



## IoT-Based Intelligent System for Real-Time Soil Nutrient Monitoring and Decision Support in Farming: Potential for Deployment in Rice Farming in Nigeria

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Review Article

### Abstract

*This paper presents a comprehensive examination of the design, potential implementation, and existing technological landscape of Internet of Things (IoT)-based intelligent soil nutrient monitoring systems for rice farming. While the paper presents a model contextualized for Niger State, its findings offer insights relevant to rice-producing regions across Nigeria. Rice farmers face significant challenges related to soil fertility management, often due to reliance on inefficient traditional methods. By reviewing recent developments in sensor integration, embedded systems, and cloud-based platforms, this paper explores how such technologies can be applied to provide continuous, real-time monitoring of essential soil parameters like nitrogen (N), phosphorus (P), potassium (K), pH, temperature, and moisture. The findings suggest that IoT-enabled systems, complemented by mobile applications and decision-support tools, offer a low-cost and scalable solution to enhance yield, optimize fertilizer use, and improve data-driven decision-making for small and medium-scale farmers. This paper aims to provide a state-of-the-art overview of current trends and contextualize the proposed system within the global and local technological ecosystem.*

**Keywords:** IoT in Agriculture, Precision Farming, Soil Nutrient Monitoring, Smart Farming, Rice Production, Nigeria

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### 1. Introduction

Agriculture remains a crucial pillar for food security, economic development, and employment, particularly in Sub-Saharan Africa. In Nigeria, rice is one of the most consumed staple foods and contributes significantly to household food demand. However, local production is insufficient due to multiple constraints including poor soil fertility management and lack of real-time data to guide decision-making. Although Niger State serves as the model environment for system demonstration, this review explores its broader potential for deployment across Nigeria's rice-farming zones. In Niger State, a leading rice-producing region in Nigeria, many farmers still depend on manual soil analysis, guesswork, or seasonal practices which lack precision, resulting in lower yield and inefficient fertilizer usage.

Traditional soil testing involves transporting samples to distant laboratories, which is costly and time-consuming. Moreover, farmers lack the knowledge or financial means to access such services regularly. Consequently, there is an urgent need for affordable, efficient, and user-friendly solutions to monitor and manage soil nutrients in real-time.

The Internet of Things (IoT) has capability to collect, transmit, and analyze real-time data through sensors and embedded systems, thus offering a compelling solution. When coupled with cloud computing and machine learning, IoT systems support intelligent decision-making in precision agriculture. This review explores the current state of such IoT-enabled agricultural technologies with a focus on soil nutrient monitoring in rice farming. In particular, a model tailored to the context of Niger State is presented as a case study, contributing to the ongoing discourse on smart farming practices. The paper aims to synthesize relevant research, examine implementation strategies, and evaluate how IoT-based systems can enhance productivity, reduce environmental impacts, and support small and medium-scale farmers in developing economies. The subsequent sections of this paper include a Review of Related Works and Technological Developments, a detailed System Design Approach: A Review with Case Application, and an outline of Expected Results and Outcomes from Reviewed Model. The paper concludes with a Discussion, followed by the Conclusion and Future Work.

### 2.0 Review of Related Works and Technological Developments

This section reviews advancements in precision agriculture and smart farming technologies, which have gained considerable attention globally as sustainable solutions to growing food demands and climate-related agricultural challenges.