



Research Article

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« INDUSTRIAL REVOLUTION OF AFRICA’S AGRICULTURAL SECTOR A PARADIGM SHIFT TRANSFORMATION »

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Abstract:

Agriculture is still the dominant occupation of over 70% of the African rural farmers. Increasing the operations of Africa’s agriculture is thus very essential in attaining industrial revolution and shift resulting in Africa’s agriculture sector growth and obliteration of poverty in African countries. The sudden break-out of industrial agro-revolution experienced an overwhelming increase in agricultural outputs and sector development. Improved methods of production involving the use of machines and mechatronics had drastically reduced the use of old methods of cultivation (animal and human labours) which deface agriculture making it a tedious enterprise. Furthermore, the invention and introduction of advanced emerging technologies in agriculture had overhaul the entire sector aligning and fortifying it into a profitable and viable enterprise thus driving agro-industrial revolution cum transformation.

This has further increased the level of agricultural productivity in terms of yields, outputs, and overall economic gains. Conclusively, agricultural innovations, revolution and transformations are currently at the third stage of industrial revolution awaiting metamorphosis into the fourth industrial revolution where advanced technologies and its drifts such as the virtual reality (VR), agro-robotics (AR), Internet of Things (IT), and artificial intelligence (AI) are domiciled and seriously changing our work patterns and ways of life. Hence, African governments are to exploit the benefits of industrial revolution via the use of advanced technological tools and inclusive policy instruments to nurture economic growth, sector development and overall transformation of the African economy.

Keywords:

Agriculture, Africa, Industrialization, Transformation, Policies, Revolution.



Introduction:

Agriculture remains a prevailing occupation in Africa accommodating above 69% of the populace who makes a living out of it. It represents about 20% of Africa's gross domestic product (GDP) and about two-third of the total value of its exports (Block, 1999). Raising the performance of Africa's agriculture is very significant in achieving sustained industrial revolution and transformation resulting in overall development of the agricultural sector and reduction in poverty which had ravished majority of the African countries. Most of the households in Sub-Saharan Africa live in rural areas and practiced agriculture as their main source of livelihoods (Osuji, 2017). Before now, most of these households operate their own farms making use of family labour while few people are hired as paid workers. The advent of innovative technologies in recent times has replaced most the crude ways practiced in agriculture by the crop farmers. The changes in production, manufacturing and transportation that commenced with fewer things being made by hand are now made using machines in larger-scale factories (Herrero et al. 2017). The emergence of the agro-industrial revolution experienced a large scale of agricultural production. New sources of energy and power, especially coal and steam, replaced wind and water to create labor-saving machines that dramatically decreased the use of human and animal labor and, at the same time, increased the level of agricultural productivity. In turn, power machinery called for new ways of organizing human labor to maximize the benefits and profits from the new machines (Be'ne et al. 2019). However, the relevance of African agriculture to secure food security and availability cannot be perfected without the advent of emerging technologies which plays a vital role in the development of the agricultural sector. It's obvious that the poor rural living standards make the agricultural sector a prominent focus for policy direction in developing countries (Augustine et al. 2018). Many African countries are concerned with moving the agricultural sector away from a subsistence level and placing it towards higher productivity and market preference. Others are concerned with the sector's capacity to absorb workers, in policy environment where urban occupations in the formal sector are in short supply. Still others focus on supporting the agricultural sector to meet domestic food needs and to avert over dependence on imported goods and services which have bedeviled most of the African countries over the past decades (World Bank, 2018). Hence, with the emergence of agro-induced technologies, all the above concerns had been laid to rest. Africa's agriculture has witnessed a shift from the traditional labour intensive

economy based on farming and handicrafts to a more capital intensive economy based on manufacturing by machines, specialized labour and industrial factories. The rapid development of large agro industrial factories encouraged mass movements of people from the rural areas to urban areas where impersonal co-existence replaced the traditional intimacy of rural life (AMIS, 2018).

Higher levels of productivity led to a search for new sources of raw materials, new consumption patterns, and a revolution in transportation that allowed raw materials and finished agro-products to be moved quickly around the world (AMIS, 2018). The changes in novel methods of farming and stock breeding that characterized this agricultural transformation led to a significant increase in food production. African agriculture could now feed more people at lower prices with less labor.

AGRO-INDUSTRIAL TRANSFORMATION AND INDUSTRIAL REVOLUTION IN AFRICA

Agro-industrial transformation is a process that leads to higher productivity on farms, commercially orients farming, and strengthens the link between farming and other sectors of the economy. Efforts have been made to transform Africa's agriculture into a modernized sector to help lift farmers' incomes, make farming attractive to the youth, and increase employment (Tashi, 2018). This has equally led to the full development of agricultural value chains in Africa, in turn producing more agro-technological-related jobs and has improved the living standard of African farmers. Aside from boosting employment rates generally, modernized farming to an extent had specifically addressed the issue of widespread unemployment amongst the educated youth. The vision of a [transformed African agriculture](#) includes higher productivity on farms so that growers can produce enough food for both consumption and sale in regional and global markets. This will release labor, especially the youth, into on and off-farm value-addition activities in agriculture to improve welfare outcomes and eradicate poverty (Gilani et al. 2015). Successful agro-industrial transformations and revolutions had in time past reduced poverty, been powerful engines of rural economic growth. The dynamics of an agricultural transformation and industrial revolutions start with increasing the income of rural households, higher productivity on farms, and greater demand in local markets. As the sector becomes more productive, larger industrial markets are served, agro-processing of farm products expands, and some farmers may decide to spend

less time farming and take other non-farm jobs to support their income (AGRA, 2014). With few exceptions, as countries move along an economic-development path, their agriculture sector modernizes, becoming more efficient and less labor intensive. At the same time, non-agriculture sectors in the economy (for example, manufacturing and service sectors) grow and absorb more labor. Agro-industrial technologies had revitalized and transformed agriculture while restoring degraded land and maintaining or strengthening the ecosystems that underpin agriculture hence, ensuring high productivity of the farm lands. Investments in Agro-industrial technologies which stemmed from industrial revolutions had increased land tenure security of most farmers positioning them for greater exploits in farm production and agro-allied services that increases crop output, yields and income (Osuji et al. 2017). Furthermore, agro-transformation and industrialization presents a promising prospect for development of the agricultural sector. With the right policies and enabling environment in place, it has the potential to bring the best of agricultural, manufacturing, and services sectors. Due its forward linkages, it increases value addition in GDP and elevates the continent through the global value chain, creating employment opportunities and increasing incomes, strengthening food security and improving nutrition to promote a healthier and productive workforce, and ultimately, alleviate poverty. Agro-industrial transformations are seen as drivers of post-harvest activities involving the transformation, preservation and preparation of agricultural production for intermediary or final consumption. It comprised of artisanal, minimally processed and packaged agricultural raw materials, the processing of intermediate goods, and the fabrication of final products derived from agriculture (AGRA, 2014). Agro-industrial revolution has contributed immensely and empowered most of agriculture-related industries including also distribution and trading activities. It has brought enormous changes within the subsectors of agriculture by integrating advanced technologies in food-processing and beverages industries, accounting for more than 50 percent of the total formal agro-processing sector in low and middle-income countries (AGRA, 2014). This number is much higher for some African countries such as Ethiopia, Eritrea, and Senegal for whom food and beverages represent more than 70 percent of agro-industry value added and 30-50 percent of total manufacturing. Processing of meat, fish, fruits, vegetables and fats, bakery, macaroni, chocolate, and other foods also constitute a sizeable proportion of the total value addition. Agro-industrial revolution has also brought

structural transformations in tobacco and textiles, as well as leather industries making them competitive with other non-African countries such China, Brazil, Italy, etc (Tashi, 2018). Considering the entire food system, including the production of goods and commodities, marketing, and retailing, which account for more than 50 percent of the GDP of developing countries, agro-industrial revolution played a vital role in the creation of income and employment opportunities in Africa. From the point of view of sustainable economic growth, food security, and poverty reduction, the contribution of agro-industrial revolution is paramount. Studies show that due to their forward and backward linkages, agro-industries have higher multiplier effects in terms of job creations and value addition (Larson et al., 2014). Agro-industrialization stimulates businesses well beyond the closest links with its direct input suppliers and product buyers. It has the potential to bolster a range of ancillary services and supporting activities in the secondary and tertiary sectors. Furthermore, since most agricultural products are bulky and perishable, many agro-industries and small-scale agro-processing enterprises are now located close to sources of raw materials owing to industrial revolutions. Their impacts on rural off-farm activities, employment, and poverty alleviation in general are hence, enormous. Economic literature has often explained different stages in African agriculture and development. As noticed in advanced countries, it is believed that countries undergo certain structural changes as they transit from one level of development to another. In Africa, one of the observable structural changes is the changing share of agriculture in both GDP and total employment (Larson et al., 2014). This emerges with agro-revolution and industrial transformations. As they advance to higher levels of development, more transformations are recorded leading to the growth of the agricultural sector. Manufacturing and service sectors take prominence as the rural labour force is transited to innovative technologies in terms of auto-mechanical and electrical machines, thus agricultural productivity increases with more science-based innovation (Marenya and Barrett, 2007). This phenomenon has been observed in Europe, America and in some parts of Asia as industry and service sectors have become the engine of agro-transformations and growth. However, structural transformation in Africa saw the shift away from agriculture at a time when production and productivity in agriculture had increased due to science-based innovative technologies (McCullough, 2015). This allowed reallocation of labour to non-agricultural sectors with little or no consequences for food security. This was possible owing to the facts that intensive use advance machines in

agriculture had outlived labour usage. It is on this backdrop that the following questions were raised? How much labour can agriculture release? Has African agriculture attained production levels that permit withdrawing labour? Is this labour being replaced by mechanization? It is evident to know that all these concerns have been handled and documented (Paarlberg, 2002). In Africa, low agricultural productivity plus an increasing population calls for onward development of the agricultural sector via the use of advanced technologies to sustain economic growth, reduce poverty and ensure food security at all levels. The timing of resource reallocation between sectors of the economy matters for the development outcomes of structural transformation. When resources move from one sector of the economy to another, it tends to improve development outcomes due to more efficient use of those resources (Mundlak, 2000). Consequently with the advent of innovative agro-technologies, most of Africa's rural subsistence agriculture is being transitioned to commercialized farming producing just what is sufficient for home consumption and commercial marketing (McMillan and Harttgen, 2014).

AGRO-INDUSTRIAL POLICIES CUM INNOVATION AND TRANSFORMATION IN AFRICA'S AGRICULTURE

Before now there was no policy in place aimed at mobilizing resources specifically for raising productivity in the agricultural sector and ensuring food security. Over the years African countries have evolved a good number of emerging industrial agricultural policies geared towards strengthening the agricultural sector (Tombe, 2012). The emergence of Forum for Agricultural Research in Africa (FARA) since 2000 has helped in alleviating most of the problems facing African farmers at a time. It helped in developing agro-industrial policies which focus on the mechanization of large farms and modernization through the supply of improved inputs such as fertilizers and hybrid seeds. Crop industrialized marketing and agricultural credit schemes were organized through public institutions aimed at assisting farmers secure credit facilities to expand production (Baldos and Hertel, 2015). The introduction of the Structural Adjustment Programmes (SAP) aimed to reduce public expenditures through privatization and liberalization through the abolishment of price controls, the reduction of trade barriers and the scrapping of fixed exchange rates brought enormous industrial transformations in Africa's agricultural sector. Through SAP, African governments were able to set up an enabling environment for the agro industrialized markets to encourage private players to take over the marketing of

both inputs and outputs (Swinnen, 2011). Hence, these medium increased inputs availability and accessibility. The signing of the Maputo Declaration in response to African industrial development policies saw a revitalization of the agricultural sector. Pan-African agricultural policies and the Maputo declaration of the African union are widely perceived to be significant milestones in the industrial development of the agricultural sector in Africa (Tiffin and Irz, 2006). The CAADP and the Maputo Declaration were signed by the African heads of state at the Second Ordinary Assembly of the African Union in 2003 laying the foundation for the Comprehensive Africa's Agricultural Development Programme (CAADP) and the Maputo Declaration, Pan-African agricultural policies. The main driving force behind this initiative was the need to address the structural food gap in sub-Saharan Africa, where a high share of agricultural imports co-exists with a large incidence of undernourishment and hunger, and to drive the structural and industrial transformation process as envisioned by the African Union Agenda (Thurlow and Van-Seventer, 2002). The CAADP was divided into two periods: the first decade of the programme (2003-2013) and the second decade (2015-2025). After the first decade of the programme, the African Union decided to shift its policy focus and put a more intensive monitoring mechanism into place. The primary objective of the first CAADP was to increase investment in agriculture through advanced technology and generate growth in the agricultural sector. In the Maputo declaration, African governments pledged to allocate 10% of the national public expenditures to agricultural transformations by involving emerging industrial agro-technologies such as farm robotics, mechanized irrigation, farm technologies, auto driven tractors, electrical machines, etc (Stifel et al. 2012). The CAADP is seen as a set of guidelines for a process to shape agricultural policies within countries and across countries, in collaboration with and supported by a wide range of actors. The aim is to foster an inclusive process bringing onboard diverse stakeholders, such as farmers' organizations, the private sector and women's associations, to gain consensus for a national agro-industrialized policy (Stifel and Minten, 2008). The first step in any national CAADP process is stocktaking and round table discussions, whereby relevant stakeholders in the country discuss emerging agro-industrial technologies and policy priorities. Subsequently, the stakeholders jointly sign a CAADP country compact, followed by the development of national agriculture and food security investment plans. These plans provide the detailed blueprints for achieving the goals and targets in the CAADP compacts. Again, the New Partnership for Africa's

Development (NEPAD), African National Planning and Coordinating Agency (ANPCA) is the facilitating unit, ensuring that countries write up investment plans that are consistent with the CAADP objectives (Wade, 2003). In addition, the Regional Economic Communities (RECs), such as the Southern African Development Community (SADC) and the Common Market for Eastern and Southern Africa (COMESA), play a role to push for the implementation of CAADP in the countries themselves, while coordinating region wide investments in innovative emerging technologies through the regional CAADP compacts (Robinson, 2011). The Regional Strategic Analysis and Knowledge Support System (RSAKSS) are responsible for monitoring national and regional progress through the provision and analysis of key data, supported by the International Food Policy Research Institute (IFPRI). The strategy outlined in the policy framework document of CAADP, stresses the role of smallholder farmers' in fulfilling the dominant goals of the Maputo Declaration (Robinson, 2011). The agricultural industrial policies cum structural transformation pillars focused on smallholder farmers. For the first pillar of, Land and water management, irrigation benefiting smallholders (including mechanized irrigation systems) is central. The second pillar focuses on the crucial role of infrastructure and the importance of rural roads in connecting smallholder farmers to markets. In addition, the strategy mentions soft infrastructure, notably communication and price and market information for farmers. The importance of involving the private sector to spur market access is established. The third pillar concerns raising food supply and reducing hunger, and improved technology among small scale farmers and the creation of an enabling environment for the provision of extension services and rural development. Structural safety nets, in the form of basic food or cash to support vulnerable groups in society are put forth as a component of reducing hunger and poor nutrition. The fourth pillar - agricultural research and dissemination – focuses on enhanced extension to producers, and risk and cost reduction of technology adoption for smallholders specifically. (Jacoby and Minten, 2009).

NIGERIA AND THE PARADIGM SHIFT TRANSFORMATIONS

Nigeria has witnessed a lot of transformations in virtually all the sectors of the economy due to the technological innovations and inventions of the 21st century. Before now, Nigeria was bedeviled with a lot structural defects and sectorial decadence owing to neglects and share abandonment of her productive sectors. Thus, over time

the following sectors of the Nigerian economy have received diverse transformations, not to mention but a few;

1. **Agricultural Sector:** Agricultural sector has high potential for tackling socio-economic challenges including high levels of income, poverty and food insecurity. Given the importance of the sector as a source of livelihood for the large majority of the population, and a base for foreign exchange earnings; The Agricultural sector has been revitalized against its crude methods by enhancing the capacity in value chain addition and agro-processing via advancement in technological developments and innovations. The transformation strategy in the agricultural sector has driven income growth, accelerates achievement of food and nutritional security, generates employment and transforms Nigeria into a leading player in global food markets to grow wealth for millions of her citizens.

2. **Educational Sector:** Education is a life-long process which develops the human mind, making functional, rational and productive. Its emphasis cannot be undermined. It is a mechanism through which the society generates the knowledge and skills required for its survival and sustenance. To this extent, the Education sector has witnessed a lot of transformation from what it used to be in the past via the establishment of the Universal Basic Education Commission, UBEC to fund the primary and post primary cadre and Education Trust Fund, ETF, alongside the Petroleum Technology Development Fund, PTFD to assist the development of our universities, polytechnics, and college of educations. Also experienced in the Educational sector was the establishment of nine new federal universities across the state of the federation.

3. **Health Sector:** Over the years, the health sector had been in a pitiable state with performance generally low. This had caused series of death with high maternal mortality inclusive. Hence, there has been huge improvement in service delivery in most health institutions across the country. The health sector witnessed the establishment of six teaching hospitals with modern equipments and laboratories. There has also been advancement in Medical intelligence and surveillance which represent a very useful component in the health care system and this control diseases out-break, bio-attack, etc. There is increasing role of automated-based medical intelligence and surveillance systems such as we had in Western and European countries and this had replaced the traditional manual pattern of document retrieval in our health sector.

4. Transportation Sector: The transportation sector in time past has been in comatose owing to neglects and abandonment. This sector has equally been revitalized with the construction of most major roads and inter-link roads across the states thereby easing off transportation difficulties experienced by motorists, commuters, etc. The railway sector which was down for many donkey years is now revived and restored for the benefit of the populace with over 3,000 km of rail lines being rehabilitated across the country. Also the aviation sector was not left out as there has been major re-alignment and refurbishment considering the air-crashes witnessed in time past.

5. Information Technology and Communication Sector: Furthermore, there has been a serious transformation in the ICT sector. The liberalization of the telecoms sector in 2001 triggered a realistic opportunity of economic diversification, as the sector is adjudged to be one of the major support services needed to promote growth and modernization of other sectors of the economy. The granting of operational permits and licenses to telecom providers further increased Nigeria revenue generation engaged in most capital expenditures. This jet age era comprise of innovations in cell phones, email services, internet facilities, cyber café, etc. Thus, this had improved our communications systems and further replaced the crude methods of communications and information sharing via the manual hand writing of letters and post office services which sometimes take decades before the recipients access it.

STRUCTURAL EVIDENCE OF INDUSTRIAL TRANSFORMATIONS IN AFRICA'S 21ST AGRICULTURE

The following are notable evidences of agro-industrial transformations in African 21st agriculture

1. Ownership Land Tenure: With the revolution of the agricultural sector, cum transformations coupled with extensive farming exposures, majority of commercial crop farmers have acquired large acres of farm lands practicing mechanized agriculture involving use of emerging innovative modern technologies that lessen fatigue and other visible threats that makes farming less attractive to youth people (Munang and Mgendi, 2015). This has in turn, transformed their socio-economic wellbeing and otherwise. However, [procuring land tenure ownership and facilitating access to land](#) is critical to increasing investment in the agricultural sector and improving famers' access to fiscal resources, as there is lots of uncultivated arable land in Africa. Securing land tenures

will induce vibrant land markets that can move land and labor resources from lower to higher productivity activity.

II. Productivity Increase: With emerging agro-industrial technologies, farm productivity has increased to a large extent. Most commercial farmers now employ the use of mechanized tractors, farm agro-technology, auto-driven machines, advanced processing and storage machines, auto induced harvesting equipment's, weeding and clearing auto machines, etc to make agricultural farming and productions easier, efficient and effective. Consequently increases in productivity will go a long way in reducing [Sub-Saharan Africa's food import bill](#) and releasing labor from farm to industry, especially to export-led manufacturing. Predominant reliance on manpower is labor-intensive and thus, agricultural transformation via the use of improved technologies. Advancement in agriculture also necessitates the use of [improved technology both on and off the farm](#), as well as the incorporation of environmentally-sustainable management practices that drive green revolution in Africa (Taffesse and Tadesse, 2017).

III. Strengthen Business Models: The agro-industrial transformation has strengthened agri-business enterprises and commercial farming. Most farmers' now have subscribed to emerging technologies to develop and sustain their farm business and other agro-related services, hence making farm outputs accessible to their clients at all times without much difficult and constraints. Farm services and production had moved from a subsistence economy to a commercially-oriented modern business model that yields strong financial returns.

IV. Focus on Agribusiness: Development of the agro-value chain process in the production and marketing of farm produce have been established via the use of innovative technologies. Most farmers now keep records of their daily dealings and transactions with internet applications such phones, laptops, ipad, desktops, and cyber technologies thus, promoting agri-business at all levels. It's evidently noted that agribusiness is seen as the center of agro-transformation. Here, value addition through light manufacturing has driven the industrialization plan. This agenda supports the manufacturing of inputs on one hand and a vibrant agro-processing drive at the other hand (FAO, 2017).

V. Promote Index Insurance: Farmers can now comfortably insure their farms and other agro-allied businesses without much persuasion from insurance agencies. This

was made possible through the introduction of improved agro-technologies and inter-related industrial linkages. Unwarranted out-breaks through crop disease; fire incidences, erosion menace, etc had caused lot havoc in time past necessitating the emergence of improved technologies to subdue these ugly trends and outcomes. Insuring farm plantations against daunting risks have been established through index insurance. Unlike conventional agricultural insurance, which indemnifies policyholders for provable production losses arising from multiple risks, [index insurance](#) pays policyholders based on the observed values such as rainfall, which are highly associated with losses. Such insurance changes would help to attract investment from the private sector, increase access to finance, and improve the overall welfare outcomes of farmers on the continent.

VI. Enhance the Irrigation Sector: Gone are the days farmers have to wait for the rain to fertilize their farm productions and outputs. Developed technologies have been put in place to ensure efficient and effective application of water to farmlands mostly in drought and non-planting seasons. Majority of agricultural farmers now grow green vegetables and other arable crops in dry seasons using improved mechanized irrigation systems that are cost effective. In SSA, nearly [80 percent](#) of farms depend on rain for irrigation, and more than [78 percent of irrigation land](#) is irrigated from surface water, against almost [20 percent of water from groundwater](#). Developing ground water knowledge and understanding of how it can be used to supplement surface water has been innovated to address droughts (World Bank, 2018).

VII. Incorporated Rural Development Strategies: The provisions of modern industrial technologies in most rural areas such as modern pipe-borne water, drainages, modern palm oil drilling and extractors, modern cassava processing plants, rural electrifications, etc have made agriculture lucrative, viable and most profitable venture across most rural areas. Young rural farmers are now springing up curbing rural-urban migrations (FAO, 2017). This transformation is not biased towards large-scale farms alone, but rather advocates for [unlocking the potential of smallholder commercial farms](#). Again, agriculture been a primary occupation of most African farmers, as such, rural development in the form of public-private partnerships, developing instruments for financing, and concentrating on environmental sustainability to hasten agro-transformation are incorporated. These changes are introduced to expand employment opportunities for the African youth, while making sure

these strategies cope with climate vulnerabilities in agriculture.

STAGES OF AGRO-INDUSTRIAL INNOVATIONS AND REVOLUTION IN AFRICAN AGRICULTURE

I. The first industrial revolution was about coal, water and steam, bringing with it the steam engine and innovations that enabled the large scale production, manufacturing and transformation of goods and products, such as farm cotton and textiles. Before now, farmers cultivate on impoverished lands which are susceptible to low and poor yields making their farm income miserable, inadequate and unable to sustain their households. Production was minimal and at subsistence level with crude implements such as hoe, cutlass, machetes, which often results to fatigue, exhaustion and frequent breakdown. Human labour was the main and only source of labour employed in farm production making farming less attractive and undesirable especially by the youth. Again, animal rearing, husbandry and aqua-culture practices were very pathetic and minimal with hunting dominating the era. Storage and processing facilities were out of place, thus losses incurred from postharvest handling were very high; poor basic amenities further compounded the problems faced by the olden days farmers. Access to markets remained a recurring headache making the idea of farming very unattractive to most people. But with the first industrial revolution, agriculture witnessed quantum leap of developments as a result of the replacement of crude methods of farming with modern and attractive farming techniques and improved livestock breeding leading to expanded food production. The agricultural revolution at this time was a period of technological improvement and advancement and increased crop productivity via improved farming tools. New patterns of crop rotation and livestock utilization paved the way for better crop yields, a greater diversity of wheat and vegetable productions which has the ability to support more livestock's. Feeder roads were constructed to ease the transportation of farm produced to the markets hence, making farm productions such as vegetables, tomato, yam, coco-yam, etc accessible to consumers and at the same time increasing the income of the farmers which were used to settle other household demands and needs. The perfection of the horse-drawn seed press, which would make farming less labor intensive and more productive were initiated and formalized. These changes impacted heavily on the society as the population became better nourished and healthier.

II. The second industrial revolution came about with the invention of electricity and enabled mass production (think production lines). Dating from the late 1800s to early 1900s, from this phase emerged the internal combustion engine, and thus the automobile (FAO, 2017). The period was marked with an increased use of steel and eventually petroleum, and the harnessing of electric current. It was an improvement of the first industrial revolution which moved beyond cities and achieved economic scale across countries and continents. This phase saw the modern innovations and improvements in technology advancements via the production of agro-driven machines, automobiles and farm tractors which evidently replaced crude implements such as hoe, machete, spade, shovel, etc making agriculture more lucrative and attractive again. Large hectares of farm lands were cultivated at the shortest possible time without much stress and difficulty thus, killing fatigue which makes farming boring and unattractive in nature. The available farmland increased due to changes in landholding patterns spurred on by new methods of cultivation. Previously, the open-field system was prominent. This system was problematic because it allowed part of the land to remain unplanted at all times in order to avoid depleting the soil but had now been reversed. Again, new processing machines and improved storage innovations came on board and aided agricultural value chain. Furthermore, this era saw the development in research and extension programmes and services that assisted the rural crop farmers which before now were very backwards and unexposed in terms of scientific discoveries. The introduction of research and extension services brought enormous transformation in the agricultural sector exposing crop farmers to improved crop varieties and sustainable soil management techniques which improved the farm productivity of the farmers in general. For the first time, farmers were exposed to agricultural orientations, seminars and education, having a fore-knowledge on the various means of overcoming the challenges experienced in farm production. This era also saw the improvement in livestock production which was before now in short supply. Remains of improved crop varieties after harvest were used as hay, silage and feed for feeding the livestock's which in turns improved the income of the African farmers. Also, modern agro-irrigation systems, pipe-borne water which replaced the use of well waters and other essential infrastructural facilities were developed.

III. The third industrial revolution was all about computers and digital systems enabled devices, i.e. new ways of processing and sharing information. Transistors, micro-

processors, robotics and automation not to mention the internet and other mass communications gadgets immensely contributed in no small measure towards the growth of agro-production and economics of scale. This era saw the commercialization of the agricultural sector with heavy impacts positioning it to the world in comparison with European countries such as Germany, Spain, Poland, Russia, etc This era further projected the Agri-business as an inclusive enterprise and the marketing of agricultural products, goods and services via online mediums, reaching out to wider consumers and clients at a go without much difficulties of meeting at the farm gate markets or structural off-farm markets. Thus, the agro-industrialization triggered the on-line market liberalization making agricultural products of most African farmers easily accessible. This era also introduced value chain additions cum the marketing, and distribution of agro-finished produced of farmers. Moreover, most commercial and industrial farmers nowadays have internet services, websites, farm blogs, emails, and other information communication technology, ICT which enhances communication and information sharing with the outside world. These farmers also engaged in data storage and processing of daily transactions hence, making farm record keeping effective, efficient and retrievable when needed. This aspect of information storage and record keeping of the farmers was evidently missing before now. Furthermore, timely and accurate record keeping of the farmers eminently positioned them to receive farm loans from financial institutions without much delay and difficulties.

IV. The fourth industrial revolution is the current and developing environment in which disruptive technologies and trends such as the Internet of Things, robotics, virtual reality (VR) and artificial intelligence (AI) are changing the way we live and work (World bank, 2018). Induced agro-connected machines and independent agro-automobiles are still emerging in African agriculture and yet to interact and visualize the entire agro-production and marketing chain. Furthermore, the fourth industrial revolution saw the development of Agro-Robotics, (AR) employed in agriculture for weed control, cloud seeding, planting seeds, harvesting, environmental monitoring and soil analysis. Agro-Artificial Intelligence (AAI) for (e.g. field and/or yield mapping and prediction). Agro-machine vision (AMV) for processing, auto inspection, process control, and agro-robot guidance. Agro-wireless sensor networks (AWSN) for agricultural value chain, farm monitoring and evaluations. Agro-cloud robotics, (ACR) for computing, product storage and processing. Agro-systems integration,

(ASI) for climate change mitigations. Agro-robotics and autonomous systems (ARAS), and Agro-food robotics (AFR) are employed for increased productivity of the farms. Countries practicing these advanced technological innovations includes; Italy, France, Spain, Germany, Singapore, UK, etc. Moreover, advanced robotic manipulators and mobile robots, such as Franka arms and fleet of Thorvald robots; advanced sensing, imaging and agro-camera technologies; have excellent links to fourth industrial revolution. Also, robotic fruit farms, including polytunnel and cold storage facilities are also part of the fourth industrial revolution in agriculture. Thus, this stage of industrial agro-revolutions are novel and yet to be experienced in African agriculture and its entire sub-sectors. It is being considered a distinct era in the African agricultural sector. Hence, African agriculture is currently at the third stage of industrial revolution awaiting metamorphosis into the fourth industrial revolution.

CONCLUSION AND RECOMMENDATIONS

African countries have evolved a number of policies geared towards strengthening the agricultural sector and other sectors growth inclusive. The driving force behind this developmental policy measures was the need to address the structural food gap in Sub-Saharan African countries where a high share of agricultural imports co-exists with a large incidence of undernourishment and hunger. The emergence of Forum for Agricultural Research in Africa (FARA) has aided in alleviating most of the problems facing African farmers at a time, and helped in developing agro-industrial policies which focused on large farm mechanizations using emerging modern and advanced technologies such as Agro-automobiles, etc. These advanced technological tools brought enormous industrial transformation of the African agriculture and its entire sub-sectors with visible impacts. The African agricultural sector witnessed a quantum leap in agricultural productions and farm incomes with emergence of the first industrial revolutions. Improved sources of energy and power (coal and steam) replaced wind and water to manufacture labour savings machines that drastically reduced the use of animal and human labour which deface agriculture making it a tedious enterprise.

Furthermore, the invention and introduction of advanced emerging technologies in agriculture had overhauled the entire sector aligning and fortifying it into a profitable and viable enterprise thus driving agro-industrial revolution cum transformations. Conclusively, agricultural revolution and transformation is currently at the third stage of

industrial revolution awaiting metamorphosis into the fourth industrial revolution where disruptive technologies and trends such as the Internet of Things, robotics, virtual reality (VR) and artificial intelligence (AI) are domiciled and seriously changing the way we live and work. Hence, African governments are to exploit the benefits of industrial revolution via the use of advanced technological tools and inclusive policy instruments to nurture economic growth, sector development and overall transformation of the African economy.

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