

## **Résumé**

L'érosion est une des principales causes de dégradation des sols et le plus grand défi pour une gestion durable des ressources naturelles et pour la sécurité alimentaire du continent africain. Au cours des dernières décades, les organisations qui œuvrent pour le développement agricole se sont intéressées à la vulnérabilité des pays africains, tout particulièrement à la détérioration des ressources de base des pays sahéliens résultant de la combinaison de facteurs naturels et anthropiques. Des études prospectives, utilisant principalement les données

climatiques, n'ont pas examiné de manière adéquate l'extension de la vulnérabilité de l'écosystème sahélien par rapport à la désertification, vulnérabilité qui résulte de l'érosion ainsi que des autres facteurs de dégradation des sols. Une approche plus appropriée consiste à combiner les effets naturels climatiques aux facteurs anthropiques de la dégradation des sols dans le suivi et l'évaluation de la sensibilité à la désertification.

Cet article donne tout d'abord un aperçu général des sols et des conditions climatiques qui influent sur la vulnérabilité à la désertification de l'écosystème sahélien. En second lieu, les tendances historiques relatives aux populations humaines et au cheptel de ces régions sont utilisées pour montrer l'impact des activités humaines sur l'évolution des ressources et leur usage. Les résultats de l'impact climatique sont présentés sous la forme de classes de vulnérabilité à la désertification. En ce qui concerne le niveau commun de gestion des ressources, les dynamiques de la population humaine et du cheptel laissent à penser que l'écosystème sahélien est en train de se dégrader sous l'effet des sécheresses successives et qu'il ne manifeste pas de réaction de résistance.

Un cadre de travail qui combine la caractérisation de la dégradation des sols au niveau du champ, comprenant les facteurs topographiques, sociaux et économiques avec les classes climatiques de vulnérabilité, est présenté dans un essai de développement d'indicateurs de suivi et d'évaluation des conséquences de la dégradation des terres, plus particulièrement en ce qui concerne la vulnérabilité à la désertification.

**Mots-clefs** : Erosion, dégradation des sols, vulnérabilité à la désertification, cheptel/population, densité du cheptel, rapport entre bovins et le cheptel des ovins, caprins et camélidés, indicateurs de qualité des terres.

## 1. Introduction

Soil erosion is one of the greatest causes of land degradation and an important factor in desertification vulnerability in Sub-Saharan Africa (SSA). Land degradation problems can be attributed to a multitude of causes including: (a) natural calamities such as the recurrent outbreak of pests like locusts, and occasional drought, such as occurred in 1973-74, 1984-85; (b) land mismanagement that results in low land/human carrying capacity, threatens food security; and (c) economic dependency on natural resources, which often translates into overgrazing of pasture land, encroachment on marginal land, soil erosion, loss of soil nutrient, imbalances in nutrient recycling and succession of vegetation, loss of biodiversity, and reduced land productivity. The consequence is a continuous decline in food production last 20 years (Smaling, 1996), while human and livestock population percentage growth rates have not stabilized (World Bank, 1997).

A concern to scientists, land managers and development organizations like the United Nations (FAO, UNDP, UNEP, the World Bank), USAID, and USDA, as a result of land mismanagement is the susceptibility and resilience of land to desertification.

The United Nations Convention on desertification (UNCED) have identified defined desertification as "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities, especially soil erosion" (UNCED, 1992). To some observers, however, desertification is a loosely defined term (Prince et al, 1998), with a political connotation (Dregne, 1998); and to others (De Haan et al, 1997), the term "conveys images of advancing desert for which pastoralists are to blame". The basic causes of erosion include overgrazing of pastureland, over-cultivation of cropland,

waterlogging and salinization of irrigated land and deforestation (Mermut and Eswaran, 1997).

Most commonly desertification is regarded as a process resulting from drought conditions exacerbated by reduced rainfall due to changes in climatic conditions.

However, human-induced erosion is recognized today to be one of the greatest contributors to desertification and a deterrent to sustainable resources management in Sub-Saharan African countries. Effort today is in developing indicators for monitoring the driving forces of human activities that are accelerating the land degradation process. The challenge, however, is to determine how indicators will reflect the effects of the combined climatic and human-induced process in resource base deterioration and food security assurance.

According to McCracken (1988), and Tschirley (1997) a useful approach is to develop a minimum set of variables that can provide indications of the changes taking place with resource use. The question is, under given climatic condition, what are the indicators that livestock grazing, for instance, (on a hillside, valley bottom or river terrace) has gone beyond the threshold of sustainability? Collecting quality field data is a primary necessity, but usually expensive for some developing countries. Advances in remote sensing techniques today, especially with Geographical Information Systems (GIS), provide renewed capability for manipulating remotely sensed data, that can complement field-generated data.

The purpose of this paper is to examine some of the salient factors related to desertification vulnerability in Africa. First, it presents an overview of the soils and climatic conditions impacting on desertification vulnerability, drawing examples from some Sahelian UNSO countries (UNCED, 1993). Second, historical trends of human and livestock population in these countries are used to assess the impact of human activities on the resource base and resource use. For each country the stocking density, the cattle to (goat + sheep + camel) ratio, and the livestock to human population ratios are determined. Third, an attempt is made at defining an integrating framework for developing indicators for desertification vulnerability that relate biophysical factors of soils erosion, climate and human activities. It provides the basis for developing indicators for monitoring land degradation resulting from human-induced erosion and its susceptibility on desertification vulnerability.

## 2. Methodology

The desertification vulnerability of Africa map is a reclassification of two biophysical maps - one of soil classification and the other of soil climate. The soil map data is derived from the digital 1:5M scale, FAO-UNESCO Soil Map of the World. The soil climate map is an interpolation of 20,000 global climatic stations, consisting of 30-year mean monthly air temperature and precipitation. The data is input into a soil moisture balance model to estimate soil moisture regimes (SMR<sup>1</sup>) and soil temperature regimes (STR<sup>2</sup>) (USDA, 1998). Using GIS, the soil and climate maps are combined and each map unit is empirically assigned a vulnerability class. Regions that are cold, dry or humid are excluded according to UNEP's desertification definition. The soil moisture regime is the dominant factor in assigning classes, with Aridic and Ustic SMRs having the most influence in determining vulnerability. The SMR subdivisions determine which class map unit best fits, depending on the relative moisture condition. For each country, a raster country boundary map (ESRI, 1994) is overlaid

<sup>1</sup> SMR refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year

<sup>2</sup> STR refers to the mean annual soil temperature or/and the difference between mean Summer and Mean Winter soil temperatures at a depth of 50 cm from the soil surface.

on the desertification vulnerability map to calculate vulnerability class areas by country. For example, in general, areas classified as very high vulnerability have a Weak Aridic SMR (figure 1). Information derived from map unit soil classification (Eswaran, 1992) provides an important means of refining the procedure. Extreme levels of chemical and physical conditions such as soil depth and pH, as well as soil resilience are factored into the vulnerability class determination.

In assessing the impact of land management, and the livestock and human population dynamics on desertification vulnerability, historical data on livestock, and human population (WRI, 1997) was used to analyze trends over a period of 31 years. Data for six Sahelian African countries from 1963 to 1994 was used because only countries with complete data set were selected. For each country the individual livestock numbers are multiplied by a corresponding weighted factor (table 1) results in an equivalent livestock unit.

**Table 1. Weighted factors used in Calculating the Livestock Units (Personal Communication, Peter Jippe, World Bank)**

<u>Livestock</u>	<u>Factor</u>
Camel	1.00
Buffalo	0.80
Cattle	0.70
Pig	0.20
Equine	0.67
Goat	0.10
Sheep	0.10
Poultry	0.01

Figure 2 shows the stocking density that is calculated by dividing the total livestock unit by the map area that is dry and vulnerable to desertification. The rationale in using the map area that is vulnerable to desertification and dry is that livestock production on pasture and range-land occurs mostly in the semi-arid (Ustic & Xeric) and Aridic SMR regions. These regions correspond to the humid Savannah and dry Savannah vegetation where livestock rearing is the dominant land use type. Therefore, the land area used in this calculation exclude the humid (Udic) areas.

Using the same data, the ratio of cattle to (goat + sheep + camel) population was calculated as shown in figure 3. The aim of the cattle to goat, sheep and camel ratio is to establish the livestock resources use trend over the years.

Figure 4 shows the 31 years trend in livestock-human-population ratio for some Sahelian countries. The livestock-human population is calculated by dividing the total livestock units by the total population. The aim is to assess the relationship between the impact of livestock and human population dynamics on the resource base. Such a relationship is better expressed using a country's total livestock unit than using individual livestock type like cattle or sheep (De Haan et al, 1997). The rationale is that demand for agricultural and urban land, tends to be higher with increasing human population density than land area for livestock.

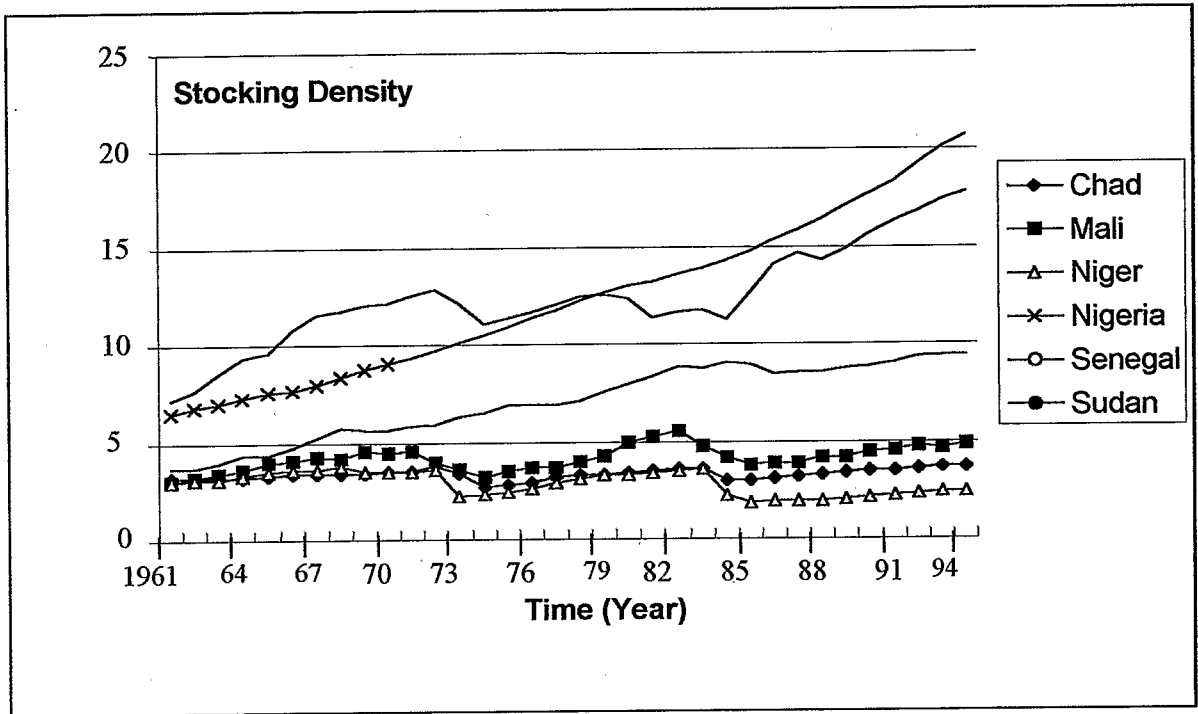


Figure 2. 31 Year Variation in Stocking density in Six Sahelian African Countries.

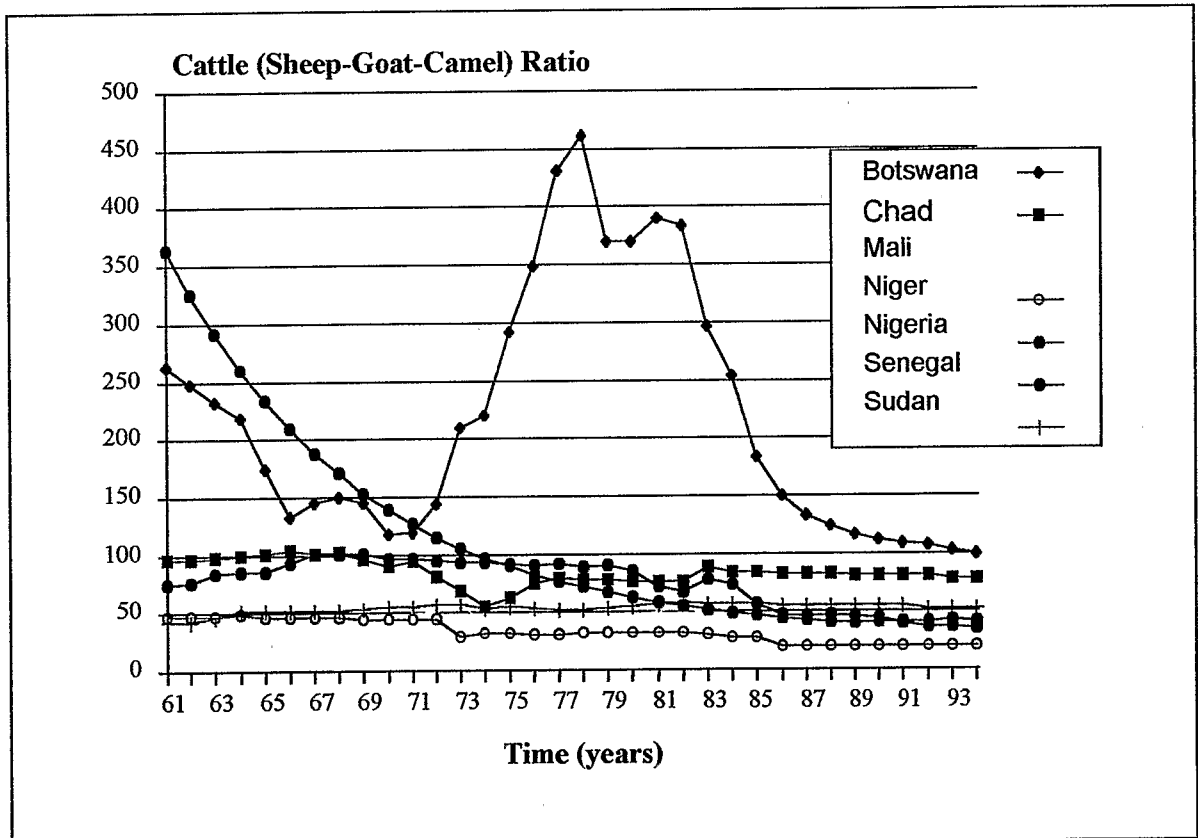


Figure 3. Cattle/(Sheep + Goat + Camel) Ratio for Some Sahelian African Countries Including Botswana (1961-94).

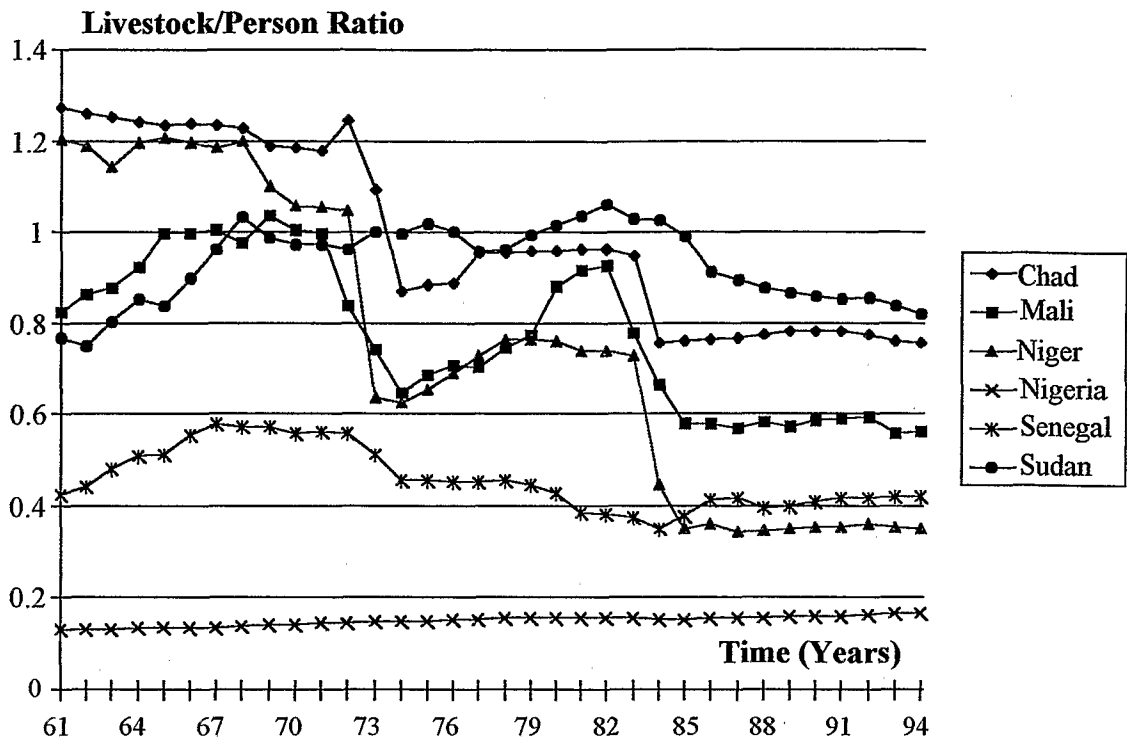


Figure 4. Cattle-Person Ratio in Some Sahelian African Countries (1961-94)

### 3. Results and Discussions.

Desertification vulnerability of Africa that results from erosion is attributed to two major interacting factors: variation of climatic conditions and the impact of human activities (Thomas, 1980; Dregne, 1998). In results and discussions, the focus, first, is looking at the spatial variation in climatic and soil conditions. Second, human activities relating to the dominant land use type, livestock rearing is examined. Third, the physical impact of livestock on the degradation of the landscape is assessed in relation to the Sahelian ecosystem and to its resilience potential.

#### 3.1. Biophysical Conditions

At the biophysical level, nearly 89% of Africa's land is either already too dry (42.7%) for sustainable agriculture or is vulnerable to desertification (45.8%). The remaining 11% humid forest ecosystems, is located mostly in the central region of the continent. As is shown in Fig. 1, there is a relationship between the desertification vulnerability classes and the SMR from south to north. From about 10° to 15° N latitude, spanning from Senegal to Ethiopia, the SMR becomes progressively dryer moving northward. The southern part of this zone is mostly Typic Tropustic, (Low to moderate vulnerable class), farther north the SMR becomes Aridic Tropustic (high vulnerable class) and continuing northward there is a band of land that is weak Aridic (very vulnerable class). It is this relatively narrow continuous band of land with a weak Aridic SMR that is very highly vulnerable to desertification. In Nigeria for example, 95% of the country is vulnerable to desertification with 85% having moderate to high vulnerability. Vulnerability increases from south to north and is very high at the Niger border.

Accordingly, the soil climate map also shows a south-north variation of rainfall decreasing northward with higher vulnerability classes. The south-north orientation of vulnerability classes also corresponds to changes in the sequence of vegetation going from the Guinean Savannah mosaic, to the Sudanian, and to the Acacian Sahelian Savannah. While there are indications of an increased resilience of the Sahelian ecosystem (Prince et al, 1998), it is still uncertain to what extent human activities are affecting resource base resilience.

### 3.2 *Socio-Economic Conditions*

While the desertification vulnerability map shows what impact soils, and climatic factors (rainfall and temperatures) have on desertification, the effects of human interactions are depicted by the social and economic factors: cattle-ratio, stocking density and person-cattle ratio. In land use, livestock rearing plays a dominant role in the economies of the Sahelian countries. The question is what story can the livestock rearing activities tell about desertification vulnerability? The 31-year trend (figures 2, 3, and 4) shows the interactions between total livestock and the resources base, between cattle and other ruminants, and between livestock and human population.

Generally, stocking density is shown to be rising slowly but steadily for the past 31 years. Even periodic drops due to the major droughts of 1973-74 and 1984-85, were followed by a recovery. The stocking density is often used as an indication of the land-carrying capacity for livestock, where it is possible to determine and to specify the area and type of pasture or range land vegetation (White and Troxel, 1997). In this case, however, the use of stocking density as a proxy for land degradation calculated as total livestock unit over the total pasture is limiting. This is because: (a) stocking density in range lands is different from that of pasture land; (b) in most of the Sahel, transhumance (periodic movement of cattle with the seasons), results in varying stocking density; (c) the vegetation and landscape type over which density calculation is made varies. Better control of livestock pests and diseases, followed by increased demand for livestock, especially in the more humid tropical regions are the principal reasons for the steady rise in stocking density over the years.

The cattle-(goat + sheep + camel) ratios show, on the other hand, the relationship of these livestock types to the resources bases for the last 31 years. The cattle and goat, sheep and camel population adapt differently to the vagaries of climate (Dow, 1986). The thrift and hardiness of sheep, goats, and camels to changing terrain conditions can provide an indication of land degradation over time. Thus as the land becomes more degraded with decreasing grass vegetation and limited water resources, its capacity to support larger livestock decreases and therefore only livestock such as goat and sheep, and camel can thrive better, compared to cattle.

Nigeria and Botswana show two contrasting situations. The parabolic decrease in cattle ratio shows the effects of a high human population density, and an increasing degradation of the land resources, due to poor management. Botswana, on the other hand, which developed a better cattle management strategy from 1972 increased its cattle ratio until 1983. The decreasing trend from 1984 was due to the cattle mouth disease rather than poor management. Thus the cattle ratio can be used as a proxy to indicate land degradation by showing how goats, sheep and camels, replaced cattle as vegetation and water resources depleted with increasing degradation of the land.

The livestock-human population ratio (figure 4) shows the combined effects of climate, human interactions and spatial conflict between agriculture and livestock on land degradation. First, the trend shows climatic adversity such as drought, 1973-74 and 1984-85 that caused significant decreases in livestock ratio. With each drought, subsequent recovery

did not attain the pre-drought levels, thus producing, a decreasing staircase configuration corresponding to the two major drought periods. The significance of this is far reaching: (a) droughts are a disaster period for both human and livestock often resulting in drastic depopulation of cattle and causing famine in humans; (b) it is an indication of the fragility and poor resilience of the land due to mismanagement. Second, decreasing ratio indicates increasing population growth rate, and increasing food demand. Third, decreasing ratio is also a consequence of increasing spatial conflict between cattle rearing and agricultural land use. As human population increases, the demand for meat increases, but the demand for agricultural land increases as well, at a higher rate. Thus livestock pasture land and forage becomes highly reduced (De Haan et al, 1997), especially where there is no intensification of agriculture and an appropriate system of livestock husbandry. Livestock-human ratio, is therefore, a good indicator of desertification or degradation of resource use in the Sahelian countries. Like other poor land uses, mismanagement with livestock is a precursor for land degradation.

### *3.3 Role of Livestock in Erosion and Land Degradation*

This and previous studies have shown that livestock plays a highly significant role in the process of land degradation and desertification vulnerability (Grainger, 1982; Monique, 1993; Nana-Sinkam, 1995). The concern here is the physical effects of livestock on the landscape. In other words, what are the physical effects or scars resulting from livestock management that led to the degradation of resources? Answers to these questions will help in identifying appropriate field indicators for use in monitoring and evaluating degradation relating to land use. The physical effects of livestock on the physical environment can be independent or interacting, but stocking of livestock by farmers tends to be incremental.

Generally farmers or pastoralists over-stock by gradually increasing herd size. Factors that have contributed to increased herd size in the last 20 years include: (a) growing human population, which leads to more mouths to feed; (b) increased market demand for meat in the more humid forest coastal parts of the continent, where the presence of tsetse fly make cattle rearing prohibitive; and (c) the introduction of better veterinary care that has decreased the mortality rates from prevalent pests and diseases (Grainger, 1990).

With no ranching, herding of livestock in the wild becomes the tragedy of the common (as the land belongs to everybody but to no body), so transhumance is generally practiced. Transhumance is seasonal movement or herding of livestock herds from the highlands to the river valleys during the dry season, and back to the uplands during the rainy seasons (Darkoh, 1994). In the process, herds of cattle that must feed, indiscriminately browsing the fields they cross, leading to rapid loss of vegetal grass cover. The resulting overgrazing is a direct consequence of increased livestock, as over-stocked livestock population browses faster than vegetation's natural capacity to recuperate. Cattle, for instance browse to the lower grass roots destroying edible species (Dow, 1986), thus decreasing, the durability of the pastures, and encouraging the establishment of ephemeral species (Grainger, 1982).

Overgrazing also leads to ground surface exposure. The scorching heat during more than six months of dry season, create an ideal soil condition susceptible for wind erosion, which is a significant contributor to land degradation in the Sahel. The nomadic life style of perpetual movement of cattle either to and from the fields, or to and from water sources also causes considerable trampling of the exposed soil surface (Grainger, 1982). On the gazing hills, these cattle hoof marks look like concentric rings from afar. The greater the number of livestock, and the more frequent the nomadic movements, the greater the trampling and subsequent wind and water erosion. Ground exposure and trampling make the bare ground



surface of Sahelian soils vulnerable to rain runoff erosion. Rainfall in the Sahel can be heavy and abundant, but with varying frequency, and distribution. Water does not infiltrate but run-off with great velocity, carrying the fragile trampled dusty ground surface along.

Frequent burning of grass vegetation in the dry season, which is aimed at stimulating the sprout grass vegetation with early rains, contributes to soil nutrient impoverishment and mining. Pastoralism depends on the natural recycling of the grass vegetation to replenish soil nutrients lost from grazing, as there are no external sources of nutrient inputs. Overgrazing, accompanied by frequent burning of grass results in soil nutrient loss because biomass ash is either blown away or washed away by run-off with the early rain storms (Thomas, 1980). Repeated wash-off of surface soils reduces the competitiveness of native grass and encourages the establishment of foreign grass species (Monique, 1993).

Low soil water availability, low stream discharge and salinalization of depressions are also the detrimental effects of overgrazing. Lack of ground cover increases runoff from rains, reducing infiltration to recharge the yearly ground water table level. Low ground water recharge renders streamlets, streams and rivers ephemeral. Furthermore, deforestation and inadequate tree vegetation for evapotranspiration often cause ground water build-up in depressions that are often saturated in sodium chloride, resulting in water and soil salinity. (Grainger, 1990).

The physical effects of livestock on the landscape are complex and interacting. By itself, livestock is not as much a problem as is management, under poor input conditions. Under a prevailing climatic conditions, an important concern is the resilience of the ecosystem resource endowment that response to the varying levels of management and land use.

### **3.4 Resilience of the Sahelian Ecosystem**

The question is, given the present level of mismanagement, how tenable are the fear of a widespread desertification and the inability of the Sahelian ecosystem to recover from the threats of recurring drought? Recent climatic studies using net primary productivity (NPP) and rain fall use efficiency, indicate there are “no fears of extensive and progressive desertification in the Sahel; and suggest that the resilience of the Sahel has not changed dramatically even in a decade that endured one of the most serious droughts on record” Prince et al, (1998). While there seem to be little fears of a wide-spread desertification of the Sahelian region from climatic causes, the effect of land use in the reduction of ecosystem resilience can not be under estimated. The results of the present studies (figure 4) show variation in the livestock-person ratio in the last 31 years. For each major drought (1973-74 and 1984-85), the livestock-person ratio did not recover to the pre-drought period level. This is a practical evidence of system vulnerability to drought. First, the significant decrease in the livestock-person ratio is due not only to loss of livestock relative to humans during droughts, but also to the lack of resilience by the system at that level of management. Second, net primary productivity as a measure of resilience is rather inappropriate and inadequate with land use, as this obscures local hotspots with high degree of resources degradation and virtual ecosystem collapse. Furthermore, other studies show that the vegetation in the Sahel can recover quantitatively but not qualitatively from a drought, as some very nutritive plant species may have disappeared (Monique, 1993). Third, NPP and RUE determined from NDVI and AVHRR (reconnaissance level biophysical 1 km<sup>2</sup> grid variables) reinforces the notion that the term desertification has more of a political connotation than physical (Dregne, 1998), as resilience is primarily a function of land use.

The issue of desertification vulnerability in Africa, therefore, is predominantly that of the combined effect of land use mismanagement compounded by the vagaries of climatic conditions. The focus today is to develop land quality indicators (LQI) that can reliably be used for monitoring and evaluating desertification.

#### 4. Framework for Developing Desertification Vulnerability Land Quality Indicators

The prime concern is looking at the relationship between climatic and human factors in order to establish when the resource base has reached a non-sustainable threshold, making it vulnerable to desertification. Land quality indicators (LQI) are intended for the purposes of monitoring and evaluating land quality concerning its potential for production and environmental management (C. Pieri et al, 1995). LQI describes the "current state or condition of a resource, as well as gauge performance and predict responses" (Benites et al, 1997). Implicitly, LQIs are intended to provide a barometer for gauging land resource degradation, and maintaining environmental quality. However, the operational links between biophysical land information and the socio-economic activities of human population are not clearly defined. On the other hand, the effect of climate is natural, cyclic and predictable, but human activities are more complex, difficult to define and not reliably contained.

In developing indicators for monitoring and evaluating desertification, key guiding signposts and challenges must be overcome including: (a) defining benchmarks or reference states for the biophysical and social-economic components of human activities (b) establishing homogeneity for data collection; (c), standardizing methodology for data collection at scale of operation; and (d) defining the scale or level of operation (UNEP, 1998).

In collecting data for developing LQIs the use of remote sensing with geographic information systems (GIS) at very small scales (1:100,000 to 1:5,000,000) has become more practical. At the regional and continental level resources management using remote sensing with techniques like Normalized Vegetation Index (NDVI) and Advanced Very High Resolution Radio-meter (AVHRR) has become more popular and easy (Eastman et al, 1997). The challenge, however, remains at the field level of operation (1:10,000 to 1:40,000) for the traditional farmer or pastoralist. It is at this field level that the driving social and economic forces are converging positively or negatively to affect the resource base.

Table 2 shows a practical methodology for attempting to develop a framework for desertification vulnerability indicators. It is based on interacting or matching desertification vulnerability classes map (figure 1) with and potential human activities like cattle- (goat + sheep + camel) ratio, livestock stocking rate and cattle-people ratio taking place at local and field levels. The concerns being addressed are: (a) establishing the different magnitudes of human interactions under the respective soil map classes on the desertification vulnerability map; in other words, what classes of human-induced activities match desertification vulnerability map; (b) finding out if there is also a south-north orientation in the severity of human activities; and (c) identifying the principal variables in human activities that are susceptible to desertification.

First, a four level classification (similar to the soil climatic vulnerability map) is established, describing the magnitude of the human-induced activities at the field level. The criteria for classification should depend on biophysical field characteristics and social-economic factors at scale of study. The major biophysical characteristics would include: topography (slope, altitude, and physiographic position); topographic domain (plateau, depression, mountain, river terrace, and river; and vegetation types (Kharin et al, 1993). Second, the classes of human activities are matched with the desertification vulnerability map

to produce a new table that captures the climatic and the human-induced effects on desertification.

**Table 2. Framework for developing desertification indicators that combine field level variable classes with climatic vulnerability classes.**

	Vulnerability Classes	Climatic Vulnerability Classes			
		Low	Moderate	High	Very High
<b>Human Activities/Land use</b>					
Cattle/Goat+Sheep+Camel Ratio	Low				
	Moderate				
	High				
	Very high				
Stocking Density	Low				
	Moderate				
	High				
	Very high				
Livestock-Population Ratio	Low				
	Moderate				
	High				
	Very high				
<b>Degradation of Vegetation Cover</b>					
Status of plant Communities					
Loss of Productivity					
Types of fallow vegetation					
Incidence of weeds					
Etc.					
<b>Landscape Degradation</b>					
Type of water erosion					
Slope of landscape					
Stream density					
Ground cover percentage					
Etc.					
Type of land use					
<b>Wind Erosion</b>					
Sod cover					
Amount of moving sand and dunes					
Etc.					
<b>Socio-Economic Characteristics</b>					
Type of land use					
Off-farm activities					
Dominant type of livestock					
Etc.					

\* These activities are also put in four vulnerability classes.

(b) show the differences in vegetation types, or soil degradation between areas of low and high human activity class; and most importantly (c) indicate the appropriate measures to take to improve land management. Most invariably negative climatic factors combine with land mismanagement to reinforce a locality's desertification vulnerability.

The tenet of the framework is that measurable field characteristics should be put into four levels of severity classes that can be compared with the climatic levels. Expected information from the new table will enable: (a) under high climatic vulnerability class, show how the human induced activity like the cattle- (goat + sheep + camel) ratio vary from one location to another;

## 5. Conclusion

While recurrent climatic phenomena such as drought accentuates the processes of desertification, land mismanagement is recognized as the principal factor for land degradation and desertification vulnerability in SSA. The mismanagement factor underscores on the one hand human survival experience in adapting to difficult and harsh climatic condition, with limited resources. On the other hand, mismanagement underscores the consequence of neglect or little concern shown by the policy environment toward a determined commitment to alleviate poverty, institute social justice and establish accountability. In the face of these predicaments, there are more questions than answers; but the question that is seldom asked is, how prepared are the international and local communities for dealing effectively with the advent of the next inevitable drought?

Given the present level of livestock and human dynamics, in which agriculture and livestock rearing is still largely extensive; the next drought will be yet another disaster in SSA since financial resources are available nationally and internationally for land intensification,. From a land use point, therefore, widespread desertification is eminent in most SSA, especially in the Sahelian ecosystem.

Coping with desertification vulnerability would entail addressing strongly the human and livestock population dynamics in the use of the land. Conflict in the use of land for agriculture and other purposes, inevitably accentuates degradation processes, especially where land intensification mechanisms are not in place. While livestock are reared for food and for cash income, land has to be set aside for agricultural production. To address these conflicts in land use, intensification of livestock production and agricultural crops are imperative.

Overcoming land mismanagement is still the greatest challenge, and will continue to be in the distant future, especially in the face of present day's market globalization. African countries, most of that are dependent on their natural resources, will be less competitive, and as vulnerable to external shocks of the market as to desertification. Unlike some observers on desertification contend, it is livestock and human population dynamics, that is, the land use type that will determine ecosystem resilience in these regions, and not the climatic factors. Historically, plants and livestock have always adapted to long term climatic changes, especially when human intervention or influence on the land has been minimal.

Desertification vulnerability is essentially field related. Thus indicators for monitoring and evaluating degradation of land should best be derived at the field levels. Field level data are, however, expensive to obtain, which explains partially why the use of remote sensing data has become such an important tool in natural resources management in Africa. While accepting the virtues of this technology, inadequate ground truthing, result in data gap to substantiate remotely sensed data. This renders the use of most remotely sensed data information only marginal at best. Therefore, indicators for desertification vulnerability

should be derived from a combination of remotely sensed and field-derived data. Furthermore, financial and human resources should be allocated in collecting field level data, to enable information or data to be aggregated from the field to the to sub-national, and regional and even international levels.

How vulnerable Africa will be to desertification is also be dependent on the willingness of the African governments to focus on the crucial issue of making the land livable. As most of SSA is dependent on its natural resources for social and economic development, it behooves governments to initiate programs to sustain the resource base through conservation and land use intensification. It will require a renewed national and international level commitment to fight not only land degradation but also all forms of poverty, social justice, and accountability.

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