

# SOIL EROSION MANAGEMENT FOR A SUSTAINABLE DEVELOPMENT IN THE SUDANO-SAHELIAN REGIONS OF NORTHERN NIGERIA

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## Abstract

The soil is essentially a vital resource on which all human activities evolve. The over-exploitation of environmental resources on land has created unwarranted depletion of soils, deterioration in resource bases and land degradation. The persistence of these conditions may lead to the total collapse of the interface on which all forms of life is centered. To promote and maintain an environmental equilibrium, the excesses in human exploits must be halted and the environment managed at sustainable level. The focus of this paper is to examine the factors aiding soil erosion in the Sudano- Sahelian zones of Northern Nigeria, proffers management practices aimed at combating soil erosion activities and improving the quality of land for sustainable development.

## Introduction

Soil erosion, especially in the Sudan and Sahel Savannah is a disturbing issue. Researches conducted of the phenomenon have highlighted the factors and processes that influence its occurrence, and its environmental effects (Salau, 1995; Olofin, 1995; Tukur and Ray, 2000). The fluctuation and inconsistency in climatic processes in the Savanna regions of Nigeria have been a subject of concern to environmental scientists and planners. The impermanency and uncertainty in climate has led to such climatic phenomena as, aridity, drought, desertification, deforestation, flood and soil erosion. Soil erosion is by far one of the most identifiable agricultural problems of the world (Wischmeier and Smith, 1997). High intensity rainfall or strong winds may trigger off soil erosion resulting in soil impoverishment and low agricultural productivity.

In attempt to satisfy his numerous needs, mankind has the desire of exploring and exploiting environmental resources to his optimal advantage. The consequences of his exploits have adverse environmental implications, which have created visible scars associated to the destruction of the natural resource base vis-a-vis land, water and air. The depletion of environmental resources particularly the soil has invariably expanded poverty, accompanied by over exploitation of environmental resources and intensification of agriculture which Moltimore (1989) observed, reduce productivity potential of land through over-use, lack of care and treatment. In attempt to increase land productivity by intensive soil fertilization, water in surface and underground aquifers have been polluted affecting marine bio-diversity.

## Soil Erosion in the Sudan and Sahel Regions

Soil erosion is one of the major problems affecting agriculture worldwide. Since 1970s greater emphasis has been given to erosion as a contributor to non-point pollution. Soil erosion is the detachment and transportation of loosed soil materials by mobile geomorphic processes such as water and wind.

Enger and Smith (1977) identified two types of erosion ubiquitous worldwide-namely geologic and human induced erosions.

- (a) Geologic erosion is manifested in the slow removal of soil as part of the natural geologic processes of denudations and is both inevitable and universal. Soils forming as well as soil eroding processes interplay to maintain the soil in a favourable balance suitable for the growth of plants.
- (b) Anthropogenic processes have resulted in accelerated erosion. These cause the breakdown of soil aggregates thereby, causing accelerated removal of organic and mineral particles. Erosion in this manner had produced imbalance on the environment and created irretrievable changes in the ecosystem. Man induced erosion has forced the condition of part of the earth surface or its surrounding atmosphere to become unpleasant or less useful, resulting to environmental degradation.

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Soil erosion is common in most parts of Nigeria, extending from the Southern part to the Sahel regions. Oyegun (1982) considered soil erosion as being a factor of natural rainfall. In the Sudan and Sahel regions of Nigeria rainfall though short-lived may be heavy enough to create irretrievable changes in the landscape. However, the role of rainfall as an agent of erosion depends on human impact on the environment. Many forms of land clearing are known to result in severe degradative changes especially in areas where slopes are steep, soils are shallow and rainfalls are heavy and concentrated in short period (Tukur and Ray, 2000).

Mankind therefore, exists within a natural environment that has been modified by individual or collective actions, which depletes the environmental systems and the alluding degradation of valuable resources. The natural environment, had been modified, altered and destroyed beyond conditions of nature that existed before human impact was expressed.

Human induced erosion has increased the rate of sheet erosion in which soil and earth materials are uniformly removed from the land surface leading to a great loss of several tonnes of productive soils. The increase rate of erosion may result in the development of incised narrow parallel trenches and grooves known as rills, which through micro-piracy are progressively enlarged into gullies. Gully erosion, is therefore, a clear indication of acceleration of normal geologic processes.

### **Soil Conditions and Erosion**

Savanna soils developed on basement complex rocks are predominantly sandy in nature in consonance with the silica, rich quartzose nature of most of the rocks (Areola, 1988). Aridity has enhanced the deposition of sand by wind developing into sandy loams, friable and easy to cultivate (Iloeje, 1982). Sandy soils when subjected to severe human exploits easily give way to erosion. The poor soil structure characterized by low organic matter, from absence of vegetation, high rate of chemical and bio-chemical action and abundance of microbial activity contribute towards the loss of several tonnes of soils to erosion. Olofin (1980) contends that erodibility is high in soils composed of silt and fine sand, while a high content of silt and clay result in losses through mass movement.

As observed by Courtney and Trudgill (1984) rainfall erosivity is generally high in the Savanna where up to 60 percent of the rainfall is erosive. The hydrological and soil factor in addition to slope angle, crop management and conservational practices are most important in the savanna zones. Soil erosion is prominent at the onset of the wet season because the soil cover at that time is usually scanty and cultivated fields are also loosened up causing most damage to the land. Soil detachability generally increases as the size of the soil particles or aggregates increase, soil transportability increases with a decrease in the particle and aggregate size. Though sand is difficult to transport than silt, it can be easily detached. The climate and the size of the soil particles affect the detachment and transportation of soil materials. The soil structure is affected by the infiltration capacity and the moisture holding capacity, as such dry soils are easily acted upon by wind while heavy soils that are less porous hasten overland flow accentuating soil erosion.

### **Factors Aiding Soil Erosion**

In most parts of Nigeria, soil erosion is on the increase and is assuming an alarming environmental disaster. The ever-increasing influence on the environment has resulted in a myriad of environmental problems of varying magnitude, which Adepetu and Eziashi (1988) observed, require costly remedial measures for a reversed control in favour of the environment.

The savanna ecology is extremely fragile and is already over burdened and suffering from serious human abuse. Degradation of the soil has lessened the current and or the potential capacity to produce goods and services (Food Agricultural Organisation, 1997).

Man induced processes are responsible for the irreversible destruction of the environment and contribute towards soil impoverishment. In addition, there are aspects of our socio cultural systems of land tenure operative in many parts of the country, which has led to increasing fragmentation of land holdings (Akimbode, 2002). This spurs the populations of the affected areas to increase their farming and livestock pressures on the land. Wischmeier and Smith (1978) combined both environmental site and anthropogenic factors to produce predictive model of soil erosion. The model describes soil loss in terms of the rainfall erosivity, soil erodibility, slope length, slope angle, crop management and conservation practice.

Deforestation is a major ecological problem. The vegetation can be succumbed to deliberate massive human assaults and be irretrievably lost. Deforestation is not only harmful to agricultural production but a worst threat to biodiversity. According to Myers (1989), Nigeria is currently losing over 14% of their forest every year and Africa is next to Latin America in magnitude of areas deforested annually between 1981-90. In his contribution (Jmeh (1986) observed annual deforestation of woodland in Northern Nigeria of about 92,000

hectares while the whole country consumes between 50-55million cubic metres of wood.

Agricultural practices trigger a cyclical environmental deterioration, resulting in declined yields and reduced capacity to support other productive ventures. Agricultural methods such as. oxercropping. farming on unprotected slopes, removals of plant residues from farm plots and intensification of agriculture have created sterile soil conditions. Many forms of land clearing have therefore resulted in radical degradative changes (Amanor, 1994). This is a common phenomenon in areas where slopes are steep, soils are shallow and rainfalls are heavy and concentrated in short- periods. The conversion of marginal lands into agricultural lands has increased soil erosion and low agricultural productivity has been observed.

### **Soil Erosion and Environmental Degradation**

The degradation of land is manifested in many ways, which include soil erosion, chemical and biological degradation, salinisation and pollution. All these forms of degradation lead to a decrease in soil fertility and production capacity (Amanor, 1994). The severity of soil erosion problem has led to rapid impoverishment of soil in most parts of the savanna. A study carried out by United Nations Environmental Programme (UNEP) in 1984 found out that in the semi arid and sub-lmmid regions of Africa about 6,900 million hectares (including approximately 80% of the regions crop lands) have lost between 25 and 100% of their productive capacity. It has been estimated that Nigeria's annual loss through erosion is about 25 million tonnes.

The over-dependence on the natural resources for survival' has exerted uncontrolled pressure on the land in regions characterized by inconsistency and erratic climatic processes, promoting environmental degradation. Degradation of resources in turn reduces the production of the people and exposes them more susceptible to extreme environmental events.

The clearance of forest for Swidden agriculture may create landscapes, which apparently are completely divorced from the natural environment that proceeded. Lands cleared for agriculture almost immediately become unsuitable for that use due to soil loss. Soil materials from erosion are shifted and deposited downstream, changing valley contours, extending the area subject to flooding and filling irrigation and drainage channels.

Human assaults and exploits on forest resources have accelerated soil removal by erosive agents. Such superfluous action has intensified the magnitude of desertification. Salau (1995) observed that about 650,000sq km of arable and grazing lands on the Southern margin of the Sahara are estimated to have suffered from desertification in the past fifty years. The desert boundaries of Sahara are presumed to be extending southward into the Sahel and Sudan savannahs at alarming rate. About 6.6 million square kilometers of Africa's Land is estimated to be at very high risk of desertification. Bradsaw and Weaver (1995) observed that in the 1970s and 80s million of people were at risk of starvation in the Sahel region of Africa. Desertification therefore is accompanied by decline in per-capita food production resulting in threat in starvation and exodus of large portion of the population. Drought is on the increase in both frequency of occurrence and extent. The Sudano-Sahelian regions of Africa are vulnerable to drought and as such both human and animal population have dwindled in size and in some years to come these regions may stagnate and human habitation completely wiped out.

The siltation of most surface water reservoirs in-rivers, streams and lakes has reduced the potential utilization of most water resources and has increased the incidences of flood. The occurrences of flood have resulted in the relocation of several thousand tonnes of productive soiis. destruction of crops on farm plots leading to crop failure, starvation, poverty and death.

Man induced measures have intrinsically increased population growth culminating in an upsurge in food demand. The exploitation of marginal lands in semi-arid regions has depreciated land productivity resulting in soil erosion, deforestation and drought. Colonialism introduced foreign economies such as foreign goods and cash crops, which resulted in the use of the most productive

land for foreign goods and the exploitation of marginal lands for cash crop and subsistence agriculture. Improved technology has created imbalance on the land through over tillage of the friable sandy soils and exposing them to environmental extremes.

The protection of environmental quality has now become an important issue in the affairs of man. Since the Stockholm conference on the environment in 1972, concern, for the environment has stressed the need to maintain the environment for a sustainable development. For a land use to be sustainable it requires conservation not only of soil but also of the whole range of resources on which production depends.

### **Soil Erosion Management for a Sustainable Environment**

Soil erosion is still a universal problem, which has defied human solutions. Man's assault on the natural environment through deforestation, overgrazing, bush burning and agricultural methods have resulted to calamities such as desertification, drought, flood, sterile lands, starvation and death. Soil erosion control has

been of interest to environmental conservationist. A landmark was attained with the formulation of the World Soil Charter and with increased emphasis on erosion control in Food Agricultural Organisation Policy (FAO, 1977). The main objective of erosion control is to minimize disutility in the use of land and attain environmental sustainability. A sustainable development is viewed by World Commission on Environment Development (WCED, 1987) as that development that meets the needs of the present without compromising the ability of future generation to meet their own needs. The most sustainable use of environment is that which strikes a balance among competing demands in place and time.

Young (1990) emphasized on the need to control soil degradation. To this end he proposed two different approaches:

- (a) Traditional approach whose most attention was focused to erosion of croplands than that of grazing lands and with focus mostly on rates of soil loss.'
- (b) Recent approach, which regards erosion as one of a number of forms of soil degradations, including deterioration of the physical, chemical and biological properties all of which require attention, as such efforts have been directed to assessing the effects of erosion on soil properties and crop productivity.

In their contribution Weishmeier and Smith (1987) provided a model that portrays erosion as a product of rainfall erosivity, soil erodibility factor, length and steepness of slope, amount of vegetation or the protective surface of the soil and the conservation method. Man induced erosion can be modified by the regeneration of plants and conservation measures. To achieve these objectives, two main approaches are worth mentioning:

- (a) The barrier approach, which is to check run off by means of barriers such as, erection of earth structures, terracing grass strips, or barrier hedges and contour ridging. This approach helps in tackling erosion on steep slopes.
- (b) Cover approach. This is to check raindrops impact and run off through the maintenance of a soil cover, formed of living and dead plant materials including herbaceous plants, crop residues and tree litter. Technique includes intercropping with cover crops. Including, minimal tillage and afforestation.

As the environment continues to deteriorate and soil becomes depleting in nutrients it has been observed that farmers, even those in difficult climatic and topographic circumstances devised ingenious measures to preserve and improve soil resources. Rotation, which involves the planting of two or more crops simultaneously or successively on the plot of land, helps to preserve fertility or provide plant cover on the soil.

Terracing as practiced on hill slopes helps in breaking water or wind speed and reduces the amount of soil loss to such mobile geomorphic processes. Field trials in Nigeria indicate that cultivation on a 1% slope results in a soil loss at or below the rate of soil formation. Farming on a 15% slope would totally strip a field of its soil cover.

Fallowing which allows a field idle for some specified years, replenishes the swidden plot with nutrients and enhances the regeneration of the biomass. The applications of additives such as organic manure contribute towards maintaining a balanced soil structure, improving soil fertility and

productivity. In the Kano closed settled zone Moltimore observed an increase in the frequency of application of organic waste (Taki) on farms intensively cultivated. The fertilization of impoverished soils by chemical fertilizers though beneficial to crops growth pollutes water in rivers and streams.

Tillage if minimized will not only combat the menace of soil erosion but will improve crop performance. This can best be achieved by no till farming which involves special planters that place the seeds in slits in the soil that still has on its surface residues from the previous crops.

Afforestation protects the soil from erosion and improves the biomass. The forest also acts as natural windbreaks, which reduces the mechanical force of wind and raindrops. Forest reserves help in maintaining a favourable environmental balance thus affording protection to land which otherwise might have been lost through erosion and desiccation.

The creation of shelter belts as practiced in some parts of the Savanna should be encouraged. Shelter belts check on the advancing deserts by acting as wind breaks and so protect the soil of the destructive wind action.

Check dams, improve soil moisture and resuscitate vegetal growth. As soil moisture is raised and vegetation cover increases, the destructive action of wind is reduced.

Land evaluation should form part of agricultural practices. The assessment of land to determine its requirements for alternative uses will help in a sustainable land usage. Suitability study of the soil and classification of the potential productivity of land will assist in providing best alternative uses for land.

## **Recommendations**

The following recommendations are proffered to provide feasible options for soil management in the savannah.

1. Aforestation programmes should be pursued vigorously. Shelter belts where planted serve as buffer zones to check the occurrence of soil erosion.
2. The population of humans and animals on marginal lands should be relocated to more productive areas and such areas be allowed to regenerate into forests-to improve soil fertility and reduce erosion.
3. Government should allocate more funds to erosion control programmes in the savannah and also intensify enlightenment campaigns.
4. The construction of dams in the savannah will raise soil moisture, increase vegetation and reduce erosion in this vulnerable erosion zone.
5. Erosion management should form part of the content of curriculum in schools.
6. Soil erosion management should not only be restricted to researches but should be the interest of both government and private enterprises.
7. Management of soil resources should form part of the planning schemes of developmental plans of agricultural related projects, forestry, dam construction, and urbanization.

### **Conclusion**

Soil erosion is a serious environmental problem that is now receiving more attention worldwide. The over-exploitation of environmental resources vis-a-vis deforestation, overgrazing, bush burning and over cultivation have created imbalance in the ecosystem. Human induced erosion has resulted in irretrievable changes creating permanent scars on the environment. Effective solution to the problem of soil erosion calls for an integrated research programme and especially, the cooperation of geographers, pedologists, agriculturalists, engineers and other specialists in soil morphology, soil physics, land use forestry, soil and water conservation.

To combat soil erosion indigenous control measures have to be encouraged, upgraded and upheld. Bush fallow and shifting cultivation have ceased to exist in an era where population increases the demand for food. However, aforestation, minimal tillage, controls on grazing and use of organic substances on farms can significantly minimize erosion on the landscape.

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