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Survey of emerging technologies and return on investment in oil palm business in south-south states of Nigeria

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Abstract

The difference between the oil palm business in developed economy like Malaysia and that in less developed economy like Nigeria can be traced to technological advancement. Therefore there is continuous search for production and processing technologies that can drive development of the oil palm value chain. The broad objective of the study was to investigate the effect of innovative technologies on performance of oil palm business in South-South geo-political States of Nigeria. The study employed a multi-stage sampling procedure. Well validated structured questionnaires were used as instrument for data collection. Collected data were analysed using descriptive and inferential statistical tools such as mean, Percentage, Standard Deviation, Frequency Distribution Table, enterprise budgeting, and ordinary least square regression analysis. Socioeconomic characteristics of operators were diverse, with a predominance of young, married, male farmers (60.9%) engaged in small-scale production (mean farm size: 13.2 hectares). Traditional tools still dominated harvesting, but hydraulic press (adopted by 71.1%) and automated mills (5.3%) were adopted for processing. Value addition was substantially improved by processing technology and harvesting equipment in the South-South States of Nigeria. The study concluded that appropriate innovative technologies positively impacted profitability, efficiency, product quality, sustainability, and competitiveness. Training, subsidies and robust extension services to promote adoption of innovative technologies in the South-South States of Nigeria were recommended. The study has contributed to existing body of knowledge by affirming the central role of innovation in profit function and sustainability in the oil palm sector.

Keywords: Emerging technologies; Innovation; Return on investment; Oil palm business; Nigeria

1. Introduction

The difference between Nigeria and the Asian giants in the oil palm industry hinges on the fact that on the one side, the Asian giants (Malaysia and Indonesia) have advanced into export-oriented manufacturing industries with a strong base of technological capacities, while the others like Nigeria, has remained largely low in technological capacities across most sectors (Lall and Pietrobelli, 2002). Because of technological advancement, Malaysia now accounts for about half of the world oil palm production, evolving from simple cultivation and crude processing to becoming the oil palm industry's leading technological innovator, and thus controlling the global industries value-added chain.

Given the scenario of technological innovations that have taken the Malaysian and Indonesian oil palm industry to the global scale as it is today, one is poised to look at the industry as it were with a view to ascertain the level of innovative technological advancement in the oil palm industry in the south-south states of Nigeria. This will aim to bridge the gap in technological advancement with a view to identify innovative technologies available to our local industry, and how the available technologies have helped in developing the industry.

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Technology however cannot thrive or even grow without creativity and Innovation which involve risk, mistakes and even failures. Therefore, there is need to educate and train entrepreneurs so that they can fully utilize their creative capacity and innovate new ideas, goods, and services which will enhance the development of our national economy.

The Agricultural sector has been neglected as a vehicle of development and poverty reduction, and a lack of private and public investment has led to lower productivity growth rates and stagnated production in many developing economies (Olayide, 2014).

The focus of this research work is to look at the Effect of Innovative Technologies on the performance of Oil Palm Business in South-South Geopolitical zone of Nigeria. As mentioned earlier, innovative technology represents a potential source of competitive advantage. In other words, innovative technology needs to be taken into accounts as an important new contingency factor to affect the strategy- performance relationship (Zott et al., 2010).

Firms in general seek opportunity to generate income by adapting new behavior patterns in frequently changing conditions. Their quest for new ways of operations can be facilitated by business modelling as it analyses firm processes, and shows the opportunities for innovative technologies and creativity, pointing out whether the firm is able to implement a new idea brought in from external environment, rather than seeking for the innovative technology potential internally (Hron et al., 2012). For emphasis, ever since the concept was brought to academia, innovative technology in business is considered as a source of competitive advantage (Casadesis-Masanell and Zha, 2013; Family and Lecocq, 2010; Teece, 2010) that ultimately leads to financial performance (Foss and Saebi, 2017). This prominent link is somewhat the crux, but also the corner stone of business comparative advantage.

No doubt empirical studies acknowledge that performance implications differ across firms in their early or late life cycle stages in case of more efficiency centered business innovations (Bettel *et a*l. 2012), a paucity of studies, however, remains investigating the effect of innovative technologies on the performance of oil palm business. To this end, it has therefore become imperative to empirically fill the knowledge gap that exist by establishing the effect of innovative technologies as it relates to performance of oil palm business. For the oil palm business generally, doing this research will give definite direction on the trend of available innovative technologies in the oil palm sector for possible investment attraction.

The development of emerging technologies theory has been viewed as a balance between two contrasting camps. According to Adner & Levinthal, (2002); Tushman & Anderson, (1986), one of the camps views technologies to have a slow, steady, and incremental development and the other in which technologies emerge with rapid, discontinuous, sometimes clamorous change. In the middle, is a camp that recognizes both ends of the scale and all in between points, depending on many contingencies that might occur during the life of technology's development (Musiolik and Markard, 2011). Rotolo et al, (2015) combed 2,201 publications from 1971 through 2014, eventually reducing the set to 501 journal articles they studied. That set was reduced to 12 core studies representing "science and technology policy, evolutionary economics, management, and scientometrics to conceptualize technology emergence" (Rotolo, et al., 2015). Rather than a single definition, emerging technologies are recognized by five key properties from those studies. These properties are, novelty, relatively fast growth, coherence, prominent impact, uncertainty, and ambiguity (Rotolo, et al., 2015). According to Rotolo, et al., (2015), business research supports the notion that emerging technologies demonstrate relatively fast growth rates when compared to non-emerging technologies. Rapid growth is based on patents and document counts fitted to e.g., logistics function by (Jarvenpaa et al. 2011), by 'burst of activity' in publications (Klienberg, 2002), or by co-citation analysis (Chen, 2006; Kwon, et al., 2019). The rapid growth sought is all in research domains, however and not in consumer domains (Kwon, et al., 2019; Rotolo, et al., 2015).

Rotolo, et al. (2015) developed a method for determining when a technology has ceased emerging by evaluating the inflection point of growth relative to the inflection point on the novelty curve. When they cross, Rotolo et al, determine that technology should be considered 'emerged'. This phenomenon is demonstrated by the graphic in figure which shows the curves crossing.

Practical work includes the development of technology road mapping, which developed industry (Garcia and Bray, 1997) and carried into academia (Bildosolo, et al., 2018). Road mapping identifies characteristics of the underlying technologies, determines critical components and alternatives for their development and most likely, outcomes. At the end of that exercise, the sum of most likely outcomes is used to determine an estimate of time, cost, and likely components for the target technology (Garcia and Bray, 1997).

1.1. Attribute

Emerging Technologies theory has several contributions to note. The theory attempt to define the change of the state from emerging to emerged (Rotolo et al., 2015). Emerging technologies theoreticians sees emerging technologies' uniqueness and variety of characteristics in terms of product development, market growth, novelty, ambiguity/certainty of product definition, market impact etc. Technology road mapping adoption by emerging technology theorists developed the practice in new areas, including very early emerging technologies and Precision Agriculture

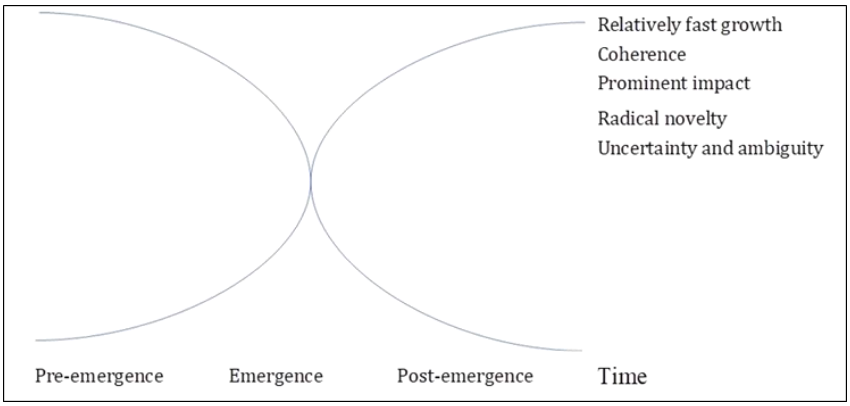

Figure 1 Emerging Technologies

2. Material and methods

2.1. Study Area

The study was conducted in the South-South states of Nigeria. The South-South states are made up of Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers States. The South-South is located at latitude 4^0N and longitude 6^0E, with an area of 84,587km^2. It has a coastline spread over 540km and was described by the World Bank in 1985, as the world largest wetland and 'Africa's largest delta'. The area is bordered to the south by Atlantic Ocean and to the east by Cameroun. The inhabitants of the zone include the Izons, Urhobo, Isoko, Ikwere, Ika, Ukwani, Abua, Itsekiri, Ogoni, Efik, Ibibio and Bini (Ibaba, 2005; Etekpe, 2007). The region has diverse vegetation belts from the largest rain forest in Nigeria to mangrove swamp, savannah, mountains and waterfalls, with rare animals, including endangered species and unusual plant families, making it one of the world's richest biodiversity center attracting scientists and tourists alike. Fishing has been a major economic activity in the area. Yams, Cassava, Plantain, Oil Palms and Bananas are the main crops grown. The inhabitants also participate in Palm Oil milling, lumbering, palm wine tapping, local gin making, trading, carving and weaving.

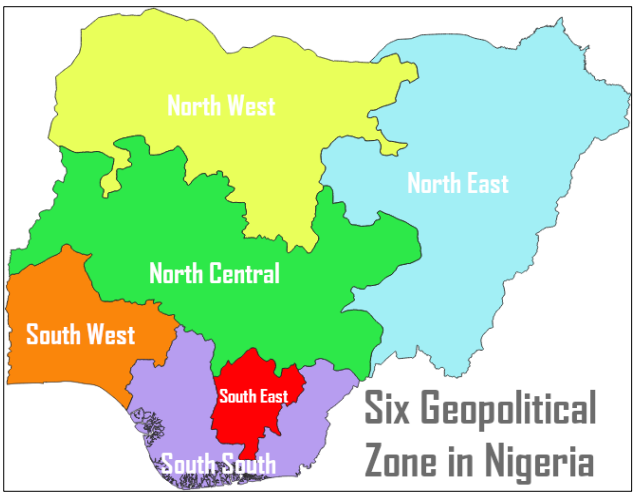

Figure 2 Map of Nigeria

2.2. Sampling Procedure

The study population comprised of all those involved in oil palm business in the six states that make up south-south states of Nigeria. For specifics, the study adopted one cash crop (Oil Palm), for the study. A multi-stage random sampling procedure using Cochran, 1984 and the table of arbitrary numbers was adopted for sample selection.

In the first stage, three states were purposively selected from the six states that make up the south-south geopolitical zone of Nigeria. Here, the issue of the three old states prior to the creation of the six existing south-south states was considered in selecting the sample states. This was to ensure even coverage of the south-south states. Here, in the old Cross Rivers State which is now Cross Rivers and Akwa Ibom States, Cross River State was selected; in the old Rivers state which is now Rivers and Bayelsa States, Rivers State was selected; in the old Bendel State comprising of Delta and Edo States, Delta State was selected. In the second stage, three local government areas each, was selected from the three states. This gave a total of nine local government areas.

The third stage involves the selection of 50 respondents from each of the nine local government areas selected for the research work. In all, a total of 450 oil palm farmers was sampled for this research work.

2.3. Methods of Data Collection.

Data for the study was collected from primary sources. Semi-structured questionnaires, designed to suit relevant data from each of the oil palm business was validated and used as the instrument for data collection using trained enumerators. The questionnaire after design was pre-tested by way of a pilot survey for reliability and appropriateness. Relevant corrections were made before field administration. The designed questionnaire was given to experts including the researcher's supervisors for scrutiny, comments and criticism. The questionnaire was sectioned according to the specific objectives of the study. The questionnaire was designed to obtain information on Innovative Technologies in oil palm business, issues of value addition in Oil Palm business, harvesting and processing innovative Technologies in Oil Palm business, new product development that have sprang from innovative Technologies in oil palm business as well as risk factors and constraints that are associated with innovative Technologies in Oil Palm business. In order to answer our research questions, data was collected from ventures and individuals who are engaged in oil palm business.

Methods of Data Analysis.

Data generated for the study were analyzed through the use of descriptive, budgetary analysis and inferential statistical techniques.

- Objective (1) was realized with the use of descriptive statistics.
- Objective (2), was achieved with the use of budgeting and profitability analytical tools.

2.4. Test of Hypotheses

Hypothesis 1 was tested using the T-test analytical technique

3. Results and discussion

3.1. Socioeconomic characteristics of oil palm business operators

3.1.1. Age

The result of the study shows that the majority of the oil palm business operators in South-South Nigeria are in the age range of 34 to 44 years, accounting for 41.8 percent of the total sample. The mean age of the operators is 50 years, which suggests that they have accumulated enough experience and capital to run their businesses efficiently. The result is consistent with the findings of previous studies on the demographic characteristics of oil palm farmers in Nigeria. For instance, Oluwatusin (2014) reported that 42.5 percent of the oil palm farmers in Ondo State were between 40 and 49 years old, while Oyekale (2017) found that 48.6 percent of the oil palm farmers in Cross River State were between 41 and 50 years old. The result also implies that there is a need for more youth involvement and empowerment in the oil palm industry to ensure its sustainability and growth.

3.1.2. Sex

From the result in Table 1, it can be seen that the majority of oil palm business operators are male, accounting for 60.9% of the sample. This implies that oil palm production is a male-dominated activity in South-South Nigeria. However, female participation is also significant, as they represent 39.1% of the operators. This suggests that oil palm production is also a source of income and empowerment for women in the region. This situation reflects the general trend of gender inequality in the agricultural sector, especially in developing countries. Several studies have examined the causes and consequences of this imbalance, such as Kabeer (2005) in Bangladesh and Odimegwu et al. (2018) in Nigeria. These studies reveal that women face various social, cultural, and economic barriers that limit their participation and decision-making power in agricultural activities, including oil palm farming. They also highlight the need for more inclusive and gender-sensitive policies and interventions to promote equal opportunities for both male and female business operators in the oil palm industry and beyond.

Table 1 Socioeconomic characteristics of oil palm business operators

Variable	**Frequency**	**Percent**	**Mean**
Age (years)			
23 – 33	4	0.9	
34 – 44	188	41.8	
45 – 55	82	18.2	50 years
56 – 66	176	39.1	
Sex			
Male	274	60.9	Male
Female	176	39.1	
Marital status			
Single	143	31.8	
Married	223	49.6	Married
Divorced	47	10.4	
Widowed	37	8.2	
Household Head			
Yes	184	59.1	Household heads
No	266	40.9	
Years of formal education (years)			
1 – 5	6	1.3	
6 – 10	103	22.9	
11 – 15	206	45.8	12 years
Above 15	135	30.0	
Farm size (hectares)			
Less than 10	176	39.1	
10 – 20	145	32.2	13.17 hectares
21 – 31	84	18.7	
Above 31	45	10.0	
Occupation			

Trading	142	31.6	
Civil servant	57	12.7	
Farming	251	55.8	Farming
Farming experience (years)			
Less than 10	36	8.0	
10 – 20	189	42.0	
21 – 31	167	37.1	21 years
Above 31	58	12.9	
Membership of Cooperative Society			
Yes	355	78.9	Member of cooperative society
No	95	21.1	
Contact with extension agents (number of times)			
Less than 2	223	49.6	
2 – 3	197	43.8	2 times
4 – 5	30	6.7	

3.1.3. Marital status

The study reveals a diverse range of marital statuses among operators, with 49.6% being married, 31.8% single, 10.4% divorced, and 8.2% widowed. The prevalence of married operators suggests that marital status may have an influence on participation in the oil palm business, potentially driven by shared responsibilities and financial security within family structures. It could also indicate the existence of family-owned or family-operated businesses in the sector, highlighting the interconnection between family dynamics and entrepreneurial endeavours. On the other hand, the significant proportion of single operators indicates the presence of a younger or unmarried demographic segment within the industry, potentially offering opportunities for targeted support, training, and financing tailored to their unique needs. The study also underscores the relevance of individuals who are divorced or widowed in the oil palm sector, constituting 10.4% and 8.2% of operators, respectively. These groups might be drawn to entrepreneurship as a means of income generation and self-sufficiency following significant life changes, and understanding their experiences and needs could be critical for providing effective support. According to Adesina and Chianu (2002), marital status is a determinant of farmers' adoption and adaptation of agricultural technologies, such as alley farming, which could enhance the productivity and profitability of oil palm production. Moreover, marital status could also affect the availability of labour, capital and social networks for the oil palm business operators. For instance, Akinwumi and Ogunsola (2018) found that married respondents had more access to family labour, joint income and social support than single, divorced or widowed respondents in Ondo State, Nigeria. Therefore, marital status is an important socioeconomic characteristic that should be considered in analyzing the oil palm business operators in South-South Nigeria. Odoemenem and Inakwu (2011) suggested that policy interventions should target the specific needs and constraints of different categories of oil palm marketers based on their marital status.

3.1.4. Household head

The result in Table1 shows that the majority of the operators (59.1%) are household heads, meaning that they are responsible for providing for their families and dependents. This implies that oil palm business is a viable and profitable venture that can sustain livelihoods and contribute to economic development. On the other hand, 40.9% of the operators are not household heads, meaning that they are either single, married but not the main breadwinners, or living with relatives or friends. This suggests that oil palm business is also accessible and attractive to different segments of the population, regardless of their marital or family status. This result is consistent with that of Odoemenem and Inakwu (2011) who found that oil palm marketing was dominated by women who were mostly household heads with low levels of education and income. Similarly, Akpan et al. (2013) found that oil palm production was profitable for smallholder farmers who were mostly household heads with an average age of 50 years.

3.1.5. Years of formal education

The result reveals that the majority of the operators (45.8%) have completed secondary education, with a mean of 12 years. This indicates that the oil palm business requires some level of literacy and numeracy skills to manage the production and marketing activities. The result also shows that 30% of the operators have attained tertiary education, which may reflect their access to information and technology, as well as their ability to adopt innovations and best practices in the oil palm sector. On the other hand, only 1.3% of the operators have less than five years of formal education, which suggests that they may face challenges in accessing credit, inputs, extension services, and market opportunities. This result supports the findings of Odoemenem and Obinne (2011) who found that 48% of the oil palm farmers in Benue State, Nigeria had secondary education, while 28% had tertiary education. Similarly, Oyekale et al. (2012) reported that 46.7% of the oil palm farmers in Ondo State, Nigeria had secondary education, while 26.7% had tertiary education. Furthermore, a study by Feintrenie et al. (2010) on the oil palm smallholders in Cameroon and Indonesia revealed that the level of formal education was positively correlated with the adoption of improved oil palm varieties and the use of fertilizers and pesticides. Therefore, it can be inferred that the level of formal education is an important factor that influences the performance and profitability of oil palm business operators in South-South Nigeria and beyond.

3.1.6. Farm size (hectares)

The result in Table1 indicates that the majority of the oil palm business operators (39.1%) have less than 10 hectares of oil palm plantation, followed by 32.2% who have between 10 and 20 hectares. The mean farm size for this category is 13.17 hectares, which suggests that most of the operators have small-scale farms. The result also reveals that only 18.7% of the operators have between 21 and 31 hectares, and a minority of 10% have above 31 hectares of oil palm plantation. This implies the presence of large-scale oil palm production in South-South Nigeria. Previous studies have shown that farm size is positively correlated with productivity, profitability, and adoption of improved technologies in oil palm production (Oluwatusin, 2014; Oyekale, 2017). However, farm size may also have negative effects on biodiversity, soil quality, and carbon emissions due to land clearing and expansion of oil palm plantations (Oyekale et al., 2012).

3.1.7. Occupation

The result in Table 2 shows that a substantial portion, accounting for 55.8%, is primarily engaged in farming. This underscores the agricultural bedrock upon which the oil palm sector in the region is founded. According to Statista (2022), Nigeria stands as one of the world's foremost oil palm producers, and this industry significantly bolsters the nation's economy, particularly through the substantial contributions of smallholder and subsistence farmers. The pre-eminence of farming within the sector highlights the profound role it plays in the livelihoods of rural communities in South-South Nigeria. This result corresponds to a broader context presented by PwC (2019) of oil palm's pivotal role in Nigeria's economic landscape, impacting both the agricultural and industrial sectors. It's worth noting that the oil palm sector's agricultural nature, as indicated by the high percentage of farmers involved, underscores its resilience and prominence as a cornerstone of the regional and national economy. The presence of trading and civil servant occupations, making up 31.6% and 12.7% of the operators, respectively, within the oil palm industry underscores its capacity to attract individuals from diverse professional backgrounds. The trading activity could encompass a range of activities, including the buying and selling of oil palm products or the provision of supportive services to the industry, showcasing the multi-dimensional facets of the oil palm value chain. Civil servants involved in oil palm operations may engage with the sector as a supplementary source of income, reflecting the sector's economic viability and potential profitability. This diversity of occupation within the oil palm sector illuminates the adaptability and versatility of the industry, making it not just an agricultural endeavour but also a business and employment opportunity.

3.1.8. Farming experience

The result from the study showed that majority of operators, accounting for 79.1%, possess over a decade of experience, with 42.0% falling in the 10 to 20-year category, and 37.1% having 21 to 31 years of farming experience. This distribution underscores a wealth of industry knowledge and expertise within the region, which is fundamental for the sustainable cultivation and management of oil palm plantations. Furthermore, the mean years of farming experience, calculated at 21 years, signifies a well-established and enduring oil palm industry, possibly indicating generational involvement and a deep-rooted understanding of best practices. This result implies not only individual dedication but potentially reflects generational involvement in oil palm farming. The result corroborates with that of Corley, Tinker and Corley (2021), who reported that the passing down of expertise and traditional agricultural practices from one generation to the next is a critical aspect of sustaining and improving the oil palm industry. Such accumulated wisdom is pivotal in tackling the multifaceted challenges associated with the sector, particularly concerning sustainability and environmental issues. This substantial experience reservoir equips farmers to adopt and advocate for sustainable

practices, emphasizing the importance of striking a balance between economic progress and environmental responsibility in oil palm cultivation.

3.1.9. Membership of Cooperative Society

The result presented in Table 1 showed that the majority of these operators, comprising 78.9%, are affiliated with cooperative societies. This high percentage underscores the recognition among oil palm farmers of the significant benefits that cooperative membership brings. A study by Zakaria, Rahim and Aman (2020), stated that cooperative societies serve as vital platforms for collective action, allowing small-scale farmers to pool their resources, share knowledge, and collectively address challenges. By joining cooperatives, oil palm operators can enhance their bargaining power, secure better prices for their produce, and access valuable resources such as credit and agricultural extension services, ultimately leading to improved socioeconomic conditions. The presence of a substantial number of operators (21.1%) who are not part of cooperative societies highlights an opportunity for outreach and support programs. Non-cooperative members may face difficulties related to resource access, market fluctuations, and limited access to agricultural extension services.

3.1.10. Contact with extension agents

The result showed that nearly half of the operators, representing 49.6%, have had limited or no contact with these essential professionals. This could signify potential challenges in accessing valuable agricultural advice and training that can significantly improve oil palm farming practices and productivity. In contrast, 43.8% of operators have engaged with extension agents between 2 to 3 times on average. This indicates that a substantial portion of operators is actively seeking guidance and support, albeit with a moderate frequency of contact. Meanwhile, a smaller percentage, 6.7%, maintains more frequent contact with extension agents, showcasing a proactive approach in seeking professional assistance. These operators may be better positioned to adopt improved farming practices and effectively address agricultural issues. Nevertheless, the overall result implies potential disparities in access to agricultural extension services among oil palm operators, which can have significant implications for their productivity and the sustainability of the oil palm industry. This result corroborates with that of Danso-Abbeam, Ehiakpor and Aidoo (2018) reported that extension services play a pivotal role in agriculture by disseminating the latest research findings, best practices, and technological innovations to enhance crop yields, reduce losses, and address sustainability concerns. The result underscores the importance of ensuring equitable access to these services for all oil palm operators in the region. It also raises concerns about the accessibility and availability of extension services, suggesting that geographical constraints, limited resources, or other challenges may be hindering some operators' ability to access this vital support. Policymakers and agricultural organizations should consider these findings when developing strategies to improve access to extension services. This could involve expanding the outreach efforts of extension agents, utilizing technology to provide remote support, or strengthening the capacity of existing extension services in South-South Nigeria to ensure that all oil palm operators can benefit from professional agricultural guidance and support, ultimately boosting productivity, promoting sustainability, and enhancing the livelihoods of those in the industry.

3.2. Innovative technologies used in the oil palm business

3.2.1. Harvesting Technologies

The result in Table 2 shows that traditional technologies still dominate the landscape, with 82.9% of oil palm operators relying on the time-honoured sickle for harvesting. In parallel, tools like chisels (41.1%), climbing ropes (38.2%), and ladders (38.0%) continue to hold a significant presence. This emphasis on traditional tools suggests a degree of continuity in manual labour practices within the oil palm sector. However, signs of modernization are discernible, with 12.9% of operators opting for mechanically driven harvesting machines, representing a shift towards more efficient and mechanized methods. The limited usage of mechanized cantas (2.9%) reflects the cautious pace at which mechanization is being adopted. This nuanced harvesting technology landscape carries several implications. According to FAO (2022), mechanized technologies offer the promise of increased efficiency, reduced labour costs, and improved productivity, aligning with the broader global trend toward agricultural modernization. Nonetheless, the transition from traditional to mechanized harvesting is not without its challenges, including the initial cost of equipment and the need for training. As such, there is a critical need for support programs and investment in research and development to advance and promote accessible mechanized solutions. The coexistence of traditional and mechanized tools also underscores the adaptability of oil palm operators, who may choose the best-suited technology based on factors such as farm size, available resources, and local conditions. These findings underscore the importance of a balanced approach to innovation in the oil palm sector, addressing sustainability, efficiency, and safety while considering regional variations and the unique needs of operators.

3.2.2. Processing Technologies

As shown in Table 2, nearly half of the operators (48.9%) still adhere to traditional processing methods. These methods, rooted in local practices and manual labour, are deeply entrenched in the region's heritage and often associated with smaller-scale or household-level production. Meanwhile, a significant majority (71.1%) has adopted hydraulic press processing machines, indicating a substantial transition toward mechanized and more efficient oil palm processing. The hydraulic press is designed to enhance oil extraction, improve yield, and reduce labour-intensive work, which can contribute to increased productivity and higher-quality oil production. In contrast, a smaller proportion (1.1%) has embraced advanced industrial processing systems, showcasing the potential for modernization and improved efficiency in the oil palm sector. Automated palm oil processing mills are used by 5.3% of operators, signifying an ongoing shift toward automation and industrial-scale processing. One of the benefits of automated mills is that they can significantly boost processing efficiency, making them well-suited for larger operations. According to Bratney (2022), automated milling machines can reduce human labour, optimize losses, and produce high-reliability products. The coexistence of these various processing methods underscores the need for continued technological advancements and investments in the sector to improve processing efficiency, oil quality, and overall productivity. Teow et al. (2022) reported that the choice of processing technology in the oil palm sector is pivotal as it has profound implications for productivity, product quality, and competitiveness in the market. Mechanized and advanced processing systems have the potential to significantly enhance oil extraction rates and the consistency and quality of palm oil produced. The transition from traditional methods to mechanization aligns with the broader global trend toward agricultural modernization, which aims to improve efficiency and meet the growing demand for sustainable and high-quality agricultural products.

3.2.3. Transportation Technologies

The result in Table 2 showed that traditional methods still hold a significant presence, with wheelbarrows being the most widely used (51.8%). These are especially relevant for smaller-scale and localized operations. In contrast, powered and mechanized technologies are on the rise, with 23.6% using powered wheelbarrows and 4.4% utilizing compact transporters, indicating a shift towards improved efficiency and reduced manual labour. The adoption of such mechanized methods enhances productivity and can significantly affect the overall logistics of the oil palm business, ensuring timely harvesting, processing, and market delivery. One noteworthy aspect is the popularity of pick-up vans, employed by a significant majority (63.6%) of operators, highlighting the importance of larger vehicles for bulk transportation and distribution. According to Varkkey (2012), vans are instrumental in the efficient movement of larger quantities of oil palm products, essential for economies of scale and the commercial viability of the sector. Additionally, the embrace of advanced technologies such as the compact transporter signifies a move toward improved efficiency and reduced manual labour, essential in streamlining productivity. The choice of transportation technology is not only pivotal for productivity but also has significant implications for worker well-being, environmental sustainability, and the overall competitiveness of the oil palm industry. This result exemplifies the adaptability of oil palm operators to diverse operational needs and geographical terrains, underlining the importance of ongoing technological advancements to ensure the industry's sustainability and competitiveness in South-South Nigeria.

3.2.4. Storage Technologies

The result in Table 2 showed that drums, employed by 50.9% of operators, represent the enduring legacy of traditional storage practices. These are often associated with smaller-scale and localized storage, reflecting the importance of local heritage in the industry. In contrast, tanks (42.9%) and tankers (48.9%) denote the integration of more modern and mechanized storage solutions, likely catering to larger quantities and scaling up production. This shift towards modern storage is indicative of a larger trend within the industry, seeking enhanced efficiency, capacity, and quality preservation. A study by Chong (2000) reported that the choice of storage technology directly influences the logistical efficiency, capacity, hygiene, and quality of stored palm oil. Tanks and tankers offer the advantages of larger storage capacities, which are essential for commercial and industrial-scale operations. They also align with stringent hygiene standards, preserving the quality and marketability of the oil palm products (Chong, 2000). As the industry continues to grow, the evolving landscape of storage technologies will play a vital role in ensuring sustainability, quality, and the market competitiveness of the oil palm business in South-South Nigeria.

3.2.5. Packaging Technologies

The result in Table 2 showed that 62.4% of operators employ gallons or jerry cans, which favoured their sturdiness and capacity to hold larger quantities of palm oil. This packaging method is well-suited for bulk distribution, often seen in the wholesale market. About 42.9% opt for plastic bottles, while 45.6% use sachets, catering to retail and consumer markets. The choice of plastic bottles and sachets signifies a preference for user-friendliness and portability, especially when dealing with smaller quantities of palm oil. The packaging technology used in the oil palm sector plays a pivotal role in ensuring product quality, marketability, and environmental sustainability. This result corroborates with that of

Abdullah and Wahid (2010) who stated that proper packaging is instrumental in preserving the freshness of palm oil, preventing contamination, and extending its shelf life, all of which are paramount for product quality and consumer satisfaction. In an era marked by increasing environmental awareness, the choice of packaging technologies also holds environmental implications. Sustainable packaging options, including the use of biodegradable materials or the promotion of recycling initiatives, can reduce waste and mitigate the sector's environmental footprint (Basiron & Simeh, 2005). Moreover, understanding consumer preferences is crucial, as it guides marketing and sales strategies to meet the demands of target markets effectively.

3.2.6. Marketing Strategies

The study showed that stocking and selling emerges as the most dominant strategy, with 70.7% of operators involved in this approach. This method entails the bulk purchase and storage of palm oil, followed by sales either directly to consumers or to other retailers. It underlines the significance of organized storage and distribution within the sector, enabling operators to regulate prices and extend their market reach. Retailing, chosen by 60.7% of operators, emphasizes the direct sale of palm oil to individual consumers through local markets, shops, or other retail outlets. In contrast, Wholesale activities, engaging 44.9% of operators, cater to bulk distribution and sales to retailers or other distribution points. These strategies are essential for reaching a broader market, including businesses and retailers that require larger quantities of palm oil. Farm Gate Sales, involving 23.7% of operators, allows for direct sales from the farm to consumers, eliminating intermediaries and enabling a more localized approach. These varied strategies reflect the industry's adaptability and its capacity to address different market segments and consumer preferences effectively. The choice of marketing strategy is pivotal for market access, distribution networks, pricing, and overall economic viability. It directly influences the industry's ability to remain competitive and sustainable in response to evolving consumer preferences and market dynamics.

Table 2 Innovative technologies used in the oil palm business

Innovative Technologies	**Frequency**	**PercentageMean/Mode**
Harvesting Technologies		
Sickle	373	82.9 Sickle
Chisel	185	41.1
Mechanized Cantas	13	2.9
Mechanically Driven Harvesting Machine	58	12.9
Climbing Rope	172	38.2
Ladder	171	38.0
Processing Technologies		0.0
Local/Traditional Processing Method	220	48.9
Hydraulic Press Processing Machine	320	71.1 Hydraulic Press Processing Machine
Advance Industrial Processing System	5	1.1
Automated Palm Oil Processing Mill	24	5.3
Transportation Technologies		0.0
Motorcycle Trailer	197	43.8
Wheelbarrow	233	51.8
Powered/Motorized Wheelbarrow	106	23.6
Compact Transporter	20	4.4
Half-track	56	12.4
Crabbie	89	19.8
Otoway System	114	25.3

Cableway System	74	16.4
Ramp/Mobile Ramp	106	23.6Pick-up Van
Roller Loose Fruit Picker	47	10.4
Head Pan/Basin	202	44.9
Tractor-driven Trailer	198	44.0
Pick-up Van	286	63.6
Storage Technologies		
Drums	229	50.9
Tanks	193	42.9Drums
Tankers	220	48.9
Packaging Technologies		
Gallons/Jerry cans	281	62.4
Plastic Bottles	193	42.9Gallons/Jerry Cans
Sackets	205	45.6
Marketing Strategies		
Stocking and Selling	202	70.7
Farm gate Sales	147	23.7
Retailing	318	60.7Stocking and Selling
Wholesale	273	44.9

Multiple responses were recorded.

3.3. Costs and returns of oil palm business in the study area

The result in Table 3 shows the costs and returns associated with the oil palm business in South-South Nigeria.

3.3.1. Variable Costs

This constitutes a significant portion of the total expenses incurred by oil palm operators. These costs cover various aspects of oil palm farming, including the initial investment required for land preparation. Land clearing, which accounts for 4.70% of the total cost, is an essential first step in creating a suitable environment for oil palm cultivation. The result also highlights the substantial investment in quality seedlings, representing 42.12% of the total cost. High-quality planting materials are vital for a successful plantation, underlining the significance of this expense. The variable costs further include expenditures on essential agricultural inputs like fertilizers (10.08%) and pesticides (3.03%). According to Darras et al. (2019), proper fertilization and pest control are fundamental for achieving optimal oil palm growth and yield. Labour costs, representing 2.92% of the total cost, highlight the manual efforts required for oil palm farming activities. Additionally, miscellaneous expenses (0.50%) encompass unclassified but necessary costs that contribute to the overall financial investment in oil palm cultivation.

3.3.2. Fixed Costs

The fixed costs in the oil palm business encompass equipment expenses, including farming and processing machinery. These costs account for a significant portion of the total cost at 34.36%. The importance of reliable equipment for various stages of oil palm cultivation and processing is evident. In addition to equipment expenses, the result includes depreciation costs, which amount to 2.29% of the total cost.

3.3.3. Revenue and Profitability

The result in Table 4.3 also sheds light on the revenue and overall profitability of the oil palm business. The total revenue, generated from the sale of fresh fruit bunches, crude palm oil, and palm kernel, amounts to ₦12,033,288.52. From a financial perspective, the gross margin, calculated as total revenue minus total variable costs, equals

₦8,662,547.03. This figure represents the profitability of the core operational activities. When fixed costs, such as equipment and depreciation, were considered, the net profit obtained was ₦6,712,804.10, with a Return on Investment (ROI) of 2.26. An ROI above one (1) indicates that the business is profitable. In this scenario, an ROI of 2.26 implies that for every ₦1 invested, an additional ₦1.26 is earned in profit. The result in this study suggests that oil palm cultivation is a profitable activity that can generate high returns for farmers and contribute to the economic development of farmers in the study area. The profitability, represented by a positive net profit and a healthy ROI, indicates the financial viability of oil palm cultivation. According to a study by Corley, Tinker and Mayes (2021) found that oil palm is the most productive global oil crop, supplying about 40% of all traded vegetable oil from only 12% of the global oil crop area.

Table 3 Costs and returns of oil palm business in the study area

Items	Quantity	Price (₦)	Amount (₦)	% of TC
Cost of Land Clearing	13.17 hectares	18,985.15	250,034.44	4.70
Seedling Cost	1,820 seedlings	1,231.43	2,241,202.60	42.12
Fertilizer Cost	35 bags (50Kg)	15,325.54	536,393.90	10.08
Pesticide Cost	52 bottles (1 litre)	3,103.77	161,396.04	3.03
Labour Cost	66-man days	2,352.91	155,292.06	2.92
Miscellaneous Expenses			26,422.44	0.50
Total Variable Cost			3,370,741.49	63.35
Equipment (Farming and processing equipment)			1,827,884.00	34.36
Depreciation Cost			121,858.93	2.29
Total fixed Cost			1,949,742.93	36.65
Total Costs			5,320,484.42	100.00
Fresh fruit bunch	187.91 tonnes	5,866.89	1,102,440.57	
Crude palm oil	37.43 tonnes	265,200.00	9,925,316.27	
Palm Kernel	6.46 tonnes	155,762.22	1,005,531.68	
Total Revenue			12,033,288.52	
Gross Margin			8,662,547.03	
Net Profit			6,712,804.10	
Return on Investment			1.26(126.17%)	

3.4. Test of hypothesis

The profitability, represented by a positive net profit of ₦6,712,804.10 and a healthy return on investment (ROI) of 1.26 (126%), indicates the financial viability of oil palm business in the study area. This result shows that a ₦100 invested in oil palm business will generate a net profit of ₦126. Therefore, the null hypothesis which stated that oil palm business is not profitable in the South-South region of Nigeria is hereby rejected and the alternative hypothesis which states that oil palm business is profitable, is accepted. This finding is in agreement with the earlier reports of Achoja, (2013) and Inoni, Ogisi and Achoja, (2017) that high net profit sustains an industry and attracts investors to it.

4. Conclusion

The study investigated the influence of innovative technologies on the performance of oil palm business enterprises in South-South Nigeria. It revealed a landscape where traditional tools coexist with modernization, notably in the processing stage where hydraulic presses and automated mills are prevalent. The study also highlighted the significance of tanks, gallons/jerry cans, plastic bottles, and specific harvesting equipment in enhancing business performance, while sachets had a negative impact. The results showed that innovative technologies contribute to product quality and value addition in the oil palm industry.

Based on the findings, several recommendations can be made to enhance the performance and sustainability of oil palm businesses in South-South Nigeria:

- Farmers should be encouraged in the adoption of innovative harvesting technologies such as chisels, mechanized Cantas, climbing ropes, and ladders, which have shown a significant positive impact on oil palm business performance. This can be achieved through training and awareness programs, subsidies, or support from agricultural extension services.
- Given the substantial role played by hydraulic press processing machines and advanced industrial processing systems in enhancing business performance, oil palm operators should invest in these technologies to improve the quality and efficiency of palm oil production.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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