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A Private Sector Driven E-Agriculture for Sustainable Food Security in Nigeria

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ABSTRACT

Food is life. It is a basic necessity for the survival of any individual or nation. The ability of a nation to provide affordable, safe and nutritious food is very vital to the development and growth of that nation. The key sector of the nation that is primarily responsible for this is the agricultural sector. Nigeria has been in pursuant of food sustainability for a long time, but little progress has been made. Machine Learning (ML) is fast finding application on several fields of life (including Agriculture) and every day, machines are learning to tackle complex agricultural tasks leading to sustainable food security, particularly in developed nations. In this paper, we explore an e-agriculture framework for sustainable food production using ML. We design private sector-driven framework, where ML plays an integral role, driving sustainable food production. Findings reveal that many of the failed agricultural projects scattered across the country can be driven by ML based technologies to increase productivity and to spur more research interest in this field.

Keywords*:* Nutritious Food, Machine Learning, E-Agriculture Framework, Private Sector-Driven Framework, Security

1. INTRODUCTION

Food security is a major concern of every nation. It is usually on the front burner on national and international discourse. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Nigeria is not different in this pursuit. Prior to the discovery of crude oil in the serene town of Oloibiri in 1959, Nigeria's economic mainstay was agriculture. But, this changed with the advent of the mineral aliased as the 'Black Gold'. However, several years down the lane, it has become glaringly clear that the country has to return to agriculture to keep its economy sustainable and vibrant. Since the 1970, governments had tried different programmes aimed at boosting the agricultural sector, but not too much success had been recorded. We have had Operation Feed The Nation (General Olusegun Obasanjo), Green Revolution (Alhaji Shehu Shagari), Structural Adjustment Programme (General Ibrahim Babangida), all aimed at achieving food security for the country. Agriculture also featured prominently in President Musa Yar'Adua's 7 Points Agenda, President Goodluck Jonathan's 5 point Agenda and now President Buhari's 'Change' mantra.

One area where ML can find application is in the field of agriculture and agricultural extension services. Agriculture is a unique business that involves crop production which is dependent on several climatic, policy and economic factors. Other factors that can adversely affect agriculture are soil, irrigation, fertilizer, rainfall, temperature, etc. (Majumdar *et al.,* 2017). Food is the most basic of all human needs, and it is the responsibility of a government to ensure sufficiency. The Nigerian government recently ordered the closure of its border to neighbouring countries, including Republic of Benin, Niger Republic, etc. in order to reduce smuggling of food products (e.g., rice, poultry, etc.) into the country. The aim is to boost production and dependence on local produce and to ensure food security. Food security is multidimensional paradigm involving the economic, environmental and social aspect of a nation (Matemilola & Elegbede, 2017). Food Security is the availability of quantitative and qualitative, hygienic and safe food. By hygienic and safety, food, for instance may be available but the source from which the food is produced or processed or preserved may be unhygienic thereby constituting health hazard (Ojo & Adebayo, 2012). The aim of this research of this work is to design an all-inclusive private driven framework to tackle the issue of food security, with machine learning playing an integral part in the framework.

2. REVIEW OF RELATED WORKS

In the course of the research work, it was discovered that little has be done in harnessing the power of Machine learning (Data mining) in boosting agricultural production in Nigeria, much less food security for her populace.

Akpojaro & Waidor, (2019) proposed a data mining framework for improving agricultural production in Nigeria. Their work focused on an all-inclusive stakeholders frame work with the Government in the middle of the whole mix, leading to the development of an information bank powered by data miners from which farmers or association of farmers could get information through a means of pull or push messages. The work also x-rayed different areas in agriculture where different data mining algorithms are applicable; however, no quantitative analysis was done to drive home their point.

The role food security and sustainability play in human existence and the sovereignty of a nation is critical (Van-Ettena *et al.,* 2019). This can be depicted in the biblical account of how the Israelites ended up as slaves in Egypt for over 400 hundred years due to shortage of food in their own land. Bronson (2019), designated as 'wicked' the twin problem of food insecurity and sustainability challenges, and attempted to highlight and categorized some digital artifacts currently in use in food systems around the globe with the hope that such digitization can help improve food security and sustainability. The research employed Big Data, which is the collection of large data using sophisticated computational technology. Such data could be collected using satellites or Unmanned Aerial Vehicles (UAV).

Digital Agriculture makes an in road to new opportunities cumulating to widespread use of modern, related and data-centric computer technologies to agriculture (Rahman, Haq & Rahman, 2014). Ozdogan *et al.,* (2017) opined that digital agricultural tools can be used in all agricultural and livestock systems.

In a literature study on application of data mining techniques to extract knowledge from agricultural data to evaluate crop yield for major cereal crops (Aishwarya, 2016; Bhojani & Bhatt, 2018) considered the effects of weather, pH, soil salinity and area of production as factors towards crop production in Bangladesh, then considering these factors as datasets for various districts, clustering technique was applied to divide regions; then appropriate classification algorithm used to obtain crop yield predictions. The study showed that Root Mean Square Error (RMSE) could be used to describe how well a machine learning algorithm performs on a certain data set, while Artificial Neural Network (ANN) gave better estimate for some crops with more missing values.

3. MATERIALS AND METHOD

In a data mining framework for improving agricultural production in Nigeria proposed by Akpojaro & Waidor, (2019) as shown in Figure 1a and 1b below, the Federal government was in the middle of the mix of a stakeholder framework as the cardinal driver of agricultural abundance in Nigeria. This, at first glance looked plausible, but posterity tells us that government is hardly successful as a key driver of businesses in Nigeria. This is exemplified in the three government owned petroleum refineries, the moribund Ajaokuta steel company, National Electrical Power Authority and several food sustainability programmes, including Structural Adjustment Programme (SAP), Operation Feed the Nation (OFN), Green Revolution (GR), etc., all of which did not outlast the government that initiated them. Also, a sorrowful tale follows other state-owned businesses such as banks, national air carriers as well as Nigeria Telecommunications (NITEL).

Another model presented in Figure 2b, shows that the authors failed to tell us who or what would be driving the e-Agriculture centre.

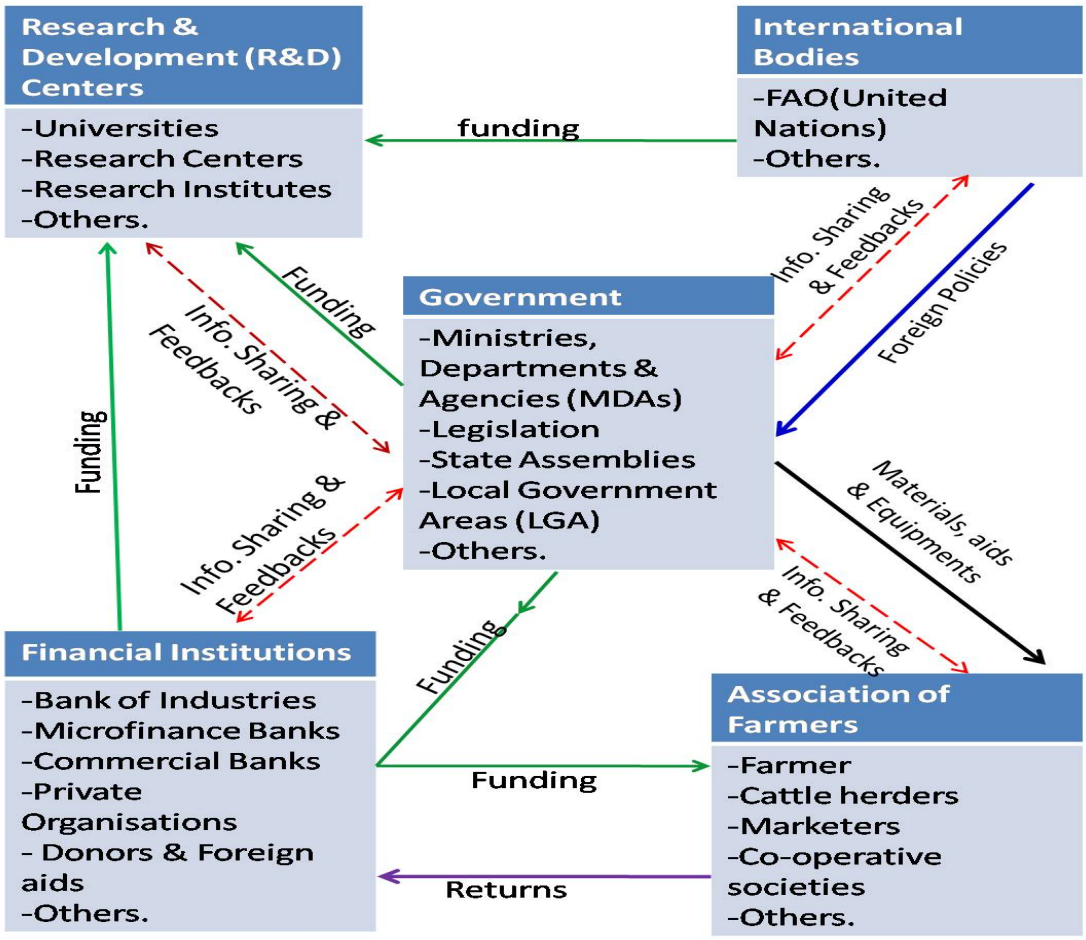

Fig 1a: Stakeholders' framework for improving agricultural produce in Nigeria. (Akpojaro & Waidor, 2019).

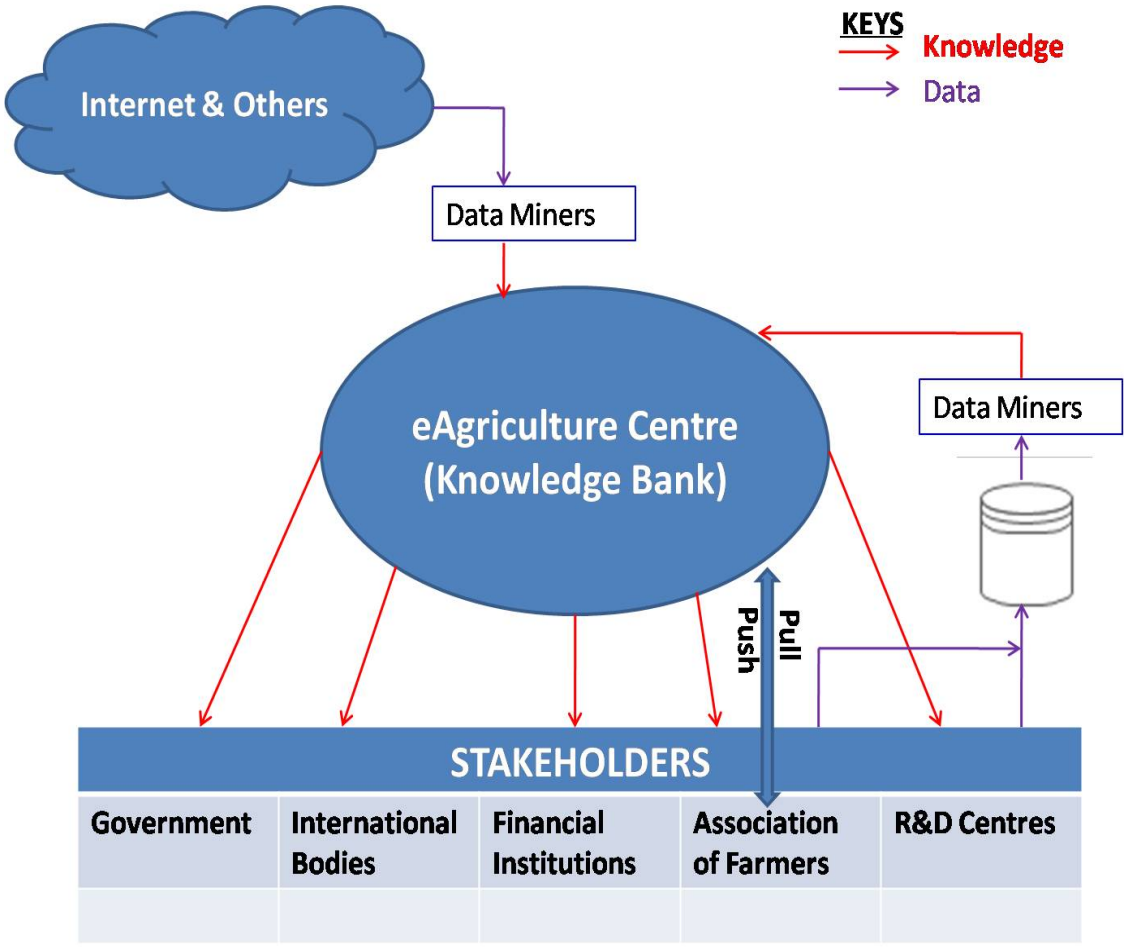

Figure 1b: E-Agriculture framework for enhancing agricultural production. (Akpojaro & Waidor, 2019).

In figures 2 and 3, a proposed private sector–driven framework with support from the government is presented. In Turkey, for instance, there are private platforms such as Tarla.io and Dokta Inc. which are driven by cloud computing, Big Data and Internet of Things infrastructure offering product and services to farmers (Ozdogan *et al.,* 2017; IPES-Food, 2016). There is no doubt that Nigeria needs a paradigm shift as agriculture power house in Africa and beyond. To achieve this, we propose a private-sector private sector-driven agricultural framework depicted in Figure 2 on the next page.

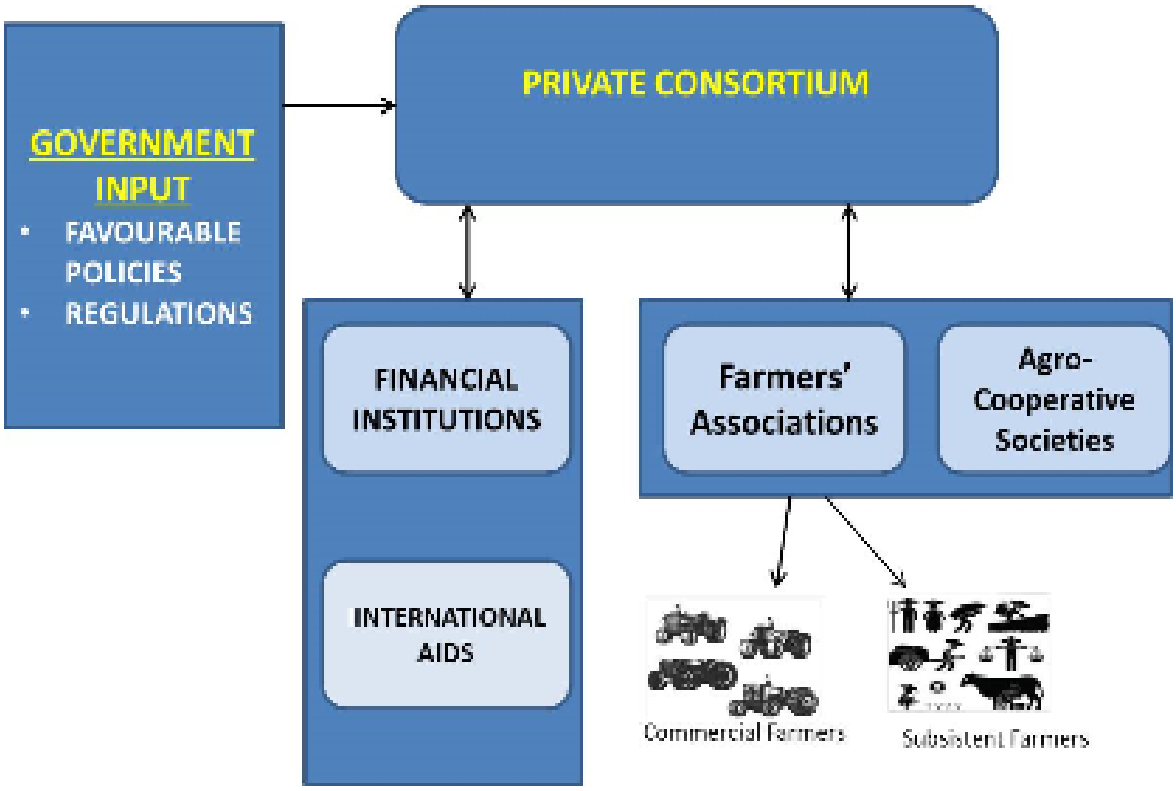

Figure 2: Private Sector-Driven Agricultural Framework

In this framework, the role of the government is to create an enabling environment for agro-business to thrive through agricultural friendly policies and regulations such as zero VAT (Value Added Tax) on farm produce, duty free on agricultural equipment importations, availability of itch-free farming area (aquatic and terrestrial), etc.

The focus here is the private consortium (Figure 3) made up of private investors, E-agriculture agencies (Data Mining, Machine Learning and E-commerce etc.), research institutions, factories & food processing centres and Agro-allied companies, interacting and sharing resources towards achieving goals of food security and sustainability for the nation.

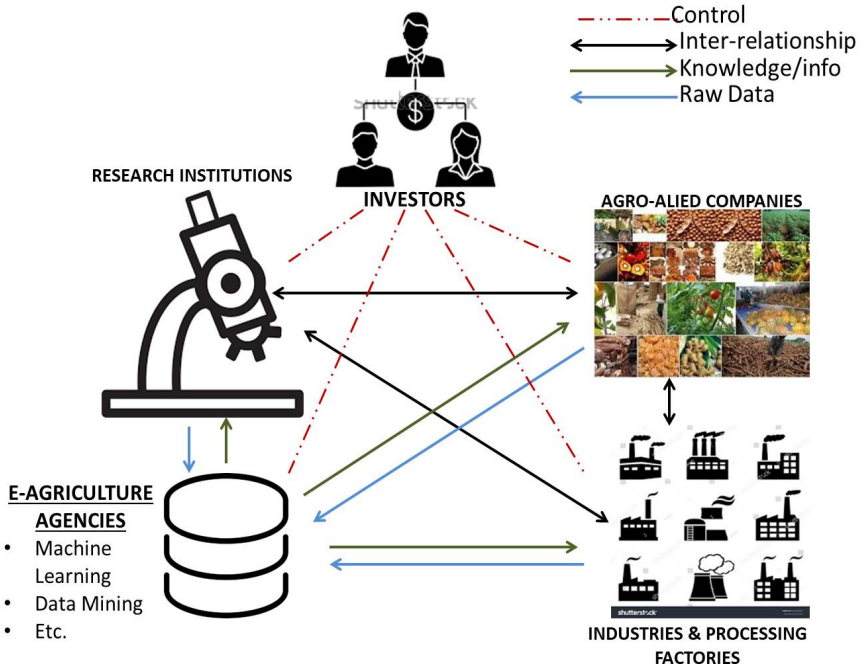

Figure 3. Private Consortium Framework

The consortium needs to be in business collaboration and alliance with financial institutions and international organizations and donors to boost liquidity and productivity. In addition, the consortium will liaise directly with farmers' association and other agro-based cooperative societies to provide useful resources such as finance, mining information (or knowledge), agro-equipment, arable lands, etc. By extension, this will filter down to the commercial and subsistent farmers.

4. DISCUSSIONS

In the framework presented in Figure 3, an e-Agriculture agency under which machine learning is categorized plays a key role in the private consortium-driven framework (van Etten, 2012). It receives raw data from other constituents of the stakeholders, applies machine learning algorithms to the data and provides very valuable knowledge-based information which filters down to the farmers. Some information required by the stakeholders includes pest control (insecticides and herbicides), crop yield prediction (Sharma & Singhvi, 2017; Prashar & Shah, 2016) with some missing values using Artificial Neural Network, ANN, (Aishwarya, 2016).

Species breeding/selection using deep learning algorithms, soil management, water management, yield prediction using Support Vector Machine, SVM, crop quality-using SVM, weed detection using ANN, disease detection, livestock production, animal welfare management are provided by the consortium when fully integrated using ML.

5. CONCLUSION AND FUTURE STUDIES.

In this work, we designed an ML framework for achieving food security and sustainable agricultural infrastructure in Nigeria. The framework is a private-centric rather than government-centric (meaning that the need for food security in Nigeria should be driven by private investors rather than government). We also looked at the cardinal role ML can play in this framework to help boost agricultural productivity in Nigeria, due to the vast area of application of ML in Agriculture and its tremendous benefit. As discussed in the study, agricultural infrastructure thrives better in the hands of private sector than in public sector. This was brought to light by the many failed public infrastructures scattered across the country.

This work also reveals that smart farms (or ML-based farms) are a rarity in Nigeria, but this can spur more research interest in this field. Considering the capabilities of artificial intelligence systems in improving agricultural production and product quality, we hope to do more specific analysis using some ML algorithms with some agricultural techniques such as pest control (insecticides and herbicides), crop yield prediction with some missing values using Artificial Neural Network (ANN), species breeding, species selection, soil management, water management, yield prediction, crop quality, weed detection, disease detection, livestock production using Support Vector Machine (SVM), animal welfare management using Bayesian models.

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