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LEVERAGING EMERGING TECHNOLOGIES FOR OPERATIONAL OPTIMIZATION AND BUSINESS MODEL INNOVATION IN AFRICAN ENTERPRISES

AUTHORS:
N. David[1], and U. Ohanado[2,*]

AFFILIATIONS:
[1,2]Department of Electronic Engineering, University of Nigeria, Nsukka, Nigeria.

***CORRESPONDING AUTHOR:**
Email: faithful.ohanado.232384@unn.edu.ng

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Abstract

The African economy has experienced substantial growth in recent years, which has increased the number of businesses created annually in the region, and this can translate into significant economic growth over the next few years. With technological advancements and digitization, African businesses can optimize their operations and improve efficiency by leveraging new and disruptive technology for innovation and development. This study discusses emerging technologies like the Internet of Things and Blockchain. It extensively analyzes the use of Radio Frequency Identification systems in Supply Chain Management as a case study. In addition, it also proposes a blueprint for leveraging emerging technologies and discusses some of the challenges these new technologies may bring. Furthermore, we highlighted how some new technologies could improve efficiency for African businesses when successfully integrated into creating business models and discussed examples of African businesses already on this path. Africa must embrace technology for economic transformation, and African businesses are tools to achieve this transformation.

1.0 INTRODUCTION

Africa is a land characterized by an abundance of natural and crude resources and endless potential. Over the past decade, the African economy has experienced steady economic growth, with an average yearly growth rate of 3.5% [1]. Since much of this economic growth is due to an increasing global demand for raw materials and the exploitation of the continent's natural resources [2], innovations and solutions must be geared towards sustainable development.

The rise in digitization has galvanized African entrepreneurs and has caused a subsequent increase in the number of startups and businesses in the region. From commerce to agriculture to finance, these businesses seek to optimize their operations, maximize production, and contribute to the development of the economy. To successfully create innovative business models, African businesses can leverage emerging technologies like artificial intelligence (AI), the Internet of Things (IoT), blockchain technology, etc. in critical elements of their business models. They can optimize elements like value proposition, channels, revenue models, and market strategy [3] by applying emerging technologies in creating business solutions. Emerging

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technologies continue to create new and endless opportunities but they also present new challenges. In the quest to make the most of new technology and innovation, business owners must be ready to navigate the challenges these new technologies bring.

This paper discusses how emerging technologies (IoT, AI, and blockchain) can be integrated into creating solutions for African businesses and unravels the challenges one may face in implementing these technologies. The paper focuses on IoT technology and analyzes Radio Frequency Identification (RFID) in supply chain management as an example of leveraging IoT technology to optimize business operations and create innovative and sustainable business models.

2.0 EMERGING TECHNOLOGY

Emerging technology is a term that generally refers to new technology. It describes technologies whose practical applications and potential have yet to be fully realized [4]. Emerging technologies are disruptive, meaning that they replace old technology and make it redundant. A crude example of this is the replacement of carriages with automobiles. Some key attributes of emerging technology are:

i. Growth potential: impressive growth rate and rapid expansion in their practical applications.
ii. Novelty/Newness: Introducing new ideas and concepts that previously were not in existence.
iii. Transformative potential: ability to leverage technology to disrupt existing industries, markets, and socio-economic trends [5].

Some examples of emerging technologies include artificial intelligence and machine learning, 3D printing, the Internet of Things (IoT), autonomous vehicles, blockchain, and neurotechnology. Some applications of IoT are Home automation systems designed using Arduino[6], internet-based security systems[7], and many more.

2.1 Technology in Africa

The history of technology in Africa can be quickly described in three developmental stages [8]: the first was the rapid emergence and widespread of African agricultural and metal-using technologies [8]. The second stage was characterized by a period of trade and contact with the outside world; however, various elements of Asian and European technology were not adopted. During this time, local manufacturers produced items that matched the quality of preindustrial Europe [9]. The third stage, the last century of colonial and postcolonial regimes, saw the importation of advanced technology into the African ecosystem, albeit with poor integration into locally based systems [8].

Africa has adopted many technologies and inventions of Western science and has implemented some of them to improve its existing culture and practices; however, Africa still lags behind the world regarding technology. In recent years, Africa's digital transformation has opened the African economy and ecosystem to endless possibilities. Technology has revolutionized service delivery, and companies and entrepreneurs are creating new solutions and ways to overcome business barriers through technology.

2.2 IoT Technology

The Internet of Things (IoT) describes devices with sensors, software, processing ability, and other technologies that are connected within a system of devices that communicate and share data over the Internet or a communication network [10] [11]. IoT involves using these connected devices to utilize the data gathered by sensors and actuators from the physical environment.

2.3 Brief History of IoT

IoT's origin dates back to the late 1960s when researchers sought ways to create systems that are interconnections of computers and other devices. An early example of this was ARPANET- Advanced Research Projects Agency Network, created by the Advanced Research Projects Agency (ARPA) of the U.S. Defense Department and mainly used for research and academic purposes [12]. This network was a precursor to today's Internet. By the 1980s, the advent of local area networks (LANs) introduced an effective way to share data and documents and communicate across a network of PCs in real time.

In 1997, Kevin Ashton, MIT's Executive Director of Auto-ID Labs, began exploring radio-frequency identification (RFID) [13], a technology framework that would allow the interconnection of physical devices through wireless signals and microchips. In 1999, he coined the phrase "the Internet of Things," this technology has since continued to evolve with the advancement in software algorithms and improved processing power of computer technology.

2.4 IoT Components

Components of IoT technology include sensors and actuators that retrieve data from the physical environment and carry out actions based on this data [14], connectors or gateways that comprise the channels and networks through which the retrieved data is stored, and processors that handle the storing,

processing, and analysis of the data received from the sensors [15].

2.5 Emerging Technology Applications

There are numerous applications of disruptive technology in business operations. Proper utilization of these technologies can help increase productivity and efficiency and bring innovation to the industry. Some examples include:

i. Nanotechnology in Agriculture for Pest Control
ii. Radio Frequency Identification(RFID) in Supply Chain and Inventory Management
iii. Blockchain Technology for Finance and Transacting
iv. AI in Customer Services
v. IoT for Data Management
vi. IoT for Appliance Control and Automation, etc.

3.0 RADIO FREQUENCY IDENTIFICATION (RFID) IN SUPPLY CHAIN MANAGEMENT

Radio-frequency identification (RFID) technology uses electromagnetic fields to track, detect, and identify tags attached to objects [16]. It is used to capture data from objects carrying an RFID tag. The tags carry data that include different attributes (like production date, serial numbers, color, etc.) that serve as identification for the tagged object [17]. RFID in an IoT system is a valuable tool in managing supply chains because it increases overall efficiency and optimizes individual processes across the supply chain [18]. From production to distribution, RFID can optimize warehousing, inventory, transportation, and logistics [19]. Notable African companies like Dangote and Kobo360 largely use RFID in their supply chain management and logistics operations. Retail giants like South Africa's Shoprite also implement an RFID-based self-checkout system.

3.1 A Simple RFID System

A typical RFID system consists of the RFID tag, the RFID reader, and the application (Figure 1).

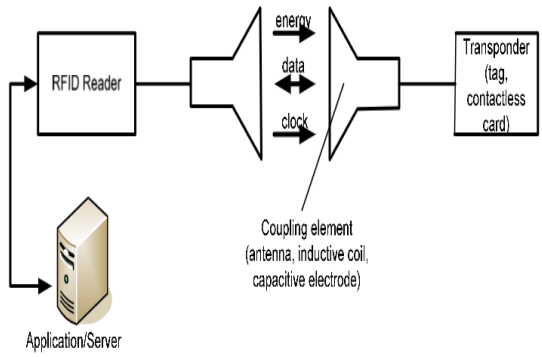

Figure 1: A typical RFID system [20]

The RFID tag consists of a microchip and an antenna. It contains valuable information for identification and can be attached to products, shipping units, packages, etc. The RFID reader/writer energizes the tag. When a tag is within the reader's range, it is immediately energized and automatically sends the data on the tag. The application is the backend of the system. It is responsible for organizing and utilizing the collected data.

i. ***Chip-less RFID:*** Chip-less RFIDs are RFIDs that do not contain microchips in their tags. These tags are referred to as passive tags. The passive tags are associated with a particular RFID reader. To retrieve data on the tag, the RFID reader sends an electromagnetic signal toward the tag and captures the reflection of the signal from the tag. The received signal is then processed to recover the information contained in the tag [21].

3.2 RFID Applications in Supply Chain Management (SCM)

RFIDs have numerous applications, and one of the most widely implemented uses is in supply chain management. RFID technology can track tagged objects in motion [22]. This functionality can be a valuable addition for African businesses in various sectors, including healthcare, retail, production, travel, hospitality, and more.

RFID improves the efficiency and accuracy of the supply chain when implemented in individual supply chain processes. It can be deployed in distribution, logistics, warehouses, Point of Sale (PoS), etc.

Figure 2: A supply chain network

Figure 2 describes a simple supply chain network. Each block involves unique functions and processes that can be improved by applying RFID technology. Functions like inventory management, packaging, shipping and delivery, warehouse management, and distribution can be augmented with RFID technology to optimize business operations.

RFID technology can improve inventory management by ensuring accurate data collection across the supply chain, from raw materials obtained through the supplier to warehouse storage and distribution. RFID tags can generate valuable data from manufacturers to retailers. These tags allow real-time tracking of goods and products, making it possible to identify issues and provide alternative solutions swiftly.

3.3 RFID vs. Barcode

RFID technology is also useful in retail to identify incoming products and manage inventory. Although it is similar to the already-in-use barcode technology, RFID is more efficient. Barcode technology requires a line of sight to scan each code [23], but RFID can scan multiple codes simultaneously and is better for scanning more products.

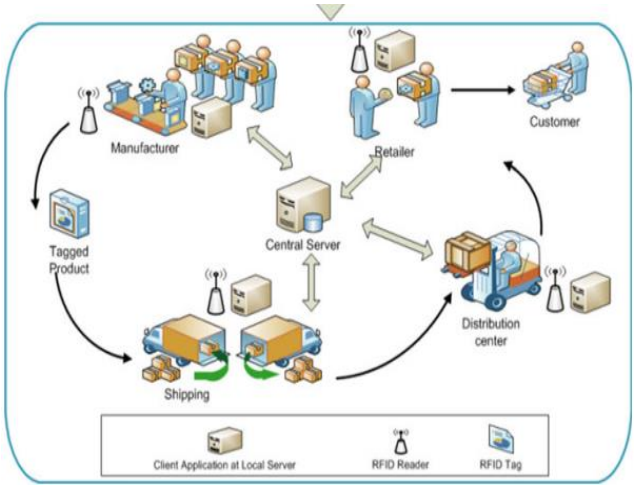

Figure 3: RFID-enabled supply chain flow [24]

Figure 3 shows the movement of a tagged product through different stages of the supply chain. It also shows the RFID reader and client application in the stages where they are used and shows the connections of the RFID components at each stage to a centralized server.

3.4 Benefits of RFID in Supply Chain Management

i. ***Improved Inventory Management****:* Implementing RFID enables businesses to quickly and accurately locate items in their warehouses and during the supply chain journey. RFID automates inventory management, reducing the risk of overstocking, out-of-stock, and human errors. The system also provides information on product distribution and storage issues.

ii. ***Real-Time Asset Tracking:*** The items to be tracked are encoded with RFID tags, and the data is entered into the system. RFID readers can then retrieve data in real-time from the tags at warehouses or during distribution. Concurrent data from the RFID system, such as the location and condition of shipments [18], can help with decision-making and optimize supply chain operations.

iii. ***Reduced Business Cost:*** The Automated inventory management decreases the need for manual labor. Subsequently, businesses can reduce operational costs and avoid wastage with real-time asset monitoring.

3.5 Effects of RFID Technology on Supply Chain Processes

Table 1 shows how implementing RFID technology can affect individual processes in the supply chain.

Table 1: Differences In Supply Chain Processes

SCM Process	Without RFID	With RFID
Warehousing	Manual inventory tracking.	Inventory management is automated.
	Risk of errors in data entry.	Automated data capture reduces the risk of error in data entry.
Shipping	Tracking of products and shipments is done manually.	Active RFID tags can track shipments in real time.
	Shipment issues are manually detected, so there is a delay in resolution.	Shipment issues can be detected and resolved promptly.
Distribution	Risk of errors and mix-ups in order fulfillment	Improved accuracy and efficiency in order deliveries
	Manual tracking	Automatic tracking
Retail	Inventory is managed manually, so there is the risk of errors in data entry.	Inventory management is automated, so there is a reduced risk of data-related errors.
	Problems of overstocking and out-of-stock are common.	Stocking is optimized, reducing cases of overstocking and stock-outs.

3.6 The Use of IoT Technology in African Businesses

Like RFID in SCM, emerging technologies can enhance individual processes in business operations. Some African businesses are already on this path of innovation and are leveraging these technologies in their business models. We can look at a few examples and see how technology has contributed to the success of these organizations.

i. ***IoT in Supply Chain Management:*** Kobo360: Kobo360 is Africa's leading technological and innovative platform for integrated logistics solutions and truck brokerage [25]. It connects cargo owners to trucks and drivers and oversees haulage operations to achieve an efficient supply chain framework for customers through an all-in-one logistics platform.

ii. ***Leveraging Technology in the Business Model - Kobo360:*** Through its platform, Kobo360 uses big data and technology to reduce supply chain risks, manufacturing waste, logistics bottlenecks, low turn-around, and loss of goods [25]. Here, the use of technology is at the heart of their operations. The Kobo360 platform provides a digital ecosystem that gives suppliers and drivers access to the largest network of registered drivers and trucks and offers end-to-end visibility [25].

It also provides real-time tracking of goods on every delivery and implements IoT technology to give users real-time insights into their goods and the delivery status. Its Global Logistics Operating System (GLOS), shown in Fig. 4, uses an artificial intelligence engine to match truck requests to available transporters and IoT technology to manage requests and payments.

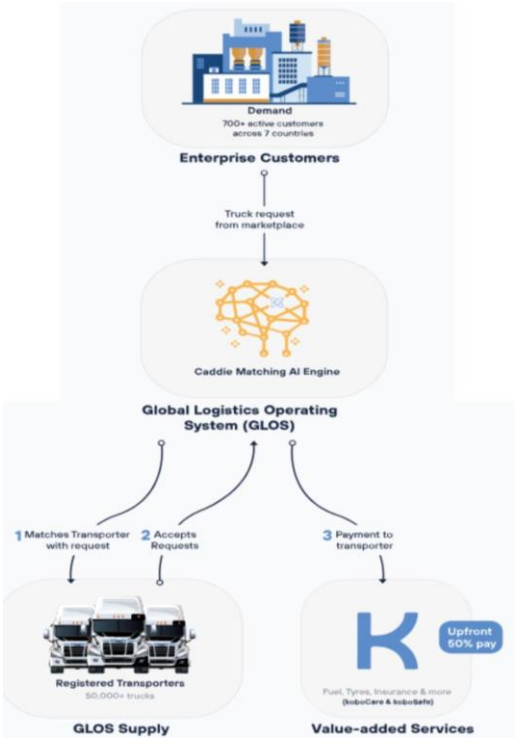

Figure 4: Kobo360 Logistics Operating System [25]

iii. ***IoT Technology in Agriculture - HelloTractor:*** HelloTractor is an ag-tech company focused on improving Africa's food and income security. It provides convenient and accessible tractor services to farmers and offers additional income by introducing smart tractors. Its IoT platform also provides asset tracking for tractor owners and prevents misuse through tractor monitoring. HelloTractor utilizes its IoT platform to help farmers, banks, dealers, and farm equipment owners earn more [26]. It is currently operational in 15 African countries [27], and its services benefit tractor owners, farmers in need of tractors, tractor drivers, and tractor sellers. It uses IoT technology to track and monitor tractor location and activity, connecting farmers and tractor owners.

iv. ***Leveraging IoT in the Business Model - HelloTractor:*** HelloTractor services include GPS monitoring of tractors, fuel history and usage, Fleet management, tracking of tractor activity, and farmer bookings [27]. Data and IoT technology have enabled it to bridge the gap between farmers who need tractors and tractor owners and optimize the use of tractors and other farm equipment. HelloTractor leverages IoT in its value proposition and market strategy to provide a set of solutions that include;

a. ***Low-Cost Monitoring Device and Tractor Owner App:*** The monitoring device can be fitted to any tractor to get insights into the tractor's operation and maintenance [28]. Here, GPS or RFID technology is implemented for tractor whereabouts. The tractor owner app allows tractor owners to monitor tractor activity in real-time and access full reports on tractor performance and maintenance [28].

b. ***Scheduling App & Booking Agents****:* The app also offers scheduling services, allowing farmers to demand tractors through booking agents in their area, ensuring that farmers can access the required service [28]. Their business model leverages best-in-class technology and innovation in the local context to provide solutions and optimize business operations.

3.7 IoT as a Tool for Transformation

IoT applications stretch across various sectors and industries. As an emerging technology, it wields the power to transform any industry and has yielded significant impact when implemented as a tool for innovation in the African economy.

i. ***Agriculture*****:** Agriculture plays a vital role in human survival. To cater to an ever-growing population, technology has been introduced to improve efficiency and productivity in farming. The impact of IoT technology in the agricultural sector cannot be overemphasized.

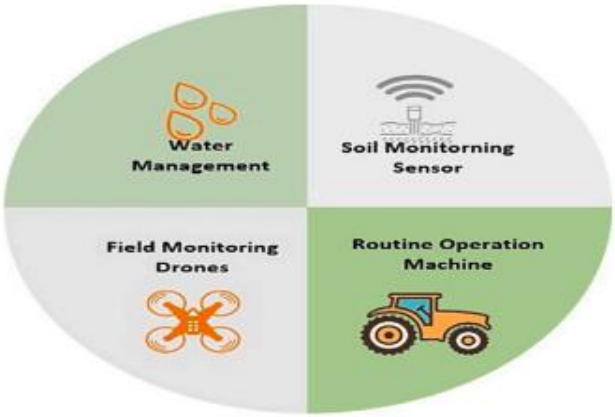

Figure 5: IoT applications in agriculture [29]

From applications in farm machinery (Routine Operation Machines, Field Monitoring Drones) to farming procedures (water management, soil monitoring), as depicted in Figure 5, IoT has enabled farmers to reduce waste and enhance productivity [29]. Crop and livestock management is far more efficient with the adoption of smart farming methods. Integrating IoT devices in farming procedures allows for real-time data analysis through sensors and drones, which maximizes resource use [29]. IoT technology has transformed agriculture with various applications, including remote sensing, automated crop housing/greenhouse technology, drones, nano-tech in pest control, asset tracking, etc.

ii. ***Industrial Automation:*** Implementing IoT technology in industrial automation provides production data in real-time from linked equipment and sensors [30]. The data acquired can offer valuable insights that can be used to tailor the production processes and increase productivity. IoT technology offers numerous benefits in industrial automation. IoT devices can predict machine failures before they occur, reducing downtime and increasing production [30]. IoT technology can also optimize energy usage and save operational costs with regulators and switching devices that can be automatically controlled.

iii. ***Finance:*** IoT has significantly impacted the finance sector. From increasing the speed and ease of transacting to strengthening security, IoT technology offers numerous benefits and applications in the finance industry.

Section 3 highlighted how retail companies like Shoprite implement a self-check-out system. IoT technology can augment this process with IoT payments. It allows customers to pay with their smartphones, cards, smart watches, etc., making the payment process smooth and seamless. Financial institutions also leverage IoT technology for fraud detection, credit risk management, and auditing [31]. IoT devices provide analysts with real-time data and enable them to make data-driven decisions.

3.8 Measuring the Impact of Technology on an Industry

We may consider metrics like cost-effectiveness, customer satisfaction, and adoption rate to measure technology's impact on an industry. To understand the level of impact technology can bring to their industry, stakeholders and business owners can analyze these metrics using relevant data and adequately measure the technological impact on the economy.

i. ***Cost Efficiency:*** In agriculture, smart machinery has proven to reduce manpower significantly and optimize the use of farm equipment. In industrial automation, technology reduces costs by automating repetitive tasks. Technology generally makes business operations easier to perform. In finance, we find that financial technology banks (fin-techs) operate at a lower operational cost than traditional banks. A higher level of technological integration in fintechs makes them more innovative, faster in operations, and more cost-efficient.

ii. ***Customer satisfaction:*** Technology has helped to further reduce the gap between business owners, service providers, and their customers. AI has introduced chatbots that allow customers to perform self-service and provide real-time feedback. Technology brings inclusiveness, allowing the customer to be more involved in business decisions.

iii. ***Adoption Rate:*** The adoption rate is the pace at which the general public adopts and uses new technology. Technologies like 3D printing, drone technology, etc., have low adoption rates in African businesses due to various challenges that we will later discuss in Section IV. These loosely adopted technologies struggle to make the necessary impact, and business owners often avoid including them in their business strategies. A higher adoption rate implies a more conducive environment for the technology to thrive.

4.0 DISCUSSION

4.1 Steps to Leveraging Emerging Technology for Innovative Business Models

i. ***Understand the problem:*** Use data collection tools to gather the required data and get proper insights into the problem. Completing this step will place you on the right track to present the necessary solutions and understand what technology can be implemented to actualize these solutions.

ii. ***Develop a Digital Strategy:*** Once the business clearly understands the problem, it can identify areas to implement emerging technologies and create ideas and strategies aligning with the company's goals. For example, IoT can be used for data collection and monitoring, AI for decision-making, and blockchain for security.

iii. ***Validate and Scale the Solution:*** After the ideas and strategies have been developed, the resulting solutions can be validated by the customers and users. Methods like customer feedback, experiments, and user testing can be used to gauge the solution's impact on the business. Businesses can also judge the outcome of the implemented digital strategies with metrics like revenue, customer satisfaction, profit margins, and changes in demand for products or services. After validation, solutions can be scaled to create more impact and reach more customers. Business owners can also leverage emerging technologies to scale these business solutions.

iv. ***Learn from Challenges:*** Challenges may be technical, legal, or even ethical and may hinder or limit the solutions or their applications. Methods like risk analysis, SWOT analysis, Gap analysis, etc., can be used to identify and attenuate the challenges.

4.2 Challenges in Implementing Emerging Technologies in Africa

The African economy poses some challenges to the seamless integration of emerging technology for businesses in the region. These challenges range from political to socio-economic, and entrepreneurs and business owners must navigate these obstacles to facilitate the smooth introduction of these emerging technologies into their business models. Some of the challenges affecting the implementation of emerging technology include;

i. ***Poor Infrastructure:*** A significant hindrance to technology integration in Africa is the lack of proper infrastructure. Many African countries still face problems of inconsistent electricity supply and unreliable network and telecommunication networks. Other countries suffer from unreliable energy, poor road networks, and inefficient seaports, all of which impede economic growth and discourage the proper application of technology. Technologies like IoT require consistent power supply, preferably from renewable sources [32], and quality network and communication infrastructure to operate seamlessly, which means that the cost of implementing an IoT system will be significantly greater in areas that lack consistent power supply.

ii. ***Government Policies/ Fiscal Constraints*:** Government policies hamper investments in many parts of Africa, especially Nigeria and South Africa [33]. Nigerian authorities have a history of imposing excessive fines on multinationals, and in 2023 alone, about four multinational companies stopped operations in Nigeria for business reasons [34]. Many other small and medium enterprises have also shut down nationwide.

One causes of this problem is corrupt and unstable policies from bad leadership in the region. Few countries west of the Sahara have recently gone under military rule, while other regions still struggle with corrupt leaders and officials. These corrupt or incompetent leaders have created policies that have had adversarial effects on the economy and hindered the growth of technology in the region.

iii. ***Human Capital:*** Implementing new technology requires the skill to operate, manage, and maintain the technology. The talent pool available in Africa is relatively small, leading to significantly higher salaries [33], and there is not enough skill and talent in the African market to foster rapid growth in the use of technology in the region. Although many African countries have invested in training facilities to equip the youth with the necessary skills to lead the charge for innovation in the region, there is more to be done, and Africa must invest in technological education, even at lower levels [35], to overcome this deficit. Private businesses can also adopt employee training at different levels to improve the skills and talent of their workforce.

4.3 Solutions and Strategies to Mitigate the Challenges of Implementing Emerging Technologies in Africa

With the right strategies and policies, the challenges affecting the technology implementation in the African economy can be mitigated, and more businesses and stakeholders can be encouraged to join the trend of leveraging these technologies in their business operations. Some of these potential solutions and strategies are discussed in the following points:

i. ***Quality Public Administration:*** The public administration must be able to identify, implement, and monitor these projects within the existing resource envelope [36]. The African economy will greatly benefit from competent leadership and administration as well as proper management of public enterprise.

ii. ***ICT Education and Improving Human Capital***: Introducing technology into a business ecosystem without developing existing talent will be

disadvantageous in the long run. Stakeholders must invest in training and educating IT (Information Technology) graduates to adopt the required skills lacking in the market, enabling them to secure IT jobs and champion innovation and evolution of technology in Africa.

In countries like Nigeria and Kenya, multiple tech hubs and tech training programs have been created to improve the skill level of the talent market. Other African countries can adopt this approach at all levels of education. Government bodies can also incentivize highly skilled African talents back home to add more skill and capacity for innovation to the workforce and invest their knowledge in training upcoming talents.

iii. ***Involving the Private Sector:*** Given limited public resources, we can look to the private sector to get involved and mitigate some of these challenges. Private companies and organizations can invest in infrastructure and human capital; and collaborate with public enterprises to offer solutions. An example of such public-private partnerships is the case where private companies are contracted to build and develop projects before they are transferred back to the public after an agreed period. The private sector can also invest in public enterprises in sectors like electricity generation or water provision, taking up part or full responsibility for the services and amenities provided.

5.0 CONCLUSION

Technology is continuously advancing, and Africa must learn to adapt and evolve to accommodate innovation. Emerging technologies like the Internet of Things (IoT), blockchain, and artificial intelligence have the potential to accelerate economic transformation in Africa, especially in less developed countries (LDCs) [37]. Businesses and startups in the region can learn from their counterparts in developing countries already taking these initiatives.

With emerging technology, companies can adopt new work patterns and adjust business operations to optimize productivity and performance. From the case study discussed in Section 3, i.e., the use of RFID in supply chain management, we can visualize how technology can affect individual processes in business operations, providing more safety and security and increasing efficiency. As listed in Section II-E, these technology applications can transform any business by shooting up productivity and offering a whole new experience to customers.

Great power often connotes great responsibility, which is no different with technology. Africa is rich with natural resources and numerous possibilities but is also plagued with a many challenges. Leverage technology for business in the African economy would require one to overcome a host of challenges, from lack of infrastructure to fiscal constraints. Business owners must take adequate steps to navigate these challenges, and other agencies involved, including government bodies, must play their part to support the integration of technology in their respective industries.

5.1 Recommendations

A collaborative effort is necessary to drive the integration of emerging technologies in African businesses. Governments and regulatory bodies must create policies that encourage innovation and provide an environment for technology to thrive. Private stakeholders must also join hands with the government to invest in infrastructure and human capital, reducing the barriers to technology adoption by African businesses.

Fostering a culture of innovation is vital for sustainable economic development and growth. Future trends in emerging technology suggest a shift towards edge computing for swift and real-time data processing, continued evolution of AI and robotics, advancement in machine learning and blockchain applications in cybersecurity and finance, virtual and augmented reality in healthcare treatments, and so much more. IoT is expected to continue expanding, and with more devices connected to the Internet, there are new possibilities for data collection and analysis. African businesses, governments, and stakeholders must keep abreast of these new technological trends and be ready to adapt and embrace them to create innovation and sustained economic growth.

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