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EMERGING APPROACH TO SUSTAINABLE LAND USE PLANNING AND MANAGEMENT: A CASE STUDY OF NAOC GREEN RIVER PROJECT PEDON PACKAGE

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ABSTRACT: In the face of current global food crisis and the decreasing arable land due to industrialization and population explosion, it is common to cultivate agricultural land until its productivity declines. The existing agricultural practices in Nigeria such as the slash and burn, absence of enough land to allow for shifting cultivation for land fallow, and other unsustainable agricultural practices have actually impeded agricultural revolution in Nigeria. Green River Project (GRP) was established by Nigerian Agip Oil Company Ltd. with a vision to facilitate the development of a strong food production system in full respect of customs and cultural heritage of host communities. GRP in collaboration with Saipem SpA, Italy has developed a software for a sustainable land use planning and management linked with a graphical user interface Geodatabase Network console to ensure sustainable agricultural practices in NAOC host communities. This software was developed using Microsoft Access software with the implementation of procedures and functions in Visual Basic and is integrated into the NAOC Geodatabase network console. Within the framework of Millennium Development Goals, National Economic Empowerment Development Strategy, Federal government policies on Small and Medium Enterprise Association of Nigeria and National Empowerment Programs and Presidential Committee on Cassava, Rice, Oil Palm, Plantain, etc, NAOC GRP intends to make a giant leap in land use planning and management in NAOC host communities using the GRP Field Extension workers implementing the NAOC GRP PEDON package.

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INTRODUCTION

Before the discovery of oil in Nigeria in 1956, agriculture was the mainstay of the national economy, contributing more than 60% of the national budget. With the advent of oil and during the oil boom in the 80s, agricultural productivity had declined drastically till now that crude oil contributes about 95% of the national budget. Nigeria, once the food basket of Africa is now a major importer of agricultural products like grains, palm oil, fish, etc. Nigeria is not spared by the ongoing global food crisis. This has come as a result of lack of land use planning and management.

In the face of current global food crisis and the need for more agricultural production as well as the dwindling arable land due to industrialization and population explosion, it is common place to cultivate any given agricultural land until its productivity declines. The existing traditional agricultural practices in Nigeria such as the slash and burn, absence of enough land to allow for shifting cultivation for land fallow, and other unsustainable agricultural practices have actually

impeded agricultural revolution in Nigeria. This has led to the utilization of hitherto neglected wetland soils for agricultural productions in recent times (Udotong and Akpanekon 2007a, b).

In view of the above and to address the agricultural problems, the Federal Government in 1986 directed that companies should diversify into agricultural activities. In compliance with the Federal Government directive for all foreign oil companies to implement projects for Agricultural support, NAOC J.V decided to engage ENICHEM AGRICOLTURA with relevant experience in various countries to study and make its contribution in this sector on most suitable project to be applied in its own oil concession areas. After appropriate baseline surveys and studies in 1986 by the Rivers State University of Science and Technology, the Green River Project (GRP) was established. It was initially located in a part of Oil Concession OML 61 in Rivers/Imo States; in 1992 it was extended to OML 62 in Delta State and later extended to OML 63 in the year 2000 to cover Bayelsa State. Today, the GRP activities spans across 11 and 7 locations in the Land and Swamp Areas, respectively.

GRP was established with a vision to facilitate the development of a strong food production system backed by a broad technology base, globally sustainable under present socio-economic and environmental conditions, in full respect of customs/traditions and cultural heritage of host Communities. Its mission is to develop and sustain poverty alleviation schemes and employment generation programmes and to foster the living standard of rural people through the promotion and growth of agricultural sector, which accounts for at least 75% of the occupation of the people of the Niger Delta.

GRP evolves on a Modular Integrated Unified Extension Service system (MIUES) linked to:

- Improvement of the traditional agricultural system by the introduction of modern farming techniques through extension services.
- The introduction of new crops of nutritional and economic interest,
- The large-scale multiplication of planting material of improved varieties of locally grown foods crops.
- The promotion of co-operatives and associations. The dissemination of information on the use of agricultural products, correct nutrition, land conservation and management.
- Provision of micro credit schemes to rural farmers and development of skills for youths & women empowerment
- Sustainable Enterprise Development and nurturing of small and medium enterprises to large scale commercial concerns.
- Proffer and implement appropriate Agricultural mechanization and processing strategy in line with the local content policy
- Effective partnering with local and International Development Agencies, Research and Academic Institutions to enhance our service delivery and meet up with the World Class standards.

In response to an invitation by the GRP of Nigerian Agip Oil Company Ltd (NAOC), Saipem SpA, Italy responded and accepted to collaborate with it to develop software for a sustainable land use planning and management linked with a graphical interface geodatabase network (GDBN) console to ensure sustainable agricultural practices in NAOC host communities. The PEDON software package is designed to manage information on the following:

i. Area General Information
ii. Soil Testing Data
iii. Crop Schedule
iv. Crop Nutrient uptake information
v. Identification and management of fertilization programmes
vi. Soil Sampling, and

vii. Map Production and Profile descriptions

This article describes the NAOC GRP PEDON software package. The NAOC GRP PEDON software is dedicated to the calibration of crop fertilisation programmes through the elaboration of crop and soil data, as well as through the correlated functionalities, such as the provision of electronic charts on crop management (cultivation aspects, fertiliser recommendations, pest and disease control, etc.), the production of electronic documentation for fertilisation management and maps production. This software was developed using Microsoft Access software with the implementation of procedures and functions in Visual Basic and is integrated into the NAOC Geodatabase network console.

THE NAOC GEODATABASE (GDBN) CONSOLE

General

The Geo Data Base Network Project (herein after referred to as the GDBN) is a system for collecting and managing project and environmental information, both alpha-numeric (Data Base) and geographic-spatial (Geographic Information System – GIS) using the company intranet network. This system was created within the development of the Nigerian environmental impact studies for the acquisition of permits needed for project realisation.

The GDBN enables rapid collection and optimisation of information, reduces timing and costs, and enables the users to share large amounts of data, thus avoiding the repetition of studies and/or surveys. The data entered into the database include but not limited to the principal aspects of environmental impact studies such as land use, physicochemical characteristics of vegetation / plant tissues, soil, air and water quality, hydrographic network, meteorological data and socio-economic aspects such as transport infrastructures, urban areas, settlements, health and social infrastructures, social organization and cultural features, heritage, protected areas, sacred areas, economic activities, oil spills and conflicts. Leonardi *et al*, 2004; Drigo and Salbitano 2008. The data are spatialized above cartographic layers and satellite imageries.

The potentiality of the GDBN is given by its capability of combining project and environmental data for assisting preliminary design in facilities location, managing risk and emergency and logistic and safety plans, defining environmental monitoring plan and managing oil spill plan. This system, using the company (NAOC) intranet network, has enormous potential as a data integration tool too, as it enables sharing of the geographic database among the NAOC departments (inside the same building) and the main office in Nigeria and in Milan (trans-boundary connection).

In the same way, it could be used to collect and use data from every region in which it is possible to create an intranet network.

Organization of the GDBN Console

The NAOC GDBN is organized such that four different packages (GRP, HSE Manager, Meteorological network and the Oil Spill Manager) are linked to the console with a Graphical User Interface (GUI), (Fig. 1). The PEDON package, with facilities for soil data collection with GPS, soil analyses data input and soil management as well as soil fertilization plan are incorporated into the GRP PEDON package.

NAOC PEDON PACKAGE

A schematic presentation of the main functions of the NAOC PEDON software is presented in Figure 1.

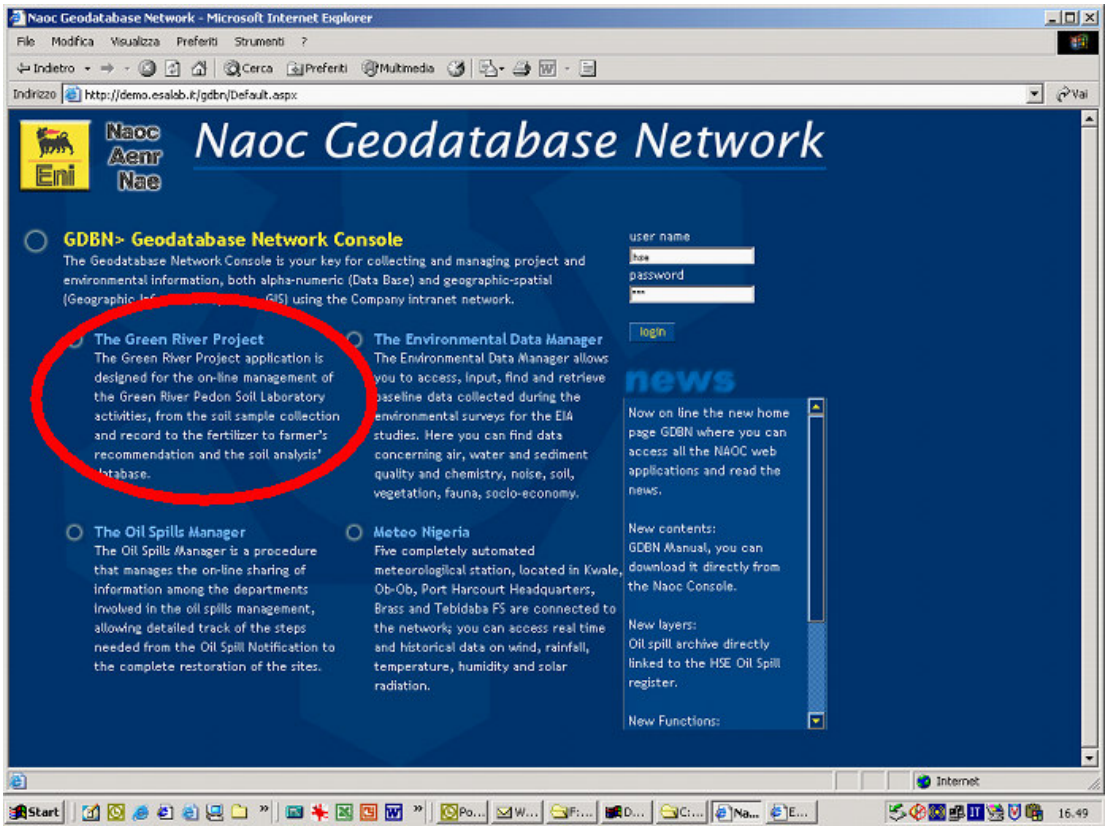

Figure 1: A Demo Geodatabase Network

Area information management

Data storage and management of the following information relevant to the site where the soil sample is taken:

a. Area code
b. Progressive number
c. Surveyors' name
d. Date
e. Location
f. Coordinates (GPS)
g. Altitude (GPS)
h. Land use
i. Previous crop
j. Superficial characteristics
k. Colour (Munsell charts)
l. Progressive sample n.
m. Depth of sampling

Soil testing data

The data arising from the soil testing at the NAOC PEDON laboratory, established at the Plant Propagation Centre (PPC), Obie in Obrikom (Rivers State), are recorded into the Soil Testing Archive, linked with the previously mentioned Area Data. They are:

a. Texture (Skeleton, sand, silt, clay)
b. Apparent Density
c. pH
d. Electric conductivity
e. $CaCO_3$
f. Organic Matter contents
g. Organic C contents
h. Organic N contents
i. C/N ratio
j. $NO_3 + NH_4$ contents
k. P_2O_5
l. Exchangeable K
m. ECEC

Crop Schedules
The PEDON software contains information on botanical, technical and agronomic aspects, crop requirements (climatic conditions, soil, uptakes, etc), fertilisation modalities and pest and disease management recommendations of the following crops cultivated in Nigeria:

- Cereal Crops: **Maize** (Zea Mays L.)
- Root and Tuber Crops: **Yams** (*Dioscorea* spp.), **Old Cocoyam** (*Colocasia esculenta* (L.) Schott), **New Cocoyam** (*Xanthosoma sagittifolium* (L.) Schott), **Cassava** (*Manihot esculenta* Crantz), **Sweet Potato** (*Ipomea Batatas* Lam.)
- Leguminous Crops: **Soybean** (*Glicine max* (L.) Merr.), **Cowpea** (*Vigna unguiculata* (L.) Walp.)
- Oil Crops: **Oilpalm** (Elaeis guineensis Jacq.), **Soybean** (*Glicine max* (L.) Merr.)
- Vegetable Crops: **Okra** (*Abelmoschus esculentus* (L.) Moench), **Plantain** (*Musa acuminata* x *Musa balbisiana*), **Tomato** (*Lycopersicon esculentum* Mill.), **Carrot** (*Daucus carota* L.), **Watermelon** (*Citrullus lanatus* Thunb.)
-

Crop nutrient uptake information
For the above mentioned crops and others inserted by the users, it is possible to process the data and formulate fertilisation programmes. In particular, the information will be addressed to:

- Crop uptakes of the main nutrients (N, P_2O_5, K_2O) in relation to crop production level
- Tolerance and/or intolerance, deficiency/excess responses to specific microelements and trace metals present in the soils

Identification and management of fertilization programmes
Using the NAOC PEDON package, the formulation of fertilisation programmes are carried out as follows:

Input data:
a. Intervention area and/or farm general data
b. Soil data

Data elaboration:
c. Selection of crop and indication of foreseen nutrient uptakes related to the production level (N, P_2O_5, K_2O)
d. Insertion of factors allowing for nitrogen balance estimation (organic matter mineralization, inorganic nitrogen, leaching and immobilisation)

Outputs:

e. Automatic calculation of nutrient requirements
f. Automatic elaboration of a fertilisation program taking into consideration the available fertilisers, the preferred form of fertiliser in function of soil and crop characteristics, the amount of fertilisers to distribute, as well as time and modalities of fertiliser distribution.

Data storage:

g. The elaborated fertilization programme is saved for future consultation
h. Possibility to insert updated information regarding crop productions, uptakes and other agricultural results.

Future software applications could be oriented to the realization of a database of fertilization programmes elaborated for different locations and integrated with the crop production results. This database would be useful in providing a wide range of information to the users and for statistical analyses on agronomic practices and crop production results in different intervention areas, as well as for the production of thematic maps.

The list below presents a brief description of complementary activities to be developed within this proposed software:

- Insertion of default data into the programme pertaining to previous soil analyses in the same location
- Preparation of crop charts
- Insertion of data referred to crops, to organic and commercial fertilisers
- Preparation of a user manual
- Training in the use of software, and
- Provision of technical assistance

Soil sampling

Particular care has been dedicated to the phase of soil sampling; extensive training has been and will be dedicated to raise the awareness of the NAOC GRP field officers of the importance of their role; they have been equipped with a personal GPS device that will record the location of the sample and other relevant features, like field perimeters, market locations and villages. Downloading the information into the system has been made error-free by dedicated software that replicates electronically the field sample template.

In the soil sampling phases that foresee the collection of superficial soil samples (between 0-15 cm, and 15-30/40cm), the field and laboratory results yield data that can only be used for crops with a superficial root system because the results do not take into consideration factors such as: deep mineral horizons, water table, the requested depth for the roots, and lithic contacts. The data collected are nonetheless sufficient to evaluate the soil fertility and hence agricultural productivity.

The data concerning the superficial soil sample pertain to the location site of the soil. The information collected are listed at point 1 above. As said, the field file chart is user-friendly. The file chart lists as many fields as possible so the soil surveyor needs to only indicate with an "X" the result, thereby limiting the amount of possible errors made by the soil surveyor. Attached to the field file chart is an easy and succinct manual that illustrate, by means of diagrams and photographs, the correct manner for filling in the field file charts as well as provide clear instructions on the proper utilisation of the GPS (Salbitano, 2006).

Map production and profile descriptions

Through the collection of field data, the laboratory results and the elaboration of fertilizer formulas for a series of predefined cultures, it will be also possible to draft (for each culture) the following maps on large scales (> 1:20.000) which can provide useful indications on the purifying capacities of the soil with regards to polluting agents:

- Fertility capability classification maps;
- Land capability classification maps;
- Texture maps.
- pH maps

The data collected until present can be used effectively only if they are geo-referenced, mapped on paper or otherwise if they have precise references that circumscribe the sample area.

Maps that may be produced on a detailed scale in pinpointed pilot areas can enable correct land evaluation for zones of particular agricultural and environmental interest. In these areas a soil surveys may be conducted that supply profile descriptions, locations of cartographic units and agronomic evaluations deriving from the field samples as well as from the laboratory tests.

For example, to produce a map at the scale 1:20.000 the density of the observations is equal to 1 in every 12.5 ha of the area under investigation with a profile/ drills proportion of 1 to 6 (for example: with reference to 1000 ha, 80 observations of which 12 profiles and 68 auger holes).

For the description and the sampling of profiles for a greater number of horizons reference will be made to the file chart of the FAO publication "Guidelines for soil profile description."

A part of the survey campaign (superficial observations and/or auger holes) can be executed by local personnel adequately trained by a training course of one week duration.

The data and information drawn from the foto-interpretation, from the field surveys and from the laboratory tests will allow the realisation of the following maps in the pilot areas:

- Land capability classification for specific cultures
- Fertility capability classification
- Soil capacity to protect deep waters from pollutants
- Texture maps

All the maps will be geo-referenced and will be linked to the geographic database (GDBN).

The most representative zones of the whole area are identified as the pilot areas. The objective of carrying out specific surveys in the determined areas is not only to put in order detailed data of particular interest, for example on Agricultural use, but also to consent for the interpolation of information taken from the whole area even if utilizing the data obtained from superficial soil sampling.

CONCLUSION

The efforts made by NAOC in rationalizing their action towards sustainability are well represented by the activity of GRP. Focusing on development of a strong food production system backed by a broad technology base, they invited Saipem, Environmental System Division, to design a comprehensive package for the sustainable land use planning, through a software dedicated to the calibration of crop fertilisation programs, called PEDON, as well as

the elaboration of crop and soil data,. The system is complete with correlated functionalities, such as the provision of electronic charts on crop management (cultivation aspects, fertiliser recommendations, pest & disease control, etc.) and the production of electronic documentation for fertilisation management and maps production.

To achieve the objectives of the NAOC PEDON package of sustainable land use planning and management in NAOC host communities, there is an extensive involvement of NAOC GRP Field Extension / Farm Officers. For them to fully implement the PEDON package, our main focus is on capacity building / training of the Field Officers both within and outside Nigeria.

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