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Planning Sustainable Soil Management Under Intensified Crop Production System in Nigeria: An Ecosystem Approach

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ABSTRACT

Nigeria soils are fragile, deficient in nutrients and organic matter. Land use intensification under the influence of population growth is aggravating the problem of soil degradation. Many poor farmers (over 80% of the population) turn to labour – led intensification – farming on the same land which does not enhance sustainability. This has led to reduced fallow periods and increased planting density, thus putting more pressure on the land. But few can afford to offset this mining of soil nutrients by applying fertilizers and manure to maintain soil fertility and prevent soil exhaustion. Extracting soil nutrients without corresponding recharge is one of the most important agricultural issues in Nigeria and at the backbone of food crisis. Current levels of production are being maintained by progressively depleting soil nutrients, hence the land becomes easily degraded thus forcing many farmers to open up new lands. About 3 to 5% annual increase in food production is required to lead Nigeria out of poverty and hunger. This target cannot be met easily with the present farming systems, which have led to a continuous degradation of the agro-ecosystem and environment. Previous attempts made to minimize soil degradation in the past by the introduction of leguminous shrubs (Leucaena and Gliricidia) failed because of lack of proper adaptation to already existing farming systems. The introduction of edible grain legumes as opposed to the inedible species may be more adaptable to the rural communities.

To successfully implement sustainable soil management programme, soil scientists and agronomists should be actively involved. Although, local successes have been reported on individual farmer's field, these need to be articulated into well-focused local, regional and national soil management programme. Encouraging active participation by farmers, helping project managers in identifying realistic target and development of a guideline for impact monitoring of sustainable soil management projects should be the focus of soil scientists and agronomists.

KEYWORDS: Sustainable, Management, Intensified, Crop production, Ecosystem.

INTRODUCTION

Agricultural cropland, including agroforestry as well as forested lands, range, and pasture lands, is under increasing pressure because of population migrations to marginal land areas and agricultural intensification on existing lands. Sustainable land use intensification requires the maintenance and / or enhancement of the productive potential of the land resources. Increases in food supplies must come from agricultural intensification rather than expansion. This must, however, be done without degrading the land resource on which production depends.

Sustainable soil management is essential in Nigeria to cope with increasing pressure of population on the land. Soil quality management technologies are needed to support sustainable agricultural development in the different agro-ecological zones of Nigeria.

Sustainable land management presents a long-term strategy for farmers to manage their land in a sustainable manner, while recognizing the sensitivity of the agro-ecosystem to system-distorting external inputs. The basic criteria for sustainable soil management are meeting the food needs of the present and future generations in terms of quality and quantity and the demand for other agricultural products (FAO, 1991). According to these criteria, the sustainable management of agricultural soils should maintain the soils' productivity for future generations in an ecologically, economically and culturally sustainable system of soil management.

A World Bank Environmental Assessment rep. (World Bank,1993) identified land degradation as the most important problem facing Nigeria. Soil degradation was estimated to affect about 50 million people with likely long-term costs in excess of US$3 billion annually. In another report by the FAO (1991), it was stated that in spite of the country's vast land mass, its population of over 100 million (Fig. 1), already exceeded the carrying capacity of its land resources when farmed at low levels of crop husbandry. It is therefore clear that the consequence of a combination of population pressure, fragile land resources and slow adoption of appropriate farming practices is land degradation, with the most adverse effect being irreversible loss of productive land to erosion. This has lead to increased pressure, depleted water and wood supplies, loss in soil fertility and yield decline, weakening food security and increased food, fuel and fertilizer imports.

This paper will (a) briefly review the contentious debates about why priority should be given to soil quality management and improvement, (b) provide some suggested alternatives, drawing upon recognized point successes, and (c) focus on the most vexing issue: if soil quality management is so important why is it handled by agriculture policy makers so poorly at present or to put it positively, how can broad scale soil quality management be implemented, and how can soil science research community contribute to this major endeavour?

This paper is not only about soil productivity increase through improved technologies, it is also about soil quality improvement as a building block of a sustainable land resources use.

Natural Resource Base

Nigeria covers a land area of 924,000km^2 of which 75 percent is cultivable. The growing period in the semiarid zone ranges

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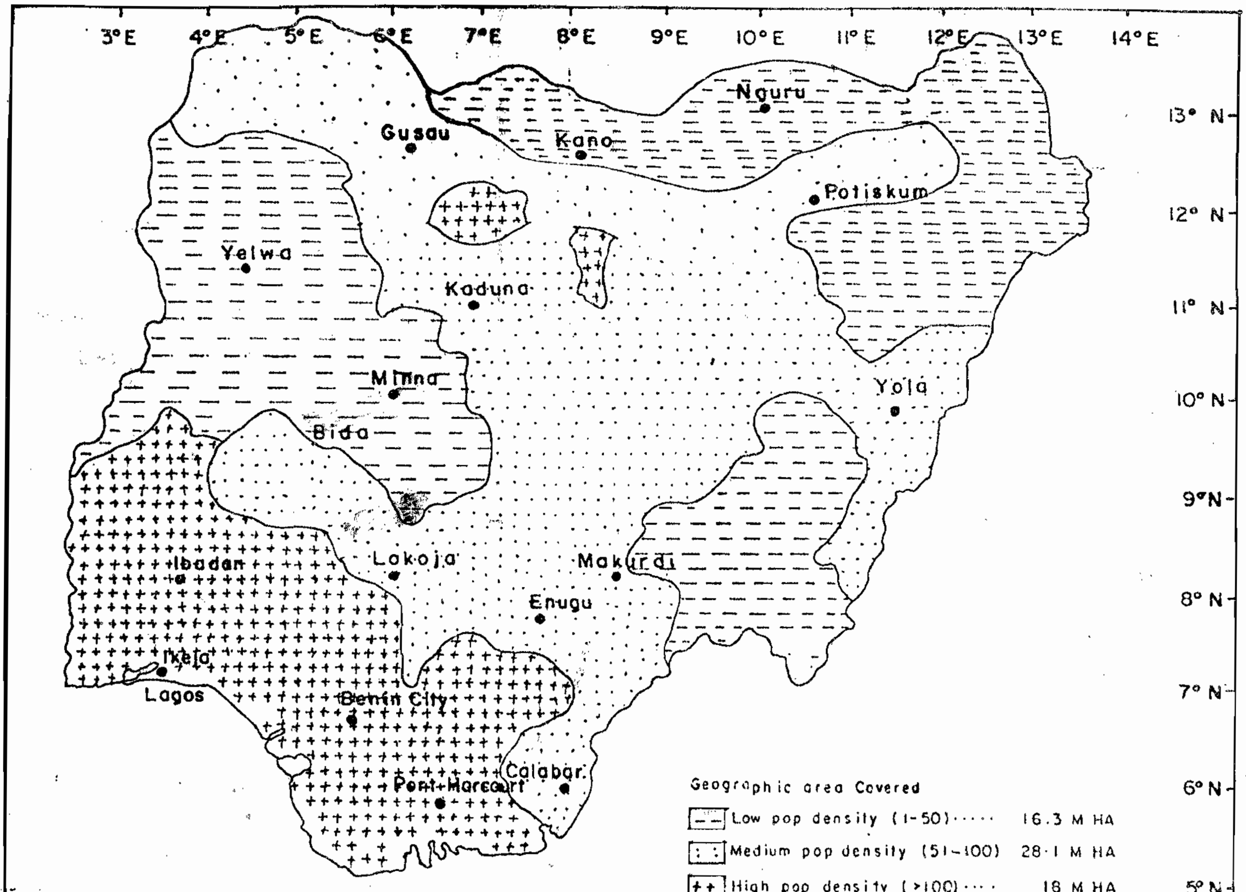

Fig. I
Population density (people per sq. km)
source: Manyong et al 1996

from 90 to 150 days and in the sub-humid from 150 – 270 days. The sub-humid savanna zone of Nigeria is divided into the northern and southern Guinea savanna and the derived savanna. The total rainfall and length of growing season increase from north to south (Key, 1959). Other factors being equal, soil organic matter content is positively related to total annual rainfall and length of growing season especially in the sub-humid and semiarid zones (Jones, 1971). Soils are as diverse as the climate. Many are derived from recent wind-borne and alluvial materials. Soils in many areas are light textured, low in fertility and organic matter and prone to erosion (Fig. 2). Soils in the sub-humid zone are dominated by Alfisols with associated Entisols and Inceptisols. The soils are characterized by low activity clays, coarse textured surfaces, slightly acid to neutral soil reaction, low levels of organic matter (< 10g/kg organic carbon), low nutrient and water holding capacities, low supply of N and P and sometimes of K, S Zn and B and susceptible to soil compaction and erosion (Kang and Spain, 1986). Acid soils in the more humid areas may suffer from excess aluminium, where management of structure and terrain becomes important considerations for continuous crop production.

Crop and Cropping Systems

Increasing rainfall from the semiarid north to the very humid tropical rainforest in the south allows widening food crop diversity from short season cereals like sorghum and millet in the north, to cassava, yam, maize and rice in the southern areas. In the drier areas cash crops like cotton and groundnuts are grown while in the south cocoa, rubber and oil palm are grown. In the moist savanna, which covers an area of 45.3 million hectares (estimates from Manyong *et al.,* 1996), a diversity of crops is grown. In the northern Guinea savanna, millet, sorghum and maize are the main staple food crops. These are sometimes grown in pure stands, but are more often intercropped with cash crops and other food crops, such as sorghum/millet, maize/sorghum, maize/cotton, maize and vegetables. Cowpea and vegetables (tomato, pepper and okra) are also grown to supplement the cereal diet and provide cash income. Rice and sugarcane are grown in well-watered areas of river floodplains and inland valleys (Kowal and Kassam 1978; Elemo *et al.,* 1990).

In the southern Guinea savanna, root crops such as yam, cassava and cocoyam are predominant, either as intercrops with cereals, such as sorghum and maize or in pure stands. The major crop mixtures include yam with some or all of the following: maize, cowpea, okra, melon, pepper and cassava. Other common associations are sorghum/groundnut, soybean/sorghum, maize/sorghum, maize/cassava, rice/sorghum and rice/maize, among others (Elemo *et al.,* 1990). Root crops predominate in the rainforest derived savanna zone. The cropping system is dominated by yam or cassava-based systems. Other crops like sweet potato, maize; sorghum, groundnut, and rice are predominant, with the cassava or maize-based systems as the most common cropping systems (Fig.3).

Cropping Systems Dynamics and Land Degradation

Nigeria is a nation of smallholders. The World Bank data for

1985 indicated 9 million rural families (63 million people) farming an average of 2 ha per family, often split between a home garden and a bush farm. The area actually cultivated is about one-third of the potential cultivable, with the remaining two-thirds in fallow, forest or bush. The 3.5% annual population growth rate has serious implications for traditional methods of soil fertility restoration based on fallow; already little cultivable land remains outside the cultivable cycle. The prolonged cultivation has resulted in reduced fallow periods with nutrient outputs exceeding nutrient inputs. The consequence of this is a marked loss of organic matter and a decrease in soil fertility as reflected in soil mining and increase in soil acidity. Coming on trail of these observations is a drastic drop in crop production. Any expansion must be at the expense of the fallow period and will result, under current practices, in declining yields.

Water and N are the major determinants for food production. Weber *et al* (1996), stated that the soil must supply approximately 60kg N in plant available form for each tonne of grains produced for the most commonly grown cereal of maize, sorghum and rice but this is not obtainable under the fallow rotational system. Average annual nutrient loss as for Sub-Saharan Africa was reported as 22kg N, 2.5kg P, and 15kg K in 1982-84 and will be 26kg N, 3kg P, and 9kg K by 2000 (Stoorvogel *et al*, 1993). The reduction of fallow from 6 to 2 years has resulted in yield declines from 11t/ha to less than 2 t/ha for cassava and from 3 t/ha to about 0.7 t/ha for maize in certain areas (Sanginga *et al.*, 1996).

There is, therefore, clear evidence throughout the country that land use is intensifying under the influence of population growth and medium-term low rainfall especially in the north. Given uncertain land tenure systems, untimely availability of fertilizers at affordable prices and epileptic extension advice for low-input systems, these processes of intensification are generally assumed to be causing land degradation. Cropping intensification of upland ecosystems occurs at the expense of the resource base quality. Studies on shifting cultivation, in mainly maize-based systems, indicate that cropping intensification reduces the soil organic matter content (Agboola, 1994; Hien *et al.*, 1994) with an associated decline in soil N (Gigou, 1992) and increasing weed infestation (Adesina *et al.*, 1994). In this situation, the physical degradation (erosion and compaction) of the soils is rapidly emerging as the major production constraint (Pieri, 1992).

A survey of Imo State, in South East Nigeria indicated that over a 20 year period, fallow period had declined from 1-9 years to 0-6 years – much less than the 5-7 years necessary to restore fertility (Eboh, 1992). Besides the resultant low yields, the decline in fallow periods had reduced capacity to supply stakes, fuel-wood, fodder or browse, foodstuffs and medicines. Farmers then had to purchase these requirements or open up new land areas. Some highly degraded areas suffer from extreme erosion or become colonized by spear grass (*Imperata cylindrica*) and become almost completely useless. In some villages of Anambra State in the same zone,

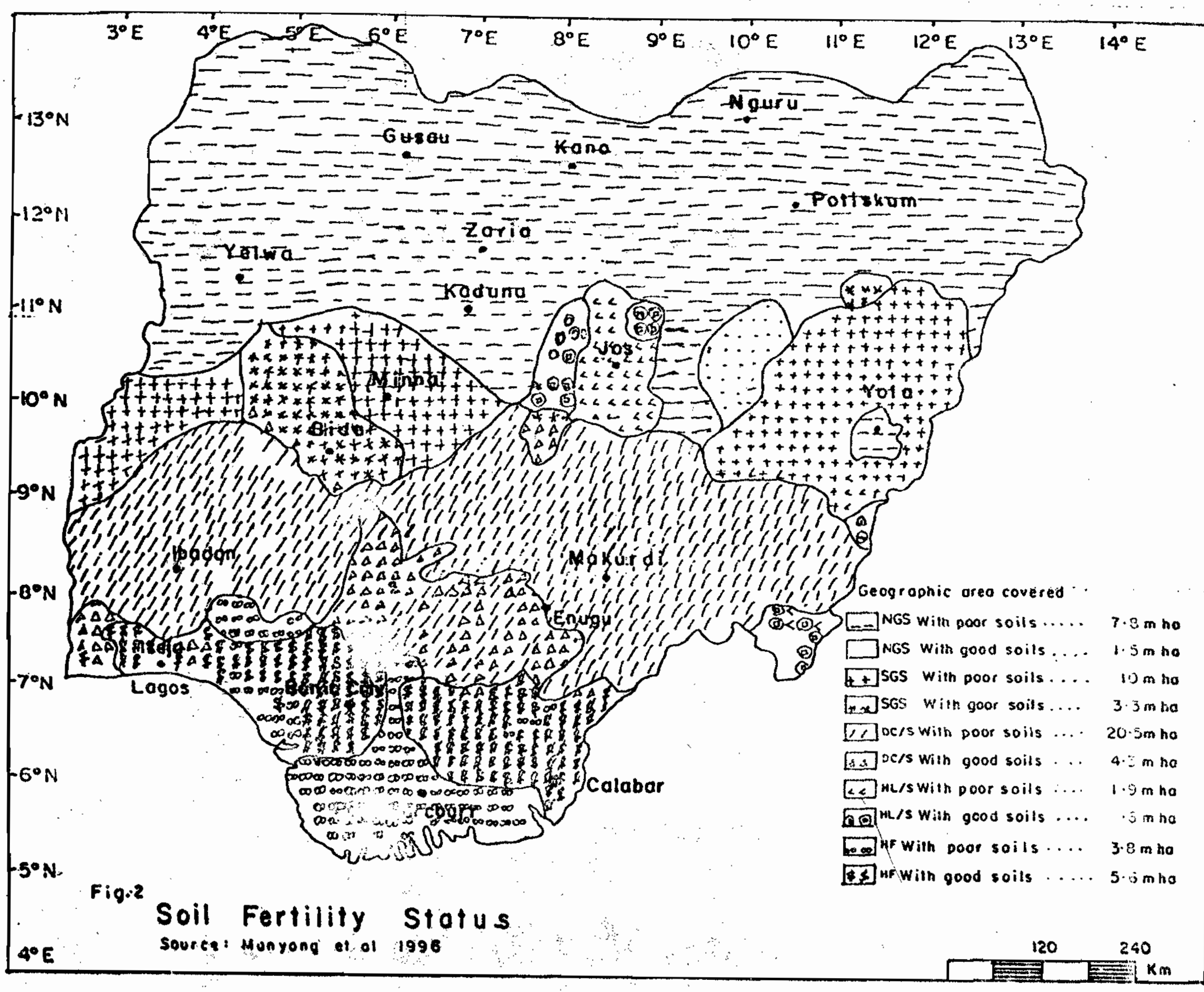

Fig.2 Soil Fertility Status
Source: Manyong et al 1996

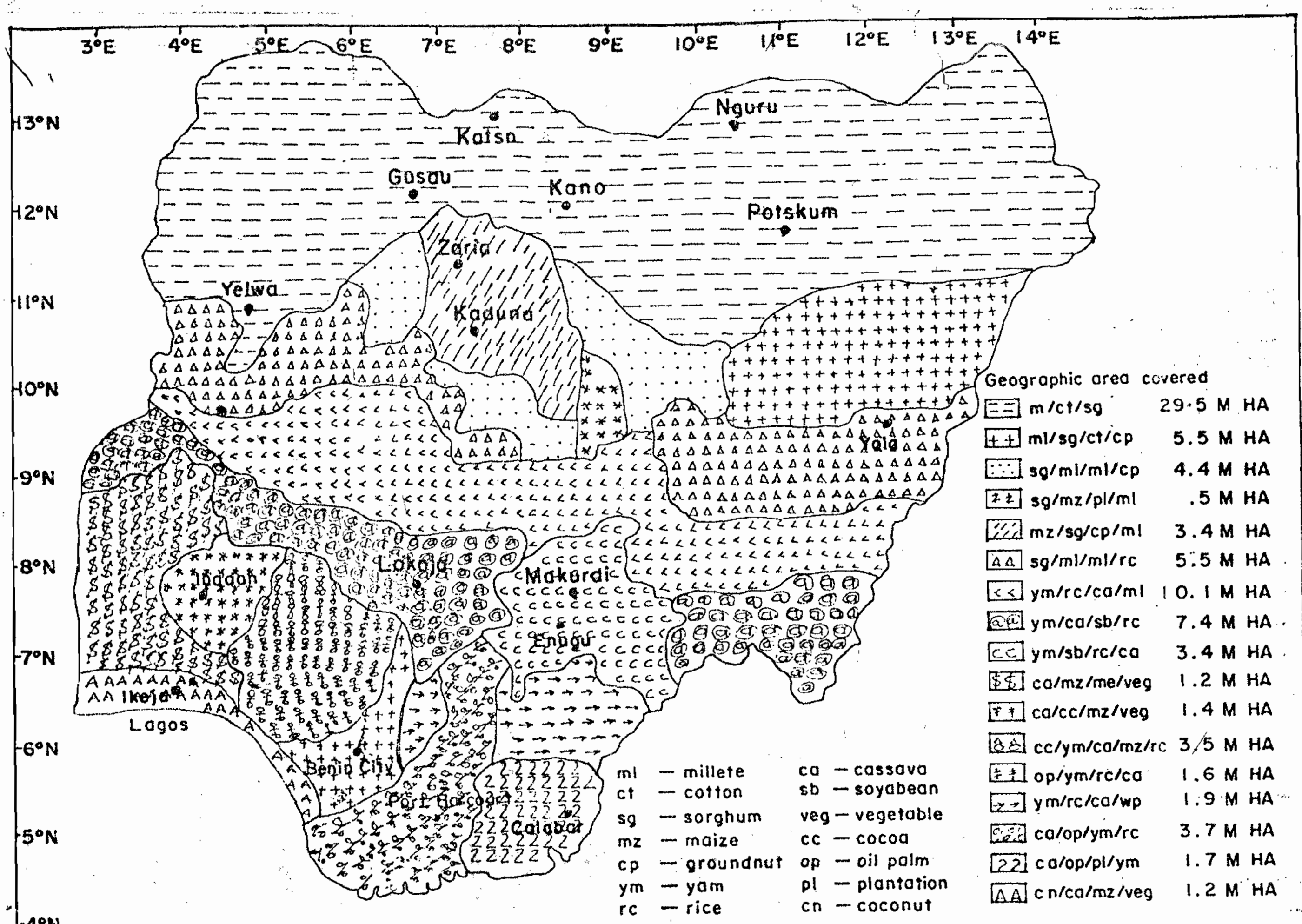

Fig. 3: Cropping systems in Nigeria
Source: Manyong et al 1996

the Land-Use Intensity Index (the ratio of cultivated land to uncultivated land plus fallow) is 80% (Eboh, 1992). In upland areas, intensification causes loss of organic matter and nutrients, and structural deterioration.

Given the current intensity of land use and the fragility of upland soils, production gains from subsistence food crop agriculture are likely to be low, despite the large area occupied by these systems. Technology generation should be realistically aimed at sustaining productivity gains and stabilizing intensified subsistence food-based systems. One of the most prominent cropping system alternatives is the improvement on the quality of fallow vegetation, through the introduction of leguminous cover crops (Balasubramanian and Sekayange, 1992). Despite a large variability, mean N accumulation in cover legume crops is reportedly high (about 100kg N ha^{-1}) and a major share of this (about 70%) appears to be derived from BNF (Becker et al., 1995; Peoples and Craswell, 1992). The encouraging result of three decades of cover legume research in Asia (Carangal *et al.*, 1994), Latin America (Lathwell, 1980; Burle *et al*, 1992) and in Africa, (Hartmans, 1981; Agboola, 1982; Lal, 1993; Hulugalle *et al.*, 1986, Mulongoy, 1986; Tarawali, 1991; IITA, 1993; Becker *et al.*, 1995a: Carsky *et al*, 1998) have resulted in promotion and extension of such technologies to improve soil fertility throughout the tropics. These efforts, however, are very much at variance with farmer's rate of adoption of improved fallow technologies in crop production systems.

Yet, the high genetic yield potentials that have been achieved by plant breeding in recent times need to be exploited by also making use of the available ecological yield potentials. It is therefore necessary to initiate a well-articulated land quality improvement programme under intensified cropping system.

TOWARD SUSTAINABLE SOIL MANAGEMENT.

Current Status.

A wide range of agroeco-technologies exists, both indigenous and introduced, which offer prospects to soil management issues in Nigeria. Those that hold greatest promise for widespread application are found in farming system practices aimed at soil quality decline and degradation. Adjustment of cropping patterns to maintain maximum soil cover throughout the year, maximizing the application of organic manure and compost could all contribute to the more sustainable use of farm land, given their relatively low cost. Most of these essential agro-ecosystem approaches to conserve soil and water resource are likely to be financially attractive to farmers. In fact, most edible legumes have been a component of crop mixture among farmers in Nigeria. In southern and north central Nigeria, *Cajanus cajan, Pachyrhizus ahipa* and *Arachis hypogea* have been grown in mixture with yam, cocoyam, cassava, maize and sorghum. In northern Nigeria, *Arachis hypogea*, and *Vigna unguiculata* are common with sorghum, millet and maize.

A review of more than 250 published references indicates that full integrated soil management system (ecosystem) which incorporates biological nutrients sources (Lal *et al* 1979; Tian *et al*, 1993; Agboola, 1994; Ong *et al*, 1996; Sakala *et al*, 2000) is a solution to resource base degradation.

In northern Nigeria, maize grain yields were found to be greater following groundnut crop than after crops like cowpea, cotton or sorghum. The yield increase was related to an increased availability of mineral N in the soil after groundnuts (Jones, 1971). In Zimbabwe, the yield of maize was greater after bambara groundnut (7.6t/ha) than after groundnut (6.2t/ha), upland fallow (4.3k/ha) or maize (3.9t/ha) (Waddington and Karigwindi, 2001). Groundnut and cowpea were found to have roughly equal residual effects on the growth of subsequent maize crop in northern Ghana equivalent to the addition of 60kg fertilizer N/ha (Dakora *et al*, 1987). Over a 12 year period, yields of sorghum were consistently higher following a sorghum/pigeon pea intercrop than after an oil-seed crop, sunflower, and the soil N had increased significantly where pigeon pea had been grown (Rego and Rao, 2000). Yields of maize grown after soybean on an Alfisol were increased from 2.5 to 4t/ha (Kasasa *et al*, 1999). In Zimbabwe, the yield of maize was almost doubled, from 2.5 to 4.6t/ha, after a groundnut crop that yielded only 0.4t grain/ha, even though most of the stover was grazed by cattle (Waddington and Karigwindi, 2001). These authors reported that leguminous cover crops such as *Canavalia ensiformis, Cajanus cajan, Stylosenthis species, Mucuna cochinainsis, and Cassia occidentalis, Lablab, Glycine max, Arachis hypogea, Vigna subterranean*, and *V. unguiculata*, contribute to the maintenance of soil N, soil organic matter and improvement in soil physical properties in intensified cropping systems. Also results from improved legume fallow system trials have indicated that tremendous yield advantages of between 25 and 50% are possible (Kasasa *et al*, 1999). All these technologies need to be articulated into a well-focused soil management/farming system programme which is focused on small scale farmers who constitute over 90% of the farming population in Nigeria.

Farmers' Experimentation on the use of Legumes.

Most Nigerian farmers practice *intercropping/multicropping* system, where a series of crops are grown on a plot of land. This system may be practised as row intercropping, relay cropping, mixed intercropping and strip cropping. The few case studies in Africa presented here are to illustrate the reality of both socioeconomic and environmental impact of sustainable soil management and the conditions conducive to its adoption.

Mucuna pruriens was introduced into Benin Republic in the late 1980s, specifically, in response to farmers' problems in controlling *Imperata cylindrica* (Versteeg and Koudokpon, 1990). Prolific growth of mucuna in most cases gave good weed control and the number of farmers using mucuna rose rapidly from 20 in 1988 to more than 10,000 in 1996 (Versteeg *et al*, 1998; Manyong *et al*, 1999). Land tenure was an important factor in determining whether or not farmers invested their time in growing mucuna. Farmers recognized the fertilization and mulching effects of mucuna in sustainable crop production.

An on-farm research using legumes as green manures in Uganda gave a good increase in crop yields, although over a three – crop cycle the green manure did not compensate for the time it occupied on the field. Nevertheless, an economic evaluation of different legumes as green manure indicated that only those species that could control weed effectively and reduce labour cost gave increase in savings over continuous cropping. A simple guide has been developed to assist farmers in deciding which of the legume specie is best for a given niche in the cropping system. On-farm adaptive farmers' managed trials were conducted by our team in two adopted villages in Southwestern Nigeria for three years. The positive effect of the traditional cropping systems involving some legumes on the yield of associated crops is shown in Table 1.

There was increase in maize yield as a result of its association with legumes. The increase was 79% and 61% for pigeon pea (*Cajanus cajan*) and cowpea (*Vigna unguiculata*), respectively over the yield obtained from sole planting of maize and without fertilizer application. The low effect shown by mucuna could be due to its climbing/creeping ability, which retarded the growth

Table 1: Effect of intercropping and relay cropping of maize with legumes on the yield (t/ha) of component crops.

	Intercropping				Relay cropping					
	Legume		Maize		*Maize		Legume		**Maize	
Crop	F	Nf	F	Nf	F	Nf	F	Nf	F	Nf
Pigeon pea	1.05b	1.25b	2.45b	2.06a	3.88a	1.65a	2.68b	2.32b	4.45a	3.45a
Mucuna	3.05a	3.36a	1.62d	1.20b	3.92a	1.28b	3.40a	3.55a	4.61a	3.25a
Cowpea	0.98b	0.70c	2.06c	1.85a	2.95a	1.37ab	1.36c	0.95c	4.30ab	2.58b
Groundnut	0.80b	0.60c	1.98d	1.32b	3.80a	1.50ab	0.84d	0.71c	4.34ab	1.85c
Sole maize	-	-	3.68a	1.15b	3.98a	1.26b	-	-	3.72b	1.04d

Figures having the same letter(s) along the column are not significantly different at P=0.05

F – 120kg NPK 20 – 10 – 10 per hectare *before legume

Nf – 0kg NPK 20 –10 –10 per hectare **after legume of maize plant. Similarly, legumes such as pigeon pea and mucuna seemed to be highly suitable for use in a relay cropping system. The lower coverage ability of cowpea and groundnut plants might be responsible for performing lower than the other legumes. On the whole, planting of legumes in mixture with maize in both cropping systems was beneficial in maize production.

In other On-Farm Adaptive Research (OFAR) trials, planting of *Mucuna puriens*, *Cajanus cajan* and *Canavalia ensiformis* as fallow crops for three years, raised the soil N by 62-91%, phosphorus by 88-170% in comparison with values at pre-cropping period (Fig. 2). It was established that the effectiveness of the fallow crops depended on their ability to establish on farmland, suppress other weed plants, produce high biomass, its regeneration capacity and social/economic value attached to the crops.

Sustainable Soil Management

While the above case studies clearly demonstrate the increased profitability of improved soil management practices, the positive environmental impacts have been highlighted in presenting the case studies, in particular, with respect to soil erosion and water quality. In addition, sustainable soil management and soil quality improvement based on an agroecological approach may induce a decrease in the rate of deforestation and protection of fragile soils. The adoption of the legumes will in fact be dictated by socioeconomic values attached to them. Edible legumes will be more readily adopted than non-edible ones.

IMPLEMENTING SUSTAINABLE SOIL MANAGEMENT PROGRAMME

If the rational for sustainable soil management and what to do are clear and compelling, the question arises as to why this is not happening more pervasively in Nigeria? All the obvious reasons have been reviewed by many experts, including market distortions, socio-cultural factors, land degradation, etc. However, they do not help in defining a clear strategy to address this burning issue (Sanchez *et al*,1997). Perhaps the answer is that there is no such thing as a clear unique strategy to develop and implement the right solution.

Firstly, soil management improvement is complex with many crossroads and options based upon a wide array of interacting factors; some historical and cultural (Harris, 1996). Some other factors are structural such as macroeconomics, environmental or legal (land tenure), and some unpredictable variables such as prices or climatic functions. Strategies that are well calibrated to local circumstances and can be implemented with flexibility are needed (Adams and Mortimore, 1997).

Secondly, the adoption of improved technologies to achieve soil quality improvement and sustainable soil management is not a linear process, and certainly not the end of the story. Observations made by COSECHA, a non-governmental organization (Bunch and Lopez, 1996), reveal that the adoption of conservation technologies, such as green manure, crop rotations, etc., had continued to grow since the termination of their project. However, COSECHA observed that "successful technologies have been developed, adapted, adopted, dropped and superseded by new practices developed by the farmers. Clearly the technologies themselves are not sustainable, and the conclusion of the authors is "what needs to be made sustainable is the social process of innovation itself".

Finally, we acknowledge that the answer to the question of "how to" cannot be straight forward and experts and scientists should be very humble in the quest. However, two points have to be made. Firstly, if there is no single road map, the need to have a clear goal remains. Secondly, to embark on this journey towards sustainable soil management, some basic conditions or objectives should be met in order to increase the probability of a successful outcome and farmers' adoption.

Several local successes have been made in sustainable soil management practices, but a large-scale breakthrough in local region is yet to occur.

Goals and Objectives

Problem Statement

Nigerian soils are fragile and deficient in nutrients and organic

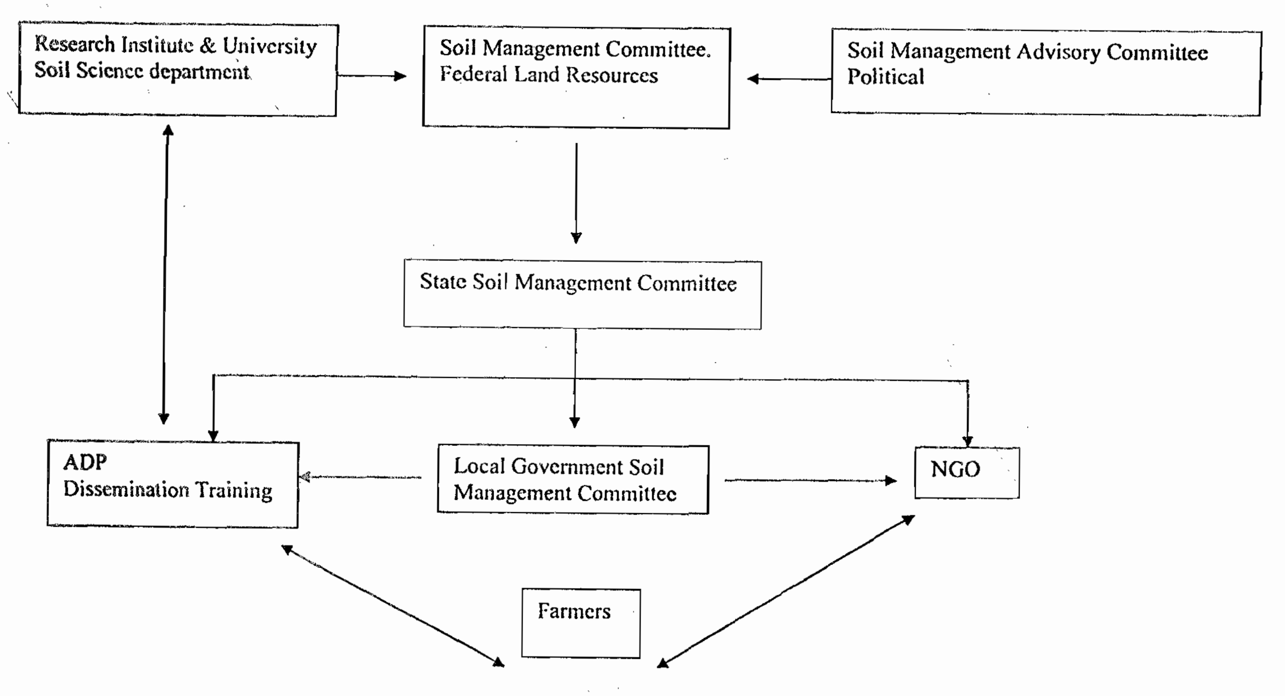

Fig. 4: Diagram illustrating implementation strategies for sustainable land management programme.

matter, and in the absence of conservation practices are susceptible to degradation and loss of nutrients leading to low productivity.

Overall Goal

The overall goal is to maintain a non-negative and, preferably, an increasing trend in per capita productivity while maintaining or enhancing soils capacity to produce economic goods and services without degrading the environment.

Intermediate Goals

Increase productivity of soils under intensive use.
Increase productivity through improved inputs use efficiency, and Arrest and reverse resources base quality decline.

General Objective

The general objective is to transfer agro-ecological technology for major arable cropping system to help intensify traditional agricultural systems while conserving the natural resource base. In this context, soil quality maintenance/improvement, as a component of sustainable land management, is best achieved through technologies that mimic processes in unmanaged ecosystems. In this system most of the nutrient supply results from the turnover of soil organic matter predicated by soil organisms. These agro-ecological techniques, such as crop rotation, improved fallow, use of legume cover-crop, etc minimize and balance the use of external inputs, and both limit the losses and increase the efficiency of available resources, particularly plant nutrients, soil organic and biological resources, and surface water.

Some Operational Recommendation

Based upon the lessons learned from current and past experiences illustrated by the case studies presented above, any programme targeting soil quality improvement with the goal of building or maintaining healthy soils, should put in place a comprehensive rural policy that will address the following:

a) Farmers' organizations (e.g. practising Farmers Association of Nigeria), villages and rural communities should be the major "target group" of any programme dealing with soil quality improvement under sustainable land management following a participatory approach. This group is the first in the establishment of the hierarchy of users' needs (Pieri, 1997). Farmer organizations should also be central to the development and implementation of a comprehensive workplan targeted at the overall goal of soil quality improvement.

b) There must be functional markets. These include input markets, output and commodities markets, financial markets, including credit, land market (land tenure) and labour market. To achieve effective functioning of market is a gigantic task, and probably an impossible one in a short run. The key message here is "prioritization". This means that, during the diagnostic phase preceding the preparation of the programme, representatives of the major land users must identify selectively the most limiting socioeconomic and legal constraints to the adoption of sustainable soil management, and how best to overcome these constraints in the short run. Very often, there is no more than one or two major constraint(s) which prevent farmers' socioeconomic environment from being conducive to the adoption of improved technologies. It can be price policy, transport infrastructure, fertilizer market weakness, labour availability, etc.

c) There must be a decentralization of decision making for improved soil management. The development of "soil committee" at local, state and regional levels with clear mandate and responsibility is advocated. A local government soil commission is to select, on the basis of established criteria (Manual of operation), the micro-catchments to benefit from the project, engage local institutions, get political support, and monitor activities at the local government level. A micro-catchment soil committee, which together with the extension system of the Agricultural Development Programme (ADP), should be responsible for the preparation and implementation of micro-catchment and individual plans of soil management. These commissions together with the public institutions will realign the research focus on OFAR and encourage strong participation of private agribusiness to adopt improved soil management practices.

d) Small soil management funds should be established on the basis of the plans approved at catchment and local government levels. The funds' objectives will be to demonstrate recommended practices and to accelerate adoption by changing farmers attitudes and behaviour with respect to land management.

e) Finally an intensive training programme concept should be put in place to disseminate knowledge at local, state and regional levels and to increase awareness among all stakeholders (Fig. 4)

f) A participatory approach is central. However, to ensure that this approach is more fruitful than the traditional top-down approach it requires that first, the strength of people participation lies in the practical application of the participatory approach (Pieri, 1997). Pretty (1998) observed that this approach can range from manipulative and passive participation, where people are told what is to happen, and act out predetermined roles to self mobilization, where people take initiatives largely independent of external institutions. Secondly, when it comes to diagnosis, design, implementation and monitoring soil management issues, too often, Rapid Rural Appraisal (RRA) participatory methods are used as an alternative to participatory approach in order to properly diagnose land issues. Superficial identification of the causes and driving forces behind the observed land and soil issues often lead to inappropriate recommendations and inefficient actions (Pieri, 1998). The success of the "farmers field school" approach developed by the Global Facility for IPM (Integrated Pest Management) calls for a parallel approach to sustainable soil management issues jointly diagnosed by "expert farmers", extensionists and scientists. The soil scientific community should contribute more to the development of practical guidelines to assess soil management issues at field and village levels, such as the field manual recently developed for soil erosion assessment (Herweg, 1996).

g) Soil scientists and agronomists can significantly help project managers in identifying realistic targets, which can be met in a given catchment area, by providing menu of technical alternatives and the basis for geographical stratification of the area. For example, the soil management issues in the South-East Nigeria may be different from those of North-East. Therefore, internationally standardized land resources information systems that can help to identify soil and terrain constraints in a special format and map areas of intensification potential for agriculture are needed. So soil scientists are the best qualified group to provide practical guidance to those who will be in charge of implementing specific actions of soil quality maintenance/improvement.

h) Their impact and the sustainability of their result should assess the programme.

At the local, regional and national levels, decision makers need to assess the impact through simple cost-effective indicators (Dumanski *et al*, 1998). The international initiative on Land Quality Indicators (LQI) is an initial response to this challenge (Pieri, 1995). However, guideline for impact monitoring of sustainable soil management projects has been developed (CDE, 1998).

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