



Review Article

Analytical Situations of Land Degradation and Sustainable Management Strategies in Africa

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ABSTRACT

Methodologies for sustainable management of land degradation, economic growth and poverty reduction have become re-occurring topical issues in present African research activities because of the danger they pose. Land being finite and a potentially productive natural resource and on which human life's depend on for sustenance - food, clothing, shelter, material or precious stones, has been under constant degradation. The process of land degradation is caused by biogeophysical (natural e.g., climatic vagaries of water & wind erosion); socio-economic (burgeoning human population) activities - poor land use, inadequate land and water management policies, deforestation/over-exploitation for forest ecosystem services, pollution/contamination of land resources, etc. and institutional factors (inadequate land policies). The phenomenon has debilitating impact on human well-being, livelihood systems and environment through the reduction of or damage to physical, social, cultural or economic features and/or reduction of ecological system diversity. Ecological functions of land resources in terms of essential environmental services required by human - food, water and fuel and climate regulation are reduced. In particular, reduced land resource productivity scales up food insecurity - a widening "food gap" and general poverty. In order to reverse this trend, this paper attempts to address the problem by discussing the methodologies necessary for sustainable land management, to ensure improved food security, rapid economic development and poverty reduction in developing countries of Africa.

Key Words: Land degradation; Food security; Poverty reduction; Land management

INTRODUCTION

The population of the world is increasing astoundingly in the recent years. Present projections suggest that it will be 11 billion by the year 2100 (World Resources Institute, 1992). Population increases in developing African countries are at geometric trend too and most of these human populations live in urban, peri-urban and rural areas.

Human population, whether urban, peri-urban or rural depends on the benefit of land resources (land being defined here as a concept that encompasses soil, water, vegetation and climate) for sustenance - food, clothing, shelter, etc. Land as a finite and a potentially productive natural resource represent our basic food production facility, but the diversity of residents and intensive use of the resources by the increasing population coupled with economic activities and global market drive unprecedented land use and land cover changes. These changes lead to transformations in the hydrological, ecological, geomorphologic and socio-economic systems and which are often neglected by both rural and urban administrations.

Land being limited in supply is pressured and competed for several uses-food production, conservancies (aesthetic uses, games reserves) rapid urban development in

terms of modern housing, transportation and other infrastructure as well as industrialization, etc., which often leave pool effects on land market and economy. Therefore, misuse of land due to these activities lead to serious degradation.

Land degradation may be defined as the loss of utility or potential utility through the reduction or damage to physical, social, cultural or economic features and/or reduction of ecosystem diversity. It is also the temporary or permanent decline in the productivity of land.

The cause of land degradation may be single or a complex mix of causes. Some are biogeophysical (natural-climatic vagaries of water & wind erosion that dominates the soil & bio-resources); some socio-economic (human) activities, while some are institutional factors e.g., inadequate land policy frameworks and it is quite possible that causes (s) may be indirect, perhaps cumulative and difficult to identify.

Scientists and development practitioners acknowledge that the most potent source of land degradation is from anthropogenic (human) activities that accelerate changes in land use and land cover through un sustainable land use; in appropriate land and water management research and policies; expansion of agricultural land (especially into

marginal lands & fragile ecosystem); deforestation and/or over-exploitation for forest ecosystem services; urban and peri-urban growth; intensification of agriculture; poor waste disposal; soil and water pollution contamination; unsustainable use of fresh water resources; large mining concessions; civil strife and regional conflicts; HIV/AIDS pandemic; lack of land ownership and land tenure security that undermines technological adaptations and de-investments in land management initiatives. Other causes of land degradation may be associated to imbalance in power, wealth, knowledge and access to resources.

Intensive use of resources limits the capability of natural restoration of these resources and which are sometimes destroyed (resilience). Hence, misuses of land affect the productive capacity, physiological, cultural and ecological functions of land resources through reduced essential environmental services required by humans - food, water, fuel, climate regulation, disease control, etc. Also the changes in land use diminish the capacity of the land to provide benefits in terms of yield and productivity. The consequence is inability of the populace to feed itself, while food insecurity (a widening "food gap"- the difference between what is to be produced & what is needed to maintain minimal food nutrition) and health degeneration deepens. Inadvertently, this affects individual and national economies, which also retard development in urban, peri-urban and rural areas. Other impacts of the land use and land cover changes include build-up of green house gases; the loss of biodiversity, changes in climate and their effects (on rainfall & temperatures; frequency & severity of drought; flooding; fire hazards; phenomenon such as El Nino & the rising sea level).

The interrelationships among land degradation, land resource productivity and rural-urban poverty are most manifested in the developing countries that lack the technological capacity to offset the negative aspects of vicious cycle of poverty. Consequently, poor rather than rich people in this part of disadvantaged economic countries suffer disproportionately due to land degradation blighting a significant proportion of the land surface. Productive lands in developing countries have been reduced to the extent that meeting up food with burgeoning population is an arduous task. The magnitude of the task at a global scale is illustrated by a report (IDRC, 1992) that shows that if we are to meet the needs of the anticipated population, the amount of food we must produce in the next 50 years equals the total production for the past 500 years of agricultural history.

Given these scenario of the impact of urbanization on land use (land degradation) and the multiple consequences on human wellbeing and his environment, the land in the urban-rural continuum must, therefore, be managed to ensure sustainable and improved food security, rapid economic growth and development for poverty alleviation. According to Smith and Dumanski (1992) agriculture is expected to continue to be the engine of economic growth

and development but for this to be realized, it has to be increasingly more productive, more economically efficient and more environmentally and sustainable friendly.

The objective of this paper is an attempt to address the problem of land degradation effects on land resources and human well being and to identify appropriate approaches (possible options) to the sustainable management of land in developing countries of Africa.

The impact of land degradation. About 16%, representing 494.2 million hectares of land is degraded in Africa (Ayoub, 1994) (Table I). However, as a percentage of the degraded areas, soil erosion is the most extensive followed by nutrient depletion, soil physical problems and contamination. The annual monetary value of lost production through land degradation is \$65 million (UNEP-GEO out look) consisting of:

- \$ 35 billion from rangeland, primarily in arid and semi-arid zones,
- \$ 12 billion from rainfed crop land, much of this under subsistence farming,
- \$ 17 billion from irrigated lands through salinization and ground water pollution.

Land degradation generally impacts human well being and livelihoods through:

(a). Food insecurity. A widening "food gap" in Africa. A USDA report (Oldeman *et al.*, 1991) calculates that the increase in malnourished people is 15% this decade in Africa. This was evidenced by the total cost of \$3.8 billion for Africa to purchase 19 million tons of cereals in 2003 alone as replenishment for the lost production caused by land degradation.

(b). Poverty. Land degradation affects the poor much more than the rich. Degraded lands not only produce less, but they demand more resources to manage. The poor are vulnerable because they farm marginal areas: - rely more in the intrinsic quality of their soils and landscape; have fewer capital assets to improve their land or invest in conservation technologies; tend to migrate to seek urban based income, denying their land the necessary labor to manage the resources in a sustainable way and have less resources to be resilient in the face of major problems such as drought, floods and diseases such as AIDS/HIV.

Other impacts on human condition are through loss of ecosystem services and functions, especially water conservation and regulation, provision of food, fuel as well as cultural richness and diversity.

These impacts - physical, biological, social, cultural and economic are some times direct, indirect or cumulative on short-term or long term basis.

Land degradation processes. In this paper, land degradation will be used interchangeably with soil degradation. The processes of soil degradation are the mechanisms responsible for the decline in soil quality and they are grouped into three types: physical, chemical and biological type, each of which has different processes affecting it (Lal *et al.*, 1989). However, FAO in 1994

grouped all processes of land degradation into six classes: water erosion, wind erosion, fertility declines, salinization, water logging and lowering of the water table:

- Soil erosion by water includes interill and rill erosion, gullying and mud-sliding caused by clearing of vegetation and civil construction works.
- Soil erosion by wind produces sand dunes.

The extent of soil degradation in Africa due to erosion is shown in Table II. The table shows that 227 and 217 million hectares of land are eroded by water and wind, respectively and this represents 16% of the total land area seriously eroded.

- Soil fertility decline refers to deterioration in soil physical, chemical and biological properties caused by (a) reduction in soil organic matter (OM) status leading to decline in soil biological activity; (b) degradation in soil physical properties (structure, aeration, water holding capacity) caused by reduced OM; (c) adverse changes in soil nutrient status, including reduction on availability of the major nutrients (N, P, K), initiation of micronutrient's deficiencies and development of nutrient imbalances; and (d) build up of toxicities (by heavy metals, xenobiotics & acidification through incorrect use of fertilizers). Table III shows the extent of physical and chemical soil degradation in Africa.

- Salinization refers to all types of land degradation brought about by increased concentration of salts in the soil. It occurs by ill-planning and mismanagement of irrigation schemes (salinization) and sodicity (also called alkalization) which refers to the dominance of the exchange complex by Na^+ .

- Waterlogging is caused by over irrigation and restricted infiltration of water into the soil. This lowers land productivity through rise in ground water close to the soil surface.

The processes of land degradation can be summarized as "Desertification", soil degradation [compaction, loss of fertility, pollution, waterlogging, acidification, salinization, alkalization, laterite & hard pan formation; erosion]; range land degradation, degradation of vegetation cover, deforestation, impoverishment of wild life habitat and loss of species.

The environments for land degradation in Africa include deserts, savannas, rangelands, forests, woodlands, tundra; mountain environments; wetlands, flood lands; irrigated lands; sand-dunes; coastal zones, islands, urban, peri-urban and rural environments.

Causes of land degradation. Climatic vagaries such as droughts, alternating with floods have led to the loss of top rich soil through soil erosion and sedimentation, rendering large tracts of land worthless to those that depend on exploiting an area's bio-resources.

Rapid urbanization occurs when towns and cities develop on productive farm lands and forests. As urban areas grow, these productive lands that once grew food disappears under concrete, thus making remaining less land

to compete for other uses such as industrial, residential and infrastructural facilities, etc. As population grows socio-economic activities and intensive use of resources increases, thus driving unprecedented land use and land cover changes. For instance, Ethiopia is at a turning point of urbanization process/development in the housing sectors and modernization of infrastructure and facility that is yet unparallel.

Unsustainable land uses. Most farmers who live in the rural areas are poor and practice small-scale rainfed agriculture and /or pastoralism. They lack the facility to employ appropriate improved farming technologies. HIV/AIDS pandemic has significantly compounded the problem of non-management of land and hence its degradation through severe loss of mature population and subsequently loss of farm labor and agricultural knowledge. Also, brain drain (migration of young ones into cities & leaving behind unproductive old men, women & children in the villages) cripple viable planning and natural resource utilization. Civil strife and prolonged war e.g. Democratic Republic of Congo, Angola, Sudan, Somali have plundered resources and have rendered large areas unusable because of land mines and destroyed infrastructure such as irrigation scheme. Poverty increases with very low available land per capita.

Further causes of land degradation include population pressure and human activities such as over cultivation (agricultural intensification), which exhausts the soil; overgrazing which removes the vegetation cover that protects soil from erosion; deforestation/over-exploitation for forest ecosystem services, which removes trees and vegetation that binds the soil to the land, and poorly designed irrigation that turn cropland saline as well as oil exploration degrades land by affecting aquatic life.

- Over use of nutrients for high value crops (horticulture & floriculture) occur in peri-urban agriculture. These excess nutrients often mix with pesticides to pollute soil and water. Poultry, pig and sea food production bring very large quantities of nutrient efflux and pollution. These organic wastes are inherent environmental externalities that cause cities, stream and coastal areas pollution.

- Fire and burning of vegetation; tillage related practices; low input agriculture, energy production/consumption, altered communication and large mining concessions are all part of land degradation.

Administrative and institutional problems include. Destructive and poorly conceived land tenure policies that undermine old-age land management mechanism. Lack of ownership and tenure security undermines innovative technology adoptions and de-investment in land management initiatives; There is inadequate budgetary allocations and lack of poorly articulated regulations on implementation of policies; inadequate capacity to enforce policies as well as lack of commitment and political will undermine management of land degradation.

Also, networking is lacking among the stakeholders

Table I. Soil degradation in Africa (million ha⁻¹)

a. Proportion of degradation			b. Components (Causes) of degradation		
Total degraded surface	494.2 (17%)		Overgrazing	243.0 (49%)	
Total waste land	732.2 (25%)		Agricultural practices	121.4 (24%)	
Total other terrain	1739.1 (58%)		Deforestation	66.8 (14%)	
Total	2965.6 (100%)		Over exploitation	62.8 (13%)	

Source: Ayoub (1994)

Table II. Global extent of soil degradation due to erosion in Africa and world (million⁻¹)

Region	Area evaded by water erosion				Area eroded by winter erosion				Total area evaded	Total area seriously eroded	Total area seriously eroded as % of total land used
	Light	Mod	Strong to extreme	Total	Light	Mod	Strong to extreme	Total			
Africa	58	67	102	227	88	89	9	186	413	267	16
World	343	526	223	1094	269	254	26	548	1642	159	12

 Source: Oldeman *et al.* (1991)

Table III. Global extent of chemical and physical soil degradation in Africa and the world (million haY)

Region	Chemically degraded are				Physically degraded area			Total degraded areas as % of total land used
	Lost nutrients	of Stalination	Pothetion	Acidification	Compaction and crusting	sealing Water logging	Total Degraded area	
Africa	45	15	-	1	18	1	81	4.8
World	136	77	21	6	68	11	328	3.7

 Source: Oldeman *et al.* (1991)

Table IV. Causes of law degradation according to GLASOD assessment

Types of degradation	Percentage of area degradation caused by			
	Deforestation	Quergraing	Agricultural activities	Over cutting of vegetation
Water erosion	61	67	2	44
Wind erosion	21	46	1	98
Soil fertility decline	25	0	75	0
Stalination	34	30	14	87
Water logging	0	0	85	33
Lowering of water table	12	22	65	34
All types of degradation	37	46	15	63

Note: up to two causes are given for each type of degradation, 80 percent sum top more than 100

Table V. Comparison of soil degradation in different land use types in Africa to the world (million ha⁻¹)

Region	Agricultural Land			Permanent Pasture			Forest and Wood			All used land		Seriously Degraded	
	*	**	***	*	**	***	*	**	***	*	**	*	***
Africa	187	121	65	793	243	31	683	130	19	1663	494	30	231
World	1475	562	38	3212	685	21	4048	719	18	8735	1966	23	1216

Note: *, **, *** = Total degraded, percent (%), respectively.

 Source: FAO (1990) for all totals; Oldeman *et al.* (1991) for others.

and there is failure to share vision; there is increased duplication of efforts leading to increased inefficiency and failure to create a critical mass of expertise around land degradation management issues.

Inadequate research and inappropriate land management policies as well as international agencies donor rigidity usually drive most developing countries into accumulation of large debts, thus limiting investment on land degradation management.

External forces including the state of global economy, inaccessible markets and unfavorable commodity prices, the debt burden, unequal terms of trade and protectionism plus import barriers in developing countries increase rates of natural resource exploitation by preventing diversification.

The causes of land degradation according to Global

Assessment of Human induced Soil Degradation and Oldeman *et al.* (1991) comparison of soil degradation in different land use types in Africa are summarized in Table IV and V.

Effects of land degradation. In areas with high population densities and fragile ecosystem inappropriate land management increases loss of productivity of resources of poor and urban population and in turn affects their food security and livelihood. Unstable land use drive soil erosion, nutrient depletion, water scarcity, salinity, disturbance of biological cycles, which significantly diminishes production, biodiversity and ecosystems services and contributes to climate change.

Soil erosion manifests in depreciation of the physical, chemical and biological properties or indicators of land

Table VI. Links between state changes in land and human wellbeing

State change	Environmental impact	Material needs	Human health	safety	Socio-economic	
Cropland expansion and intensification	Loss of habitat and biodiversity, soil water retention and regulation; disturbance of biological cycles; increase of soil erosion, nutrient depletion, salinity, eutrophication	Increased food and fibre production – doubling of world grain harvest in last 40 years. Competing demands for water	Spread of disease vectors related to vegetation and water (e.g. schistosomiasis) associated with Exposure to agrochemicals in air, soil and water	Increased hazard from flood, dust and landslides during extreme weather with Irrigation	More secure livelihoods and economic growth. Changes in social and power structure	
Loss of forest, grassland and wetlands	Loss of habitat, biodiversity, stored carbon, soil water retention and regulation; Disturbance of biological cycles and food webs	Diminished range of water resources Diminishes water and quality	Loss of forest goods, including potential medicinal products.	Increased hazard of new flooding and landslides during extreme weather and tsunamis	Loss of forest products, grazing, fisheries and drought reserves Loss of livelihood, cultural values and support to indigenous and local communities Loss of recreation opportunities and tourism	
Urban expansion	Disruption of hydrological and biological cycles, loss of habitat and biodiversity, sealed surfaces, Concentration of pollutants, solid and organic wastes, urban heat Islands	Increased access to food and shelter; increased choice; satisfaction of needs highly dependent on income	Respiratory and digestive tract diseases due to air pollution, poor water supply and sanitation Higher incidence of stress and industry-related diseases Higher incidence of heat stroke	Increase exposure to crime Traffic and transport hazards Increased hazard of flooding caused by soil sealing and occupation of hazardous sites	Increased opportunity for social and economic interaction and access to services. Increased competition for financial resources Diminished sense of community; increased sense of isolation	
Chemical contamination	Polluted soils and water s	Water scarcity and non-potable water	Poisoning, accumulation of persistent pollutants in human tissue with potential genetic and reproduction implications	Increased risk of exposure and contamination of chains (e.g. food). In severe cases, areas uninhabitable	Loss of productivity due to ill of health. Diminished productivity of contaminated systems	
Land Degradation	Soil erosion	Loss of soil, nutrients, habitat, loss of property, sedimentation of dams and sand-dune encroachment in agricultural lands	Loss of food and water security Turbidity and contaminated water	Hunger, malnutrition, exposure to disease due to weakened immune system	Risk of flood and burial to infrastructure, particularly in coastal and riverine areas	Loss of property and Decreasing hydropower generation due to sedimentation of reservoirs Diminished development in farm and forest sector lack of development in farm sector, poverty
	Nutrient depletion	Impoverished soils	Diminished farm production	Malnutrition and hunger		Lack of development, poverty
	Water scarcity	Diminished stream flow and groundwater recharge	Loss of food and water security	Dehydration Inadequate hygiene, water-related diseases	Conflict over water resources	
	Salinity	Unproductive soils, unusable water resources, loss of freshwater habitat	Diminished farm production	Non- potable water		Loss of farm production Increased industrial costs of corrosion and water treatment Damage to infrastructure
Carbon cycle	Climate change, acidification of ocean surface waters	Shift from fossil to renewable energy conflicts with food production. Shift in growing seasons and risk of crop failure	Respiratory diseases related to air pollution	Risk of flood-related damage to property, particularly in coastal and riverine areas	Energy supply is to 80% derived through Manipulation of the carbon cycle	
Nutrient cycles	Eutrophication of inland and coastal waters, Contaminated groundwater Depletion of phosphate resources	Non- potable water	Health effects from bioaccumulation of N or P in food chains		Benefits of food security and bio-fuel production	
Acidifying cycles	Acid depositions and drainage damaging land and water ecosystems Acidification of ocean and fresh waters	Freshwater fish resources declining. Risk of further collapse of marine fisheries	Poisoning from increased plant uptake toxic metals		Economic damages to forests, fisheries and tourism Corrosion of infrastructure and industrial plant	
Desertification	Los of habitat, biodiversity Reduced groundwater recharge, water quality and soil fertility Increased soil erosion and dust storms, sand encroachment	Diminished farm and rangeland production Loss of diverse germless Water scarcity	Malnutrition and hunger Water-borne disease, reparatory problems	Conflict over had and water resources increasing flash floods, dust hazard	Poverty, marginalization, decreased social and economic resilience, population movements	

degradation. Physical indicators relate to reduction in structural status of soils. Chemical indicators increase toxicities and acidity (Table III). Biological indicators are related to lowered soil organic matter (SOM) levels associated with biological activities. Each of these indicators is mediated by SOM; hence its loss from the ecosystem causes a lot of strains and stress in the ecosystem balance. Further more, the indicators have decomposed effects such

as decline in soil fertility and loss of biological production and economic value of land.

The report by Europeans Commission on Agriculture (ECA, 2006) observes that land abandonment resulting to land degradation can substantially reduce the value of land. This is by decreasing of agricultural (and other) values attributed to the land, the loss of infrastructure related to agriculture and forestry, e.g., rural roads, irrigation systems

etc and may decrease its potential for tourist and recreational activities. Significant land value depreciation leads to land abandonment and out migration, which can also lead to further isolation and marginalization of vulnerable rural population. This is the true situation in Africa and has contributed to an unbalanced demographic structure, the loss of knowledge and tradition of land management, the disappearance of social and community values and structures as well as increased health issues including depression and alcoholism.

Out-migration from rural areas has led to an increase in social costs in urban areas. The poorer inhabitants of rural areas migrate to urban peripheries, which are often already pockets of deprivation. The provision of social services (e.g., education, health care, care for the ageing people, etc.) especially in urban and rural areas is generally more costly and some Governments in African countries are forced to discontinue providing these services for budgetary reasons. As welfare is decreasing at the social level the society also witnesses more crime related activities with increases in health (e.g., proliferation of HIV/AIDS) and environmental pandemics. Consequently, national economics are affected and coupled with debts can not easily import food. Together with low internal production (low productive land per capita) food security is threatened, which leads in a helter-skelter down ward spiral to worsen poverty among the populace.

- Africa has abundant forest resources. Deforestation and over-exploitation of the forests lead to loss of their important intrinsic value, biodiversity and genetic resources, which are important resources for improving agriculture, medical and industrial products. Massive usage of forestry for energy has depleted the land cover with ensuing erosion scourge that has damaged most green areas.

- Loss of biodiversity over time is from the perspective of both habitats and species. Intensive and monoculture farming systems as against extensive and diversified farming systems lead to low intensity biodiversity. Hence, ECA (2006) pointed out that biodiversity increases immediately after the cessation of cultivation practices though; in the medium to long term it decreases. For example, after short periods as three years, abandoned areas can lose up to 25% of their species.

Deforestation. Also leads to loss of important conservational functions of forests especially in mountainous villages. Protective forests serve as watershed, prevent avalanches and slope erosion. They protect the villages and infrastructure in the valley bottoms as well as downstream by guaranteeing a constant and clean water supply and preventing flood. They also conserve herbal or medicinal plants; provide constant fuel wood and hunting opportunity for variety of wild life animals. These important functions are diminishing. It is instructive to note that a substantial loss in biodiversity and genetic resources has negative consequences for future research and development in Africa.

Fig. 1 Relationships between land degradation, population and poverty

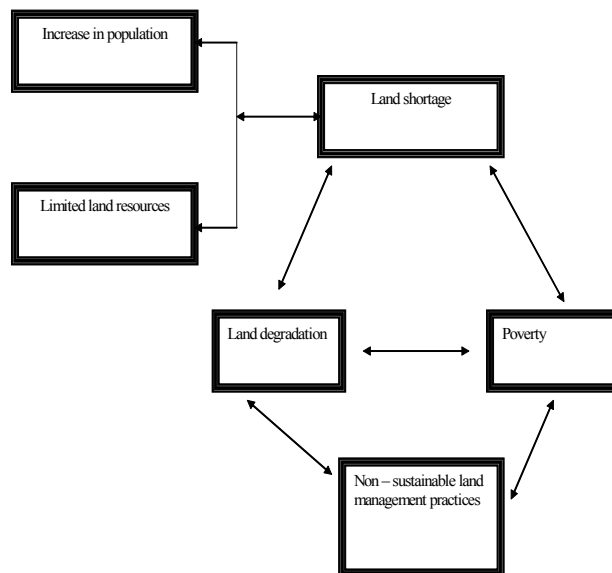
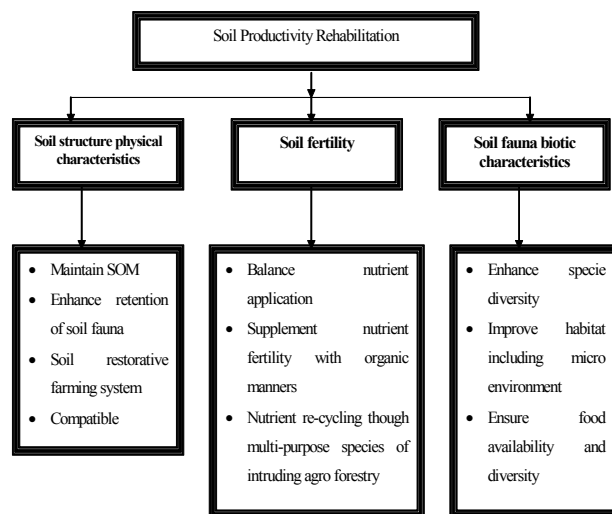


Fig. 2. Approaches to rehabilitation of soils/environment for sustainable production



- Environmentally: over-grazing leads to flooding and anaerobiosis. Flooding leads to pond water which is a habitat for organism that carries water borne diseases; loss of pastures and consequent over growth with shrubs, which increases the danger of uncontrolled fire. Inappropriate agricultural practices such as misuse of chemical fertilizers and residues and animal wastes are further sources of acidification. Furthermore, destruction of water sheds, opening up of river banks and discharge of particulates from construction sites lead to pollution of the aquifers system, situation of river beds and loss of water courses.

Petroleum prospecting with its attendant oil pollution

problems such as spills, oil well blow-out, oil blast discharge, improper disposal of drilling mud create problem of loss of the aesthetic values of natural beaches due to unsightly oil slicks; damages in marine wildlife, modification of the ecosystem through species elimination and the delay in biota (fauna & flora) succession; and decreases in fishing resources (Isirimah, 2003). Furthermore, acid precipitation due to gas flaring degrades fresh water and forests in coastal areas through ecosystem heat stress.

Burning of fossil fuel contributes to global warming through emissions of CO₂ and other radioactively active green house gases such as CH₄, Co, N₂O and NO, each of which is poisonous at relatively high concentrations (FAO, 1979). Global warming modifies the general atmospheric circulation, causing changes in rainfall pattern, which lead to different land use patterns. For example, droughts due to low precipitation in the savannas of Africa aggravate desertification.

- Extreme land degradation results in desertification (here defined as when land becomes desert & is unable to support any vegetation). Desertification affects millions of people particularly in savannas of Africa through reduction in agricultural production and loss in productivity.

Further elucidations were given by Mbagwu *et al.* (2005) as: Total abandonment of land, reduced crop yield; increased inputs at greater costs; reduced response to inputs; reduced productivity in irrigated lands; loss of flexibility in land management; greater production risks; loss of water for irrigation; diversion of resources to reclamation; increased landlessness through abandonment of degraded land; lower and less reliable food supplies (e.g., reduced crop yields, increased inputs & consequent reduced farmers return from labor); labor for reclamation and rehabilitation is lost in production; lower income (e.g., increase inputs of labor or reduced out put of labor).

The cumulative effect of land degradation on agricultural productivity is food insecurity and increase in hardship and poverty. Report by Lal and Okigbo (1990) shows that in West Africa, especially in areas with high land degradation, more than 30% of the children died before the age of five. These are children from poor families who do not have the resources of production.

The above scenario can lead to the conclusion that due to diminishing land resource base, the poor both in the urban and rural areas are both victims and agents of environmental change. The detailed linkages between state changes in land and human wellbeing is shown in Table VI, while Fig. 1 illustrates the relationship between land degradation, population and poverty.

Sustainable land degradation management strategies. Africa is naturally endowed with natural resources: Oil deposits; great salt mining sites; Forest resources/reserves; water resources such as rivers connected to oceans and fertile lands as well as raw material resources for construction purposes, tourist attractions (wild life, rivers,

etc.) and cash crops. However, these natural endowments and population activities mean that African urban, peri-urban and rural areas are locations of critical water towers, carbon sinks and biodiversity hotspots. The ecosystems have become endangered because of hunting, habitat destruction, over-exploitation, deforestation and pasture degradation. The vulnerability of these areas could be due to slow economic recovery, rapid growing population, natural hazards, climatic change, while lack of adequate legal and fragmented and incomplete policy framework make the problem of land and resource degradation very relevant.

If the present diminishing availability of productive land resources continues unabatedly and unchecked, then the survival of African population will be seriously threatened. As a revolution in the new millennium, sustainable land management, therefore, becomes imperative to restore, sustain and enhance the productive and protective functions of the trans-boundary ecosystems, so as to improve food and fiber production, the socio-economic well being of the citizens for poverty reduction and social equity; ensure households are utilizing the ecosystems resources, while preserving its unique landscape and globally important biodiversity.

Against these backgrounds, this paper discusses the following sustainable management strategies, though may not be the only panacea to solving land degradation problems, but critically minimizes the scourge.

1. Information, Monitoring and Assessment of Land Degradation

(a). Monitoring and assessment of land degradation. The best approach to the catalogue of problems of degraded land and environment starts from understanding of their state and the causative factors. This will hasten the reversal of the degradative trend and start the restorative processes.

Clear evidence of land resource problems must be identified and assessed with a view to mobilizing institutions and stakeholders for finding sustainable solutions. However, conventional statistics, collected by administrations coupled with geographic information systems (GIS) if available provides comprehensive, accurate and up-to-date information on the current status and trends of land resources, including tenure, use and degradation and can help identify constraints and prioritize actions among stakeholder groups. FAO, UNEP and other institutions have developed specific database models, guidelines, maps, indicators, information systems and other tools and networks (e.g., SOTER, WOCAT, AQUASAT, AEZ, digital soil maps, etc.). These international bodies could be consulted for adequate support in planning and management of land resources in Africa through the use of the models.

In an earlier study, Ezeaku and Agbede (2005) recommended some methods and modeling tools that could be used as intervention possibilities by Governments for land use planning and management. For instance, stochastic modeling (based on relationships among data in a particular area); Empirical or Expert models (based on relationships

among data in other areas), Dynamic, Simulation and Process models. Tools to use include Multiple Goal Analysis Techniques, Integrated Information Systems, combination of Land Evaluation and Farming Systems Analysis (LEFSA), etc.

Cooperative frameworks can also be used for land degradation assessment such as charters (World Soil Charter), codes of conduct; action plans (e.g., Leipzig Global Plan of Action on Plant Genetic Resources, Soil Fertility Initiative, National Action Plans for the Convention on Desertification (CCD). Funding mechanisms that could serve as models include Global Environment Facility (GEF) and the Global Mechanism for CCD. All these need to be exploited fully for advancement of African countries.

(b). Exchange of information and experiences. International cooperation is driven by the need for governments and people to share information and experiences in planning and management of their land resources and to help each other in solving common problems, especially land degradation. Regional cooperation through networks and workshops is important. Particular efforts should be made to expand and improve access to international databases and information systems in land-use, land-use change and land degradation, for monitoring performance in attaining agenda 21 goals. Cooperation among all concerned institutions is essential in addressing land use and related cross-sectoral issues that involve several agencies and for the development and implementation of joint activities for capacity building and transfer of technology for integrated land use planning and management. Land information management is an integral part of urban-rural development and management.

2. Social Issues

(a). Stakeholders participation. Effective stakeholder participation in land use planning and management is a key issue for the sustainable use of land by all resource users. Successful experiences and projects, providing good examples of the participatory process and the ecosystem are: Australian Land Care Approach, the Farmer Field Schools, Conservation Tillage/Agriculture Systems, The Plan Sierra Eco-development project of the Dominican Republic. Broader consultation and public participation on land use planning and decision-making need strong improvement and support.

Sewerage and solid waste disposal problems can be solved by increasing resources, budget from the three tiers of government. There should be strict rules by the central government of each country through the national agency in charge of environmental protection to guide the waste disposal and sewerage systems. Also, private sector participation and organization of small-scale and micro-enterprises should be promoted to provide door-to-door services since in most cases these are lacking.

(b). Capacity building. Countries in Africa, need to seek for strong support by UN agencies to develop tools and capacities for integrated approaches to ecosystems and land

use systems, such as river basins, wetlands, mangroves and biosphere reserves. Other capacity building programs and initiatives ought to focus on issues such as land vulnerability, food insecurity assessment, drought mitigation and environmental accounting. Capacity-building in policy-making, land use management, land and water information, monitoring and assessment is needed at all levels for all to address critical problems of land degradation, including prevention and rehabilitation.

(3). Policy Issues

(a). Access to land and land tenure issues. There is need for critical review of property rights and land tenure systems laws in African countries so as to open up land marketing systems, which take into account private, public, informal and indigenous regimes to ensure equal access to land and the security of land tenure, in particular for disadvantaged groups, including women, the poor and indigenous people. The challenge is to ensure legal and social rights for traditional 'owners' and users of areas with various forms of communal tenure.

With appropriate legislation, land supply can be increased by legalizing land tenure thereby reducing land values and making land less attractive for capital accumulation. Access to land tenure is a major incentive for the low income groups to invest in housing, infrastructure and food production. It is important, therefore, that land registries and property cadastres are created, re-established or strengthened where such exists.

(b). National land use strategies, plans, programs and policies. International agreements and conventions have stimulated international and national policies and programs to promote integrated land use planning and management. Several developed countries (e.g., Japan, Australia, Britain, USA, etc.) have adopted comprehensive land use plans and programs. In developing countries, National Action Plans and Strategies have been prepared for the CCD and the CBD (less advanced) but the implementation is always constrained by financial resources. Synergy between the various conventions (CCD, CBD, FCCC & Wetland); national programmes and policies is encouraged so that their implementation can provide greater benefit, increasing effectiveness and saving of resources.

Government need to develop policies on land use that are holistic and not fragmented and incomplete and which can not be implemented because of institutional barriers, conflicting mandates and the prioritization of economic over social and environmental goals and of short-term development over long-term goals. Land use strategies as part of National Agenda 21 and environmental action plans need to be formulated. The scope need to expand from a focus on delimitation of areas of protection (nature reserves), critical watersheds and other critical areas or pollution problems, to encompass sustainable land use plans in a wider geographical and longer term perspective.

The decentralization and devolution of power in land use planning and management is developing in many

African countries but is often a source of conflict among the local, regional and national institutions involved. However, clear responsibilities need to be assigned, at all levels, for various aspects of land use planning and management and mechanisms developed to overcome institutional barriers between agencies at central and local levels.

(4.) Soil productivity restoration approaches. The major soil management techniques that can restore the productivity of agricultural lands are summarized below.

- **Fallow systems.** Long fallow (shifting cultivation), short fallow (recurrent cultivation) and no fallow cultivation. A ratio of 3 and 6 years fallow to 1 year of cultivation is sufficient in the rain forest environment to maintain soil organic matter (SOM) at 75% of its original level. Savannas are less efficient regenerators and require between 10 and 20 years of fallow before re-cultivation (Young, 1979).

- **Use of organic residues (of plants & animals whether composted or fresh).** It has been reported that application of 5% poultry manure, compost manure, rice husk and saw dust as amendment are more effective in restoring degraded lands than a combination of high doses of 120, 30 and 120 kg ha⁻¹ NPK in Nigeria (Mbagwu, 1984). In Ghana, Kwakye (1980) reported the effectiveness of combined use of mineral fertilizers and organic manure.

- **Integration of cover crops/mulch in different cropping systems** (crop rotation, mixed cropping and relay cropping) provide a protective cover, reduce the rate of soil moisture loss through evaporation from soil surface, improve SOM, total N, CEC, infiltration and water retention capacity. *Leucaena spp* can fix 300-400 kg ha⁻¹ N annually (Asadu *et al.* 2004).

- **Livestock grazing.** Stocking rate of 4-8 cattle per hectare has been found adequate to maintain a stable and healthy grazing environment.

- **Agroforestry and alley cropping.** Combination of both is a form of land use where trees are combined with crops or pastures or both in time and space. It can be phased with the objective of sustained optimization of total production per unit area. They return organic matter in their leaves or through N fixation and "Pump Up" lost nutrients from the deeper soil horizons. The application of this technique reduces the length of exposed bare surface area, serve as shelter belts especially in arid zones. Some of the recommended fast growing trees include neem (*Azadirachia indica*), *Eucalyptus camaldulensis*, *Acrobataii*, *Leucaena lucocephala*, *Gliricidia sepium* (Anonymous, 1990). They could be used as an alternative to slash-and burn as well as field-fallow agricultural systems in the humid and sub-humid zone in Africa.

In terms of crop production, the trees have been reported, based on field experiments, to increase the yield of cowpea from 397 kg ha⁻¹ in 1995 through 602 kg ha⁻¹ in 1996 to 615 kg ha⁻¹ in 1997 in Nigeria, while as high as a 130% increase in maize yield was possible with the use of *Gliricidia spp* planted at 5 m x 5 m spacing (Lal & Coupe,

1990).

- **Tillage systems.** Minimum tillage such as sub-soiling, roto tilling and zero tillage reduce negative effects of soil compaction (associated with mechanical cultivation) on crops and soils.

In contour tillage, the use of vetiver system could be used as an effective approach in controlling erosion onslaughts (Asadu *et al.*, 2003). The system involves establishing a vegetative hedge on the contour and aligning planting furrows to the contour guidelines. After 2-3 years of establishment, the vetiver hedge slows down the run off, spreads it out and filters out the silt allowing the silt less water to continue down the slope at greatly reduced speed. The grass has peculiar characteristics and can grow in all types of soils; tolerate a wide range of climatic conditions - temperature of 9 to 50°C and rainfall of 200-600 mm per year; resistant to fire, over-grazing, drought and flood (a xerophytes & a hydrophytes).

- **Exploiting the genetic potentials of C4 grasses.** The potentials of N-fixing micro organisms on the root of non-leguminous plants have been explored for the replenishment of N in arable soils. In 2 years of field trials, Kapulnik *et al.* (1981) achieved significant increases in the yield of inoculated stands of maize, sorghum, *Penisetum miliaceum* and *Setaria italica*. As high as 70-80 kg ha⁻¹ increase in the yields of maize and sorghum were obtained in Israel. This was achieved because C4 grasses have efficient use of water and light and have high potential for associated energy for N fixation, which requirement is only about 19%.

The summary of the approaches to rehabilitation of soils and environment for sustainable production is shown in Fig. 2. The application of these restorative processes ultimately would improve the soil physico-chemical and biological indicators of degradation, which in turn would restore productivity of degraded lands in Africa.

CONCLUSION

From the foregoing discuss, it can be seen what land degradation is all about in terms of definition, causes, scope, impacts and effects. Sustainable land management strategies are discussed in relation to information, monitoring and assessment; social issues - stakeholders participation, capacity building; policy issues, and soil productivity restoration. All these are to control and/or mitigate land degradation.

It should be noted that sustainability as used here entails that natural resources (soil, water, biota, etc.) and infrastructure be properly managed so that applied practices do not cause degradation and/or pollution, while a stable economy is achieved.

Recommendations. The importance of addressing land use planning and management through a holistic approach such as ecosystem-based management can not be over-emphasized. There is need to access and rights to land, water and other natural resources, as well as the need for

national and local measures to protect critical natural resources. It is important that social and health aspects of land use systems should be integrated in the overall planning process. Other priorities are highlighted below.

- **Prevention and/or mitigation of land degradation.**

There is an urgent need for appropriate policies, institutional frameworks and measures to change production/consumption systems into sustainable ones so as to combat land degradation, desertification, deforestation and loss of biodiversity and therefore improve food security, alleviate poverty and mitigate the effects of climatic change on population.

- **Access to land and security of tenure.** Equal access and the security of land tenure including for women, poor people, indigenous and local communities, have to be guaranteed by national and local policies and laws. Adequate land administration systems must also be developed to support sustainable land tenure. The participatory approach is strongly encouraged for land tenure reform processes and for the planning and management of land resources.

- **Critical sectors and issues are highlighted, with specific measures** to take for:

Biodiversity: Recall on the importance of (a) areas containing high concentrations of biological diversity; (b) threatened ecosystems; and (c) species at risk. This calls for ratification and implementation of the Cartagena protocol on Biosafety and vigilance on the use of biotechnologies because of possible risks for health and environment.

Agricultural and forests resources: Initiate and implement strategies, tools and policies to promote the management, conservation and sustainable development for multi-purpose utilization of forests and agricultural resources. This is to ensure sustainable development at economic, social and ensure environmental levels.

Desert/dry lands: Institute appropriate measures to combat drought and desertification and for the protection, restoration and sustainable use of fragile land resources and water resources in dry lands. Particular attention is required for areas with high population pressures and droughts.

Techniques should also be developed for the protection against ground surface water erosion and soil degradation; improvement of scientific support to the development and application of protection and restoration strategies and measures, development and demonstration of best practices, control measures, operational analytical methods, for decision-making and sustainability impact assessment of combating options.

There is also need for development of harmonized data- information system so as to evaluate and improve on the efficiency of existing mitigation and adaptation techniques and for guidelines for the protection of land. Production and dissemination of manual with methodological approaches, best practices and policy relevant material for combating land degradation is required.

- **Mountain areas:** There is need for specific measures

and particular attention to the economic balance of these areas to ensure a sustainable management of mountainous areas and water sheds.

- **Wetlands and coastal zones:** Conservation of wetlands and particular attention to coastal areas in relation to fragile marine ecosystems.

- **Natural disasters:** Design and implementation of warning systems and intervention plans, as well as short to long-term strategies for disaster management. National, regional and international relief and remedial support is needed on risk management and mitigation with the aim of evaluating strategies for disaster reduction, while integrating socio-economic impacts of disaster.

Efforts should take into account the potential for the operation of the methods and techniques developed, their efficiency and cost implementation and the characterization of high risk areas through remote sensing, will contribute towards improved pre-disaster planning and damage assessment.

- **Rehabilitation of mining areas:** Social, economic and environmental impacts of mineral extraction and metal production must be considered and strategies must be implemented for the rehabilitation of land degraded by mining.

- **Rural-urban and land management interaction:** The development of urban areas, including transportation, housing, infrastructure and urban/peri-urban agriculture need careful management to ensure its sustainability. Particular attention is required for the impact on the living conditions of the poorest and interactions with rural areas.

Stakeholder participation is strongly encouraged in rural and urban land use planning and management. Government is encouraged to develop and strengthen capacity and institutional frameworks for effective participation of all stakeholders, including women, land workers, poor people, indigenous and local communities.

The responsibilities of local authorities and stakeholders in sustainable land use should be recognized and local governments and communities empowered for the formulation and implementation of appropriate practices, through financial and technical support.

The above indicate that there is need to develop strategies to identify sustainable urban, peri-urban and rural land use relationships, with emphasis on understanding, planning and forecasting tools as well as evaluate costs for their implementation. Improved and new GEO compatible databases and tools will integrate the multiple functions in an urbanizing society. The analysis of the interaction between growing urban areas, the peri-urban and rural land uses, the environment, the industry, the agriculture production, the multi-purpose utilization of forest resources and coastal zones, the natural and leisure parks and the biodiversity will consider the impact of forecasted and scenarios based demographic changes (in total number, age proportions, etc.) and migration patterns. This will enable policy makers assess social (in terms of equity), economic

and ecological relations, linkages and impacts between urban areas, the surroundings and the rural areas.

- **Development of tools and mechanisms for impact assessment of land use policies:** It is important to develop compatible databases and tools for understanding, planning and forecasting impacts of land use policies on sustainable development, in particular on biodiversity and supply of public goods and services. Any related competitiveness with other countries will be analyzed in relation to environmental and socio-economic impact in order to evaluate the thresholds of sustainability and externalities.

- **International cooperation:** Including that for capacity building, information sharing and technology transfer is strongly encouraged, in particular to support the implementation of agenda 21.

Access to up-to-date information, appropriate technologies and support systems (e.g., GIS, GPS, etc.) should be improved where they exist or introduced through the assistance of UN, World Bank and developed countries.

The development of land use indicators and monitoring systems is encouraged to assess progress in the implementation of programs for sustainable development. Kyoto protocol and the 3 UN conventions (CCD, CBD & FCCC) specified the needs for regional and international cooperation and support in terms of technical and finance to each member country. It is necessary that developing countries should study, sign and ratify the protocol and conventions. This will enable knowledge network to share experience, knowledge and best practices against land degradation and to find viable solutions in view of technology transfer opportunities.

Finally, embarking on the strategies discussed in this paper in anticipation to restore our degraded land resources and to achieve higher productivity with a scaled-up poverty reduction, there is need to consider the words of Francis Bacon, “We cannot command nature except by obeying it” and that of Benjamin Franklin “Whenever we attempt to amend the scheme of Providence and interfere with the governance of the world, we had need to be very circumspect lest we do more harm than good”.

Methodologies for reducing and/or mitigating land degradation exist in the developed world. In less developed countries, we are still trying to articulate land management systems to achieve this purpose. How and when will this be achieved it is not known. One thing certain is that someday a topic like; “Land Degradation and poverty in developing countries” will cease to be a major concern in their national conferences because solutions for them have been found.

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