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Comparative Analyses of Users and Non-Users Of Digital Platform and Traceability Technology (DPTT) in Maize Production in Cross River State, Nigeria

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ABSTRACT

Comparative analyses of users and non-users of digital platforms and traceability technologies (DPTT) in maize production was studied. The study was undertaken to achieve the following objectives: identify DPPT used by maize farmers in the area, determine the factors influencing the output of maize production in the area and compare the output of maize farmers between users and non-users of DPTT in the area. Result of analysis showed that farm size, labour input, quantity of seed, educational attainment and access to credit were significant to influence the use of DPTT. The DPTT identified in the area included: information and communication technology (ICT), blockchain, radio-frequency identification (RFID), The Internet of Things (IoT), cloud-based databases, artificial intelligence (AL) and machine learning (ML). The mean output of users of DPTT in kg was 46,100.0000 while that of non-users of DPTT was 9,550.0000 kg. The large standard deviation for users (36,107.88 kg) suggested considerable variation in their output, while non-users show much less variation (6,082.55 kg). The study concluded that the use of DPTT had positive effect on maize production in CRS. Key factors such as illiteracy, cost of DPTT, interest rate, internet connectivity and electricity were found to significantly influence the use of DPTT. Overall, DPTT has played a role in reducing poverty among maize farmers in the area, further efforts are needed to address the ongoing challenges. Based on the findings of this study, the following recommendations were made; government should encourage a platform where users of DPTT can share knowledge, practices, and experiences with non-users to encourage the later to adopt this method of agriculture and the government should facilitate farmers' access to microfinance and low-interest loans, to enable them to acquire DPTT.

INTRODUCTION

Agriculture is the mainstay of the Nigerian economy, contributing 23% of GDP and more than 60 per cent of the estimated economically active population of the country depends on it for their livelihood (Federal Ministry of Agriculture and Rural Development (FMARD), 2020). Agricultural production grew throughout the 1980s-1990s to attain self-sufficiency in major staples like maize, sorghum, millet as well as in cassava, yams and cocoyam. Though the perceived growth mainly came from increase in land area under cultivation and not on the use of DPTT in farming. The sector growth however became unsatisfactory afterward especially when measured in terms of improved production, productivity, food insecurity and malnutrition. Food production gains have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency.

World agriculture needs to undergo a major transformation especially in the use of digital platform and traceability technology to meet the future demands of a growing population (Van-Loon *et.al*.,2018). Over the years there has been issues surrounding food production: global changes in population, economy, and climate continue to impose grand challenges on agriculture. It is estimated that by 2050, the food industry will have to face the daunting challenge of feeding about 10 billion people by almost sustainably doubling its food supply (UNDP, 2021). Providing sufficient, safe and nutritious food to all people is one of the major global concerns historically and in the twenty-first century. T"Mbieka (2021) noted that recent developments in digital platforms and traceability technologies and big data combined can enable farmers to better understand the agronomics of crop and animal production and to vary their management practices in response to site-specific growing conditions, which can increase the efficiency of input use and increases agricultural (Zagorda and Walczykova, 2018).

Experts are worried that current rates of increase in yields of agricultural output will not double agricultural production by 2050 and will not march the estimated mouths to be fed during that time without the use of smart practices like digital platforms and traceability technologies (United Nations Conference on Trade and Development(UNCTAD) (2017)**.** Ninety percent (90%) of agricultural production in Nigeria is the output of inefficient methods and technologies and low systems of production by small-scale farmers, who form 85% of farmers in the country (Food and Agriculture Organization (FAO) (2019). Increased demand for food must be met with greater agricultural intensification based on a combination of inputs, DPTT especially those with minimal effect on the environment (Pfost and Casady, 2020). This because DPPT allows farmers use resources more efficiently, applies water, fertilizer and pesticides precisely where and when needed and making better management decisions from data. Eighty percent of the increase in production in Nigeria should be able to come from improved crop yields, higher cropping intensity, which could be achievable through the use of DPTT in agriculture. Large scale and export (or revenue generation) oriented agriculture have suffered great setback in recent times. But with the recent quest of the Federal and some State governments into the development of large-scale agriculture and mechanized farming in order to shore up food security and foreign exchange earnings, there is need for adoption of DPTT, which offer a wide range of applications in order to effectively harness human, natural and man-made resources for sustainable agricultural production (Zagorda and Walczykova, 2018).

According to Opaluwa *et.al*., (2023) maize is a staple food and significant crop in Nigeria, with the country being the largest maize producer in Africa. It's widely consumed, utilized for animal feed, and plays a crucial role in Nigeria's economy, accounting for a portion of the country's GDP (Opaluwa *et. al*; 2023). Nigeria's maize production has significantly increased over the years, with local production meeting about 72% of the total annual demand in the country. Researchers believe that the use of DPTT in the crop production would ensure sustainable production for local consumption and export purposes (PricewaterhouseCoopers Nigeria, 2021). Maize production is also of utmost importance to the Nigerian economy, considering its commercial prominence and food values, which has successfully made incursion into the diets of Nigerian.

Digital traceability in the agri-food industry can be defined as the use of digital technologies to monitor food products as they move through the supply chain system (Kalu *et. al*., 2024). This includes identifying the origin, processing, distribution, and sale of food items, as well as any intermediate steps in their journey. Community Regulation 178/2002 defines traceability as the ability to trace and follow a food, feed, food-producing animal, or substance intended to be or expected to be incorporated into a food or feed through all stages of production, processing, and distribution. Abdulsalam (2019) posited that digitalized tracing in this industry has offered substantial contributions to enhancing food safety and quality, offering consumers authentic and trustworthy food products. These advanced technologies according to International Institute for Tropical Agriculture (IITA) (2021) include, but are not limited to, information and communication technology (ICT), blockchain: used to create a secure and transparent record of a product's journey through the supply chain. RFID: Radio-frequency identification (RFID) tags can be attached to products to track their movement and location. The Internet of Things (IoT); uses sensors and devices to collect data from various points in the supply chain. Cloud-based Databases (CBD):; provide a centralized and secure location for storing and sharing data. artificial intelligence (AI) and machine learning (ML); used to analyze data and identify patterns and trends in the supply chain and the Internet of Things (IoT). Opaluwa *et.al*. (2023) noted that additionally, tools such as smart sensors, autonomous tractors, and spray drones (leveraging 5G technologies) exemplify the digitalization of the agri-food industry in contemporary times. These technologies not only aim to revolutionize the agri-food value chain but also aspire to promote sustainability. Notably, blockchain technology, when applied to food chains, offers the potential to refine traceability regarding pesticide usage and enhance the transparency of food information and product location as items traverse the supply chain from farm to fork (Pfost and Casady, 2020). Digital platforms facilitate the collection of data from various sources, including sensors, RFID tags, and other tracking mechanisms. AI and ML can then be used to analyze this data for predictive insights and data-driven decision-making.

Digital platforms and traceability technologies are transforming the face of modern farming. Digital advancements such as wireless communication, data analytics, and data-driven genome editing, are rapidly being applied in agriculture as they provide more accuracy in decision making and practice (T"Mbieka, 2021). Satellite and Global Positioning System (GPS) technologies, sensors, smart irrigation, drones, and automation, to list a few, provide the means for digital platforms and traceability technologies, which further aids in effective resource utilization. Van-Loon (2018) noted that DPTT is becoming an attractive idea in managing natural resources and realizing modern sustainable development of agriculture based on information technology. It is bringing agriculture into the information and digital age and incorporates technologies such as Geographic Information System (GIS), Satellite Remote Sensing and Global Positioning System (GPS). With the recent launch of the NigeriaSat-1, an earth observing satellite for the meteorological, natural resources, hazard observation and management purposes, Nigeria now joins the league of nations that have access to the opportunities afforded by DPTT in revolutionizing their agriculture (Kalu *et.al.,* 2024). As a result of the high consumption rate in the face of low output occasioned by non-use of DPTT in its production, domestic production has never been able to meet demand thereby leading to considerable importation of food to bridge the gap between domestic demand and supply (Zagorda and Walczykova, 2018). The study is predicated on these assertions and is designed to achieve the following objectives:

i. identify digital platforms and traceability technologies used by maize farmers in the area
ii. determine the factors influencing the output of maize production in the area.
iii. compare the output of maize farmers between users and non-users of DPTT in the area.

METHODOLOGY

Study area

Cross River State (CRS), Nigeria is the study area. What is now CRS was part of the former Eastern Region until 1967, when it became South eastern State and received its present name in 1976 (Cross River State tourism guide, 2009). The Cross River, after which the state is named, rises from the Cameroun Mountains and flows southward, forms most of the state boundaries. It is also an important commercial resource especially in the rainy season. The State is bounded by the States of Benue in the North, Ebonyi on the West, Akwa Ibom on the South west. It is bordered on the east by the Cameroon Republic and fronts the Atlantic Ocean on the South (Boundaries Commission, Newsletter, 2010).

The state lies between latitude $4^{o}15^{1}$ North and $7^{o}00^{1}$ North and longitude $7^{o}15^{1}$ East and $9^{o}30^{1}$ East (Cross River Ministry of Lands and Survey Bulletin, 2010). According to Federal Office of Statistics (FOS, 2007) the land area of CRS is about 7,782 square miles or 20,156 square kilometers and the population standing at 2,888,966 persons (NPC, 2006). Following an annual growth rate of 2.9%, it is expected that the population of CRS will hit over 4,400,000 million people by 2025. The state has a climate characterized by two distinct seasons-the dry and wet seasons. The dry season spans from November to late March, while rainy season spans from April to October with a short spell in August called "August break". The mean annual rainfall is between 1,300mm to 3,000mm, which varies from place to place across the state (Cross River State Tourism Guide, 2011). The vegetation of the state parades four distinct features: Mangrove Swamp (wetland), rainforest, derived savannah and parkland (Cross River Tourism Bulletin, 2010). The type of soil found in the area is deep laterite fertile and dark clayey basalt. Hence, agriculture is the major activity of Cross Riverians. Studies by Abang & Agom (2009) noted that over 75% of the people of the state are engaged in agriculture. For convenience of administration, the eighteen local government areas the state is divided into were further subdivided into three agricultural zones by the Cross River State Agricultural Development Project (CRADP). The Southern zone comprises the following local government areas. Akpabuyo, New Bakassi, Calabar municipality, Calabar South, Biase, Akamkpa, and Odukpani, with headquarters in Calabar municipality. The central zone has Yakurr, Abi, Obubra, Ikom, Etung and Boki, with headquarters in Ikom while the northern zone has, Ogoja, Bekwarra, Yala, Obanliku and Obudu, with headquarters in Ogoja.

Sampling technique and data collection: Stratified random sampling technique was used to select 120 respondents for the study. The three agricultural zones which reflected the demarcation structure of the State were covered. In the first stage, two LGAs were purposively selected into the sample. This gave a total of six LGAs in the sample. The second stage involved the random selection of five farming communities from the ten LGAs of the sample. The third stage involved a random selection of four farmers from the selected communities, two each of users and non-users of DPTT, resulting to a total of 120 respondents. Data for this study were obtained from primary source, obtained using a set of structured questionnaires. The questionnaire administered to respondents contained information on their socio-economic characteristics, types of agricultural technologies, cost of production, etc.

Data analysis

Data were analysed using the descriptive and inferential statistics, . Levene's test was used to compare the mean output of users and non-users of DPTT. The test examines whether the variances of the two groups are equal, while the Ordinary least squares regression model was used to analyse the factors influencing the output of the farmers.

Model specification

Multiple Regression

Model specification for Cobb- Douglas function for both users and non-users of DPTT

$$Y = b_0 + X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + ei \quad \text{(i)}$$

Where Y= output (kg)
X_1= farm size (hectares)
X_2= labour input (man days)
X_3 = quantity of seeds planted (kg)
X_4 = quantity of fertilizer (kg)
X_5 = educational attainment (years)
, X_6 = access to credit (1 = yes, 0 = no) e = error term
X_7 = farming experience (years)
e_i = Error term.

RESULT AND DISCUSSION

Types of digital platform and traceability technology used in maize production in the study area

The frequency distribution of respondents according to type of digital platform and traceability technology used in the study area is shown in Table 1. The use of relevant DPTT in maize production would enhance the output of the enterprise (Opaluwa *et. al*., 2023). From Table 1, 20% of the respondents indicated the use of blockchain in the study area, 8.3% indicated the use of RFID, another 16.7%, 25% and 8.3% indicated the use of IoT, Cloud-based Databases and AL respectively. and extension services 8.3%, 20% indicated the use of DLT and finally 16.7% accepted the use of ML in the study area. This trend is quite poor as could be seen as one of the reasons for the low output of maize in the study area.

Table 1: **Distribution of respondents according to type of digital platform and traceability technology used in maize production in the study area (n=120)**

Technology type	Frequency	Percentage %
Blockchain	24	20
Radio-frequency identification (RFID)	10	8.3
The Internet of Things (IoT)	20	16.7
Cloud-based Databases	30	25
AI (artificial techn.)	10	8.3
Distributed ledger technology (DLT)	24	20
Machine learning (ML)	20	16.7
Total	**138***	**115***

* Multiple responses were obtained

Source: field survey, 2025.

Factors influencing the output of maize production in the area

According to Table 2, the double log functional form provided the best fit and hence was chosen as the lead equation. This is based on the fact that it has the highest value of coefficient of multiple determination (R^2), highest number of significant variables and conformity to *apriori* expectation (expectation of the signs and magnitude of the variables). The F-ratio was statistically significant at 1%, implying that the sample data fitted the model and that the independent variables are important explanatory factors of the variation in the dependent variable. The R^2 was 0.926, meaning that about 93% of the total variation in the dependent variable was accounted for by the independent variable. The Table also shows that the coefficient for farm size, labour input, quantity of seed, educational attainment and access to credit were significant, while the coefficients of quantity of fertilizer and farming experience were not significant.

The coefficient of farm size was positive and significant at 1% level, implying that there is a direct relationship between farm size and the output of maize farmers and that an increase in the hectare of farmland, would invariably lead to an increase in the output of maize. The coefficient of labour input was also positive and significant at 5%level, implying that an increase in labour input would invariably lead to an increase in the output of maize. The quantity of maize seed was positive and significant at 1% level, showing that an increase in the quantity of maize seeds cultivated would invariably lead to an increase in the output of maize. Educational attainment was also positive and significant at 1% level, this indicate that the higher the level of educational attainment of the farmer, the higher his output. This is because adoption and non-adoption of DPTT in maize production is influenced by educational level of farmers. Adoption rate is high on as educational attainment of maize farmers increases. The coefficient of access to credit was also positive and significant at 5% level, implying that an increase in credit accessibility will lead to an increase in the output of maize production, this is so because DPTT use and non-use depends on funds availability, which is influenced by access to credit. This result conforms with that of T"Mbieka, (2021) in his study of cost and returns of paddy rice production in Kaduna State.

Table 2: Multiple regression results of factors influencing the output of maize production in the area

Variables	Linear form	Double log form	Semi log form	Exponential form
Farm size (X_1)	0.6550	0.9450	0.9340	0.6620
	(6.488)***	(9.350**	(6.080)***	(4.831)***
Labour input (X_2)	-0.1190	0.2150	0.0600	-0.0430
	(-0.398)	(1.116)*	(0.859)	(-0.668)
Qnty of seed (X_3)	0.4300	0.2000	0.4100	0.2410
	(4.800)**	(3.836)**	(5.165)**	(1.984)**
Qnty of fertilizer (X_4)	-0.0130	0.0390	0.0430	-0.1200
	(-0.134)	(0.751)	(-0.543)	(-0.937)
Educational level (X_5)	0.0450	0.0700	0.1980	-0.1200
	(1.043)*	(1.629)**	(3.018)***	(-0.375)
Access to credit (X_6)	0.0370	0.0510	0.0000	0.0790
	(0.885)	(1.231)*	(-0.0060)	(1.375)*
Farming experience (X_7)	-0.0560	-0.0760	-0.0050	-0.0300
	(-0.8930)	(1.072)	(-0.420)	(-0.350)
R^2	0.9030	0.9260	0.8290	0.8590
F-ratio	4.2264	2.9185	16.1218**	6.3358
Constant	18.2908	15.4209	38.9126	29.0422

*** = significant at 1%, **= significant at 5%, *= significant at 10%

Determination of the level of output of users and non-users of DPTT

The analysis demonstrates a statistically significant difference in mean output non-users of DPTT. The mean output of users stands at an impressive 25,951kg surpassing the significantly lower output of non-users which registered at 9,550kg. The analysis clearly shows a statistically significant difference in the mean outputs between the two group of farmers. The significant gap in mean outputs indicates that users have seen remarkable improvements in productivity, efficiency, and overall farming practices. These findings affirm the success of DPTT interventions in enhancing the capacity of farmers to produce.

Table 3: Mean output of users and non-users of users and non-users of DPTT in kilogram per hectare

CLASS	MEAN	DIFFERENCE
Users	25951	16401
Non-users	9550	

Source: Computed from field survey, 2025

As shown in Table 3 below, the mean output of users of DPTT in kg per hectare is 46,100 kg while the mean output of non-users of DPTT is 9,550.0000 kg. The high output (46,100 kg) of users is high probably because DPPT allows farmers use resources more efficiently, applies water, fertilizer and pesticides precisely where and when needed and making better management decisions from data for improve output (T'Mbiebaka, 2021) There are two parts that provide useful information: (i) Levene's test for equality or variance and (ii) t-test for equality or means. Levene's test for equality of variance: This test results for Levene's test from left to right. F is the test statistics of Levene's test. The objective of this analysis is to compare the mean output between 60 users and 60 non-users of DPTT in maize production using an independent samples t-test.

Users of DPTT

Mean = 46,100.0000 kg

Standard Deviation = 36,107.87930 kg

Standard Error = 8,073.96726 kg

Users of DPTT

Mean = 9,550.0000 kg

Standard Deviation = 6,082.54621 kg

Standard Error = 1,360.09868 kg

The users have a much higher mean output (46,100 kg) compared to non-users (9,550 kg). The large standard deviation for beneficiaries (36,107.88 kg) suggests considerable variation in their output, while non-users show much less variation (6,082.55 kg).

Levene's Test for Equality of Variances

F = 20.208, Sig. = 0.000:

With a p-value of 0.000 (less than 0.05) it means that the variances between users and non-users are significantly different, so we will use the row labeled "Equal variances not assumed" for the test results.

Independent Samples Test for Equality of Means

Equal variances not assumed

t = 4.464

df = 20.077

Sig. (2-tailed) = 0.000:

The p-value is less than 0.05, meaning the difference in mean outputs between users and non-users of DPTT is statistically significant. The results indicate strong evidence that the mean output for users is significantly higher than that of non-users.

Mean Difference = 36,550.00000 kg: on the average, users produce 36,550 kg more than non-users. The t-test results show a significant difference in the mean output between the two group of farmers, with users producing an average of 36,550 kg more than non-users. The high statistical significance (p = 0.000) confirms that the use of DPTT has a positive and substantial impact on maize production output. The confidence interval also provides strong evidence that this effect is real and not due to random variation.

Group Statistics

	Category	N	Mean	Std. Deviation	Std. Error Mean
Output	Users	20	46100.0000	36107.87930	8073.96726
	Non users	20	9550.0000	6082.54621	1360.09868

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Output	Equal variances assumed	20.208	.000	4.464	38	.000	36550.00	8187.72	19974.82	53125.18
	Equal variances not assumed			4.464	20.08	.000	36550.00	8187.72	19474.93	53625.07

CONCLUSION

The study concluded that the use of DPTT has had a positive effect on maize production in CRS, with users achieving higher average outputs than non-users. Key factors such as illiteracy, cost of DPTT, interest rate, internet connectivity and electricity were found to significantly influence the use of DPTT. Overall, DPTT has played a role in reducing poverty among maize farmers in the area. Based on the findings of this study, the following recommendations were made; non-governmental organizations (NGO's) and other stake holders should provide a platform where users of digital platform and traceability technology can share knowledge, practices, and experiences with non-users to encourage the later to adopt this method of agriculture and farmers' access to microfinance should be encourage by the banking industry to facilitate procurement and use of DPTT by farmers, relevant stakeholders should be made to address the ongoing challenges of use of DPTT and low-interest loans, to enable them acquire DPTT.

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