HUMAN NUTRITIVE HEALTH, FOOD SECURITY AND ANIMAL PRODUCTION: ISSUES AND CONCERNS FOR GENETICALLY ENGINEERED ORGANISMS AND TECHNOLOGICAL INNOVATIONS

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Abstract

Genetically modified foods (GMFs) – products whose original DNA structures have been changed – came to the forefront when a single U.S. Supreme Court Ruling in 1980 allowed for the first time the patenting of life forms for commercialization and; since then, GM yields have continued to geometrically increase every year encouraging planting to at least more than 175 million hectares of GM varieties worldwide in spite of the persistent health and environmental controversies on GMOs/GMFs. Sustainable agriculture (SA) leads to sufficient healthy food, healthy environment, wealth, and long life. Nigeria has arable land and the population that can be mobilized to produce sufficient food for local consumption and export. Yet, in spite of numerous public agricultural policies, strategies, projects and programmes aimed at boosting agricultural production for the attainment of food security in the past consecutive five decades, Nigeria has woefully failed to attain food security. Consequently, seven (7) out of ten (10) Nigerians remain food insecure. Using the literature review method, this study examines human nutritive health, food security, and animal production: issues and concerns for genetically engineered organisms and technological innovations, with a view to appropriate sustainable food security, crop production technology for Nigeria towards attaining food security, vis-à-vis their inherent environmental sustainability challenges. Results show that food security, improved animal production and sustainable agriculture evolve, requiring trend of mechanized agricultural production, innovation, storage system and preservation of agricultural products, which remain alien to Nigerian agricultural system and practice. Therefore, in enhancing animal production, agri-production economy and solving global food and protein insecurity, animal production and food security improvements that may not rely heavily on machines is the way to go.

Keywords: Genetically engineered organisms, Technological innovations, Food security, nutritive health, Animal production

INTRODUCTION

Genetically engineered (GE)/genetically modified (GM) plants, animal or foods are those products whose original DNA structures have been changed. DNA is the basic blueprint of each living thing. By altering the DNA, the characteristics or qualities of a living organism (in this case, plant) can be changed (Smithson, 2003).

One of the ultimate aims of genetically modifying organisms includes the need to make plants like soybeans or corn resistant to the herbicides used in the fields. As such, when the fields are sprayed with the

herbicides, all the weeds are killed but not affecting the actual crops (Smithson, 2003; Union of Concerned Scientists, 2006).

Other concepts that have surfaced recently include the delivery of '*edible vaccines*,' made possible when a gene with vaccine potential (e.g., a viral surface antigen) is introduced into tomato or potato plants. The aim is to deliver low-cost vaccines to remote, inaccessible places in, for example, rural Africa (California Department of Food and Agriculture, 2003).

In the theoretical sense, this makes a good model for the farmer who is trying to grow more crops and wants to avoid damage from the weeds. However, issues associated with genetically modified organisms/foods may not be that simple. Gravest of these risk-issues arguably is an unintended genetic outcome resulting in a trait that is harmful to human health, though it is important to note that no adverse consequences for human or animal health from consuming GM foods have been recorded in some regions as the European region (Lemaux, 2008; European Academies Science Advisory Council (EASAC), 2013).

More so, with GMOs/GMFs, food safety has been jeopardized. GMFs introduce new allergens, toxins, disruptive chemicals, soil polluting ingredients, mutated species, and unknown protein combinations into our bodies and into the whole environment, create new allergens and reduce nutritional content (Batalion, 2000). For instance, research has identified that toxins emanating from GMOs have been found in maternal and fetal blood. GMO corn has also been linked to rat tumours. Glyphosate, a toxin found in GMO is linked to many diseases and ailments; birth defects, autism, parkinson, alzeimer, breast cancer, and more. Compounds found in GMO can trigger early puberty, cause thyroid problem and infertility. The DNAs of GMO can be passed to humans that consume them (Nigerian Institute of Advanced Legal Studies, 2014). In addition, GM monoculture threatens the biodiversity and resilience of all future crop farming practices (Batalion, 2000).

Pesticides contain commonly known carcinogens such as bromoxynil used in transgenic cotton and glufonsinate used on genetically modified soybeans, corn and canola (Oxfam, 2005; Batalion, 2000). These pesticidal foods have genes that produce a toxic pesticide inside the food's cell. There is little knowledge of the potential long-term health impacts (Oxfam, 2005; Batalion, 2000).

The resistant qualities of GM bacteria in food can be transferred to other bacteria in the environment and throughout the human body. This may explain the growing resistant of bacterial infections and resurgence of infectious diseases to antibiotics misused in bioengineering (Batalion, 2000). Genetically modified foods have lower levels of vital nutrients in particular phytoestrogen that serves to protect the body against heart disease and cancer (Oxfam, 2005; Batalion, 2000).

A brief profile of food security in Nigeria

Before attainment of political independence in 1960, Nigeria was self-sufficient in food production and exported not only food but also raw materials to England. The establishment of the Department of Botanical Research in 1893; the acquisition of over 10 sq. km. of land at Moor Plantation in Ibadan for cotton production in 1905; the establishment of the Department of Agriculture in the North in 1912 and the establishment of Central Department of Agriculture after the Amalgamation of 1914 put Nigeria on a steady path to agricultural development. In the early 1960s, Nigeria was one of the world's most promising agricultural producers. Regionally focused policies based on the economic principle of commodity comparative advantage ensured that the agricultural sector served as the

nation's main source of food and livelihoods (Ibirogba, 2018).

The immediate post-independence years were the golden era of agriculture in the country. Service accounted for 32%, manufacturing 11% and agriculture over 30% of the country's gross domestic products (GDP). The productiveness of Nigerian soil, enhanced by conducive climate and weather, supported the production of a variety of foods and cash crops. Until early 1970s, Nigeria was leading in the production of cash crops, such as cocoa, cotton, groundnuts, palm oil/kernel, rubber, etc., which were mostly exported to Britain, United States of America (USA), Canada and Germany. Till the early 1980s, animal husbandry, fishing and poultry contributed more than 2% to the country's GDP. A 1987 report of the United Nations Food and Agriculture Organization (UN FAO) submits that there were 12.2 million cattle, 13.2 million sheep, 26 million goats, 1.3 million pigs, 700,000 donkeys, 250,000 horses, and 18,000 camels in Nigeria around this period. Most of these livestock were owned by rural dwellers (Odumade, 2017).

Nigeria soon turned to petroleum as the mainstay of the nation's economy, neglected agricultural sector and rapidly grew into a major food importer. The oil-economy quickly polarized the nation's population into a small fraction of high-income group that benefit from the oil wealth and a major fraction of low-income group suffering food insecurity because it cannot afford imported foods. Nigeria became shackled in food insecurity (Matemilola and Elegbede, 2017).

Engagement of a sizable ratio of the population in subsistence agriculture and high regulation of the economy of 1960-1986 became the responses, which could only ensure supply, but not affordability and accessibility, of food (Adebayo, 2010). Food supplies improved considerably in the subsequent deregulated economy that followed the adoption of the Structural Adjustment Programme (SAP) in 1986. But, food accessibility, utilization and security status worsened. Between 1980 and 1990, per capita agricultural production even declined or stagnated (Dauda, 2006).

Currently, Nigeria's estimated 200 million population grows at an annual rate of 2.6. Yet, staple food crops are under-produced. Maize, vegetables and cassava crops yields are constant in the past 10 years in Nigeria because there is no right hybrid seeds and seedlings for cultivation; those available are adulterated. Crops yields are 1.2mt/ha maize and 2mt/ha cassava, as against 3mt/ha and 6mt/ha respectively by peers in other African countries. Nigerian farmers record the least yield/ha in Africa. Tomato yield is 7mt/ha in Nigeria, 20mt/ha in Kenya, 8mt/ha in Ghana and 76mt/ha in South Africa. Maize yield is 1.6mt/ha in Nigeria, 2mt/ha in Kenya and Ghana, and 6mt/ha in South Africa. Potato yield is 3.7mt/ha in Nigeria, 15.5mt/ha in Kenya, and 38.8mt/ha in South Africa. Rice paddy yield is 2mt/ha in Nigeria, 3mt/ha in Kenya, Ghana and South Africa. Nigeria has the lowest yield/ha globally. Crops yield gaps are high in Nigeria. Average rice yields in Nigeria are between 1 and 2.5 tons/ha against potential yields of 5–6 tons/ha. Maize yields in Nigeria are less than 2 tons/ha on average compared to greater than 9 tons per hectare attained in the USA. Half of fruits and vegetables get lost to post-harvest rot because of inadequate storage facilities and huge road deficits. Nigeria is the poverty capital of the world with 91.8 million Nigerians living in extreme poverty. Rural communities account for 52.8% of poverty in Nigeria. This low productivity results in extensive and persistent food insufficiency/insecurity and poverty. Up to 70% of Nigerians are food insecure (Okojie, 2019).

It is worth noting that more than one billion people are hungry in sub-Saharan

Africa (SSA), Latin America and the Caribbean (LAC), and 2 billion people eat too much wrong food (Kaur, 2019). Global hunger according to the findings of the Global Report on Food Crises 2022, is rising at an alarming rate and there were approximately 193 million people who were highly malnourished in 2021 representing a 40 million increase over the previous year 2020 particularly in the four countries of Yemen, Ethiopia, southern Madagascar, and South Sudan, where people are facing a catastrophe of starvation and death (World Food Programme, 2023; Food Security Information Network, 2022).

This figure of either undernourished or unable to sustain regular intake of a nutrient-dense diet especially protein is rising around the world thus, 2.37 billion people are either undernourished or unable to sustain regular intake of a nutrient-dense diet (United Nations, 2023b). One-third of childbearing women are anemic as a result of these malnutrition issues (United Nations, 2023b). 22 per cent (149.2 million) of children under the age of five have a low quality of food, 6.7% (45.4 million) are malnourished, and 5.7% (38.9 million) are obese (United Nations, 2023b) needing assistance with their livelihoods to reduce the risk of natural disasters and so they would not fall into a state of acute food insecurity. This critical situation of either undernourished or unable to sustain regular intake of a nutrient-dense diet especially protein increased four times in 2020 from the previous years and seven times in 2021 because of the COVID -19 outbreak. In the year 2021, there were an extra 236 million people who were classified as being in the food crisis across 41 countries and territories (World Food Programme, 2023).

The World Food Program (WFP) and the Food and Agriculture Organization (FAO) have already warned that hungry people – persons with a sense of inner emptiness – are bereft of a sense of discernment of right and wrong. They settle for anything that can minister to their empty stomachs, even if it offends someone. What is bitter tastes good to them and thus, food problems such as food security, quality, safety, and availability that could worsen in the upcoming decades (Food Security Information Network, 2022) augmenting due to issues of Covid-19 may intensify abject lack of food, clothing and shelter, increase destitute scavengers of waste dumps (Schuldt, 2019; Ghufran, Ali, Ariyesti, Nawaz, Aldieri, & Xiaobao, 2022).

Whereas food security is one of the most crucial elements for the existence of the human race and amidst numerous incredible technological advancements, public agricultural policies, strategies, programmes and projects we still cannot ensure food security, quality, safety and availability (De-Vries, 2021). This unacceptable situation informs the SDG 2 which aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" by 2030 in all the countries of the world (United Nations, 2023a). The first United Nations Millennium Development Goal (MDG 1) had aimed to "eradicate extreme poverty and hunger" between 2000 and 2015 in all the countries of the world. Poverty is connected to food. Indeed, the thresholds for determining that someone is poor were originally calculated as the budget necessary to buy a certain number of calories, plus some other indispensable purchases, such as housing. A poor person is essentially someone without enough to eat (Banerjee and Duflo, 2011). At the end of the target year, 2015, the G8 countries might have hit the MDGs, but Nigeria certainly did not, with hunger rising and poverty deepening to the point that Nigeria became the poverty capital of the world by 2019 (United Nations, 2023a).

It is hoped that SDG 2 which aims to end hunger, achieve food security and improve nutrition, promote sustainable

agriculture will fare the global way particularly Nigeria and that pest, disease, foodborne illness which is more severe in underdeveloped and developing countries, contaminated food – a significant concern for consumers also in developed countries (Moradi *et al*., 2020), economic components (finance/investment issues that aids or un-aids food sustainability), land tenure/utilization issues, environmental resource use, agricultural sector forest depletion, emissions (from all sectors), social/cultural issues (anaemia among women and unemployment of especially women and youths), resilience/sustainability capacity (food production variability and indigenous plant and species extinction) will not deter and/or deepen the food insecurity situation.

Therefore, scenario case research review approaches especially, GMOs in improving animal production, overcoming food concerns and enhancing food security, hygiene, quality and availability of food and animal cum animal products is essential (Ghufran et al., 2022; Njage, Sawe, Onyango, Habib, Njagi, Aerts *et al*., 2017). This study reviews GMO studies in relation in connection to unveiling issues, concerns and understanding the different factors such as pest, disease, foodborne illness which is more severe in underdeveloped and developing countries, contaminated food – a significant concern for consumers also in developed countries (Moradi et al., 2020), economic components (finance/investment issues that aids or un-aids food sustainability), land tenure/utilization issues, environmental resource use, agricultural sector forest depletion, emissions (from all sectors), social/cultural issues (anaemia among women and unemployment of especially women and youths), resilience/sustainability capacity (food production variability and indigenous plant and species extinction) amidst other issues important and of concern in the improving animal production mix and food security challenge. Thus, the need for this study

Genetically Modified Foods in Nigeria

Before the oil boom, Nigeria was generating foreign exchange from crops like cocoa, kola, groundnut etc. and farming was a factor part of productivity in the country. The oil boom saw agriculture decline over the years, leaving every citizen to depend on annual budget based on oil sales and depending on day-to-day expenditure based on the parallel market (Omenazu, 2005). Presently, Nigerian agriculture is facing the growing encroachment of urbanization, industrial expansion, and an expanding transport infrastructure – save for recent interests due to lingering economic downturn in Nigeria. Deforestation and cultivation in fragile ecosystems is also leading to soil degradation (Oluwatuyi, 2004). Consequent upon these challenges on agriculture, Nigeria imports a lot of things especially food from other countries (Olaniyan, Bakare & Morenikeji, 2007).

An investigation carried out by Environmental Rights Action/Friends of the Earth (2003) on the potential presence of GM ingredients in Nigeria has found food aid as one of the potential channels. Nigeria is in principle not a food aid recipient, but continues to receive rice from the United States as food aid. In 2003, Nigeria received 11,000.6 metric tonnes of soy meal as food aid from the US Food for Progress programme (Watch GM, 2005). Taking into account that over 80% of soy beans in the US are genetically modified, it is therefore likely that Nigeria has been receiving GMFs without prior information to the government and the people (Environmental Rights Action/Friends of the Earth Nigeria, 2005). Another source of potential introduction of GMF is through commercial imports of food containing ingredients from corn and soy. It has been reported that China may have

released genetically modified rice into the market in 2006 (Environmental Rights Action/Friends of the Earth, 2005). With the bulk of rice consumed in Nigeria coming from Asia, it is a matter of time before genetically modified rice from China floods Nigerian markets (Olaniyan, Bakare & Morenikeji, 2007).

The International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria is making efforts to prevent the outbreak of virulent Cassava Mosaic Disease in Nigeria, which could lead to food shortages in the country (Dixon, 2006). GM cassava was created at the Donald Danforth Centre in St. Louis, United States and sent to Nigeria for experimentation through IITA (Environmental Rights Actions/Friends of the Earth Nigeria, 2006). However, the application to test the GM cassava was withdrawn by IITA due to its failure to achieve the required resistance to cassava mosaic disease (Watch GM, 2005).

The genetic modification of foods makes excellent economic sense for major agribusiness and food corporations – that have and continues to flood the Nigerian food market – and has been strongly backed by them. Some of the biggest names in the food business openly use genetically modified components, while others will not disclose whether they use them or not. Such companies include Arnotts, Cadburys, Coca-cola, Coles and Woolworths' house brands, Golden Circle and Nestle (Peter, 2003).

Already, Nigeria has drafted a biosafety law allowing the use of GMF technology, which the National legislature is yet to approve (Environmental Rights Actions/Friends of the Earth Nigeria, 2006). The country also does not have any policy on the importation of GMF, unlike some African nations such as Angola, Ethiopia, Kenya, Lesotho and Zambia, which have banned the import of GMFs. Also, multinational biotech companies like Syngenta, Monsanto and DuPont have all shown interest in investing in Nigeria. This sounds like a brilliant idea but these big biotech multinationals companies who are in control of the world food supply ways have hidden agendas; they own patent of some GMO and concerns are that the local biotech companies will be driven out of the market (Nigerian Institute of Advanced Legal Studies, 2014).

Perception to genetically engineered organisms

According to the *Business Dictionary*, perception is the process by which people translate sensory impressions into a coherent and unified view of the world around them. Though necessarily based on incomplete and unverified (or unreliable) information, perception is equated with reality for most practical purposes and guides human behavior in general.

A survey of consumer acceptance of GM foods in Japan, Norway, Taiwan, and the United States showed wide differences in consumer acceptance across countries (Chern & Rickertsen, 2002). For example, although Norwegian consumers seemed better informed about GM issues, and a higher percentage of them viewed GM foods as "very safe," Norwegian consumers tended to accept GM foods much less than US consumers. In Japan and Taiwan there was also a large difference in consumers' willingness to pay for GM foods. Although Japanese consumers were the most skeptical in this survey, Taiwanese consumers seemed to have similar attitudes as those in the United States. These survey results may imply that consumer attitudes are strongly influenced by cultural and institutional factors (Zhong, Marchant, Ding, Lu, 2002).

Focusing more on Asia, consumer surveys conducted in China, Indonesia, and the Philippines suggest that most Asian consumers have a positive attitude toward GM foods (Asian Food Information Center, 2002, 2003). Results indicated that about two

thirds of consumers not only accepted GM foods but also believed that they would personally benefit from consuming GM foods. This finding is consistent with previous observations in Taiwan. However, this survey does not reveal Asian consumers' knowledge of GM foods (Zhong, Marchant, Ding, Lu, 2002).

In a study of lecturers' perception towards consumption of genetically modified foods in Nigeria and Botswana, Oladele and Subair (2009) observed that there was significant difference between lecturers from the two countries ($Z = –6.65$, $p < 0.05$); with higher mean rank for Botswana (108.02) than for Nigeria (58.01). Lecturers from BCA agreed and were positively disposed to 12 (80%), while lecturers from south western universities in Nigeria agreed and were positively disposed to five out of the 15 statements (33.3%) on the rating scale (Oladele and Subair, 2009).

However, in a related study on "Knowledge and Perception of Genetically Modified Foods among Agricultural Scientists in South-West Nigeria," most of the respondents perceived that GM has no negative effect on the environment and were therefore, in support of the introduction of GM foods in Nigeria (Alarima, 2011). Another survey indicated that only one-in-five Nigerians (20 percent) were aware that genetically modified food products are currently on sale in supermarkets; about one-fifth (22 percent) believe that creating hybrid plants through genetic modification is morally wrong, even as majority (70 percent) of Nigerians, however, did not view such practices as being immoral (Alarima, 2011).

Given its importance – consumers perception (knowledge, discourse optimism and attitudes) towards GMFs – this research sought to assess food consumers' perception on genetically modified foods in Enugu metropolis, Nigeria – an ancient coal-city of great political, commercial and socio-economic importance and; thus will be beneficial to; the Nigerian government, not only in terms of attitudes' towards GMOs/GMFs, but also with respect to the technology itself; the development community, policy-makers, scientists, farmers and non-governmental organizations in developing relevant policy and institutional frameworks, and necessary reforms to create an enabling environment for GMOs/GMFs; the wider socio-political context, donors, on how a holistic programme in its entirety can, if necessary, be conceived, steered and managed in context to GMF industrialization.

GMOs and improving animal production and food security

Scholars posited enhanced cultivated area and crop production capacity by including chemicals and technological innovations as sine qua non to improving animal production and solving global food insecurity (Ali, Ghufran, Nawaz, & Hussain, 2019). Technological innovations such as genetically modified (GM) crops and food have multiplied the food production capacity since their invention (Aldemita & Hautea, 2018; Raman, 2017; Toma, Barnes, Sutherland, Thomson, Burnett, & Mathews, 2018) without consuming too many natural resources, such as water because GM crop-seeds are more resilient in the harsh environment as compared to traditional and organic food (Ali et al., 2019; Ghufran *et al.*, 2022).

This framework on the one hand notably divides scholars into domains and raised concerns on security and nutrition hygiene of packed GM foods which is part of the United Nations Sustainable Development Goals (SDGs) to eliminate the hunger problem in the entire world (Ali, Nawaz, Ghufran, Hussain, & Hussein Mohammed, 2021; Siegrist & Hartmann, 2020; Szenkovics, Tonk, & Balog, 2021). Technological innovations of GM crops

particularly may have climate change devastating impact, severely affecting the food supply chain and causing food insecurity (Descheemaeker, Oosting, Homann-Kee Tui, Masikati, Falconnier, & Giller, 2016; Sekaran, Lai, Ussiri, Kumar, & Clay, 2021; Smith, Sones, Grace, MacMillan, Tarawali, & Herrero, 2013). Due to these facts, farmers utilize fertilizers and pesticides such as phosphates, nitrogen, organochlorine, neonicotinoids, pyrethroids, biopesticides, carbamate, and urea to increase food production to fulfil consumer needs (Carvalho, 2017; Chen, Wang, Ma, Zou, & Jiang, 2020) as against GMO prerogatives of improving animal production with potential of solving food insecurity without consuming too many natural resources, such as water because GM crop-seeds are more resilient in the harsh environment as compared to traditional and organic food (Ali et al., 2019; Ghufran *et al.*, 2022).

Further, this intervention of enhanced cultivated area and crop production capacity by including chemicals and technological innovations increases fertilizers and pesticide utilization on an extensive scale. While the pesticides are mainly used to kill extra herbs in the farmland and insects harming the entire crop, the fertilizers come into the mix to increase soil fertility and production capacity without understanding.

On the contrary, technological innovations of GMOs may address, resilience/sustainability factors of food and animal production variability and conservation of plants and endangered species, which are vital to dealing with food security issues. This solution may reduce use and the side effects of both on human health of compounded mix of fertilizers and pesticides used by crop and mixed animal farmers. This compounded mix of fertilizers and pesticides, a number of researchers posit is creating a harmful impact on human health (Adewunmi & Fapohunda, 2018; Anani, Mishra, Mishra, Enuneku, Anani, & Adetunji, 2020; Bonner & Alavanja, 2017; Carvalho, 2017; Reeves, McGuire, Stokes, & Vicini, 2019; Thompson & Darwish, 2019), causing foodborne diseases thus exposing the entire advanced food system leaving vital economic, environmental, social and resilience/sustainability issues unaddressed.

Further, technological innovations of GMOs may be is novel particularly when the world faces unprecedented climate change that intensify food and animal production and supply variability (Campi, Dueñas, & Fagiolo, 2021) and, even more novel with the Covid-19 crisis (Béné, 2020), conflicts between countries like Ukraine and Russia (Donnellon-May & Teng, 2022), etc. In these circumstances, technological innovations of GMOs may play a strategic role in attaining food security, improving animal production, attaining resilience and sustainability in the food and animal sector through increasing the production of food and animal, cultivation of land, and effective use of existing land and agrarian space (Pawlak & Kołodziejczak, 2020; Smyth, Phillips, & Kerr, 2015; Wegren & Elvestad, 2018) and most importantly, the inclusion of the potential to deal with drought and harsh weather situations responsible for limiting the agriculture productivities (Ali *et al.*, 2019; Ali *et al.*, 2021) because GM crop-seeds are more resilient in the harsh environment as compared to traditional and organic food (Ali et al., 2019; Ghufran *et al.*, 2022).

However, scholarly domain posits that GMO animal production and food security improvements may still increase specifically the pest, disease, foodborne illness which is more severe in underdeveloped and developing countries, contaminated food – a significant concern for consumers also in developed countries (Moradi et al., 2020), economic components (finance/investment issues that aids or un-aids food sustainability), land

tenure/utilization issues, environmental resource use, agricultural sector forest depletion, emissions (from all sectors), social/cultural issues (anaemia among women and unemployment of especially women and youths), resilience/sustainability capacity (food production variability and indigenous plant and species extinction) and particularly the environmental climate change conundrum issues which may not have been solved by traditional animal production and traditional and organic food production (Ali et al., 2019; Ghufran *et al.*, 2022).

Technological innovations, food insecurity and animal production: concerns to be addressed

Smallholder subsistence farming

In Nigeria, farms below 10 ha still account for over 95% of agricultural production (Njoku, 2000). This is predicated on land fragmentation which still holds sway, especially in South-east Nigeria, where customary inheritance laws operate. Labour-intensive smallholder subsistence farming promotes intensification/extensification to use more land and farmers, more resources and structures to produce less food with attendant costs to the environment. On the other hand, mechanized farming promotes intensification to use a smaller number of farmers and resources to produce more food (Njoku, 2000).

Agricultural technological innovations of mechanization will help the small farmers in developing countries to increase production and sell more crops to combat global hunger and poverty (Drake, 2013). Aditya (2020) submits that agricultural technological innovations particularly agricultural mechanization and mechanization of the agricultural and farming process applies machines to work for agricultural production of crop farming and animal production. Agricultural technological mechanization replaces animal power with machine power aimed at reducing the drudgery of certain operations which have to be performed either by human labour or by a combined effort of human beings and animals.

According to Ndubuisi (2019), partial agricultural technological mechanization (only a part of the farm work is done by machine) or complete agricultural technological mechanization (animal or human labour is completely dispensed with by power-supplying machines) benefits the food security status and animal agricultural production in, reduction of manual labour drudgery, food sufficiency, foreign exchange generation through exportation of excess produce, employment generation through improved youth participation in agricultural activities, longer shelf-life of produce through improved preservation and packaging, among others which are key to food security in developing countries especially Nigeria (Emami, Almassi, Bakhoda and Kalantari, 2018).

Poverty or lack of investible fund

While labor-intensive smallholder subsistence farming promotes intensification/extensification to use more farmers, more land and other resources to produce less food with attendant costs to the environment, agricultural technological innovations are sometimes capital intensive but promotes intensification to use less resources to produce more food. Thus, technological innovations are sometimes capital intensive. Attendant to this is that seventy-five (75%) of the world's farmers who farm small plots of land about, the size of a football field is usually in food insecure developing economies despite technological agricultural innovations that will help the small farmers in those developing countries to increase production and sell more crops to combat global hunger and poverty (Drake, 2013).

Hampered by poverty or low income and low investment or lack of investible fund to purchase inputs whose absence promotes smallholder subsistence farming characterized by a vicious cycle of low productivity, poverty or lack of investible fund laden that technological innovations are not adopted (Emami *et al*, 2018). This un-adoption of technological innovations, even in the era of 4th Industrial Revolution means that, most Nigerian farmers still use traditional hand-tools (hoe, cutlass, pick-axe, shovel, etc.) for agricultural practice, unable to mass-produce food for her teeming population causing unaffordable, easily assessable food and other agricultural produce to Nigerians of all socio-economic statuses.

Comparatively, Ogundele (2019) asserts Canada and the U.S where the adoption of technological innovations has meant that easily assessable affordable food and agricultural produce are mass-produced reducing, disposable income spent on food from, 25% eighty years ago to around 10% (the lowest in the world) today. On the other hand, and compared to potentials, un-adoption of technological improved seeds and seed varieties cause, marginal crop yields of less than 2 tons/ha maize yields in Nigeria on average compared to greater than 9 tons/ha bumper harvest in the USA – corresponding a rich technological agricultural environment (Okojie, 2019).

Further, lack or non-adoption of technological innovation supplies like appropriate chemicals for pests control and preservation of agricultural yields, absence of storage and preservation facilities which predispose half of fruits and vegetables to loss or post-harvest rot and pest attack, in addition to field losses (Eneh, 2011) and dependence on rain-fed agriculture is still the vogue in agricultural technological un-advanced countries where agricultural production is food insecure like African countries despite technological innovations of macro, medium and micro-irrigation for dry season crop production (Sachs, 2008; Odumade, 2017).

Use of unimproved varieties of seeds and other inputs

Amongst other issues of pest, disease, foodborne illness which is more severe in underdeveloped and developing countries (Moradi et al., 2020), land tenure/utilization issues, environmental resource use issues, agricultural sector forest depletion, emissions (from all sectors), social/cultural issues (anaemia among agricultural women labour force), sustainability capacity issues (food production variability and indigenous plant and species extinction) and specifically use of unimproved varieties of seeds, other inputs and particularly economic components (finance/investment issues that aids or un-aids food security), climate change that devolves the animal nutritive and overall agricultural food security health and, enhance the food and protein insecurity of the globe and Nigeria amongst others which may not have been solved by traditional animal production and traditional and organic food production; enhancing animal production, agri-production economy and solving global food and protein insecurity, animal production and food security improvements that may not rely heavily on machines, is the way to go (Matemilola and Elegbede, 2017). Further, Marketing infrastructure, such as, maintained culture of regular and supply of adequate power generation and distribution facilities will take care of the daunting challenges to Nigeria's agricultural production. This is in line with the report of Ndubuisi (2019).

Conclusion

Nigeria needs technological innovations and agricultural technological innovations adoption to provide improved varieties of seeds and other inputs to ensure. Such STI

techniques are tissue culture, use of genetically modified organisms (GMOs) to produce genetically modified foods (GMFs), among others.

In conclusion while, many authors including: Ndubuisi (2019), Matemilola and Elegbede (2017) posit Nigeria to utilize more technological innovations like storage and preservation practices (to solve Nigeria's issues of agricultural field and post-harvest losses), electricity power supply, appealing infrastructures, network of feeder roads and railways to challenge her daunting agricultural production issues others like Moradi et al. (2020), Ghufran et al. (2022), Ali et al. (2019) posit continuing researching best options including, waste-to-wealth or trash-to-treasure solutions amongst others that improves the animal production agricultural economy, that does not increase specifically the pest, disease, foodborne illness which is more severe in underdeveloped and developing countries, contaminated food – a significant concern for consumers also in developed countries (Moradi et al., 2020), but further addresses, land tenure/utilization issues, environmental resource use issues, agricultural sector forest depletion, emissions (from all sectors), social/cultural issues (anaemia among women and unemployment of especially women and youths), resilience/sustainability capacity issues (food production variability and indigenous plant and species extinction) and particularly economic components (finance/investment issues that aids or un-aids food sustainability), the environmental climate change conundrum that devolves the pollution-waste hazard, enhances animal nutritive and overall health and, enhance the food and protein security of the globe and Nigeria amongst others which may not have been solved by traditional animal production and traditional and organic food production

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