Computerized Agro-Distribution Framework

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Abstract

According to UNICEF, about 67% of children in the age range of 6 months to 2 years are undernourished (UNICEF, 2023). This is attributed to our food system which includes all aspects of feeding and nourishment. The current strategies adopted in our existing food system e.g. farming, processing, food supply chain, production and distribution affect the health of the people and call for proper distribution of agricultural products and services from where they are produced to where they are needed by the final consumers. This paper therefore presents a computer-based framework for agro-distribution of products and services. It handles prompt distribution of agricultural products and services to help manage food crisis which is one of the Sustainable Development Goals (SDGs). Majority of agricultural firms in third world countries suffer lack of proper management of resources including information about products, services, latest agricultural developments, delay in decision making and improper synergy between producers and prospective buyers leading to lobe-sided distribution of agro products. This is due to improper documentation of agricultural accomplishments, failures and feedback, absence of cost effective agricultural information dissemination system for training farmers and extension workers, improper use of ICT and big data tools in dispersing agricultural knowledge and latest technologies. The proposed framework handles proper dissemination of agricultural information leading to effective distribution of products and services. The framework ensures proper advertisement and linkage of consumers to the desired producers so as to manage the food crisis and poor industrialization confronting third world countries. It manages the distribution of agricultural products from local government to state and federal levels and hence recommends the agricultural products to be imported and exported. The application that demonstrates this framework is available at: https://github.com/Ogbodiya/George-.

Keywords: Agro-distribution, food security, big data, ICT Tools, food crisis.

1. Introduction

The world population is estimated to be about 10 billion people by the year 2050, and the available food production and distribution method certainly will not be able to match the rising demand for food without a corresponding advancement in productivity, efficiency and distribution method. The estimated population of undernourished people globally indicates that over 670 million people on earth are still likely to be undernourished by 2030. This figure was estimated to increase to over 78 million more people as a result of the effect of COVID-19 challenge which ravaged the world (FAO et al., 2022). The available natural resources like land, water, etc. are even scarcer as a result of the increasing world population, and the usual methods adopted in food production have further degraded the environment and depleted these natural resources. Again, up to 33% of the food produced in the world especially in Africa is either wasted or lost as a result of the effect of these environmental problems. These problems are further worsened by the challenges posed by climate changes e.g. global warming and its effects like unfavourable constant changes in the weather, such as storms, flooding, drought as well as increasing insecurity in most parts of the world which constitute a serious threat to the security of food thus making it imperative to develop a better efficient, climate resilience, productivity and distribution food system.

"Agri" or "agro" is a general term that refers to agriculture, denoting the science and art of crop production and animal husbandry for economic purposes. Agro distribution is the efficient movement of agricultural products from surplus rural areas to deficit urban areas. Agri distribution on the other hand is the distribution of agricultural goods produced in factories and/or commodities to desirous customers. Agriculture is one vital sector that has incredible possibilities for challenging the difficulties associated with accomplishing a country's financial development, decrease in poverty, food security, wealth creation and employment. In most third world countries e.g. Nigeria, agricultural sector contributes on the average about 40% of Gross Domestic Product (GDP), utilizes over 60% of the active working populace and is capable of contributing more to poverty alleviation than any other sector (Oyakhilomen, et al 2014). But unfortunately, agriculture in Nigeria is one of the sectors with the poorest capital allocation and the most minimal nature of private sector investment within the national economy. And though it has the capacity to boost productivity and industrialization in the developing nations, it is none the less confronted by poor marketing strategies, inefficient information dissemination system and poor advertisement of goods and services. Due to the challenges

experienced in the agricultural sector by most developing countries of the world such as production of products that could feed the increasing populace, poor utilization of the available natural resources and human resources (Jean-Claude, 2011), developing and managing a sustainable economy via agriculture among others, it becomes expedient and of great importance to develop an agile computerized agro-distribution system for proper guidance and distribution of available agricultural products and services to ensure food security. An agro-distribution system would help in reducing the difficulties by helping to provide adequate information to the farmers on how to enhance productivity of their farm produce, create a platform for farmers to have direct access to their consumers for better interactions and feedback. The platform would also help to advertise agricultural produce to consumers, link customers to more farmers, Government and Non-Governmental Organizations, provide adequate market information to the public, and ensure that agricultural products are made available to the prospective buyers.

The benefits of a computerized agro-distribution system for agricultural products and services include: provision of employment, provision of raw materials for industries, adequate and timely food supply, wider showcasing of agricultural produce and evaluations, enhanced earnings, intensified competition and enhancement in the agricultural sector, availability of information from Government or Non-Governmental Organizations to farmers or even the general public, among others.

2. Related Works

Any food system is described as being sustainable only when it is able to supply consumers with sufficient nutritious need for everyone without lowering the health of the planet or the capacity of the future generations to satisfy their food need and nutritional requirements. In order to meet the SDGs with respect to security of food, there is need to reform and reposition the existing food systems in order to meet the increasing demand for food. Food system transformation is geared toward creating a sustainable future where all citizens in any country have unimpeded access to healthy food, can produce food in resilient and sustainable manner, restore distorted ecosystem and ensure livelihood that is equitable and sustainable (FAO, 2021). A digitized agro food transformation mechanism can help to manage the challenges of food crisis by enhancing productivity, ensuring equitable and efficient distribution as well as food production sustainability. By adopting contemporary computerized digital technologies in agriculture, food safety and improved food traceability can be ensured.

Use of computer-based technologies in agriculture can help transform agrofood systems by enhancing performance, reducing waste and improving food production sustainability. This is seen in IoT based agriculture, where Global Positioning System (GPS) drones and sensors/transducers capture the changing weather conditions, the condition of the soil along with the data on crop growth for prompt analysis. The collected data is further subjected to analysis to optimize irrigation, fertilizing and planting leading to higher crop yields and reduced production costs. Monitoring of farm animal in animal management is another section where computer based technologies are used to track the health status and behavior of farm animals in animal husbandry. The result of the deployment of these contemporary technologies ultimately improves the health and wellbeing of livestocks and prevent disease spread in the farm. Automation and Robotics is another area where digital technology can help to automate tasks that are repetitive in nature like watering, harvesting and planting, thereby reducing cost of labour which ultimately results in enhanced productivity and efficiency. Computer based technologies can be deployed to enhance the understanding of the effect of change in climate in agriculture and develop mitigation strategies. Use of these technologies have resulted in better sustainability, greater efficiency, and resilience in agrofood systems and management, but such computer technology should not only be affordable and accessible to agricultural stakeholders like farmers, but should also ensure that they are utilized in a manner that protects and respects the livelihood and rights of the communities in the rural areas.

2.1. Impact of Big Data in Agriculture

Agriculture is advancing toward digital economy through the use of advanced technologies and the result is precision agriculture. The deployment of these advanced technologies in agriculture has resulted in the generation of very large amounts of data called big data. Although data are valuable asset to farmers, these very large amount data has created problems in managing them. With the evolution of data interfaces and data science, agriculture has migrated to a highly data driven business in terms of the volume of objects, events, fungicides, pesticides, herbicides, fertilizers, seed quality, etc. Data has today become another important factor of production after land, labour and capital thus increasing the factors of production by one (FAO. 2023). The technology of big data allows farmers to take better decisions regarding product and services distribution, procurement, financial and human management, production and so on. The reason being that real time data provides information on edaphic attributes, crop data, climate information, market and livestock data thereby allowing farmers take real-time, better and more efficient decision. According to

Lassoued (2023), more than 80 international expert survey in plant breeding revealed the efficacy of data driven agriculture as well as software based decision support system and IoT in agriculture.

2.2. Digital Agriculture, Big Data and Food Security

In the last few years, there has been a tremendous increase in the volume of data collected on farms in particular and agriculture in general (Kosior, 2019). A number of new actors coming from the private sectors like data companies, high-technology corporations and agricultural technology providers are playing even more significant roles in product distribution, analysis, data collection, processing and storage in agriculture. As observed by Kosior (2019), over 250,000 data samples were generated per day from an average farm in the year 2015. It is further predicted that agricultural data generation is estimated to increase from over 500,000 data points per day in 2020 to over 2 million data points in 2030 as a result of further advancement in agricultural technologies tailored towards enhanced agricultural production and distribution of goods and services. Big data have revolutionized the agricultural sector through the use of ICTs, IoTs, advanced computer technologies to mention but a few and have played a game changing role in productivity boost, removing risks and managing global food crisis in line with the SDG goals. United Nations estimated that the world population would grow to almost 10 billion people by the year 2050, which amount to a drastic increase of about over 2 billion people from today and hence suggests that there must be a corresponding increase in crop production and management to support and sustain the global increasing population (Talend, 2023). This population boost directly implies that there is urgent need to produce more food using the limited agricultural space available to be able to manage the increasing need for food and ensure food security. It therefore suggests that governments all over the world must device more proactive strategy to manage environmental and climatic changes that affect food production and animal husbandry via policymaking and use of advanced technologies involving big data, cloud computing, ICT, IoT, etc. The analysis of the trend in the market size points to an estimated increase of over USD 585 million in 2018 to over 1.24 billion in 2030 – about 16% annual increase in rate of growth in the size of the market (Talend, 2023).

In recent times, there has been an overall increase in research towards the agribusiness sector (Ngowi, 2018). Numerous pressures from evolving situation have stimulated these endeavors. On the market side, the sector faces a growing presence of players in the distribution and commercialization channel which are accompanied with sophisticated consumer demands for a healthy, environmentally friendly and the production of diverse products. On the side of the firms, the sector is changing from family-based (subsistence) with small scale wealth creation, to huge and commercial agriculture resulting to large scale production and distribution chains. Agribusiness is ending up basically to more industrialized, more competitive and much more technological and administrative based agriculture (Dodor, 2014). A research carried out by Parmar (2019) revealed that information gotten from ICT sources on agricultural production and marketing had a significant positive influence on the access of the farmers to information on agricultural production and marketing, whereas the information gotten from non-ICT sources had significant negative influence on the farmers' access to information on marketing and production.

In Reddy (2014), a framework for a cost-effective agricultural information dissemination system (AgrIDS) was proposed. The proposed framework intends to enhance agricultural productivity by disseminating expert agricultural advice to the farmers in a timely and personalized way by using the available agricultural technology related to the crop and the most recent information about the crop situation received through the web in the forms of text and images. The AgrIDS is comprised of four sections: farmers, coordinators, agricultural specialists and agricultural information system (AIS). All parts are accessed through the web. The farmers are the end users of the framework; a coordinator is concerned with gathering farmers and has the agricultural experience as well as the essential information. The Agricultural specialists are agricultural researchers who give proper advice by studying the agricultural information system (Barnabas, 2013). The coordinators get the advice by accessing the system via the internet.

In Reddy (2007) the development and testing of an agricultural information system based on AgrIDS called eSagu ("Sagu" implies development in Telugu dialect) was introduced. The key interests in the framework which was developed in India over existing traditional systems are accessibility of a group of broadened specialists at a single place; management of time, money and energy; aiding correct diagnosis of the problem; robust database to support decision-making; zooming ability which adds an extra dimension; employment generation; documentation of accomplishments; and feedback which helps to weigh and advance its performance.

According to Armstrong (2015), a farmer decision support framework (FDSF), which has been made to help farmers in their decision making, was developed. The delivery of information collected from numerous sources such as publications, internets, agricultural advisers and other farmers is through government and private specialists. Notwithstanding, getting this data and disseminating it is usually a challenge. As a result, information websites were developed for breeding animals and seed companies with information about obtainable crop varieties, enabling

farmers to access this information. The express government's Department of Agriculture and Food (DAFWA) which is located in Western Australian provides producers with a site that offers downloadable reports and the ability to post comments about varieties.

3. Existing Agro Distribution System

In a research carried out by Bissinger (2019), it was noted that consumers are willing to purchase a product that is certified sustainable even at a higher price. According to AfricaLink (2020), which is a knowledge base that contains the list of registered agricultural distribution sites in Nigeria, there are a number of systems that have been designed for the purpose of buying and selling of agricultural products, these systems are limited in the following ways:

- They are strictly for subjective gains.
- They have no link for the farmers to have access to the general public.
- They do not have links to NGOs, government and consultants to interfere in their business and as well interact with the farmers.
- There are little documentations on them for references.

At present, agricultural product distributors in Nigeria buy from farmers as whole sellers and advertise the purchased products to the general public for their personal gains. The proposed system will not only allow for the distribution of agricultural produce but would also enable both governmental and non-governmental organizations to interact directly with the farmers and the general public as well as create direct access that enable farmers to interact directly with the consumers and the general public. This will in turn benefit the general public, government, NGOs and importantly the farmers who had been shortchanged by the wholesalers.

3.1. Design of the Proposed Agro-Distribution Framework

The proposed agile Agro Distribution framework is a web-based framework that provides a platform for farmers to have direct access to their customers, fellow farmers as well as be open to partnerships. The framework has some distinctive features which are essential to every agribusiness operating over the internet. These features include a logical roadmap, showing how the system is designed to work, crucial business information, contact information, easy navigation, security, social media integration, frequently asked question (FAQ) and so forth.

The overall aim of the proposed framework is to design a computerized agro-distribution framework for agricultural products and services that would implement the functionalities stated thereby making for a more reliable system. These functionalities from the related works include enhancing agricultural productivity by disseminating expert agricultural advice to the farmers, accessibility to a group of broadened specialists at a single place which aids management of time, money and energy, helping farmers in their decision making by developing an information site for receiving information collected from numerous sources such as publications, agricultural advisers and other farmers, thereby, enabling farmers access information which was previously available only through the government. This proposed framework would enable adequate information availability to both farmers, consumers and the general public, provision of a platform where farmers get their products to favorable buyers with private agents or governmental links where the situation demands, help to regulate market prices by allowing farmers fix uniform favorable prices for their products, provide a platform that would work with public and private sector partners to enhance agricultural productivity, quality and processing, thereby improving utility and adding value.

The role of each stakeholder in the framework is briefly described.

- Farmers: The farmer registers to access the system and can advertise and sell his agro-products, view his customer's interest, access relevant and helpful agricultural information posted by either government organizations or non-governmental organizations.
- Customers: The customer registers with the system and gets access to view available agro-products and services, orders desired agro-products directly from farmers, make e-payments, view the relevant agricultural information dispatched by either the government organizations or non-governmental organizations and as well as have access to the system.
- Government Organizations and Non-Governmental Organizations: The Government Organizations and Non-Governmental Organizations register with the system and then get access to view the agro-products, view the helpful agricultural information posted by either the government organizations or non-governmental organizations, update relevant information and as well as have access to the system framework. Government can therefore effect price control.
- Administrator: The administrator has access to both the system and its database, this is to enable him to perform some functions such as the resolution of issues between the different stakeholders and the system.

The administrator can also register new product or service, order a product or service, advertise new technology, products or services, register and advertise products and services, etc.

The use case diagram and the agro distribution framework are shown in figures 1a and 1b. From the framework:

Let $A = \sum_{i=1}^{n} \{a_1, a_2, a_3, \ldots, a_n\}$ equ (1)

where A= is the nation e.g. Nigeria and $\{a_1, a_2, a_3, \ldots, a_n\}$ are the states in the country with x_s as the state collection centers. For Nigeria, n = 37, i.e. 36 states and Abuja, the FCT (Federal Capital Territory). For each State,

Let $a_i = \sum_{i=1}^{n} \{b_1, b_2, b_3, \ldots, b_n\}$ equ (2)

Where $\{a_1, a_2, a_3, \ldots, a_n\}$ are the states in the country and $\{b_1, b_2, b_3, \ldots, b_n\}$ are the local government areas (LGAs) in the various state (n = 774 LGAs) with c_s as the LG collection centers. For each LGA,

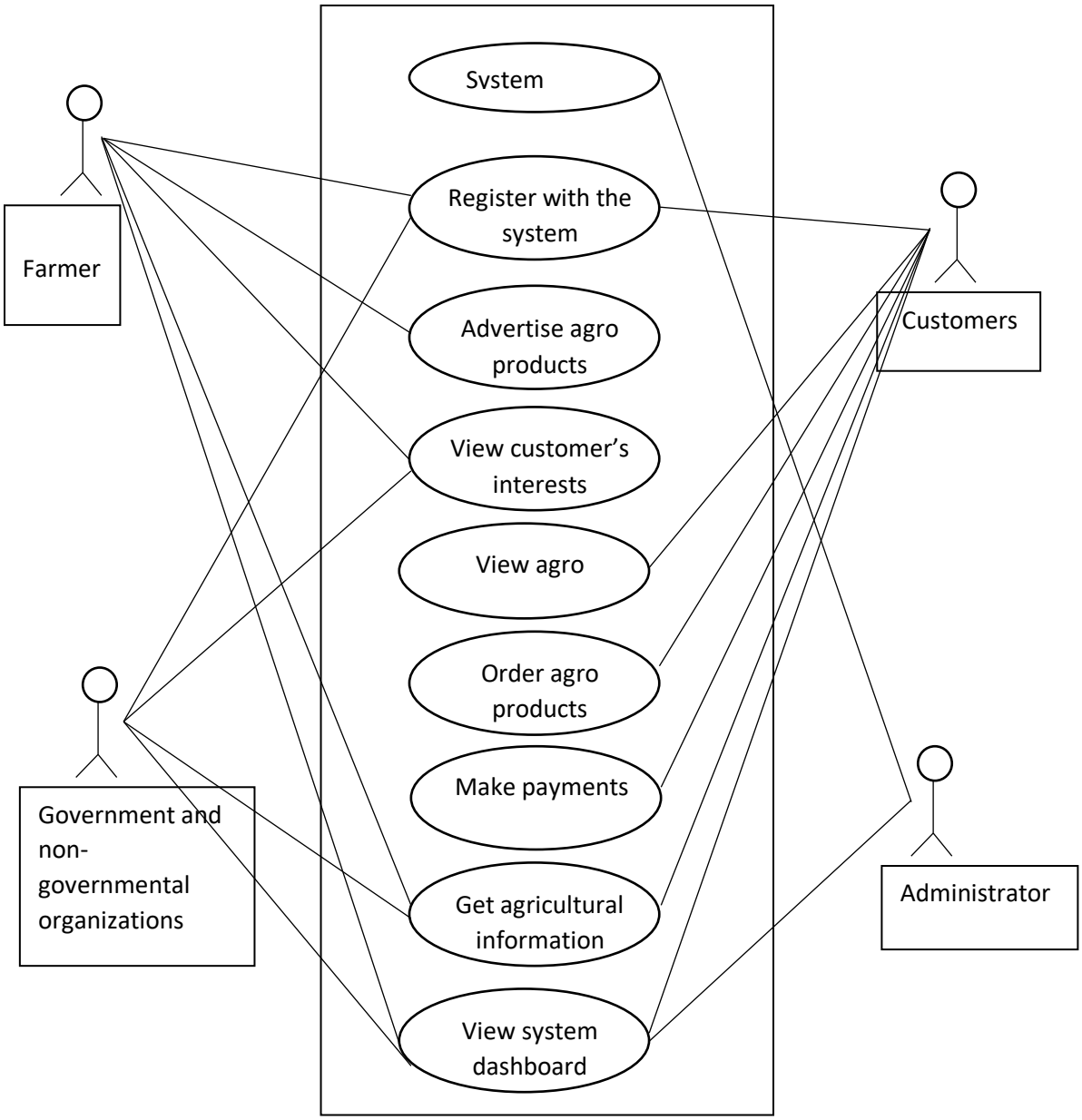

Figure 1a: Use Case diagram of the agro distribution

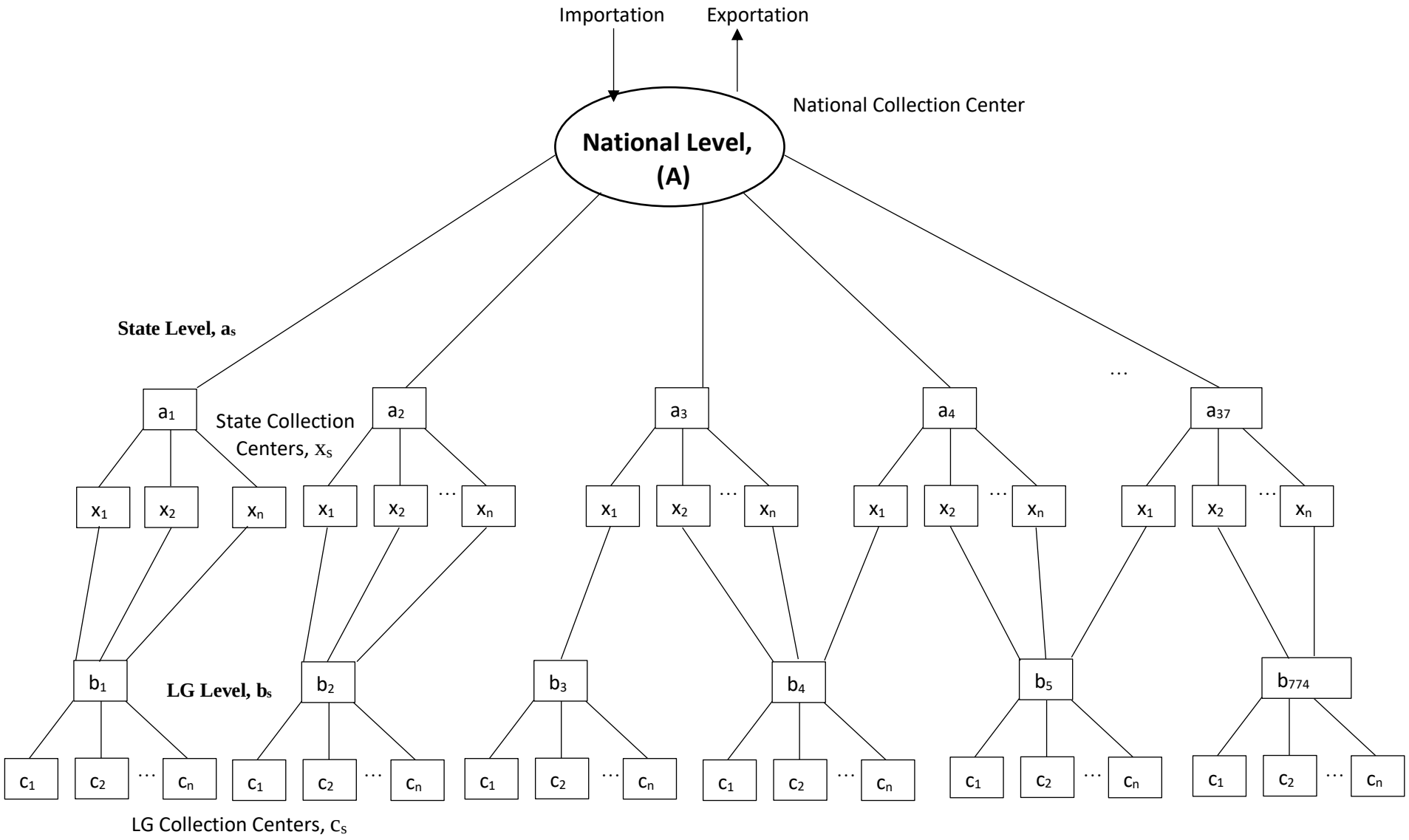

Figure 1b: An Agro Distribution framework

$$\text{Let } bi = \sum_{j=1}^{n} \{c_1,\ c_2,\ c_3,\ \ldots,\ c_n\} \qquad \text{eqn (3)}$$

Where $\{b_1, b_2, b_3, \ldots, b_n\}$ are the LGAs in the state and $\{c_1, c_2, c_3, \ldots, c_n\}$ are the towns/communities in the various LGAs (n = number of town/communities in an LGA). In brief:

1. A ← a_i
2. a_i ← bj
3. bj ← c_k

where ← implies takes value from.

National (A) ← States (a_n) ← LGAs (b_n) ← Towns/Communities (c_n)

Where A = National (the country); a = states; b = LGAs; and c = towns/ communities. Using Nigeria as an example:

i: $1 \leq i \leq 37$ i.e. 36 states plus Abuja.

j: $1 \leq j \leq 774$ i.e. 774 LGAs in Nigeria.

K: $1 \leq k \leq n$ i.e. n = number of towns/communities in a LGA.

The implementation and the Agro Distribution Framework architecture are shown in Figures 2 and 3.

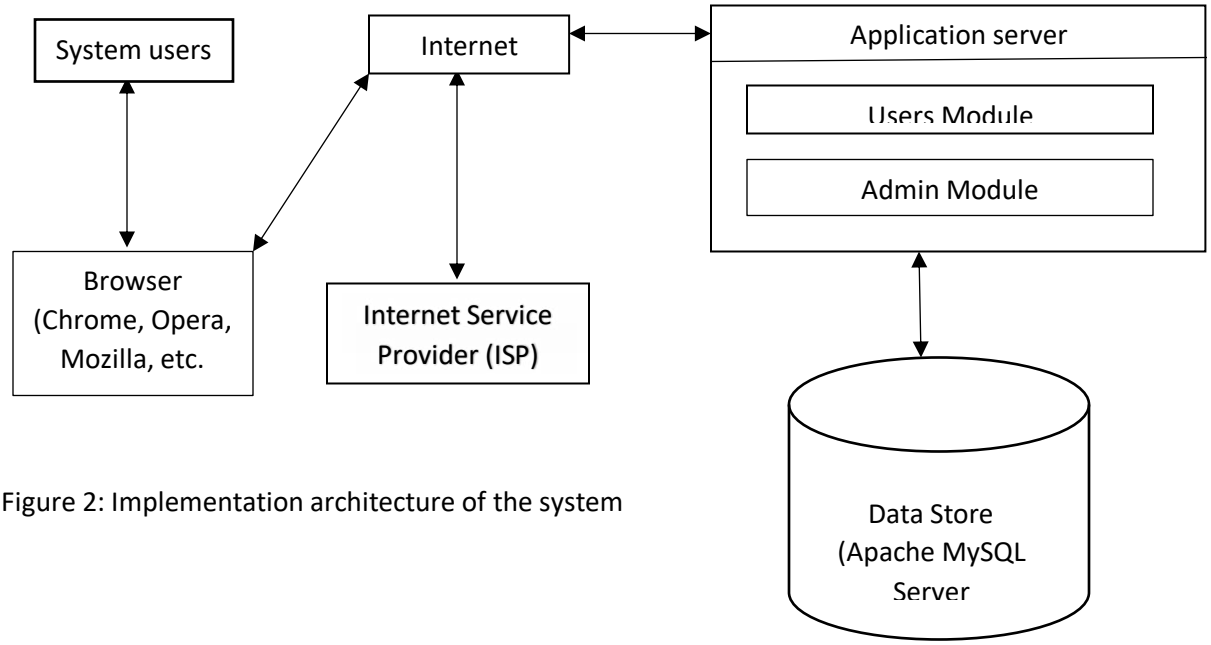

Figure 2: Implementation architecture of the system

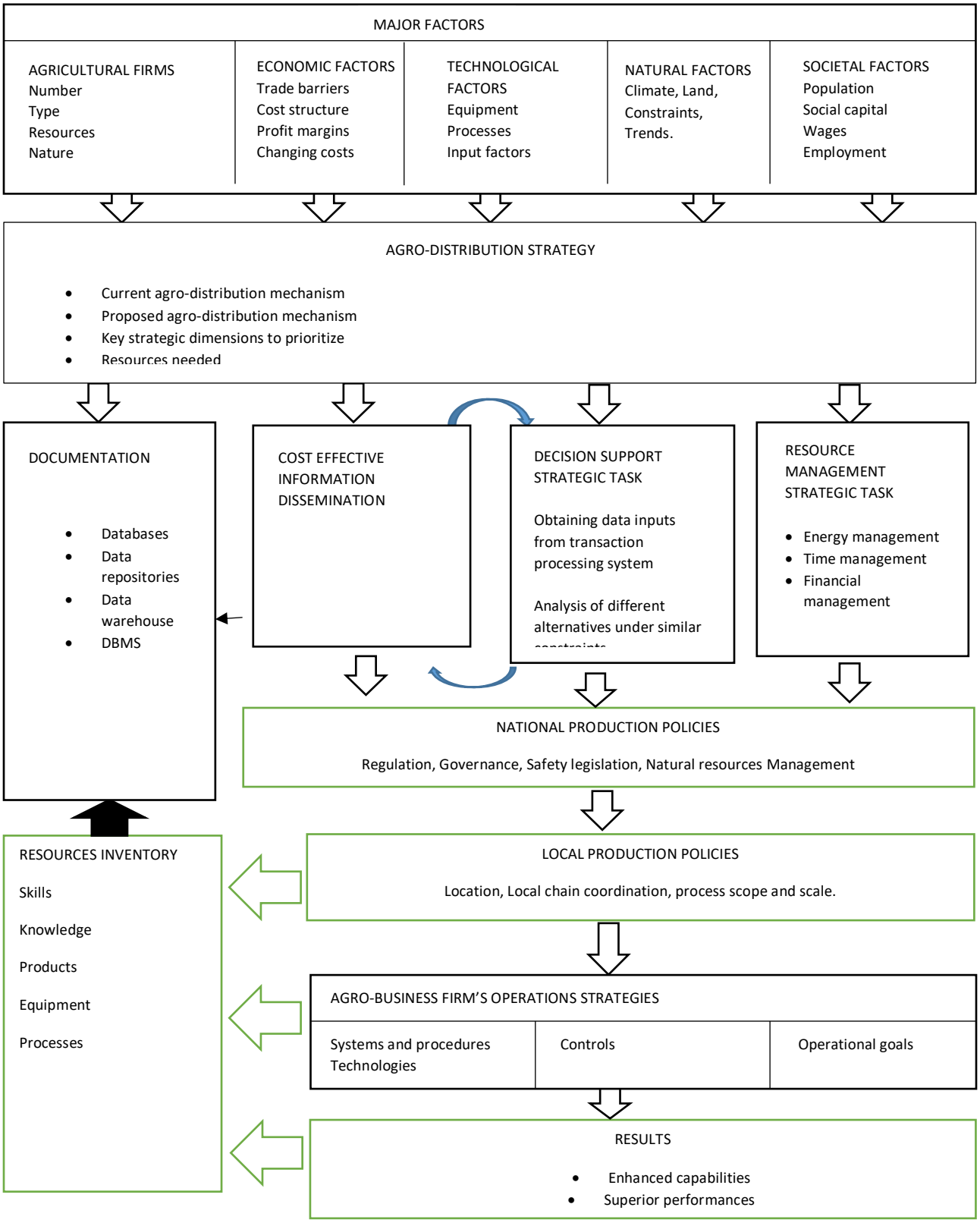

Figure 2: Agro-distribution architecture

Figure 2 shows the architectural procedures that were considered in the development of the agro-distribution framework.

The major factors include:

- Agricultural firms: These are the competitors involved in agribusiness. Their features include, their number (whether they are very many or few in number), their type (the type of product produced), resources (the human, material or financial resource available to them), and their nature (the type of services they render).
- Economic factors: These describe their existing businesses, i.e. what have been the trade barriers that might have been experienced by others, what their cost structure is (this can be used as a tool to determine prices), their profit margin, etc.
- Technological factors: This has to do with the type of equipment that have been in use, their technological processes as well as their input factors.
- Natural factors: This implies climatic factors, land factors, the constraints and trends experienced in the various locations.
- Societal factors: This include population, social capital, wages and employment statutes in the region.

3.2. Agro-Distribution Strategy

These factors include:

- Current agro-distribution mechanism consisting of documented observations.
- Proposed agro-distribution mechanism consisting of enhancement to the existing system.
- Key strategic dimensions to prioritize ways of making the system to be more user-friendly.
- Resources needed for the new system to meet requirement specification.

These strategies are stored in the database section of the framework (that is, the database needed for the running of the entire system).

Other considerations drawn from the strategy include:

- The cost effective information dissemination: The framework accommodates both governmental and non-governmental organizations as well as other resources that would help disseminate the necessary information to the farmers and other stakeholders for an improved farm quality, productivity and distribution.
- Decision support strategic task: This aids the consumer and the general public in their decision making as a result of the availability of alternatives presented to their advantage.
- Resource management task: This involves the management of the resources needed for the framework.

All these stated factors conform to the production policies of the nation, not conflicting the nation's regulatory policies, governance, safety legislation, natural resource management especially as it relates to agriculture. Again, the system makes room for inclusion of state governments where the products and services are located. These factors work in conformity with the local production policies (state policies) and make provision for adjustment if for any reason it is slightly different from the nation's policies. The framework makes provision for individual firm's operational strategies, systems, procedures, technologies, controls and operational goals. The final result is a system with enhanced capabilities and superior performance. Resources inventory documented in the database assist firm in tracking their progresses.

3.3. Benefits of the Proposed Framework

The benefits the agro-distribution framework to both the farmers and the general public include:

- Wider showcasing of agricultural produce and evaluation.
- Enhanced earnings.
- Intensified competition within the states which is adequate in the agricultural sector and inclusion of more small stakeholders into the supply chains.
- Increased effectiveness, profitability and supportability of small scale farmers.
- Availability of information about pest and disease control from both governmental or non-governmental organizations, fellow farmers and the general public.
- Better approaches to optimize production and directions for quality control.
- Increased markets, better informed choices about future products, commodities and services.
- Availability of information about product location and venue.
- Up-to-date market information on costs for commodities, inputs and consumer trends.

- Reduced social isolation, expanded views of local communities to the world in terms of new business opportunities.
- Seamless access to goods and services.
- Agro Information about new ideas, inventions, critiques, and lots more can travel around the globe in seconds. Information will no longer be just for the privileged but can be shared by all.
- Ensures even distribution of agro products within the states of the federation.
- Easily identifies the products for import and export among other benefits.

4. Conclusion

Information about agricultural products and services for prompt decision making is at the hub of digital agricultural transformation. The integration of contemporary technology in agricultural processes has resulted in better decision-making in agriculture resulting in enhanced efficiency and increased productivity. Agricultural products and services need a systematic distribution framework that gets the products from region of surplus to the areas where they are in short supply. The framework rewards not only the farmer, but also marketers and the consumers. It makes information about agricultural products and services readily available to all agricultural stakeholder including government and non-governmental organization.

5. Future Work

Agricultural firms should consider employing the use of artificial intelligence techniques in agro distribution. Artificial intelligence which is about designing systems that can reason like humans using cognitive science approach would go a long way in drawing and mapping out plans to ensure best and equitable distribution of agricultural goods and services. The authors hope to explore how to use artificial intelligence in specifying the optimal agro distribution framework for agricultural firms. This requires the need to incorporate artificial intelligence and machine learning in agro distributions. This is an area of research which should be explored in agro centric countries like Nigeria and researchers are called to explore machine learning based agro distribution for goods and services.

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