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Digitisation of Soil Data Management Using Web Applications: Digital Transformation of Smyth and Montgomery (1962) Soil Classification Disc of Soil and Land Use Surveys of Central Western Nigeria as Case Study.

[1]Adekayode, F.O. and [2]Adekayode, S. J.
[1] Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria.
[2] Dolapo Frank Farmers Organization (NGO), Clearview Estate, Akure, Ondo State, Nigeria.

Abstract

The data on the soil classification disc of soil and land use of Central Western Nigeria published in Smyth and Montgomery (1962) were digitalized with the use of WordPress software. The published work on the mapping of soils of Central Western Nigeria was summarily reported to consist of forty-six soil series grouped into eight soil associations and the morphology of each soil series described. The WordPress administrative dashboard, provided a platform for the creation and management of functionalities in the form of posts, changing styling in the form of themes, site identity, layout, menus and lots more that could provide basic information. Graphic User Interfaces were designed for the associations with each soil association hyperlinked to a page that listed the accompanying soil series which were further hyperlinked to pages that gave the descriptions and the agricultural values of the respective soil series. Each interface had a linkage named point through which the desirable pages and interfaces could be accessed. The web application was accomplished with the creation of a domain named iranyus.com from which a subdomain soilresources.iranyus.com was created at which the research output could be accessed on https://soilresources.iranyus.com or on the specific site at https://soilresources.iranyus.com/index.php/soil-association-soilseries-3/

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E-mail Address: f**oadekayode@futa.edu.ng**
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1.0 Introduction

Soil information system (SIS) consists of a series of soil databases that are used to store soils data from the point of collection, through analysis to interpretation and application. It enables detailed soil properties such as soil texture, compaction, root zone depth, moisture retention and availability, and soil fertility to result in appropriate decisions on such soil use as tillage, manure application and irrigation for crop production. There is a desirable need for specific information about the suitability of various soils for particular crops (Rao *et al*., 2019; Adeyolanu *et al.,* 2020).
The conventional approach of storing information about the soil as point observations and maps had been deemed suboptimal and this necessitated the transformation of analogue soil data to digital form, to facilitate their storage and quick retrieval by users (Nadkarni and Prügl (2021). Furthermore, national and international soil information systems around the globe can be accessed from the internet (Heuvelink *et al*., 2010).

The digital SIS had been summarily expressed to serve as a computerised database containing information about the topography, soils, climate, vegetation and land use linked to a geographic information system; it is also to relate and model crop yield to soil and climatic conditions and management inputs (Shreeja, 2019).
The use of SIS in soil fertility and soil resources management in South Korea, reported in Lee *et al.* (2014) revealed fertilizer recommendation program to be based on fertilizer equation computed from soil physical and chemical properties that produced appropriate fertilizer rates that enabled farmers to apply fertilizers economically while Adekayode and Akomolafe (2013) used computer programme in manure quantification for optimal fertilizer rates for crops. The SIS in embedded GIS technology, embedded database technology and soil nutrient balance model, had been used to develop a soil fertility management information system in Jianshui County in Yunnan Province, China (Xiaolin *et al*., 2012). The method provided the technology that guided farmers to fertilize more

rationally and also assisted the Government to develop sound agricultural policy.
The interpretation and utilization of data from the soil information system for identifying soil suitable for irrigated agriculture in Kuwait were reported in Roy and Grealish (2004). In the study, the rating was applied to each of the soil property classes and subclasses to determine the most limiting factor for each soil in order to produce a suitability map. The information was provided in a digitized format that was extended to interpret general land uses.

The advantages of digital analysis methods of topographic data over the traditional soil survey methods reported in Mohamed (2017) revealed that the traditional methods of soil survey could be expensive and time consuming due to a large number of observations. This could be precisely carried out with the advances in computer and information technology that introduced a new group of tools, methods, instruments and systems, to obtain relevant digital surface data to the soil. The data could be incorporated into the structure of a soil information system, to carry out comprehensive soil mapping that was cost-effective and in a shorter time.

The application of digital soil studies as an effective means of determining and maintaining soil fertility was emphasized by Adekayode (2012). The study in Using ASTER Imagery in identifying and assessing fadama and the associated soils, revealed digital soil mapping to facilitate the creation of data and visual aid to provide insight for soil attributes in a given geographical area and further that digital soil mapping enabled identification about thematic maps of different soil properties such as soil suitability for mechanised farming, soil drainage, soil texture and soil ecological zones in a given area.
The use of digital techniques in soil studies was reported in soil texture determination (Adekayode and Akomolafe 2014). The several analogue global soil information systems that existed and which suffered several inconsistencies and limited spatial details justified the digitalization of soil data and such an approach enabled the presentation of soil information or data in a digitized manner for general land use evaluation. The digital technique in soil data acquisition, storage and presentation was reported in Adekayode and Balogun (2019) in the use of an Arduino embedded system for assessing moisture requirement in a dry season orchard farm. In the research, a hygrometer to which a soil moisture sensor and global positioning system receiver were attached, was inserted into the soil and remotely linked to mobile phones to receive soil moisture data as alert messages on the user phones.
The soil classification at the series level, of soils in Central Western Nigeria, reported in Smyth and Montgomery (1962) was concisely represented in a cardboard paper disc with slits that revealed correspondingly related soil information that could be viewed simultaneously. The objectives of this investigation, was to digitalise soil data presented on the disc, and to also hyperlink to each other, different pages using the WordPress software.

2.0 Materials and Methods

The analogue soil information system on soil data of Central Western Nigeria by Smyth and Montgomery (1962).

The secondary data upon which this investigation was based was the data on soils and land use in Central Western Nigeria carried out by Smyth and Montgomery (1962) and summarily reported on cardboard with designed slits or small openings. The report identified 46 soil series grouped into eight soil associations. The slits were cut on a hard cardboard paper disc which enabled a soil type that showed in a slit to reveal in specific slits on the cardboard all corresponding and related information of that soil type (Figures 1 and 2).

The digital information system with the application of WordPress software.

The first step was the registration of a domain name identified as iranyus.com with Garanntor hosting provider. A subdomain name soilresources.iranyus.com was created from the domain. The WordPress software was installed on the hosting account. The dashboard on the software, which was an information management tool was accessed to perform the back end operations.

The WordPress administrative dashboard, provided a platform for the creation and management of functionalities in the form of posts, changing styling in the form of themes, site identity, layout, menus and lots more that could provide basic information. User Interfaces, making the front end, were designed for the associations with each soil association hyperlinked to a page that listed the accompanying soil series which were further hyperlinked to pages that gave the descriptions and the agricultural values of the respective soil series (Figure 3).

3.0 Result

The analogue soil information system on soil data of Central Western Nigeria by Smyth and Montgomery (1962).

The two sides of the hard cardboard paper disc used in an analogue presentation of soil data upon which the digital presentation was developed are shown in Figures 1 and 2.

The disc page that displayed the soil types, provided soil morphological properties of the soil series, soil colour, texture, mode of formation, parent rock, presence of ironstone concretions, presence of stones and gravels, percentage of the total area covered and the provisional crop recommendation (Figure 1).

The disc page that displayed the relationships between parent rocks and soils, provided information on the name of the rock group, nature of rocks, associated topography, important associated soils, colour and texture of associated soils and the general features of associated soils (Figure 2).

Figure 1: The disc page displaying Iwo series and the corre-

sponding properties and uses.

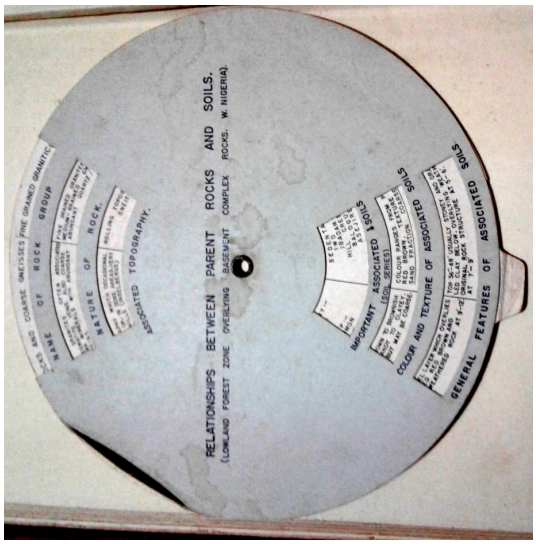

Figure 2: The disc page displaying Iwo series in relation to the parent materials and underlying rocks

The menus on the copied dialogue box indicated the soil description such as the soil morphological procedures, soil survey procedures, soil profile description.

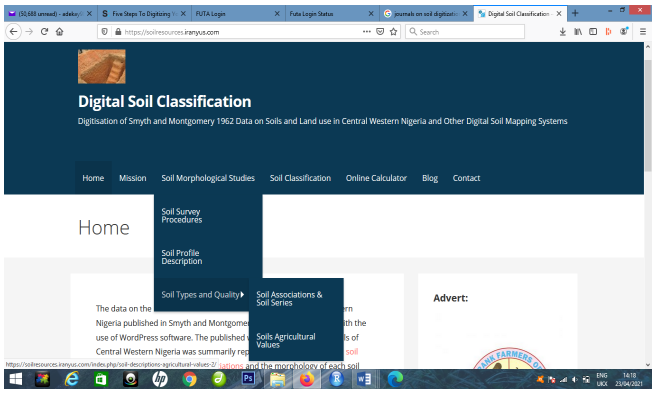

Figure 3: The copied User Interface showing soil descriptions as menus.

The hyperlinked pages are shown in Figures 4 and 5 whereby a click on Iwo series in Figure 4, popped up the description and agricultural values of Iwo series in Figure 5.

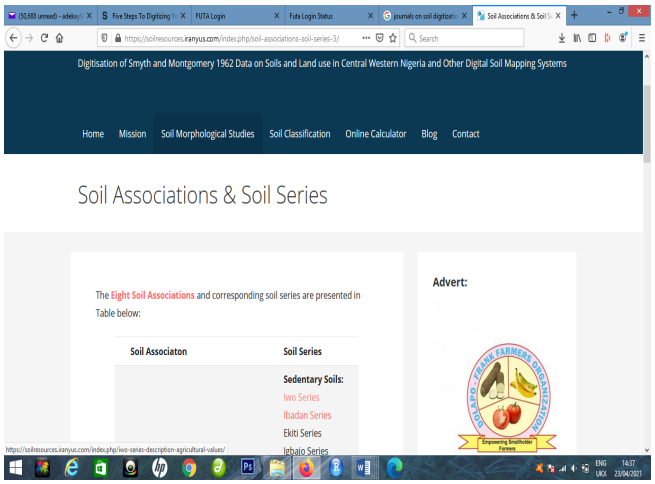

Figure 4: The dialogue box, showing Iwo or Ibadan series

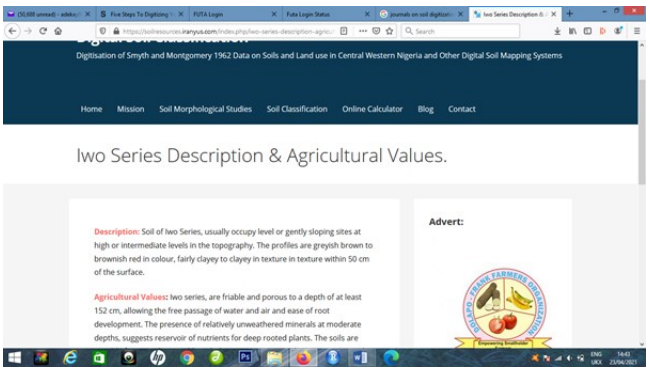

Figure 5: The dialogue box showing the description and agricultural values of Iwo series

4.0 Discussion

The information on soils displayed in Figure 1 was obtained from the morphological descriptions of soil profiles dug across the study areas. Soil morphological properties having diagnostic significance were reported as used in previous soil research (Fasina et al, 2015). The Forty-six soil series grouped into eight soil associations identified from both the morphological properties observed in the field laboratory studies were identified from representative profile pits dug and described for each of the soil series using such parameters as soil depth, soil colour, texture, structure, contents of quartz gravel, stones and ironstone concretions, mottles, cutans, pores, horizon boundaries, contents of weatherable minerals, contents of organic matter**,** clay, and soil pH (Smyth and Montgomery, 1962). The appropriateness of the morphological descriptions and productive potential of the soils were confirmed and updated by later researches (Periaswamy and Ashaye, 1982; Nsor and Ibanga, 2007 ; Nwachokor and Uzu, 2008). Samples were collected from the various horizons and then subjected to laboratory analyses for the physical, chemical and biological properties of the soils and used as criteria for classification.

The information on soils relationships to the geological formations displayed in Figure 2 evidenced the strong influence of parent rock or parent material on soil properties. The coarse-grained granites and gneisses corresponded to Iwo associations, the medium-grained granites and gneisses corresponded to Ondo association, the fine-grained biotite gneisses and schists corresponded to soils of Egbeda association, the amphibolites corresponded to soils of Itagunmodi association, quartz gneisses and schists corresponded to soils of Okemessi association and sericite schists corresponded to soils of Mamu association (Smyth and Montgomery, 1962). The relationship between parent rock and overlying soils was established in a comparative study on variation in nutrient concentrations of basement complex and sedimentary rock of teak plantations in Ogun State, Southwest Nigeria during which rock nutrient analysis was related to soil samples analyzed for soil physicochemical and micronutrients (Ogundele, 2015). The study on the morphological and Physico-chemical properties of soils formed from five varied parent materials in Cross Rivers State Nigeria revealed soil properties to be similar within the same parent materials but varied widely across the locations. The study specifically revealed that shale and basaltic rock derived soils were more endowed with organic carbon, total nitrogen and exchangeable bases than soils derived from coastal plain sand basement complex rocks and sandstone (Abam and Orji, 2019).

The use of WordPress website creation platform in the web design was premised on its possible and robust user-friendly application to create a graphical user interface (GUI) through which the user could interact with the computer for such applications as digitalisation of soil data (Pataki, 2016; WordPress Editorial Staff, 2019). WordPress is a content management system (CMS) written in PHP that uses a MySQL database (Zujaj, 2017). The hyperlink in digital operations with the use of WordPress software-enabled easy navigation within all related topics and this was applied in the soil information system research (ITegrity Web Technologies 2012). The principle was adopted in the previous digital transformation of soil data researches in the development of digital soil textural class determination using NetBeans, a Java-based integrated development environment (IDE) system (Adekayode and Akomolafe, 2014).

5.0 Conclusion

The digitalisation of soil data and the online access with WordPress website creation platform was effectively used to create a graphic user interface (GUI) for the digital presentation of soil data of Central Western Nigeria that had hitherto been in analogue form. It provided for easy navigation and retrieval of soil information on the internet.

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