UNIVERSITY OF ILORIN

THE TWO HUNDRED AND SEVENTY-FIFTH (275TH) INAUGURAL LECTURE

"UNDERSTANDING SOILS: THE BEDROCK OF MAN'S EXISTENCE AND SUSTENANCE"

By

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My dear Wife and family (nuclear and extended),
My Lords Spiritual and Temporal,
Your Royal Highnesses, especially the Oloro of Oro-Ago Kingdom, The Folagbade of Oro land and the High Chiefs here present,
Gentlemen of the Print and Electronic Media,
My dear Students of the Faculty of Agriculture, and other students here present,
Distinguished Ladies and Gentlemen,
Great UNILORITES.

Preamble

The Vice-Chancellor, Ladies and Gentlemen, I stand humbly here before this distinguished gathering to present the 275thin the series of inaugural lectures of this great University on this day March 6th, 2025. This is the account of my journey on the path of academia, my research endeavours and my contributions to societal development, which has culminated into my appointment as a Professor of Soil Science with specialization in Pedology. Permit me to proceed in profound reverence to the Lord God, Almighty- in the name of the Father, the Son, and the Holy Spirit.

Ladies and gentlemen, esteemed colleagues, and fellow enthusiasts of the natural world, welcome to today's lecture on the captivating realm of pedology and land management. The Inaugural Lecture of today is the $5^{th}$from the Department of Agronomy, and the third from the Soil Science Unit of the Department, behind Professor J. A. Ogunwale, who presented in 2004, the 76^{th} Inaugural Lecture titled, *Land: The Beginning, the Sustainer and the End of Man on Earth*, and the 242^{nd} Inaugural Lecture recently presented in October, 2023 by Professor O. B. Fawole and titled, *Intimate Strangers in Soil and Agricultural Sustainability*.

Today, we embark on a journey through the intricate world beneath our feet, where the seemingly ordinary soil holds profound secrets and influences that shape our agricultural practices, environmental sustainability, and the very foundation of our existence, the source of food. Today’s lecture is titled: **“Understanding Soils: The Bedrock of Man’s Existence and Sustenance”.**

The Vice-Chancellor, sir, in the realm of academic journeys, serendipitous encounters often shape the trajectory of one's career. Allow me to share with you a short captivating tale that illuminates the profound impact of a chance meeting and the transformative power of mentorship.

It was in the year 1986, during my second year at the Faculty of Agriculture at the University of Ibadan, when a friend ‘Kehinde Olowu’ and I decided to switch from our allocated department to Agricultural Economics. We were determined to pursue our passion for agriculture, but when we arrived at the Department of Agricultural Economics, we were met with disappointing news.

There, we were informed that due to our background in physical sciences-taking courses like Physics, Chemistry, and Mathematics-it would be impossible for us to be admitted into the Department of Agricultural Economics. We were thus advised to consider applying to the Department of Agricultural Engineering, instead. Feeling a bit dejected, my friend and I were on our way back when we unexpectedly crossed paths with a man who would become my lifelong mentor-Professor Ayoade O. Ogunkunle. In a brief conversation with him, we shared our predicament. He responded by saying that since we were already pursuing physical science courses, he would gladly accept us into the field of Soil Science. And just like that, I found my way into the world of Soil Science.

Fate seemed to be on my side because when the first set of examinations came around, I was fortunate enough to achieve the highest score with an impressive 87.00%. Coincidentally, the course was taught by none other than Professor Ogunkunle himself. Excited by my result, he sought me out to offer his congratulations, but to his disappointment, I had already returned home to assist my parents with our family farming tradition.

When I eventually met him again after the holiday, Professor Ogunkunle expressed his regret for not being able to present me with a prize he had planned. However, he warmly shook my hand and told me that I had a promising future in Soil Science. He suggested that I consider joining him for this research project, an opportunity that I wholeheartedly embraced. And just like that, my journey into the fascinating world of Pedology began.

I am truly humbled to stand before you today, moulded by these opportunities. Through this influence and the grace of God, I stand here, prepared to explore the boundless potential of Pedology and Land Management. To everyone present here today, I extend my heartfelt thanks for joining me on this auspicious occasion. Let us embark on a journey of discovery, where the secrets hidden beneath our feet unfold and guide us toward a future of sustainable land use and stewardship. Together, let us celebrate the transformative power of soil and the remarkable possibilities within its complex ecosystem.

Over the course of this lecture, I will embark on a journey of discovery; uncover the fundamental concepts of pedology and its direct implications on land management practices; explore how soil erosion, fertility, and structure impact agricultural productivity and environmental sustainability; and examine case studies and research findings that illustrate the practical application of soil science in real-world scenarios. Furthermore, I will also delve into the exciting realm of advances in soil survey techniques; explore emerging technologies such as remote sensing, geographic information systems (GIS), and data-driven approaches that revolutionise soil mapping and monitoring (before these technologies, my colleagues and I embarked on surveys using manual approaches that entailed deploying poles and lines in thick bushes- these were very tedious and dangerous days, to say the least). I will discuss the challenges we face and the potential solutions that lie ahead, emphasizing the importance of interdisciplinary collaborations and knowledge exchange.

To provide an overview of my lecture, I will define soil and its connection to ecosystems and the environment. Then, I will highlight my soil science research, which led to my appointment as a Professor of Pedology at this university in 2021. Finally, I will articulate the perspectives of a soil scientist in the ever-evolving field of soil science. Thank you, and may this inaugural lecture mark the beginning of a remarkable chapter in our shared exploration and exploitation of the vital world beneath our feet.

Introduction

The basis for my research was established in the early nineties when, at the University of Ibadan, under the guidance of Professor A. O. Ogunkunle, I assessed the variation in the major University of Ibadan farm soils (**Olaniyan**, 1992). Some of my other early research includes the assessment of the contribution of organic matter to cation exchange capacity in Elebu Soils, Nigeria (**Olaniyan** & Ajayi, 1998), and a detailed soil survey of the University farm, University of Ilorin (Ogunwale *et al*., 2000). I was appointed an Assistant Lecturer at the University of Ilorin in 1995. Before this, I had a brief stint as a Land Use Planning Officer and a Project Manager (Elebu Project Site) at the National Agricultural Land Development Authority (NALDA), Kwara State Directorate, Ilorin. There, I was saddled with the land clearing of 400ha of land, partitioning these into 4ha units and allocating them to the farmers who practised a form of Tungya farming, planting cashew as the tree crop, with groundnut and maize as legume and cereal. All inputs were supplied by NALDA, and the produce was purchased by NALDA.

It was from this position that I switched due to my zeal to contribute to societal development through research and teaching, and although the experience has not been a smooth one all the way, it has been fulfilling and has culminated in the success of today. Over the last 3 decades, my research focus has been on Soil Survey and Land evaluation. As oil survey involves the mapping of the soil in a particular area. It involves studying the different types of soil, understanding heir properties, separating/demarcating/delineating/dividing/delimiting/ grouping or partitioning them into different units and displaying their extent, to scale, on a map. Just like a treasure map helps you find treasures, a soil survey map helps farmers, builders, and scientists know the kind of soil at a given location on the landscape of interest; hence, it is very important for land use planning and for sustainable production of food.

Land evaluation, on the other hand, helps to determine how good a piece of land is for a specific purpose. It is like choosing the right place for the right purpose. If you want to grow crops, you need a land with good soil and adequate amount of water. If you want to build a house, you need land that is stable and that will not cause problems. So, land evaluation helps land users decide what they can do with a piece of land based on the properties of the soil.

Definition of Soil

Mr Vice-Chancellor, sir, in my capacity as a Soil Scientist, I would like to emphasise that soil is not just dirt, but rather a crucial natural resource similar to crude oil. Because it discloses that man was formed from dust, the biblical allusion in Genesis 2:7 emphasises the close relationship between soil and life.

Some early definitions of soil simply term it as the outer layer of the earth's crust; which is quite narrow and leaves out information on the origins and purposes of soil. Within this lecture, I adopt Brady and Weil's (2002) broad definition, which characterises soil as a dynamic collection of natural bodies on the surface of the earth that fosters plant growth and is modified by climate, living things, parent material, and topography over time. The atmosphere, biosphere, and hydrosphere all have complex interactions with the pedosphere (soil environment), which together shape the ecosystem. To address global issues like hunger, poverty, environmental pollution, and the negative effects of climate change, it is crucial to acknowledge the critical role that soil plays.

This concept highlights the different ways that soil can be used. It can be an engineering medium, a regulator of water supplies, a medium for plant growth, a way to recycle natural resources, a home for microorganisms, and an interface for different parts of the environment.

Soil science and crop science are closely related, with an emphasis on managing soil to maximise its nutrient status, physical and biological characteristics, and engineering aspects for the best possible plant growth. By understanding the fundamental principles and processes governing soil formation and behaviour, we can grasp the intricate dynamics that shape our land resources.

The atmosphere, biosphere, and hydrosphere all have complex interactions with the pedosphere (soil environment), which together shape the ecosystem as a whole. To address global issues like hunger, poverty, environmental pollution, and the negative effects of climate change, it is crucial to acknowledge the critical role that soil plays.

The soil is a dynamic matrix made up of the physical, chemical and the biological components. The interaction between these components is intricate and complex and aids the ecosystem functions of soil such as nutrient storage and release for plants, filtration of ground water, and as a suitable living environment for living organisms that help the soil to achieve these functions.

Soil formation is an intricate process driven by the interplay of physical, chemical, and biological mechanisms. This encompasses the breakdown of rocks and minerals through weathering, influenced by factors like temperature, precipitation, and vegetation. Within a soil profile, different layers or horizons emerge, each distinguished by the accumulation, losses, or transformation of materials, forming what is known as soil horizons.

This intricate system of soil formation and classification is fundamental to understanding the diverse nature of soils and plays a pivotal role in agriculture, ecology, and environmental science. The process of soil formation takes time. This underscores the vital need to understand and look after our soils with great care.

Pedology

Pedology, the study of soil formation and behaviour, plays a pivotal role in understanding and managing our land resources effectively. Soil serves as the lifeblood of our ecosystems, supporting plant growth, filtering water, and providing vital nutrients to sustain life. It is the intricate matrix of soil properties and processes that determine the success or failure of land use/management endeavours.

Pedology encompasses the investigation of the effects of factors such as parent material, climate, organisms, topography, and time on the development of soil profiles. Soil scientists analyse these soil properties, including texture, structure, pH levels, organic matter content, and nutrient availability, to assess soil quality and productivity. Pedology has a rich history, dating back centuries, with influential figures such as Vasily Dokuchaev and Hans Jenny shaping the field (Dokuchaev, 1883; Jenny, 1941). Advancements in technology and research methodologies have propelled pedology forward, enabling more accurate soil characterisation and mapping. Contemporary research focuses on understanding the impact of land use practices, climate change, and human activities on soil health and sustainability.

Soil Classification

Soil classification is the grouping of soils based on their similarities. In this case, we are talking about their properties while land evaluation groups soils based on how they behave/respond under use. When we classify soils, we can understand them better. It helps farmers know what crops will grow well, and builders understand how strong the ground is for construction.

The main principle is finding common features among soils. For soils, we look at things like colour, texture, how much water they can hold. Scientists use various ways to classify soils. One method is looking at the proportion of the different soil size particles (sand, silt, and clay). Another way is based on how much moisture the soil holds. However, soils are not discrete but grade over the landscape from one type to another.

Land Evaluation

Mr. Vice-Chancellor, at the heart of sustainable land resource utilisation lies the discipline of Land Evaluation, a systematic discipline to determining the suitability of specific parcels of land for various purposes, particularly agriculture. This practice assesses a land's physical, chemical, and biological properties alongside environmental factors such as climate, topography, and hydrology to ascertain its capacity to support sustainable land use. Proceeding without an evaluation of land suitability is akin to embarking on a journey without direction-a perilous endeavour fraught with risks of inefficiency and degradation.

Historical Context of Land Evaluation in Nigeria

In Nigeria, the practice of land evaluation dates back to the colonial era. The 1930s soil surveys by the Department of Agriculture were aimed at identifying fertile land for cash crops like cocoa, groundnuts, and cotton. These surveys provided baseline data essential for land management, serving as the foundation for subsequent developments in soil science and agricultural policy (FDLAR, 1990).Post-independence, the focus broadened with national soil surveys conducted by institutions such as the Federal Department of Agricultural Land Resources (FDALR, 1990) and the International Institute of Tropical Agriculture (IITA, 2017). These surveys introduced detailed soil classification systems and identified land constraints, enabling more targeted agricultural practices and informed policymaking.

Modern Advances in Land Evaluation

The integration of digital soil mapping, GIS, and remote sensing technologies has revolutionised land evaluation in recent decades. These tools have enhanced the precision of soil assessments, allowing for the detailed mapping of soil variability and better matching of land characteristics with crop requirements. Research efforts now emphasise agroecological zoning, which optimises land use based on a combination of soil properties, climate conditions, and socio-economic factors (Ajala *et al*., 2020).

Contributions to Agricultural Development

Land evaluation has been pivotal in shaping agricultural development in Nigeria. It has informed large-scale projects such as the River Basin Development Authorities and facilitated the promotion of integrated soil fertility management (Ajiboye *et al*., 2015; **Olaniyan** & Ogunwale, 2006). By identifying suitable lands for diverse agricultural activities, these evaluations have contributed significantly to food security and rural development. For instance, recent studies have guided the diversification of cropping systems in Nigeria's semi-arid regions, enhancing resilience against climate variability and land degradation (Obi & Ogunkunle, 2023).

Land evaluation is indispensable for sustainable land use and management. By providing critical insights into land capabilities and limitations, it supports agricultural productivity, environmental conservation, and economic development. It remains a cornerstone for achieving sustainability goals, aligning with global and national aspirations to enhance food security and mitigate land degradation.

Case Study: University of Ilorin Land Evaluation

In 2017, **Olaniyan** (2017) undertook a comprehensive evaluation of 9,000 hectares of land surrounding the University of Ilorin campus. Leveraging modern technologies like remote sensing and GIS, we identified eight distinct mapping units across various terrains. This assessment revealed varying levels of suitability for crops such as maize, cassava, and soybeans. The study's findings have since informed land use planning on the campus, demonstrating the tangible benefits of integrating scientific rigour into land management.

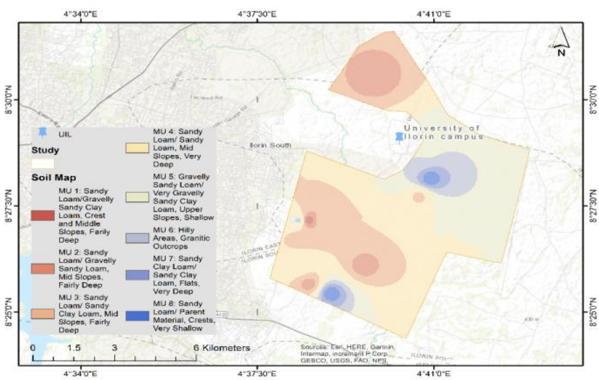

Figure 1*:* Soil Map of 9000-ha Unilorin Undeveloped Land Area

The Evolution of Digital Agronomic Advisory Systems

By examining the formation, classification, and mapping of soils, pedologists contribute invaluable insights to sustainable land management. In this digital age, the marriage of technology and agriculture has given rise to Digital Agronomic Advisory Systems (DAAS). These innovative platforms leverage data analytics, artificial intelligence (AI), and Machine Learning (ML) to provide farmers with real-time, data-driven insights. DAAS offer recommendations on crop management practices, pest control, irrigation, and nutrient application, tailored to specific soil and weather conditions. These systems are built on data acquired through soil surveys and land evaluation. Some of the importances of agronomic advisory systems in sustainable crop production are highlighted below:

1. Precision Farming
2. Resource Efficiency
3. Risk Mitigation
4. Data-driven Decision-making
5. Environmental Stewardship
6. Accessibility

Overall, digital agronomic advisory systems have empowered farmers by providing timely information, enhancing climate resilience, and transforming agricultural practices across Africa; and the backbone behind these systems is quality information derived from soil survey and land evaluation data fed into evolving technologies like artificial intelligence and machine learning.

Soils, Ecosystems and Environment

The nexus between soils, ecosystems, and the environment forms a critical foundation for understanding the intricate web of life on earth. Soils, as a fundamental component of ecosystems, play a pivotal role in shaping the environment and influencing the overall health of our planet. Soils provide the physical support and nutrients necessary for the growth of plants, which are the primary producers in terrestrial ecosystems. The diverse array of flora, from towering trees to tiny grasses, relies on soils for stability, water retention, and nutrient availability. The health and fertility of soils directly impact the richness and biodiversity of ecosystems. The diversity of life within soils, including microorganisms, fungi, and various invertebrates, contributes to the overall biodiversity of ecosystems. This rich tapestry of life within soils is essential for the provision of ecosystem services. Microorganisms, for instance, are integral to nutrient cycling, decomposition, and the formation of organic matter.

Soils are active participants in nutrient cycling, a process crucial for the availability of essential elements like nitrogen and phosphorus (**Olaniyan** & Ajayi, 1998). Additionally, soils serve as a reservoir for carbon, playing a key role in mitigating climate change by sequestering carbon dioxide. Sustainable soil management is vital for maintaining these cycles and ensuring the health of ecosystems. Human activities, including agriculture, deforestation, and urbanisation, can significantly impact soils and, consequently, ecosystems. Soil degradation, loss of biodiversity, and the release of stored carbon into the atmosphere are among the adverse effects of unsustainable land practices.

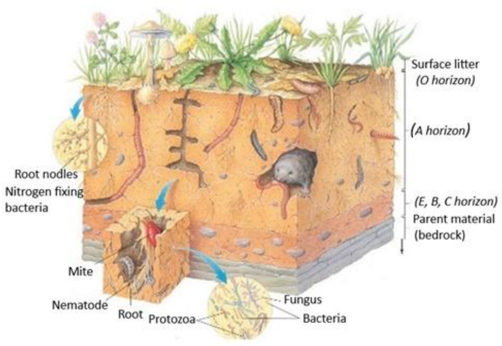

Figure 2: Soil Ecosystem
(***Source:*** EduRev at: https://edurev.in/t/212922/Genesis-of-Soils)

To safeguard the nexus between soils, ecosystems, and the environment, conservation and sustainable soil management practices are imperative. This involves adopting agricultural techniques that prioritize soil health, afforestation, efforts to restore degraded areas, and policies that promote responsible land use Fig 2.In essence, the intricate interplay between soils, ecosystems, and the environment underscores the need for a holistic and sustainable approach to land management. Recognising the value of soils in supporting life, preserving biodiversity, and regulating essential processes is vital for the overall health and resilience of our planet.

The Application of Soil Science in Real-World Scenarios- My Contributions

Theme I: Soil Properties and Their Management

Many studies in my academic research journey focus on evaluating soil properties and devising sustainable management options for optimal agricultural yield and the conservation of soil and water resources. Below, I present some key studies that exemplify these principles, demonstrating how systematic soil evaluation and innovative management strategies contribute to sustainable agricultural practices and environmental conservation.

Study 1(a): An Evaluation of the Soil Map of Nigeria: I. Cartographic Accuracy

Like most soil maps over much of the world, the accuracy of the soil map of Nigeria produced by the Federal Department of Agricultural Land Resources (FDALR) in 1990 is not known. These studies (Case studies 1a and 1b) were undertaken to provide information on the accuracy of the soil map. The minimum legible area (MLA) of the map was 4,000 ha, which implies that a land area smaller than this cannot be represented properly on the map. It also has a maximum location accuracy of 250 m. Thus, in transferring a point from the map to the land, an error of not less than 25% is involved. Hence the area occupied (on paper) by the map is too wide as indicated by an average size delineation (ASD) of 4.08 – 10.29 cm, index of maximum reduction (IMR) of 3.19 to 5.07 and minimum scale of reduction (MSR) of 1:3 million - 1:5 million. However, the map scale may not need to be reduced if more mapping units are separated at the present scale. The results of this study should generate fresh interest in the quality of soil maps being produced globally (**Olaniyan** & Ogunkunle, 2007).

Study 1(b): Assessment of Soil Map Accuracy in Kwara State

Soil maps are critical tools for agricultural planning, but their utility depends on accuracy. Our study evaluated the FDALR soil map of Kwara State, examining variability across key soil properties such as organic matter, pH, and Cation Exchange Capacity (CEC) (**Olaniyan** & Ogunkunle, 2007). Statistical measures revealed significant heterogeneity within mapping units, with available phosphorus exhibiting the highest variability (CV = 23.91–181.05%). The results highlighted the limitations of existing soil maps, calling for their refinement to improve predictive accuracy and land-use planning efficiency. This study underscores the importance of precision in soil characterization to enhance agricultural decision-making and resource allocation (**Olaniyan** & Ogunkunle, 2007).

Study 2: Land Suitability for Cashew Production in Niger State

The Kusogi land, a 500-ha sandstone-derived terrain, was assessed for its suitability for cashew cultivation. The study identified major constraints, including low calcium levels and poor drainage, affecting 86.4% and 13.6% of the land, respectively (**Olanyan** & Ogunkunle, 2006). Management recommendations such as liming and improved drainage systems were proposed to elevate land suitability from marginal to optimal. This case study illustrates how targeted interventions based on land evaluation can enhance agricultural productivity and land sustainability, ensuring economic and environmental benefits (**Olaniyan** & Ogunwale, 2006).

Study 3: Soil Characterisation and Management in Kampe-Omi River Basin

Six soil profiles from the Kampe-Omi River Basin were analyzed, revealing predominantly sandy to sandy loam textures, strongly acidic to neutral pH levels, and low organic carbon content in subsurface horizons. Nutrient deficiencies, particularly in phosphorus, necessitate management strategies involving organic amendments and crop residue retention to maintain fertility. These findings emphasize the need for continuous organic matter input and balanced fertilizer application to sustain soil health, thereby supporting intensive agriculture in the region (Ajiboye, Jaiyeoba, **Olaniyan**, & Olaiya, 2012).

Study 4: Soil Types and Fertilizer Response in the Southern Guinea Savanna

This study explored how soil types derived from sandstone and basement complex materials influenced maize's response to fertilizer under varying precipitation regimes. Sandstone-derived soils showed better fertilizer response under high rainfall, while basement complex soils responded optimally under moderate rainfall. These findings demonstrate the critical role of soil survey data in predicting crop performance, advocating for site-specific nutrient management to optimise yields and ensure sustainable land use (**Olaniyan** *et al*., 2011).

These case studies highlight the indispensable role of soil evaluation in achieving sustainable agricultural productivity and conserving soil and water resources. Through comprehensive soil assessments and tailored management strategies, we can unlock the potential of our soils, ensuring food security and environmental sustainability for future generations.

Theme II: Soil Pollution and Water Quality

Some of my research over the years has focused on unravelling sources of soil and water pollution in agricultural crop-growing areas. Studies focused on soil pollution and water quality hold significant importance for both environmental and human well-being. In simplified terms, these investigations are crucial for a variety of reasons.

Firstly, understanding soil pollution is akin to recognising the health of the Earth beneath our feet. Soil is not just a passive medium; it's a dynamic ecosystem that supports plant life, which, in turn, sustains all terrestrial life.

Study 1: Copper in Water-Soil-Plant Interactions

This study examined copper (Cu) contamination along the Asa River in Ilorin, Nigeria. Asa River serves both as industrial disposal and agricultural irrigation, making it a critical water source for vegetable production. Results revealed Cu concentrations in river water, soil, and plant tissues exceeded safe limits, with plant tissue Cu reaching 81.86 mg/kg in Corchorus olitorius. The findings underscore the food chain toxicity risks posed by heavy metal contamination, threatening human health through dietary exposure (Ahamefule, Fatola, **Olaniyan**, Amana, Eifediyi, Ihem, Nwokocha, Adepoju, Adepoju, & Babalola, 2018).

Study 2: Assessment of Water Quality for Irrigation along Asa River

Heavy metal concentrations in Asa River water (Cu, Pb, Zn, and Cd) were analysed, revealing values above permissible limits set by FEPA and WHO. Sediment analysis also showed elevated levels, implicating industrial and domestic effluents as primary sources. The poor water quality impacts soil health, reducing microbial activity and nutrient transformation. These potentially transfer heavy metals to crops, increasing cancer risks for consumers. This highlights the urgent need for pollution control measures to protect public health and agricultural productivity (Ajala, **Olaniyan**, Ahamefule, & Affinnih, 2015).

Study 3: Source Identification of Fe and Mn Pollution in University of Ilorin Dam

This research investigated iron (Fe) and manganese (Mn) pollution in the University of Ilorin Dam. High concentrations, above WHO permissible limits, were attributed to both natural (rock weathering) and anthropogenic sources (industrial effluents, domestic sewage, and agricultural runoff). Principal Component Analysis (PCA) highlighted the need for targeted pollution control to restore water quality for safe drinking and ecosystem health (Adekola, Abdu-Salam, Bale, Eletta, **Olaniyan** & Baba, 2015).

Study 4: Effects of Spent Engine Oil Contamination on Soybean in an Ultisol

An experimental study assessed the impact of spent engine oil (SPO) on soil properties and soybean growth. Results showed severe declines in soil infiltration rates and hydraulic conductivity under 3% SPO contamination. Soybean germination rates fell significantly, though moderate contamination (1% SPO) unexpectedly boosted leaf area and yield. This highlights the dual threats of soil degradation and crop toxicity from oil pollutants, with long-term consequences for soil functionality and agricultural productivity (Ahamefule, **Olaniyan**, Amana, Eifediyi, Ihem, & Nwokocha, 2017).

These studies illustrate the critical need for integrated pollution management strategies to safeguard soil and water quality. Addressing heavy metal and organic pollution will not only enhance environmental sustainability but also protect public health (with its attendant needs of hospital visits and cost implications if not death) and ensure agricultural resilience.

Theme III: Miscellaneous Soil Studies

Aside from research within the two earlier broad themes, applied pedology evolves with societal development and accompanying environmental challenges. The studies under this theme are valuable for several reasons; they contribute to our overall understanding of soil-its composition, properties, and behaviour-fundamental for effective land use planning and sustainable agriculture.

Study 1: Comparing Traditional and Modern Soil Conservation Approaches in Nigeria

This review examined the efficacy of traditional and modern soil conservation practices in Nigeria, especially under climate change pressures. While traditional methods like stone lines and shifting cultivation remain popular due to their simplicity and familiarity, their scientific validation is limited. Conversely, modern approaches such as agroforestry and plastic mulching have demonstrated clear benefits but are less accessible due to cost and technical demands. The study emphasises that sustainable soil conservation requires integrating local knowledge with modern innovations, supported by legislation to curb harmful activities like sand mining. The findings advocate for adaptive strategies tailored to local contexts to mitigate climate impacts on soil productivity (Ahamefule, Eifediyi, Amana, **Olaniyan**, Ihem, Ukelina, Adepoju, Taiwo, & Fatola, 2020).

Study 2: Biochar Application and CO_2 Emissions in Upland Rice Production

Field experiments investigated the impact of varying biochar application rates on CO_2 emissions in different soil types under upland rice cultivation in the Southern Guinea Savannah. Results showed that CO_2 emissions increased with higher biochar rates, with the highest emissions recorded in Grossarenic Kandiustalf soils. However, the percentage of biochar-C mineralized was higher at lower application rates, indicating more efficient carbon sequestration at higher rates. This study highlights biochar's potential to enhance soil quality while contributing minimally to greenhouse gas emissions, underscoring its role in sustainable soil management (**Olaniyan** *et al*., 2020).

Study 3: Soil and Land Use Effects on Weed Distribution in Nigeria's Guinea Savannah

This study explored the relationship between soil properties, land use, and weed distribution. Sampling across cropped and non-cropped plots revealed that soil texture, nutrient content (e.g., nitrogen, potassium, magnesium), and land use practices significantly influenced weed diversity and abundance. The findings suggested that targeted soil and land management can effectively control weed populations, reducing competition with crops and improving yields. This research highlights the importance of understanding soil-vegetation interactions to optimise land use and agricultural productivity (**Olaniyan** *et al*., 2018).

These studies underscore the importance of integrated and context-specific approaches in soil conservation, carbon management, and weed control. They highlight the interplay between traditional knowledge, modern innovations, and ecological principles in promoting sustainable land management and agricultural resilience.

Evaluating Key Environmental and Soil Factors Influencing the Suitability of Typical Nigerian Soils for Crop Cultivation

In my sojourn studying Nigerian soils in the past few decades, I have encountered salient recurring factors that limit the optimal functioning of agricultural lands for crop production. These cut across agroecological zones and regions, and I will talk about them under three broad headings:

Influence of Weather Cycles on Sustainable Crop Production in Nigeria

Nigeria experiences two main seasons: the wet season (roughly April to October) and the dry season (November to March). Rainfall patterns within these seasons vary across the country, shaping distinct agro-ecological zones. The north savanna receives less rain, favouring drought-resistant crops like sorghum and millet. In contrast, the southern rainforest enjoys abundant rainfall, nurturing cocoa, yam, and oil palm. But weather cycles add complexity to this script. Droughts, floods, and unpredictable rainfall patterns can disrupt the rhythm of crop production, and we are beginning to witness these events more frequently in the last decade. Climate change, the long-term change in the average weather patterns have come to define Earth's local, regional and global climates, disrupting national economies and affecting lives and livelihoods, especially for the most vulnerable.

To mitigate these effects, adopting climate-resilient crop varieties that are better suited to the changing conditions is crucial. Improving water management practices, such as rainwater harvesting and efficient irrigation, can enhance water availability. Agroforestry, cover cropping, and conservation agriculture are some of the practices we have discovered to contribute to soil health and resilience. Additionally, promoting farmer education on climate-smart practices and technologies has enhanced adaptive capacity. Collaborative efforts involving government, researchers, and local communities are essential for developing and implementing sustainable strategies that ensure food security in the face of climate change. Remember, weather cycles are not villains; they are part of the story. By understanding their influence and adapting our practices, we can ensure Nigerian soils continue to nurture bountiful harvests, even when the weather director throws us curveballs.

Organic Matter as a Limiting Factor in Suitable Land Use and Optimum Land Productivity in Nigeria

Let us imagine organic matter as a precious resource and the lifeblood of our soils, influencing their suitability for various land uses and ultimately, their ability to produce optimal yields. Low organic matter contents are a challenge in tropical lands, due to high temperatures that result in their rapid breakdown and loss.

Organic matter, composed of plant and animal residues, acts like a magic potion for soils. It improves water retention, promotes nutrient cycling, and fosters beneficial soil organisms. Think of it as a sponge, holding water for thirsty crops, a slow-release fertilizer, and a bustling city teeming with microscopic helpers. However, many Nigerian soils suffer from low organic matter content due to factors like intensive farming practices, erosion, and burning of crop residues. This poses a significant challenge, limiting the suitability of land for many crops and hindering optimal productivity.

The good news is that, we can restore organic matter and unlock the full potential of our soils. Practices like composting, cover cropping, and mulching add organic matter back into the soil, improving its structure and fertility. Let us remember organic matter is not just a soil component; it's the foundation for thriving agriculture. By nurturing this precious resource, we can unlock the full potential of Nigerian soils, ensuring food security and a sustainable future for generations to come.

Plinthite in Soils

One very common and recurring soil feature in my practice over the years is the occurrence of plinthite (yangi). Plinthite is a type of soil horizon or layer that is characterised by the accumulation of iron and aluminium oxides. It forms in tropical and subtropical climates, particularly in areas with seasonal water logging. Plinthite develops because of the alternating wetting and drying cycles in the soil. This process involves the following steps:

1. Wetting and Oxidation
2. Drying and Reduction
3. Hardpan Formation

Soil Management Influence on Plinthite Formation

Soil management practices play a crucial role in influencing the formation of plinthite and have far-reaching consequences for agricultural production, sustainable land use, and building structures. Plinthite, characterised by the accumulation of iron and aluminium oxides, is influenced by a combination of natural processes and human activities that we will look at below.

Plinthite Formation and Soil Management

Soil management practices influence the wetting and drying cycles that contribute to plinthite formation. Improper land use, such as overgrazing or inappropriate irrigation, can exacerbate the wetting and drying cycles, accelerating plinthite development. On the other hand, sustainable soil management practices, including contour ploughing, cover cropping, and agroforestry, can mitigate the impact of these cycles and, in some cases, prevent the formation of dense plinthite layers.

Sustainable Land Use

Understanding and managing plinthite is essential for sustainable land use. Inappropriate land management practices, such as deforestation or excessive land clearing, can disturb the natural balance of wetting and drying cycles, accelerating plinthite formation.

Building Structures

Plinthite does not affect agricultural production alone. The presence of plinthite can have implications for building structures. The hard and dense nature of plinthite poses challenges for construction, particularly in areas where it is prevalent. Building foundations may need special considerations and engineering solutions to account for the characteristics of plinthite, ensuring stability and durability. As a common example, the wetting we sometimes notice on the lower parts of the surface of house walls is a result of a restriction of downward water movement most times caused by plinthite. Because the water is unable to seep downward, it is absorbed by the walls of such buildings, thereby impacting their structural strength over time.

In summary, soil management practices significantly influence the formation of plinthite, and its impact extends to agricultural production, sustainable land use, and building structures. Implementing sustainable and soil-conserving practices is therefore vital for mitigating the challenges associated with plinthite and promoting resilient and productive land use. I hope these brief notes spark your interest in the fascinating world of soil and its intricate relationship with weather cycles, organic matter and land management.

Advances in Soil Evaluation Techniques

Mr. Vice-Chancellor, the field of pedology is a rigourous profession. Besides the risk of traversing thick bushes and forests during soil survey, there are also emerging security threats in the aspects of the safety of life in our society today. These make improved approaches/techniques of assessing soil properties in the field very important. Soil analysis provides valuable information for making informed decisions regarding soil management practices, and over the years, advances in analysis techniques have significantly enhanced our ability to assess soil health, nutrient availability, and environmental risks.

Advancements in soil analysis techniques have revolutionised our understanding of soil properties, nutrient dynamics, and microbial communities. These techniques provide valuable insights that inform soil management strategies and promote sustainable land use practices. Let us explore some key advancements in soil analysis:

Traditional Soil Analysis Methods: Traditional soil analysis methods involve basic chemical tests to determine nutrient levels, pH, organic matter content, and cation exchange capacity (CEC). These methods have provided valuable insights into soil fertility and nutrient deficiencies, guiding fertilizer recommendations and soil amendments (**Olaniyan** *et al*., 2011; **Olaniyan** *et al*., 2018). However, they have certain limitations, such as being time-consuming, requiring specialized laboratory facilities, and providing limited information on soil biological activity and functional diversity.

Spectroscopic Techniques: Spectroscopic techniques, such as infrared spectroscopy (FTIR) and near-infrared spectroscopy (NIRS), allow rapid and non-destructive analysis of soil samples. These techniques provide information on soil organic matter content, nutrient availability, microbial activity, and carbon sequestration potential. Spectroscopic analysis offers a cost-effective and time-efficient alternative to traditional chemical analysis methods (Vasques *et al*., 2018; Isimikalu *et al*., 2020).

Remote Sensing: Remote sensing techniques, including satellite imagery and aerial photography, provide valuable information on soil properties, vegetation cover, and land-use patterns. Remote sensing data have been used to assess soil moisture content, monitor erosion, identify areas of nutrient stress, and guide precision agriculture practices. By integrating remote sensing with soil analysis data, we as researchers have been able to make informed decisions regarding land management strategies (Ajala *et al*., 2023).

Data Analysis and Modelling: Advances in data analysis and modelling have also contributed to the field of soil analysis. With the increasing availability of big data and machine learning algorithms, it is now possible to analyse large datasets and extract meaningful patterns and relationships. These techniques have helped us to predict soil properties, nutrient availability, and crop yields based on various input parameters. By integrating soil analysis data with predictive models, land managers can optimise soil management practices and make informed decisions for sustainable land use (Ahamefule *et al*., 2018).

Access to advanced soil analysis techniques and emerging technologies remains limited for researchers in Nigeria, underscoring the need for increased funding to enhance institutional capacity. However, commendations are due to the management of the University of Ilorin for its steady progress in investing in research capacity development.

Mr. Vice-Chancellor, I implore you to keep enhancing research capabilities at the *Better by Far* University in order to propel revolutionary institutional transformation throughout the Nigerian higher education sector. The creation of research-supportive environments, improved research supervision through specialised training for mentors, and internationally competitive doctoral training are important system-level reforms. Programmes that help graduates stay involved and active in research in Nigeria will also be essential to maintaining this momentum. These strategies collectively will reinforce the University's leadership role in advancing research excellence nationwide.

Challenges and Future Directions

Despite the significant advancements in soil survey and land evaluation as well as land management, several challenges persist and warrant attention for future research and practices. Addressing these challenges is crucial to ensuring sustainable soil management and enhances land productivity. Urbanisation and land-use changes pose another significant challenge, leading to the loss of fertile land, soil compaction, and increased pollution. As the city expands, balancing urban development with agricultural sustainability is crucial.

By leveraging its academic expertise, research capabilities, and community engagement, the University of Ilorin can play a crucial role in addressing these challenges and promoting sustainable soil management. I sincerely hope that these recommendations will be considered for implementation, as they will contribute significantly to both the University’s academic mission and the well-being of the surrounding communities.

1. **Climate Change Impacts:** Climate change poses substantial challenges to pedology and land management. Rising temperatures, altered precipitation patterns, and extreme weather events can have profound effects on soil properties, nutrient cycling, and erosion rates. To mitigate the impacts of climate change, we need to develop adaptive strategies that enhance soil resilience and promote carbon sequestration (**Olaniyan** *et al*., 2020; Lal, 2020).
2. **Soil Degradation and Erosion:** Soil degradation and erosion continue to be major challenges worldwide. Intensive agricultural practices, deforestation, and improper land management contribute to the loss of fertile topsoil and reduced soil quality. Implementing conservation practices such as contour ploughing, terracing, and agroforestry can help prevent erosion and maintain soil health (Isimikalu *et al*., 2023; Govers *et al*., 2020; **Olaniyan** *et al*., 2018).
3. **Urbanisation and Land Use Change:** Rapid urbanization and land use change exert pressure on agricultural and natural lands. Converting fertile agricultural soils into built environments reduces the land available for food production. Integrated land use planning, precision agriculture techniques, and urban green infrastructure development can help minimize the negative impacts of urbanization on soils (Ciroth *et al*., 2019; Ajala *et al*., 2023).
4. **Soil Health Assessment:** Developing robust and comprehensive methods for assessing soil health is crucial for effective land management. Integrating advanced techniques such as DNA sequencing, metabolomics, and remote sensing can provide valuable insights into soil microbial communities, nutrient dynamics, and overall soil quality (Ogunwale *et al*., 2022; Mendes *et al*., 2021).

5. **Digital Agriculture and Precision Farming:** The integration of digital technologies, data analytics, and precision farming approaches holds great potential for optimizing soil management practices. Utilising sensors, drones, and machine learning algorithms can enable real-time monitoring of soil properties, nutrient status, and crop performance, facilitating informed decision-making for sustainable land management (Izuogu *et al*., 2023; Khosla *et al*., 2020).

Recommendations

The Vice-Chancellor, Sir, I would like to recommend some solutions particularly in the face of climate change, soil degradation, and rapid urbanisation which I stated earlier. Given the University of Ilorin's role as a center for research and academic excellence, I believe the institution can make a significant impact by implementing targeted solutions in these areas. Climate change continues to alter soil properties, reducing moisture retention, nutrient availability, and overall fertility. To address this, the University should:

1. invest in research focused on climate-resilient soil management practices and the development of climate modeling tools to predict soil-climate interactions;
2. organise workshops and training programmes for farmers and policymakers on climate-smart agricultural techniques such as conservation tillage, agroforestry, and organic soil amendments will also be beneficial;
3. establish demonstration farms within the university to showcase sustainable land management strategies will serve as a practical learning platform for students, researchers, and local farmers;
4. collaborate with meteorological agencies to develop early warning systems for climate adaptation can further enhance soil preservation efforts in the region;
5. play a critical role in tackling the challenge of soil degradation and erosion, which are major threats to land productivity and food security by conducting comprehensive soil mapping projects to identify areas at risk of erosion and degradation;
6. implement community outreach programmes to educate farmers and landowners on erosion control measures such as terracing, contour farming, and agroforestry will help promote sustainable land use;

7. encourage research on organic soil restoration techniques, including the use of cover crops and natural fertilizers, while also aiding the preserving soil health;
8. collaborate with government agencies and environmental organisations to facilitate land restoration projects and advocate for the enforcement of strict land-use policies that prevent deforestation and excessive land exploitation;
9. conduct impact assessments on urban expansion and providing evidence-based policy recommendations for sustainable land use planning, while encouraging eco-friendly construction practices, such as green infrastructure and permeable paving; and
10. help mitigate the negative effects of urbanisation on soil health, while working with local governments and urban planners to develop strategies that integrate green spaces into city layouts and promote responsible waste management to prevent soil contamination.

A Personal Reflection

As I am about to conclude this lecture, I want to share a personal experience that has profoundly shaped my perspective.

Recently, I faced a serious illness that posed a significant threat to my career, and by extension, to my life, which has affected my speech to an extent till now. This period of adversity was a true test of resilience and determination. There were moments of doubt and uncertainty, but through this journey, I learned invaluable lessons about perseverance and the strength of the human spirit. The support I received from my family, colleagues, and students was instrumental to my recovery. This experience underscored the importance of community and the powerful impact of having a strong support system in both personal and professional spheres.

My illness has given me a renewed appreciation for the work we do. It has reminded me of the profound implications of our research and teaching, and it has inspired me to approach my endeavours with even greater passion and dedication. I hope that by sharing this story, I can inspire others to face their challenges with courage and to recognise the strength that lies within us all.

As we continue our academic pursuits, let us remember that the challenges we face can lead to growth and renewed purpose. I will always be indebted to God for the opportunities and blessings that have moulded my life. For his advice and supervision during my undergraduate, graduate, and doctoral studies, Professor Ogunkunle has my sincere thanks.

I cannot overlook the significant contributions of other mentors and colleagues in shaping my evolution as a researcher. These individuals, among others, have played pivotal roles in my academic journey. Early interactions with these mentors and colleagues were transformative, introducing me to the intricacies of pedology and soil survey and providing essential field knowledge. While their names may appear as co-authors on numerous articles, their impact extends beyond conventional academic collaborations; they have been, in many respects, providentially placed by a higher power at crucial junctures in my life, moulding me into a genuine Soil Scientist.

This underscores that the accomplishments showcased today are the result of collective efforts rather than individual initiatives. These achievements stem from collaborative work with other scientists, with whom I have worked on both published and unpublished articles.

Conclusion

The conclusion of this inaugural lecture is that pedology and land management play crucial roles in understanding and sustainably utilising our precious land resources. Soil analysis techniques have significantly advanced our knowledge of soil properties, nutrient dynamics, microbial communities, and the impact of land management practices. Throughout this lecture, we have explored key concepts in pedology, the importance of effective land management, and the advancements in soil analysis techniques.

We have learned that pedology provides a foundation for understanding soil formation, classification, and its relationship to land use. Effective land management strategies, encompassing practices such as erosion control, nutrient management, and conservation measures, are essential for maintaining soil health and productivity. These practices help mitigate soil degradation, preserve soil biodiversity, and promote sustainable agricultural and land-use systems.

Furthermore, advancements in soil analysis techniques, including spectroscopic techniques, molecular techniques, stable isotope techniques, and imaging techniques, have enhanced our ability to assess and monitor soil properties, nutrient cycling, microbial communities, and root-soil interactions. These techniques offer valuable insights for informed decision-making and the development of effective land management strategies. however, challenges such as climate change, urbanization, and intensification of agriculture pose significant threats to soil health and require innovative approaches. Future research should focus on developing integrated models and technologies that consider the complexity of soil systems and their interactions with other environmental factors. This interdisciplinary approach will contribute to sustainable land management practices, conservation of soil resources, and the preservation of ecosystem services provided by soils.

Finally, the knowledge gained from pedology, and the application of advanced soil analysis techniques is crucial for sustainable land management, ensuring the productivity, resilience, and long-term health of our soils. It is through continuous research, collaboration, and implementation of innovative strategies that we can address the challenges ahead and pave the way for a sustainable future. On these highlighted areas of potential development, I charge you, soil enthusiasts and upcoming researchers, to employ available and emerging technologies to help us preserve our soils for today and tomorrow.

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I want to appreciate my dear parents, Mr. David Olaniyan Dada of blessed memory and my darling aged mother Mrs. Abigail Abioye Olaniyan, while my 93 year old mummy is still on. I appreciate you so much for raising me in a loving environment and for all your investments in training me. Apart from torturing me from Primary school to the Doctorate level, you inculcated in me the core values of hard-work, contentment, humility, patience and discipline among others. You are blessed parents.

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My sincere appreciation goes to the funding agencies and institutions that have supported my research endeavours. Their financial support and resources have played a crucial role in conducting the studies that form the foundation of this lecture. Without their assistance, this lecture would not have been possible. Furthermore, I would like to express my deep gratitude to the participants and students who have engaged in meaningful discussions and provided valuable insights. Their enthusiasm for learning and their thoughtful questions have greatly enriched the lecture.

I am indebted to the authors of the publications referenced throughout this lecture. Their comprehensive research and scholarly contributions have served as a reliable source of information, shaping the structure and content of this presentation. Their dedication to advancing pedology and land management is commendable. I am deeply grateful to all those who have played a role, big or small, in the development and delivery of this lecture. Their collective efforts have contributed to its success, and I am honoured to have had the opportunity to share my knowledge and insights in the field of pedology, soil survey and land management.

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The Vice-Chancellor, Sir, Ladies and Gentlemen, I thank you again for being part of this memorable occasion.

Thank you all.

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