

Review

Soil conservation, water resources and utilization for sustainable agricultural development in Nigeria

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This article presents the conservation of soil and water resources and its effective utilization as key to sustainable agricultural development in Nigeria. This requires policies and methods that emphasize the conservation of these natural resources base. Poverty, intensification and extensification of marginal lands were identified as major threats to the sustainability of soil and water resources. The study recommends “home grown: soil and water conservation practices, and water quality management techniques that are vital to ameliorate the problems of soil degradation, erosion and water quality. It is advocated that education and training of the stakeholders remains the best option for the adoption of the suggested sustainable technologies in order to avert food crisis in Nigeria.

Key words: Soil and water conservation, sustainability, food crisis, poverty, education and training.

INTRODUCTION

Nigeria is endowed with arable land and fresh water resources when viewed as a whole without considering the seasonal and annual variability that occurs within the nation. Approximately, 61 million hectares of land mass of Nigeria is cultivable while the total renewable water resources is about $280 \text{ km}^3/\text{yr}$ (FAO, 1995). The average annual rainfall varies between 1000 - 2000 mm in the humid areas and 500 - 600 mm in the semiarid areas. The nation's three principal ecological zones namely: the highly humid coastal zone in the south; the humid and sub-humid areas in the middle belt of the country and the semiarid regions in the north broadly corresponds with the tropical rain forest, the savannah and the Sudano-Sahelian regions of Nigeria.

Soil and water are basic, vital and essential resources for sustainable agriculture. Sustainability implies utilizing these resources in ways that ensure little or no damage whilst guaranteeing their continuous usage. It involves a system of management through wise use of resources while still providing food and fibre for the teeming population. It seeks to control cost and improve farm profitability. Sustainability is thus the essence of natural resources conservation. Sustainable agricultural intensification requires prudent long- term management of the natural resource base (soil and water) on which agriculture fundamentally depends.

The need for increased production has fostered ecologically unsustainable agricultural intensification in many places, leading in particular to soil degradation. Declining Sub-Saharan Africa agricultural productivity is both a cause and a consequence of the deterioration of soil and water resources. The root cause of this deterioration and improper management has been attributed to the level of poverty and the attendant struggle for survival. Poverty, environmental degradation and population growth are related. Nigeria has been classified among countries where population exceeds the carrying capacity of its land resources when cultivated at low levels of technology (FAO, 1987). The 2006 population census figures for Nigeria was about 150 million people. This is expected to increase to about 220 million by the year 2025 (Musa, 2000). It is postulated that food production be moved from 0.26 million ha in 1995 to 0.9 million ha in 2025 which requires expanding irrigated land by 350% (Musa, 2001).

Meeting the present and future needs of the population in terms of food, fibre, shelter, etc. without destroying the soil and water resource base and the environment, remains an important concern. To avert food crisis, it is expected that the rate of food production corresponds with the pace of population growth. As population increases and economy grows, the competition for the

limited supply of land and water will intensify and so will conflicts among users. Activities such as bulldozing and inappropriate mechanical tillage subject Nigerian soils to devastating processes like erosion and the formation of hardpans. In the Sudano - Sahelian region, overgrazing poses serious threat contributing to desertification and wind erosion (Fetters, 2008). Deforestation, whether resulting from demands of animal husbandry, the cutting of wood or the incidence of bush burning, usually produces soil degradation and infertility.

Conservation serves to reduce soil degradation. Various processes and practices resulting from agricultural and non-agricultural practices cause soil degradation, among which are soil erosion, soil toxicity, soil pollution and depletion of soil nutrients. Soil erosion is a worldwide problem, particularly in the tropics where rainfall is high and intense. It has been recognized for a long time as a serious problem in Nigeria (Stamp, 1938) which has several environmental and economic impacts, especially in the South East region where the resilience ability of the soil is limited. In Nigeria, erosion affects over 80% of the land. Soil erosion, which is an insidious and slow process, is the bodily removal of part or all of the soil from its resident position to other areas. This results in a spiraling decay in productive capacity and a diminished resilience of the soil system to provide a suitable medium for crop growth (Lal, 1995). The immediate consequences are urban migration and increased unemployment.

The various forms of erosion include wind, sheet, gully and beach depending on the region of the country. While wind erosion is confined to the arid north, sheet erosion is ubiquitous throughout the country. Areas susceptible to sheet wash are farmlands where the original vegetation has been cleared and the soils being impoverished, become scrubland. The most alarming form of erosion in Nigeria is gully erosion which threatens settlements and roads. The ravaging effects are felt most in the loose sandy terrain of the southeast with major sites at Agulu, Nanka, Okwudor, Amucha, Onicha Mbaise and Bende. Suffice to say that such gullies present spectacular sculptures which attract attention and threaten not only farm lands, but lives and properties. The causes of gully erosion include bad farming practices such as improper tillage and monoculture; quarrying for sand and gravel; lack of road drainage; mis-channeling of storm runoff; deforestation, especially of watershed; incision of rural foot paths leading to stream water supply sources and the lack of road maintenance (Fetters, 2008).

Shoreline erosion and flooding constitute major coastal hazards that have devastated settlements, harbour works, oil production facilities and coastal agricultural and recreational land. According to Fetters (2008), about 13 - 30 m of the Nigerian coastland is lost annually to beach erosion caused by both natural and human agents. For instance, the Bar Beach on the Victoria Island ocean front is threatened by rapid beach erosion. The natural causes

include large storm waves; destructive littoral currents; low-lying micro tidal and meso tidal nature of the coastline; easily eroded nature of coastal sediments; strong tidal currents and global sea level rise, while human action that have exacerbated the destructive impact of nature along the shoreline include harbour protection structures such as Victoria and Escravos Beaches. These structures starve other parts of the coastline of sediments, thus triggering erosion. The coastline is also affected by sand dredging and the damming of rivers in the hinterland which hitherto had supplied enough sediment to the coast to replenish what is lost to the forces of nature.

Mining and mineral processing are equally devastating to land and water supply. For instance, open cast tin mining in the Jos Plateau has produced pits and mine tailings which despoil the landscape. Petroleum production in the Niger Delta region has made the region vulnerable to oil spillage. Soil conservation therefore includes the reclamation of mined and quarry sites. Coastal environmental protection is also a vital subset of land resources management, because Nigeria occupies 800 km of the Equatorial Atlantic sea-board.

Another major concern is the issue of misuse of water. Water is becoming scarce. Seasonally variable or low rainfall limits the diversification through short growing seasons, thereby accentuating both competition for land and other inputs and also leads to seasonality of income for smallholder farmers. Water availability also has an impact on nutrient application. In the northern semiarid region, irrigation is often the only option for achieving agricultural production. In the humid south region, irrigation is also utilized to achieve multiple cropping that is necessary to compensate for the high population densities.

The quality of water required for maximizing crop production in most regions of the country is fast becoming inadequate. Surface water quality is deteriorating and groundwater is polluted and irreversibly damaged by the intrusion of salt water along the coast. Poor water control also contributes to erosion especially in hilly and highland regions experiencing deforestation due to logging and agricultural expansion and to soil nutrient leaching in wetter areas (Barrett et al., 2002). Investment in water control thus becomes very important, whether through conventional irrigation or through natural resource management practices to facilitate water harvesting, drainage or diversion as the case may be. According to Seckler et al., (1992), improvement in water management is key to increased cropping intensity of rain fed system of agriculture.

SOIL CONSERVATION PRACTICES

In order to have a clue to soil erosion control, it is necessary to understand the causes of soil erosion. The main cause is the misuse of agricultural land by man.

However, the fundamental cause of soil erosion is economic. Principally related to this is the high pressure on land due to a dense and expanding population often characteristic of developing nations. The people endeavor to make a living by clearing the forest; by cultivating lands on steep slopes; by adopting faulty methods of cultivation that neither conserves water nor soil; by felling trees for fuel power and shelter and letting their animals loose for grazing until all vegetative cover has been so reduced that it no longer offers protection to the soil (Ahaneku, 1996). Other causes of soil erosion outside the influence of man are natural factors. These include high rainfall amount and intensity, nature (texture) of the soil and the topography of the land. Thus, the primary activities that can initiate accelerated erosion are: deforestation, intensification of agricultural land use and cropping practices, over grazing by animals and construction activities, for example roads, culverts, etc.

Dwindling arable land frontier and population pressure in most developing countries where the need for poverty alleviation is critical have forced the resource poor farmers to practice both intensification and extensification. The intensification if not properly planned and executed could exacerbate the erosion problem. The limited available arable land has made shifting cultivation a thing of the past. In this circumstance, the same piece of land is tilled every year. With the fragmentation of land by families, the land witnesses each succeeding year with more pressure, resulting in the extension of cropping onto marginal lands.

The soil needs to be conserved because it is the material medium for plant growth. On these soils depend agriculture and related primary production activities. It comprises of mineral and organic matter. Nature takes between 300 - 1000 years to build 2.5 cm of soil (Onwualu et al., 2006), while a very intensive rainfall event can result in the loss of tonnes of soil. This makes soil resources a subject of importance in the drive towards natural resources conservation in the country. Efficient and profitable crop production hinges upon achieving a conducive soil environment capable of retaining adequate soil nutrient and moisture for sustained seed development and growth. It is therefore not an overstatement to say that because of the role the soil plays in sustaining plant and animal life, our very existence depends on the conservation of this all important natural resource base.

Nigeria has a wide diversity of soils under different ecological conditions and with different levels of fertility. The traditional land tenure system and soils management practices involving shifting cultivation, slash-and-burn processes and traditional tillage method ensure the maintenance of soil physical properties and the sustainability of productivity. However, land use pressure has reduced the duration of fallow to restore soil fertility below the recommended minimum threshold required for sustainability (FAO, 1985). In an attempt to remedy the

situation the following strategies have been put in place:

Conservation farming, also referred to as permanent agriculture, involves the proper use of every parcel of land (especially soil) for good sound agriculture with a view to enhancing the future (Akinbile and Odebode, 2007). This is through wise use of the natural environment, which includes protection of nature, controlled production of useful materials as well as control or elimination of environmental pollution. Several methods have been recommended to farmers for the conservation of their soils. These include the planting of vetiver grass to reduce erosion, zero tillage and minimum tillage. Farmers in their effort to make their farmlands continue to sustain their activities have adopted conservation methods that are not labour-intensive, highly cost-effective, compatible with the existing farming system, cheap and easy to install and maintain. These practices which include mulching, cover cropping and contour tillage are considered as sustainable soil Conservation practices.

Many indigenous conservation methods such as ridging, terracing, multiple cropping and fallowing were used in the pre-colonial era (Igbokwe, 1996). In the colonial times, the British Government conducted large-scale projects on soil conservation but many failed as imported technologies were inadequate. Soil fertility issues gained more emphasis after independence. Decreasing funds at the end of the oil boom in the 1980s however restricted soil conservation schemes (Slaymaker and Blench, 2002).

Agroforestry, or alley farming, is another alternative strategy to the slash-and-burn system. It is an erosion control technology that involves the cultivation of annual crops within hedgerows formed by leguminous trees and shrubs such as acacia. These legumes help in nitrogen fixation, enhance nutrient cycling through their deep roots, provide biomass for use as mulch and fodder for livestock, as well as improve soil organic matter and sustain crop yield under continuous cropping. It was introduced in Nigeria in 1980, initially to the south east and later to the south west (Adesina and Chianu, 2002). Field trials show that trees improve the soil structure and maintain a high infiltration rate which reduces runoff. Reasons adduced for adoption and continued usage include soil fertility improvement, production of staking material and poles, fuel wood, reduction of fallow length, feed for animals and erosion control.

The use of cover crops improves soil structure, increases nitrogen level, and acts as weed smotherers. Examples of cover crops include *Pueraria* and *Mucuna*. They can be planted in pure stands on an uncultivated piece of degraded land or in association as a relay with an annual crop such as maize. Tarawali et al. (2002) cited additional advantages of *Mucuna* to include increased crop yield, the ability to suppress weeds such as spear grass (*Imperata cylindrica*), thus reducing the arduous task of weeding, provide livestock feed and

income for adopters through the sale of seeds.

Application of domestic wastes (including animal waste) is an age-long traditional practice on farmlands. It is a source of nutrient as well as an ameliorative material for degraded soils. Results from a study using animal wastes as soil amendments (Ahaneku et al., 2004) showed a reduction in soil strength parameters like compaction and bulk density, arising from the increased pore spaces and enhanced infiltration capacity which ultimately minimized runoff and soil erosion. Multiple cropping, a traditional practice very common in Nigeria, also reduces erosion, improves soil properties and decreases the risk of total crop failure. However, reduced crop yield may arise when crops are combined with trees possibly because of competition for sunlight, water and nutrients.

Minimum tillage or zero tillage is an appropriate soil conservation technology in Nigeria as it reduces erodibility (Braide, 1986). This form of conservation tillage results in long-term maintenance of the soil structure and an increase in water retention and hydraulic conductivity. Zero-tillage practice is however not applicable to stem tubers and root crops which are usually planted on ridges. Contour ridging are mechanical measures common all over Nigeria, while tied ridging are common in the northern part of the country (Malgwi, 1992). Permanent erosion control technologies such as terraces were built in Maku near Nsukka (Igbokwe, 1996). The high labour and material cost, as well as the technical expertise required, has limited its use presently.

Lack of involvement and participation by farmers has been found to be one of the most frequent causes of failure of most soil conservation projects. Rural development policies and practice have taken the view that farmers are mis-managers of soil and water. Farmers have been advised, paid and forced to adopt new soil and water conservation measures and practices. Those who complied have achieved environmental and economic benefits in the short term, whilst ill-conceived policies and badly designed programmes and projects are remarkably unsuccessful often resulting in more erosion (Pretty and Shah, 1997). For farmers to be receptive to modern technologies, they need to learn about these methods in order to adopt them. The decision to invest in improved conservation techniques depends fundamentally on the farmer's awareness of the need for improvement and his or her beliefs about the potential of the new practice.

It is therefore to be noted that land cannot be restored in any significant quantity without the involvement of farmers. So there is the need to train and motivate farmers in this regard. Conservation techniques are needed which are simple, efficient and relatively cheap. Above all, there is the need for more emphasis on better land husbandry through which the restoration process is linked to improved plant productivity. For example, composting and manuring increase soil nutrient levels

and lead to better soil structure, making the system more productive and more resilient to erosion. Agroforestry methods, such as barrier hedges of nitrogen-fixing leguminous species, may have an important role to play. Grass strips are another alternative to earth bunds in areas where there is enough rainfall to support them.

WATER CONSERVATION PRACTICES

Water is an important constituent of the geosystem; it is the most abundant substance on earth. It exists in a variety of forms such as sea water, snow, surface water, soil moisture, groundwater and water vapour. In addition, water is particularly important to life; the earliest string of life on earth started in water and even though some forms have strayed away from their natural habitat to be sustained on land water is still considered for their survival. Man can live several weeks without food, but without water, the longest he can live is ten days (Chaturvedi, 1987). However, water is not only for sustenance of life, but is also essential for socio-economic development. Agriculture, the first step in enabling the development of societies, requires vast amount of water. In a single growing season, a plant may absorb as much as 2000 times its grain yield (Chaturvedi, 1987).

Crops can be grown without fertilizers and even without soil, but they cannot survive without water. Without adequate moisture, plants cannot mobilize soil nutrients and lack of water at critical stages of development will result in stunted plant growth. The demand for higher crop yields is greatest in many countries where water is increasingly scarce, either due to low annual rainfall or to concentrated periods of precipitation with long intervening dry spells. To meet future food needs, farmers will have to make better use of all available moisture by employing water harvesting, conservation and efficient irrigation methods.

Globally, agriculture consumes more than two-thirds of the water withdrawn from the earth's rivers, lakes and aquifers but, in low-income countries, agricultural water use is some 90% of the whole. Agriculture is not only the world's largest water user in terms of volume, it is also a relatively low-value, low-efficient and highly subsidized water user. In contrast, poor families in some large cities are forced to spend up to 20% of their income on water (Spore, 1995). If there is to be enough water for all, on a sustainable basis and if depleted groundwater resources are to be restored, it follows that agriculture, the prime consumer, must take prime responsibility for more efficient use. Yet, farmers are being asked to produce more food on soils which are already overworked and degraded and where water may become the limiting resource. It seems that farmers are constantly being asked to achieve more with less. So how can this dilemma be resolved? Technical, social and political

attitudes need to change. Equitable access will have to be achieved by policy-makers instituting measures to control demand by engineers using technology to increase efficiency of supply and delivery systems and by users who will have to guard against a profligate waste of a precious resource.

Traditions of water harvesting and irrigation are to be found in many parts of Africa that are centuries and even millennia old and evidence survives in land-forms, structures and practices; yet sub-Saharan Africa has the lowest proportion of irrigated land in the world. FAO estimates that the proportion of irrigated to total arable land in Asia is 37%, in North Africa 24% and in Latin America 15%, but in sub-Saharan Africa it is only 4%. Moreover, 75% of all irrigated land in Africa is accounted for by just six countries: Egypt, Madagascar, Morocco, Nigeria, South Africa and Sudan (Spore, 1997).

It has been postulated that the world will begin to run out of fresh water by 2050 because of expected population growth to 9.3 billion, according to the United Nations Population Fund. All of the projected growth, from the present 6.1 billion, will be in developing countries already straining to feed and provide basic services to their people (Clover, 2001). This warning signal should be enough to challenge conservationists.

Nigerian agriculture is basically rainfed, characterized by low productivity and subjected to the vagaries of weather. Water is therefore a limiting factor to agricultural production in most parts of the country. According to Musa (2001), there are a number of reasons why water and not land may become the most important constraint for Nigeria's food security. First, is Nigeria's extreme inter and intra annual climate variability. Second, is the strong indication that discharges from West African rivers including Nigeria have dropped significantly over the past 25 years. Third, the population growth and growing urbanization is increasing water demand for domestic, industrial and environmental uses. Lastly, when upstream riparian countries develop water resources fully, trans-border flows drop considerably leaving less internal flow for downstream users.

Potential increase in agricultural productivity lies considerably in both irrigated and rainfed agriculture. However, irrigation has the capacity to multiply yield per hectare compared with rainfed agriculture. The physical potential of the nation's irrigation is in the order of 3.14 million hectares, which is about ten times more than the land currently under irrigation (Musa, 2001). Irrigable area within the Niger River system alone constitutes more than 50% of the potential areas. About 855,000 ha of this area is under traditional irrigation system, about 4,153 ha is under sprinkler irrigation, while 90,847 ha are under surface system. The use of surface flooding in conjunction with ground water resources has augmented the production of dry season farming considerably.

Nigeria also has large potentials for small valley bottom irrigation system development. Over one million hectares

of *fadama* is estimated to be available for irrigation development. The irrigation system is constructed to divert water from the valley bottom streams and low flood plains with high water table for agricultural production, most especially rice. The technologies needed include water lifting from stream/rivers and shallow tube wells using small pumps. It is expected that the developed system would be efficient and beneficial to the farmer and that it would be incorporated into existing farming methods and institutional framework at the farmer's level.

The seasonality of rainfall results in situations where water is available and often in excess at certain times, followed subsequently by periods of intense drought. Semi-arid regions are characterized with low rainfall, high evapotranspiration rates and erratic temporal and spatial rainfall distribution. The highest rainfall amounts are recorded between June and September of each year with high kinetic energies giving rise to low infiltration opportunity time, resulting in the generation of runoff of about 20% of the rainfall amount (Ahaneku, 1997a). Thus, sustainable agricultural development depends heavily on effective utilization of scarce rain water. This requires methods that emphasize improving soil moisture availability and effective use of soil and water. According to Ahaneku (1997b), conservation tillage using chisel plough which does not invert soil, significantly increased soil moisture storage by maximizing water entry into the soil, thus reducing surface runoff and soil loss. Also, under no-tillage condition, there is higher weed intensity resulting in increased quantity of mulch material and consequent increased infiltration rates (Ahaneku and Sangodoyin, 2003).

Farmers grow water demanding crops such as vegetables, rice and maize in the lower part of the landscape to exploit natural concentration of rainfall and nutrients flowing into the valley bottoms from surrounding higher lands. Another approach is achieved by planting drought tolerant crops.

A precondition for increase in rainfed productivity is improved water control at farm and watershed level. Awareness that large quantities of rainwater are lost without being utilized led to rain water harvesting technology. Water harvesting was developed by the ancient Nabateans over 3,000 years ago in what are today Israel and Jordan (Spore, 1997). The aim is to effectively capture and manage rainwater through one of the following: in situ capture of rainwater where it falls and enhancement of its infiltration into the soil; collection, concentration and diversion of runoff into crop fields through catchment systems and collection and storage of runoff for later use in crop fields. Water harvesting involves the construction of dams particularly in drought prone regions and collection of water from rooftops and storage in tanks. Various dam designs using different construction materials abound in the country. Use of local materials at chosen dam sites effectively saves cost whilst achieving the desired result. A small rock-fill dam

designed by Makar et al. (2006) is expected to cost only one-fifth of its estimated cost owing to proximity to locally available construction materials.

It is pertinent to note that conservation of water is not limited to its quantity alone. Quantity and quality of water are two vectors in water management; the former is sometimes used in the context of resources and the latter in the context of environment. The quality of water depends on its intended use. It also depends on the amount of suspended sediments and the chemical and biological constituents in the water. The effect of sediment in irrigation water is influenced by the nature of the soil of the irrigated area. On the other hand the chemical properties of water affect its suitability for many uses. The most important characteristics of irrigation water are: Total concentration of soluble salts; Proportion of sodium to other cations; Concentration of potentially toxic elements and bicarbonate concentration as related to the concentration of calcium plus magnesium (Schwab and Frevert, 1985).

Water pollution may be classified as either from point sources or non-point sources. Point sources include hazardous waste sites, municipal and industrial treatment plant discharges and others where wastes discharge at a point directly into the streams. Non-point sources are those where the polluted water does not enter the streams at one point; such as runoff from cropland livestock pastures and forests. The pollution of our water, soil and air has largely resulted from a high standard of living, from agricultural and industrial growth and from a rapid increase in population. In the last decade or so it was recognized that further water quality improvement required reductions in non-point sources of pollutants in addition to those being brought about by point sources. This has placed land management and agriculture in particular, to the fore. The US EPA attributed 76% of the pollution in US lakes to non-point sources (EPA, 1989), with the majority of that linked to nitrogen and phosphorus derived from agriculture. Areas with intensive livestock agriculture are those most likely to cause non-point pollution of ground and surface waters by nitrogen and phosphorus (Breeuwsma et al., 1995; Sharpley and Rekolainen, 1997).

Groundwater also needs to be conserved as it has been noted that prolonged irrigation apart from causing water logging and secondary salinity can result in environmental pollution and shallow groundwater levels. In addition, over-exploitation of deeper groundwater causes groundwater pollution due to leakage from shallow unconfined aquifers (Riasat and Jiamin, 2006). Deep, open drains are effective for lowering the shallow water tables and reducing soil salinity and are therefore recommended.

Globally, land and water management is increasingly being based on watersheds. The watershed approach is being promoted as a means of bringing about environmental improvements, particularly at scales that require

changes by multiple landholders. The approach is comprehensive, involving all natural resources and human activities. Implementation of programs to improve water quality typically follows planning steps. The USDA-Natural Resources Conservation Service (NRCS) follows a nine-step process (Stinivasen et al., 1993) viz: Identify the problems; Determine objectives; Prepare an inventory of resources; Analyze the resource data; Formulate alternative solutions; Evaluate alternative solutions; Determine a course of action; Implement the plan and Evaluate the results.

CONCLUSION AND RECOMMENDATIONS

Available soil and water resources in Nigeria are threatened. These resources need to be managed to ensure optimal use for the greatest benefit of the citizenry and in perpetuity. Improved soil and water resources management is a pre-requisite for sustainable agriculture, which is itself a necessary condition for economic growth, poverty reduction and environmental conservation in Nigeria.

Slow diffusion of improved soil and water resources management practices is due to problems of weak information transfer, thus emphasizing the importance of knowledge and learning. Education and training on conservation of these resources remains the best way to increase the adoption rate of technologies. This, highlights the importance of agricultural extension agencies in the country. Also, anti-erosion measures must be encouraged through public enlightenment and awareness campaign.

To achieve sustainable conservation, farmers that were hitherto considered as problems should be seen as potential solution. The previous attitude of forcing technology upon them should be dropped while partnership and participatory approach should be adopted. There should be a major focus on building farmers' capacity to innovate and develop technologies appropriate for their own conditions. Government involvement should be primarily based on providing technical support and incentives for changing land and water management practices that will result in minimal land degradation and improved water quality.

Better land use planning and proper soil management using modern technologies like Geographic Information System (GIS) is advocated to improve soil conservation. The issue of land rights and ownership should equally be addressed so that farmer's access to land can be guaranteed.

To effectively utilize the nations' water resources potentials, there is the need to develop agricultural strategies that comprises of both rainfed and irrigated agriculture. In this regard, information on our water resources (surface and ground water) is urgently needed to facilitate irrigation planning. This issue requires very

serious attention because it is one single factor that can revolutionize Nigerian agriculture. It should however, be emphasized that irrigation is not an exclusive feature of Savannah agriculture (Northern Nigeria). This is because even in the rain forest zones of Southern Nigeria, water is a limiting factor to crop production. Accordingly, correct irrigation scheduling have to be worked out by researchers in Soil and Water Engineering for different soil types, crops and ecologies in Nigeria.

Finally, sustainable agricultural development calls for careful planning for the utilization and management of soil and water resources. The ultimate objective of this plan is to empower the farmers with the necessary tools and requisite know-how to conserve their soil and water resources. This is because, it is they who suffer when land loses its productivity and water its quality.

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