Modeling The Determinant Factor of Agricultural Productivity Growth: Small Scale Farmers in Aba Abia State

Dr C.K Okoro [1] & Dr Ehibe, Prince[2]
[1,2]Abia state polytechnic Aba, Department of Electrical Electronic Engineering Nigeria
Prince.ehibe@abiastatepolytechnic.edu.ng, cosp.prince@yahoo.com
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Abstract
This study investigates the determinants of agricultural productivity growth among small-scale farmers in Aba, Abia State, Nigeria. The study aims to identify key elements that contribute to enhancing agricultural output in the region, considering socio-economic, technological, and environmental aspects. Utilizing an advanced approach, data were collected through structured questionnaires, in-depth interviews, and field observations from a representative sample of small-scale farmers. This analysis employs statistical techniques to quantify the impact of various factors such as access to credit, extension services, farm inputs, land tenure systems, and technological adoption on productivity growth. The findings reveal that access to modern farming techniques, improved seed varieties, and effective extension services significantly boost agricultural productivity. Additionally, socio-economic variables like education level, farm size, and cooperative membership play crucial roles in facilitating productivity improvements. The study highlights the importance of policy interventions aimed at enhancing access to resources, training, and support services for small-scale farmers to sustain agricultural growth. Recommendations are provided for stakeholders, including government agencies, non-governmental organizations, and the private sector, to foster an enabling environment for agricultural productivity advancement in Aba State.

Keywords: *Agricultural Productivity, Small-Scale Farmers, Determinant Factors, Extension, Technological Adoption*

Introduction

Agriculture remains a pivotal sector in Nigeria, providing livelihoods for the majority of the population and contributing significantly to the nation's GDP. In Abia State, particularly in Aba, small-scale farmers form the backbone of agricultural production. Despite their critical role, these farmers face numerous challenges that impede their productivity and sustainability. Understanding the factors that drive agricultural productivity growth among small-scale farmers is essential for formulating effective policies and interventions that can enhance their output and Anand A and Nayyar, (2016), Computer vision, machine learning, and robotics will increasingly converge to help growers produce more food, more efficiently, and achieve greater financial returns in the process.

The algorithms rely on machine learning for pattern recognition and identifying issues and field trends. These algorithms generate metrics so that farmers can rank and prioritize the actions they need to take.

Crop simulation models, geographic information systems (GIS), global positioning systems (GPS), intelligent implements and site-specific management (SSM) farming techniques are the technologies behind precision agriculture. Mechanistic and process-oriented crop models using real-time daily climatic data obtained from a local, on-farm weather station accessed by the user's computer via a modem. Agricultural productivity growth is influenced by a complex interplay of socio-economic, technological, and environmental factors. Access to credit, availability of farm inputs, extension services, land tenure systems, and adoption of modern farming techniques are some of the key determinants that have been identified in various studies by Anderson (2008). However, the specific context of Aba, with its unique socio-economic and environmental characteristics, necessitates a localized study to identify the most relevant factors affecting productivity growth in this region.

This research aims to model the determinant factors of agricultural productivity growth among small-scale farmers in Aba State. Andrew Meola, (2016), By employing a learning method with retrogression approach for Precision agriculture (PA) that combines quantitative and qualitative data collection and analysis, this study seeks to provide a comprehensive understanding of the variables that significantly impact agricultural productivity in the area. The insights gained from this research will inform policymakers, agricultural extension officers, and development practitioners on the strategic actions required to support small-scale farmers and enhance agricultural productivity in Aba, Obinna & Nwafor (2018) Access to credit and agricultural productivity among small-scale farmers in Nigeria.

Problem statement

Addressing these problem statements requires the development and implementation of a comprehensive precision agriculture system tailored to the specific needs and challenges of Abia State. By enhancing access to modern agricultural technologies, improving soil health management practices, and promoting climate-resilient farming strategies, stakeholders can maximize crop production, enhance food security, and foster sustainable agricultural development in the region. These are the problems.

i) Limited Access to Financial Resources and Inputs:

Small-scale farmers in Aba, Abia State, face significant challenges in accessing financial resources and essential farm inputs such as quality seeds, fertilizers, and modern farming equipment. This limitation hinders their ability to adopt improved agricultural practices and technologies, resulting in suboptimal crop yields and productivity.

ii) Inadequate extension services and agricultural training:

The effectiveness of agricultural extension services and the availability of training programs are crucial for disseminating modern farming techniques and knowledge to small-scale farmers. In Aba, Abia State, many farmers lack sufficient access to these services, leading to a gap in the adoption of best practices and innovative technologies and determining the factors that influence their reach and effectiveness can help improve the support system for farmers in this region.

Objective of the study

The objectives, modeling the determinant factor of agricultural productivity growth: small-scale farmers are as follows:

1. To improve access to modern agricultural technologies and practices with characterization of learning method and retrogression.
2. This involves modeling and implementing soil mapping and soil health assessment techniques to identify nutrient deficiencies, pH imbalances, and other soil-related issues.

Providing access to weather forecasting tools, climate-smart agricultural practices, and resilient crop varieties to help farmers mitigate the impacts of climate variability and unpredictable weather patterns.

Literature review

In the subsequent sections, we will review the existing literature on agricultural productivity determinants, outline the methodology employed in this study, present the results and their implications, and offer recommendations based on our findings. Eze, C. A. (2020). Land tenure security and agricultural productivity in Southeast Nigeria. Through this research, we hope to contribute to the broader discourse on agricultural development and provide actionable insights for fostering sustainable growth in the agricultural sector of Aba, Abia State.

Precision agriculture (PA) has emerged as a transformative approach to modernize farming practices, enhance productivity, and address the challenges faced by agricultural systems worldwide. In the context of Abia State, Nigeria, where agriculture plays a crucial role in the economy, there is a growing interest in adopting precision agriculture principles to optimize crop production while ensuring sustainability and resilience. This literature review provides an overview of key concepts, technologies, and approaches relevant to precision agriculture in the context of Abia State. Antonis et al (2017)

Precision agriculture is based on the principles of using data-driven decision-making, spatial variability management, and technology integration to optimize agricultural practices. The concept encompasses various technologies, including remote sensing, global positioning systems (GPS), geographic information systems (GIS), and sensor networks, to enable precise and site-specific management of agricultural inputs.

Adesina, A., & Zinnah, M. (2019). They presented a Soil mapping and soil health assessment is fundamental components of precision agriculture. Digital soil mapping techniques such as geostatistics and remote sensing enable the characterization of soil properties, fertility levels, and spatial variability across agricultural landscapes. Soil health assessment tools, including soil testing kits and laboratory analysis, provide valuable insights into nutrient status, pH levels, and organic matter content, informing optimal soil management practices.

Akinbode, S. O., & Ogunwole, J. O. (2020). On their paper, Remote sensing technologies, including satellite imagery and unmanned aerial vehicles (UAVs), offer valuable data for monitoring crop health, detecting pest and disease outbreaks, and assessing environmental conditions such as moisture levels and temperature variations. GIS platforms facilitate the integration and analysis of spatial data, enabling farmers to make informed decisions about crop planning, resource allocation, and precision farming operations.

Eze, C. C., & Nwokocha, L. M. (2018). They publication on the article integration of IoT sensors in agriculture enables real-time monitoring of soil moisture, temperature, humidity, and other environmental parameters. These sensors, coupled with data analytics tools, provide farmers with actionable insights into crop growth dynamics, irrigation scheduling, and resource management. Advanced analytics techniques, such as machine learning and predictive modeling, offer opportunities for optimizing crop yields and minimizing input costs.

Ibrahim, H. & Mohammed, I. (2017). Accurate weather forecasting is critical for agricultural planning and risk management. Weather prediction models, coupled with historical climate data, help farmers anticipate weather-related events and adjust farming practices accordingly. Climate-smart agriculture approaches, such as drought-resistant crop varieties and water-efficient irrigation systems, support adaptation to climate variability and mitigate the impacts of climate change on crop production. Nwosu, C. P., & Onwuka, E. N. (2019). Farm management software and decision support systems (DSS) facilitate precision agriculture implementation by providing farmers with tools for crop monitoring, yield mapping, input optimization, and financial analysis. These software solutions enable data-driven decision-making and support precision farming practices, ultimately leading to improved productivity, profitability, and sustainability.

Materials and method

Conduct detailed soil surveys using Geographic Information System (GIS) technology to map soil variability, nutrient levels, pH, and moisture content. Analyze soil samples to determine optimal crop selection and nutrition management strategies. Utilize remote sensing technologies such as satellite imagery and drones to monitor crop health, growth stages, and pest and disease outbreaks. Analyze data to detect early signs of stress and implement targeted interventions.

Material used

Data was collected through a comprehensive literature review using reviews, electronic databases including Science Direct, Web of Science etc. Baggio, A. (2005)

Also, interviews were conducted to extract the utmost of the experts' knowledge and experience about the different types of indicators that may have been overlooked throughout the literature review. After investigating the aforementioned items, the number of important indicators and sub-indicators in the concerned system was listed. As an evaluation of indicators' validity, comments from farmers were perceived and examined. In the next step, a checklist comprising indicators and sub-indicators influencing the crop production system efficiency was taken from the previous step. In the second section, the survey hypothesis, judgment scale was divided into nine levels to show their relative importance (Table 1).

Table 1 survey hypothesis judgment scale of relative importance

survey hypothesis judgment scale	Numerical value
Equal	1
Marginal strong	3
Strong	5
Very strong	7
Extremely strong	9
Intermediate value	2,4,6,8

Method of Data Collection

Primary Data:

- Surveys: Administered to farmer key players ; Unit managers, safety team leads, operational supervisors, and workers in selected in farmer in Aba to gather quantitative data on their challenges implementation and effectiveness.
- Interviews: Conduct with key stakeholders, including officers and regulatory authorities, to obtain qualitative insights into the challenges and barriers to farmers' effectiveness.

Secondary Data:

- Review of farmer safety records, crop deficiency reports, and compliance audits to analyze historical data related to production implementation and crop improvement

Method

Variable Rate Application (VRA)

Fertilizer Application:

Implement VRA systems for precise application of fertilizers based on soil nutrient levels and crop requirements. Use soil sensors or satellite data to adjust fertilizer rates in real-time, optimizing nutrient utilization and reducing wastage.

A) **Irrigation Management**: Employ VRA techniques for irrigation scheduling and water management. Use soil moisture sensors or weather data to adjust irrigation levels according to crop water needs, minimizing water use and avoiding over-irrigation.

B) **Precision Planting and Seeding**
   a. **Seed Selection**: Use data analytics and historical yield data to select the most suitable seed varieties for specific soil and climate conditions in different areas of Abia State. Optimize seed rates and planting densities for improved crop establishment and yield potential.
   b. **Planting Equipment**: Utilize precision planting equipment with GPS guidance systems to ensure accurate seed placement and spacing. Monitor planting depth, seed-to-soil contact, and uniformity to promote optimal plant growth and development.

C) **Integrated Pest Management (IPM)**
   a. **Pest and Disease Monitoring**: deploy sensors, drones, or satellite imagery to monitor pest and disease pressure in agricultural fields. Use data analytics to assess risks and implement timely interventions, such as targeted pesticide applications or biological control methods.
   b. **Crop Health Advisory**: Develop a crop health advisory system that integrates data from pest and disease monitoring, weather forecasts, and agronomic practices. Provide farmers with real-time recommendations for pest management strategies, minimizing crop losses and pesticide usage.

D) **Data Management and Decision Support**

Farm Management Software: Implement farm management software platforms that integrate data from various sources, including soil maps, crop monitoring, and weather

   a. Forecasts and machinery operations. Provide farmers with customizable dashboards and decision support tools for optimizing farm operations.
   b. **Training and Support**: Offer training programs and technical support to farmers, extension agents, and agricultural professionals on using precision agriculture technologies effectively. Build capacity in data interpretation, agronomic decision-

making, and equipment maintenance to ensure successful adoption and implementation.

E) Economic Analysis and Impact Assessment

a. **Cost-Benefit Analysis**: Conduct economic assessments to evaluate the costs and benefits of adopting precision agriculture practices in Abia State. Compare input savings, yield improvements, labor efficiency, and environmental benefits to traditional farming methods.
b. **Impact Assessment**: Measure the impact of precision agriculture on crop production, resource utilization, environmental sustainability, and farmer livelihoods. Use performance indicators such as crop yields, input use efficiency, water savings, and greenhouse gas emissions to assess the overall effectiveness of the system.

F) Sustainable Practices and Environmental Stewardship

a. **Soil Conservation**: Implement soil conservation practices such as conservation tillage, cover cropping, and erosion control measures to maintain soil health and fertility. Use precision agriculture techniques to minimize soil disturbance and optimize crop residue management.
b. **Resource Efficiency**: Promote resource-efficient farming practices through precision agriculture, including reduced chemical inputs, water conservation, and energy savings. Encourage sustainable farming methods that contribute to long-term environmental stewardship and resilience to climate change.

Figure 1 ultrasound sensors close to the plants to monitor their movements and inserted NPK sensors into the soil to monitor changes in the chemical makeup (Archana et al 2018)

Case study of maize the research set up treatment groups, each containing varieties of maize. The maize plants that were not exposed to the pathogen. A test group included plants exposed to the disease. It was a cultivated disease in a separate lab setting and emulated the process of inoculation by infecting the test plants at an appropriate time. IoT sensors, installed on plants in both groups, collected data. ThingSpeak is a platform designed for monitoring, collecting, and visualizing IoT sensor data. ThingSpeak provides tools to directly monitor the data remotely through a cloud service. With ThingSpeak, data can be collected with ultrasound sensors and monitored in real time, and ThingSpeak gathers that data to share with the team of the farm manager.

These components form the foundation of a comprehensive precision agriculture system designed to maximize crop production, sustainability, and economic returns in Abia State, Nigeria. Integration of technology, data analytics, agronomic expertise, and farmer engagement is essential for successful implementation and adoption of precision agriculture practices in the region.

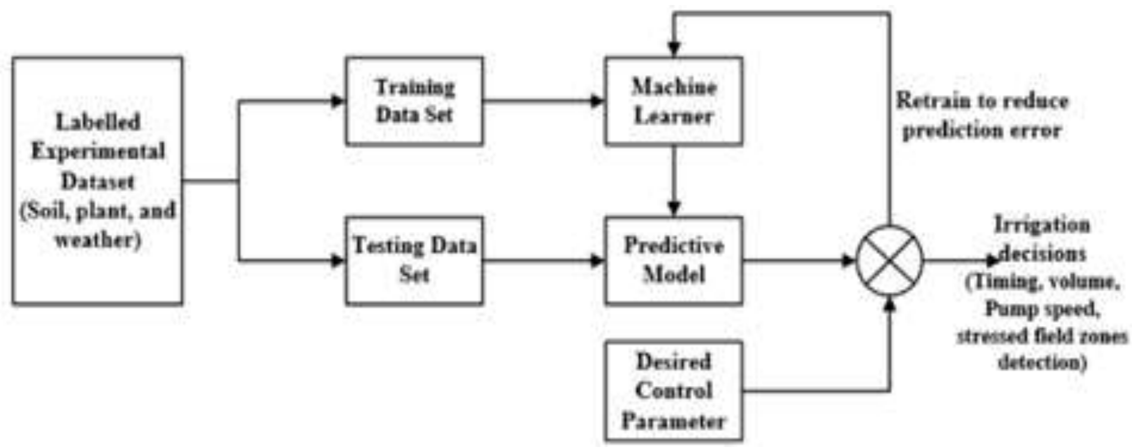

Figure 2 block diagram of supervised learning for an irrigation system

Result and analysis

Demographic characteristics of smallholder farmers in relation to agricultural productivity Smallholder farmers are characterized by many different sociodemographic factors, as shown in Table 1. The results showed that out of 609 smallholder farmers in Osisioma 1-5, 176 were crop producers and 433 were non-crop producers. The results also showed that out of 911 smallholder farmers in Osisioma ward 6-12, 210 were crop producers and 701 were non-crop producers.

Table 1Demographic features of smallholder farmers in osisioma ward 1-12

		Crop producers	Non-crop producers	Total
Province name	Osisioma ward 1-5	176	433	609
	Osisooma ward 6-12	210	701	911
Total		386	1,134	1,520

Table 2 **Demographic features of smallholder farmers in Aba Osisioma**

Variables	Crop producers (386)		Non-crop producers (1,134)		Overall Freq
	%	Freq	%	Freq	
Crop rotation					
Yes	74	286	88	1,000	1,286
No	26	100	12	134	234
Access to irrigation					
Yes	48	186	6	66	252
No	52	200	94	1,068	1,268
Access to inputs					
Yes	65	250	18	200	450
No	35	136	82	934	1,070
Access to mechanization					

Variables	Crop producers (386)		Non-crop producers (1,134)		Overall Freq
	%	Freq	%	Freq	
Yes	22	86	12	134	220
No	78	300	88	1,000	1,300

This presents the demographic characteristic variations among crop and non-crop producers. The results showed that 74% of the crop producers knew about crop rotation while 26% did not know about it. A know about it. Among non-crop producers, 88% knew about crop rotation, while 12% did not know. In terms of access to irrigation, 48% of crop producers had access, while 52% did not have access. Among non-crop producers, only 6% had access to irrigation, while 94% did not have access. Regarding access to agricultural inputs, 65% of crop producers had access, while 35% did not have access. Among non-crop producers, only 18% had access to agricultural inputs, while 82% did not have access. The results also showed that 22% of crop producers had access to mechanization, while 78% did not have access. Among non-crop producers, 12% had access to mechanization, while 88% did not have access.

Table 3 Graphical data of sensed temperature in 12th May and 12th June

Temperature degree F	Time hours	Pressure pa
10.0000	00.00.00	0.0000
20.0000	03.00.00	4.0000
30.0000	06.00.00	8.0000
40.0000	09.00.00	12.0000
50.0000	12.00.00	16.0000

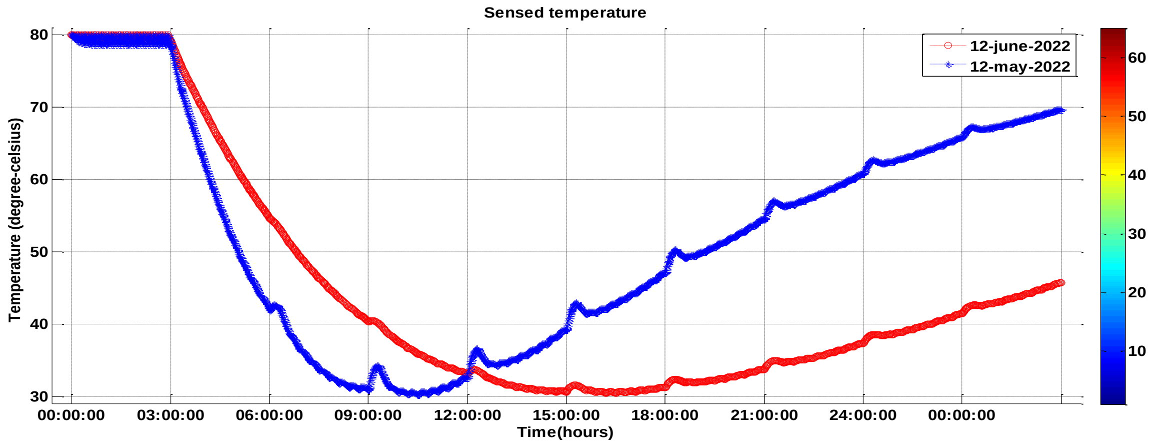

Figure 3 comparing the temperature of the tomato plant for 12th May and 12th June.

From the results of the figure 3 change of yield when two groups of conditions change, the Hydrawise Cloud platform is a mobile water management application, available on IOT, Android, and Windows Phone with an allocation of Thingspeak. The solution supports an unlimited number of controllers. The app allows farmer managers to access multiple controllers simultaneously and uses predictive algorithms to forecast the necessary water expenses based on temperature and time constraints with Thingspeak weather forecasts for crop production of plants.

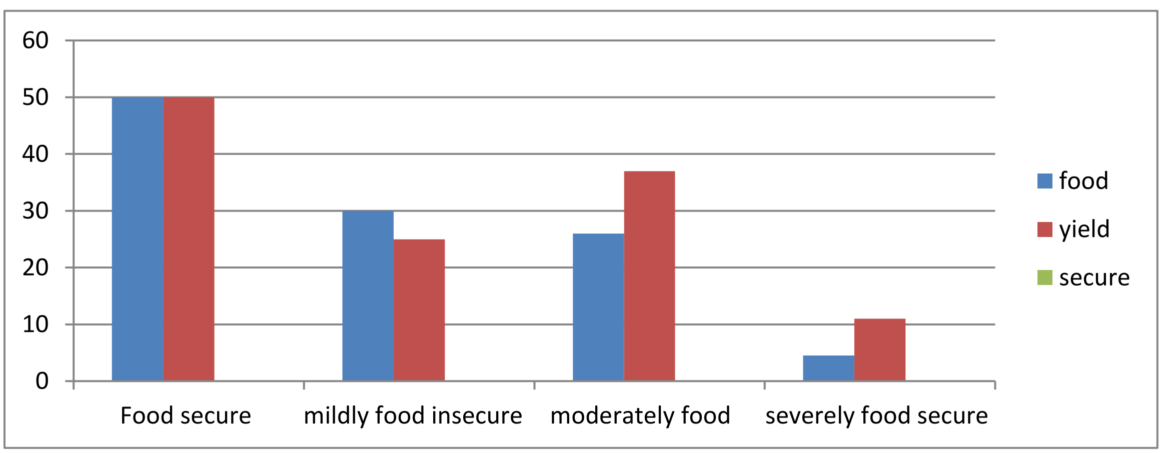

Figure 4 Food security setuiation chat

The effect of the current control food security chat in Figure 4 (dripper and sprayer) scheduling on the plant's growth shows improvement on continuous growth of the plants and growth: food, yield, and secure sensed and controlled climatic conditions and irrigation scheduling; determine a variant of food security.

Conclusion

The research on modeling the determinant factors of agricultural productivity growth among small-scale farmers in Aba State pointed to several critical insights. Small-scale farmers are fundamental to the agricultural sector, contributing significantly to food security and rural development. However, their productivity is influenced by a combination of technology and institutional factors. Key determinants identified include access to quality inputs (such as improved seeds and fertilizers), extension services. In conclusion, enhancing agricultural productivity among small-scale farmers in Aba, Abia State, will require targeted interventions that address both the micro and macro level challenges they face. Promoting sustainable farming practices, strengthening institutional support, and improving farmers' access to resources are essential for driving productivity growth in the region.

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