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INTEGRATING TECHNOLOGY INTO PHYSICS FOR FOOD SECURITY AND NATIONAL DEVELOPMENT SUSTAINABILITY

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Abstract
The Sustainable Development Goals and other international efforts to achieve food security involve new technologies as an indispensable tool for eradicating hunger. This paper discusses how physics applications may play a role in addressing the various aspects of food security. This paper highlights scientific and technical applications that can address the four dimensions of food security, namely availability, access, utilization and stability. Though the list of the technical know-how in this paper is not exhaustive, it will provide illustrative cases of how every component of the food system – from farm to market – can potentially be improved with the application of physics with technology integrated. A number of technologies can play a role in addressing concerns (climate change, water scarcity, high food prices, distribution network, micronutrient deficiencies, contamination of food, droughts, conflict and price volatility) related to the four dimensions of food security. New and existing technologies to combat biotic and abiotic stresses, raise crop and livestock productivity, improve soil fertility and make water available can potentially increase the amount of food produced. Storage, refrigeration, transport and agro-processing innovations can address the dimension of food accessibility. The production of high-nutrient staple crops can combat malnutrition, improving food utilization and use. However, using these scientific and technical applications (refrigeration, science to produce high-nutrient staple crops and agro-processing innovations), tools, and techniques require the know-how, skills, and ability to adapt, diffuse, and apply such technologies to local food security-related challenges. The Nigerian government should encourage and equip physicists across the country for positive impact because physics provides the bases for science and technology of any kind.

Keys Words: *food security, sustainability, role of physics, challenges, Technology integration in physics*

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Introduction

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2016b). Pressure has been on food production in Nigeria for the last few decades due to population growth, insecurity, climate change and food inflation leading to food insecurity according to UNICEF reports, 2023. Physics discoveries lead to new technologies which play significant roles in food quality for active and healthy life; firstly, by the substitution of chemical fertilizers and plant protection resources with physical factors for stimulation of plants and disinfection of seeds. Secondly, by the development of physical non-destructive methods for control of food quality (Aladjadjiyan, 2018). The influence of magnetic field, laser irradiation, ultrasonic treatment and microwave has been given a nod for the treatment of food raw materials (Aladjadjiyan, 2006; Aladjadjiyan, 2012). The stimulation and improvement of plant development is done by using preferably magnetic field, sometimes in combination with other factors as waters and other organic substances (Afzal et al, 2012; Tamara et al, 2015; Sudsiria et al, 2017; Abdani Nasiri et al, 2018; Valderrama-Bravo et al, 2018) other electromagnetic fields like microwave also are used (Wang et al, 2018; Poghosyan and Mukhaelyan, 2018). Microwave treatment is preferred often for preliminary disinfection of seeds (Vora and Jasrai, 2012; Zareh and Mohsenzadeh, 2015; Godefroid et al, 2016; Sujayadi et al, 2017). Less often the treatment with electric field is used (Mahajan and Pandey, 2014; Statsyuk et al, 2016; Hasan and Mehmet, 2017). Ultrasonic treatment is used also for disinfection of caw and sheep milk before fermentation (Kartalska et al, 2013). The substitution of chemical additives with physical factors brings higher quality to the raw materials for food production leading to food security as a veritable tool for national development sustainability. This integrating technology in physics is scarcely or neither in use in most parts of developing countries like Nigeria where foods are grown to address the issue of food security. Hence, this paper, to draw the attentions of the government and other stakeholders to this application in physics for food security and national development sustainability.

Food Security

Providing sufficient, safe and nutritious food to all people is one of the major global concerns historically and in the twenty-first century. Food security is usually framed in four dimensions namely; food availability, access to food, food use/utilization and food stability (FAO, 2016a). These dimensions build the overall framework of the definition established by the Food and Agriculture Organization of the United Nations (FAO): "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2016b). In addition to the short-term effects of food insecurity, there are also long-term developmental impacts of lack of food security. Beyond the direct obvious cost in terms of lost human lives and well-being, there is an indirect economic cost: Malnourished people are less productive, hungry children get no or little education, and become less capable adults even if hunger is overcome. Even short-term food insecurity has a long-term lasting impact on growth potential for the economy. About 795 million people, or every ninth person, is undernourished, including 90 million children under the age of five (FAO, 2015). The vast majority of them (780 million people) live in the developing regions, notably in Africa and Asia. Depending on the region considered, the share of undernourished people differs considerably, between less than 5 per cent and up to more than 35 per cent. In particular, sub-Saharan Africa shows high values, with almost 25 per cent of the population undernourished (FAO et al., 2015). While the hunger rate - the share of undernourished in the total population - has fallen in the region, the number of undernourished people has increased by 44 million since 1990 due to population growth.

Challenges of Food Security

FAO et al. (2015) identified differences in progress not only among individual countries but also across regions and sub regions. The economic and environmental change have

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aggravated the global challenge of food insecurity.

Agriculture, economic development, and international trade

Economic development is a key success factor in reducing undernourishment, but it has to be inclusive and provide opportunities for improving the livelihoods of the poor. FAO et al. (2015) point out that enhancing the productivity and incomes of smallholder family farmers, investment and social protection are keys to progress. Smallholder farmers across the globe are challenged by the globalization and liberalization of markets, technological advances, and climate change. Previously well-established systems of political, social, economic and environmental resilience are shifting. Food systems have also undergone a rapid transformation in recent years with significant implications for people's diets, in part because of a number of factors such as globalization, expanding food trade, technological innovations, longer food supply and processing chains, and volatile prices of food commodities. There is also concern about increasing deforestation, as well as the prospects for bio-fuel production to displace land allocated for food crops.

International trade is required to bring the production and supply of Agric-food products at national level in line with demand. In addition, it is possible to realize absolute and relative comparative cost advantages through trade. Those may improve the livelihoods of farmers. Furthermore, trade evens out local production instability, which is expected to increase in times of weather extremes caused by climate change. However, trade can be a two-edged sword, which can also result in worsening certain producers' situations (e.g. in case products from other producers reach the markets with lower costs). Relevant for international trade rules is the World Trade Organization (WTO), and the related bilateral, regional and plural lateral liberalization agreements (outside WTO). Both have an impact on agricultural production, trade and consumption.

Agriculture in developing countries now accounts for slightly less than 10 per cent of GDP. However, if non-market and subsistence production is taken into consideration, the sector generates half or more of total gross production and directly or indirectly employs 50–80 per cent of the population in many developing countries (UNCTAD, 2015). Together with mining, agriculture is still the most important economic sector, with a high socioeconomic importance for many countries (for employment, income generation, nutrition, rural development and the social fabric). Against this background, primary production, some service sectors, in particular agriculture, appear to be the only realistic drivers of economic and social development in many countries in the nearer future.

Environmental change and agriculture

Growing demand for food is a key driver of global environment change. FAO statistics show that maximizing food production by intensifying production has increased the world's cereal supply by a factor of almost 2.2, outpacing the 1.3-fold increase in population growth in the last 50 years (DeFries et al., 2015). However, this 2.2-fold increase in global cereal production occurred in tandem with a five-fold increase in the global use of fertilizers (UNCTAD, 2013a). Furthermore, biomass production (food, feed, fibre and energy) for developed countries has become a driver for environmental pressures, competition for land and nutrients in supply regions, whereas overconsumption and eutrophication of ecosystems occur in importing regions.

Food production all over the globe is not only a source of global environmental change, but is also strongly affected by it. Agriculture is primarily challenged by climate change; the related increase in natural disasters such as floods, tropical storms, long periods of drought and new pests and diseases are the most relevant drivers of food insecurity (IPCC, 2014). Drought is one of the most common causes of food shortages in the world. In 2012, there was drought in the Sahel region of Western Africa. Furthermore, high dependence on a few crops (and a few varieties within these crops) to meet food needs, increasing water scarcity and salinization of soils in many areas of heavy irrigation, continued soil loss due to wind and water erosion, and resistance of pests and diseases against a growing number of agro-chemicals, and biodiversity loss create challenges

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for agricultural production. Future projections also indicate that climate change impacts may hinder future yield increases, thus challenging FAO forecasts to meet the projected food demand in the future without much increase of cropland areas (Müller et al., 2010; Lobell et al., 2011; Challinor et al., 2014; Porter et al., 2014; Müller and Robertson, 2014; Asseng et al., 2014). Rockström et al. (2016) concluded that agriculture has become the single largest driver of environmental change and, at the same time, is the most affected by these changes. The authors call for a global food revolution based on a new paradigm for agricultural development based on sustainable intensification within planetary boundaries. Without this shift, the twin objectives of feeding humanity and living within the boundaries of biophysical processes that define the safe operating space of a stable and resilient earth system will not be achieved (Steffen et al., 2015).

National development sustainability

National development can be defined as an all-round change in a nation's growth and development, resulting in societal transformation in areas such as social, economic, cultural, political, educational, scientific, technological as well as religious (Akinyemi & Mohammed, 2023). Society for International Development (2021), defined development as a process that creates growth, progress, positive change, or the addition of physical, economic, environmental, social, and demographic components. According to Abari (2019), development is a change that deals capacity building towards self-sustenance, growth, and self-fulfillment as it affects individuals or institutions in a society. In other words, national development is that which measures the comfort and satisfaction of man in a country. It is based on increase in agricultural production through the application of modern technical know-how, application of science and technology in the production sector, the provision of various facilities to meet the needs and aspirations of the disadvantaged, deprived, and poorest segments of the population (Bawa, 2019), among others. "sustainability is a long-term goal while sustainable development refers to the processes and pathways to achieving it" (UNESCO, 2013), whose aims are to promote development that reduces problems of the society that meet the needs of the now without hampering the environment's quality for future generations. Sustainability is a mindset about the future in which environmental, societal and economic considerations are balanced in the pursuit of an improved quality of life (Akinyemi & Mohammed, 2023). Which mean to say, a developed nation is one that has healthy food provision, safe drinking water and clean air for its citizens. Amongst the tools for national sustainable development is science and technology, hence integrating technology in physics.

Science and technology for food security

The Sustainable Development Goals and other international efforts to achieve food security involve new technologies as an indispensable tool for eradicating hunger. This paper discusses how certain scientific and technical applications may play a role in addressing the various aspects of food security. This paper highlights examples of scientific and technical applications that can address the four dimensions of food security, namely availability, access, use/utilization and stability. Though the list of technologies in this paper is not exhaustive, it will provide illustrative cases of how every component of the food system – from farm to market – can potentially be improved with the application of science and technology. A number of technologies can play a role in addressing concerns related to the four dimensions of food security. New and existing technologies to combat biotic and abiotic stresses, raise crop and livestock productivity, improve soil fertility and make water available can potentially increase the amount of food produced. Storage, refrigeration, transport and agro-processing innovations can address the dimension of food accessibility. Science to produce high-nutrient staple crops can combat malnutrition, improving food utilization and use.

Food availability

Physics, the bedrock of Science and its application (technology) to improve agricultural productivity FAO (2006) identified a food gap of close to 70 per cent between the crop calories available in 2006 and the expected calorie demand in 2050. To close this gap, it would be

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necessary to increase food production by making genetic improvements, reduce food loss and waste, shift diets and raise productivity by improving or maintaining soil fertility, pastureland productivity and restoring degraded land (Ranganathan et al., 2016). In view of this, food availability will have to make up for this food gap, while considering decreasing arable land, limited water resources and other environmental, ecological, and agronomic constraints. It is estimated that in the past 40 years, almost 33 per cent of the world's arable land has been lost to pollution or erosion. Physics and what it offers can play a critical role in producing more food by creating plant varieties with improved traits, as well as optimizing the inputs needed to make agriculture more productive. The paper considers genetic improvements to crops by conventional crossbreeding and transgenic modification and also reviews a number of inputs critical for increased agricultural productivity, including physics techniques for soil management and irrigation, especially for and by smallholder farmers.

Soil management for increasing agricultural yields

Genetically improved varieties might not increase yields if constraints such as slow soil fertility are not overcome. Fertile soils play a pivotal role in sustaining agricultural productivity and thus food security. The focus on innovations and technological developments is more on crops and fighting pests and diseases and less on sustainable soil management practices. However, healthy plants grow on healthy soils that are less affected by pests and diseases.

Synthetic fertilizers have been used to increase agricultural yields for decades but their capital intensity, dependence on natural gas – particularly in the case of nitrogen – and a large ecological footprint make them unsustainable. Fertilizer and water overuse can cause environmental damage and represent an economic waste for smallholder farmers. Furthermore, the Intergovernmental Technical Panel on Soils concluded that farmers are essentially mining the soil, which is why soil should be considered a non-renewable resource (ITPS, 2015). A number of new technologies and techniques are making more sustainable fertilizer use viable. New methods of nitrogen fixation and other fertilizer components that avoid the current capital- and energy-intensive methods could make nutrient supplementation more environmentally sustainable. A recent study found that nitrogen fixing trees within critical water and temperature thresholds can increase yields by improving both the water-holding capacity of soil and water infiltration rates (Folberth, 2014; United Nations, 2015b). For example, "N2Africa" is a large-scale, science-based development-to-research project focused on putting nitrogen fixation to work for smallholder farmers growing legume crops in Africa (Giller et al., 2013).

New technologies to make biological fertilizers (composting, manure or dung) more viable and effective could also increasingly replace the use of synthetic fertilizers. Nigeria's National Research Institute for Chemical Technology (NARICT) has developed neem-based fertilizer and organic fertilizer from Moringa oleifera, which is environmentally friendly. However, such biological fertilizers, in particular those made from human waste, may require sanitation infrastructure. Furthermore, precision agriculture can help facilitate the precise application of inputs to crop type and soil conditions in ways that increase yields while minimizing potential environmental impacts (Buluswar et al., 2014).

Irrigation technologies

Technologies that make water available for food production, like soil fertility, the availability of water are a critical input for ensuring and improving crop productivity. Approximately 70 per cent of global freshwater supply is devoted to agriculture. Many farmers do not have access to water for agriculture because of physical water scarcity (not enough water to meet demands) or economic water scarcity (lack of investments in water infrastructure or insufficient human capacity to satisfy water demand), among other factors (Figure1). In response to such challenges, low-cost and affordable drills, renewable energy-powered pumps and technologies for desalination and improved water efficiency can potentially make water more available for food production.

Lightweight drills for shallow groundwater

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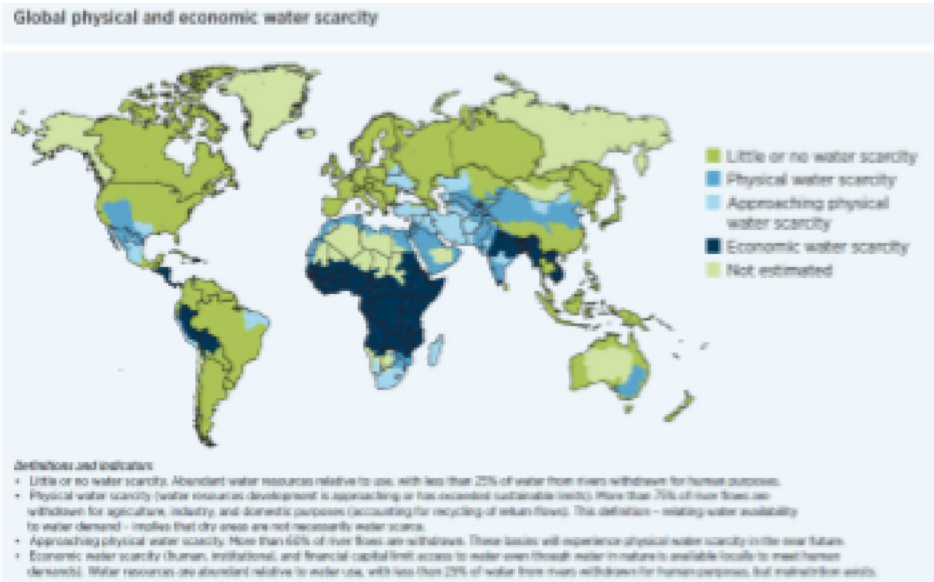
and equipment to detect groundwater can potentially make groundwater more accessible as a form of irrigation. Solar-powered irrigation pumps could potentially increase access to irrigation where manual irrigation pumps that may be strenuous to use are inadequate or expensive motorized pumps with recurring fuel costs are financially out of reach (Buluswar et al., 2014). Affordable rainfall storage systems are also a potential technology for addressing irrigation (UNCTAD, 2010).

Where diesel- or solar-powered pumps are not feasible, hydro-powered pumps (e.g. aQysta Barsha pump) can be used to irrigate fields wherever there is flowing water.

Greenhouses can mitigate the unavailability of water caused by unpredictable rainfall and enable farmers to have a year-round growing season. For example, World Hope's Greenhouses Revolutionizing Output (GRO) allows farmers to construct low-cost greenhouses ($500) in as little as two days that last over five years in Sierra Leone and Mozambique.

Even when groundwater is available, brackish water may

Figure 1: Global water scarcity



Source: Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture, 2007 (Earth scan, London).

(EDR) systems can remove salts and minerals from such brackish water.

Other technologies improve water efficiency for increased demand for agricultural products in fragile natural environments. For example, the Groasis Water box is an integrated planting technology that surrounds the bases of a plant, building up a water column by collecting dew and rainwater under the plant, and avoiding evaporation by distributing such water over long periods of time.

New fungal seed and plant treatments can help crops, such as okra, not be suitable for human consumption or crop irrigation. Water desalination technologies such as off-grid solar-powered electro-dialysis reversal maize, millet, and wheat, use 50 per cent less water, with a 29 per cent crop yield increases.

Beyond physical technologies and crop inputs, data can be used as a resource to improve water availability and efficiency. In Peru, information access to weather and climate patterns is expensive and limited. The Institute for University Cooperation Onus provides an irrigation scheduling system that recommends the best irrigation practices based on climate, meteorological, and soil data through a mobile platform. Future Water's Flying Sensors use near-infrared sensors that can detect crop stress up to two weeks before it is visibly observable.

Food access: Technologies for food accessibility

A key aspect of accessing food is minimizing food

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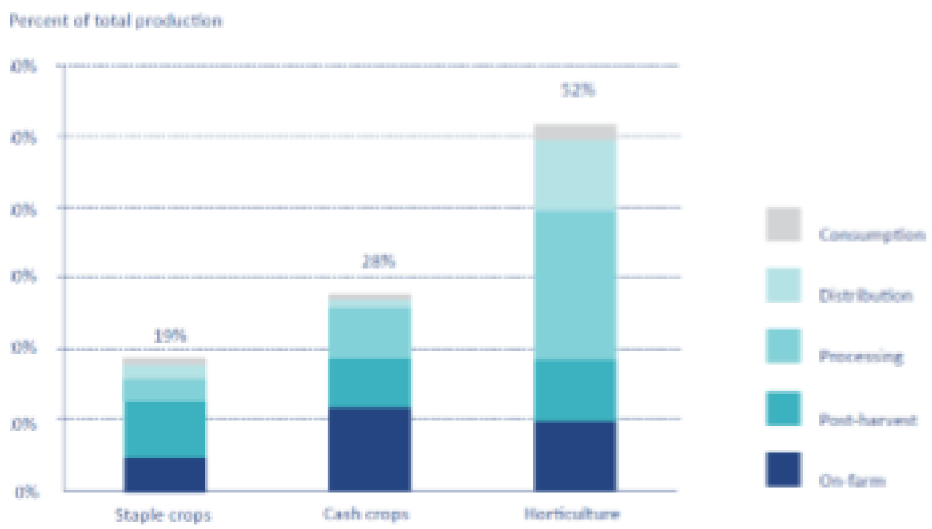
losses during production, storage and transport and waste of food by retailers and consumers. In Nigeria smallholder farmers lack access to ready markets, they tend to store their grains in inadequate facilities (e.g. no protection from moisture, excess heat, rodents, and pests) and end up with spoiled grains. Refrigeration needed for meats, fruits, and vegetables is typically lacking and even when it is there power is a problem. Processing facilities for consumable foods from raw products are lacking within the country. The need to import processed goods limits agribusiness employment prospects and drives up the costs of agricultural products farmers have to import. Lack of affordable refrigeration and of electricity limits the production, preservation, and sale of high value perishables such as vegetables, fruits, dairy, and meat. There is also a need for affordable refrigerated transport to move food from the farm to the market, while preserving freshness and navigating unpaved, rough terrain (African Cashew Alliance, 2010; Buluswar et al., 2014). The result is that all crops, particularly perishables, are susceptible to agricultural losses (Figure 2). A number of post-harvest-loss technologies are useful for storage, handling, refrigeration, transport and processing, despite challenges in

Figure 2: Agricultural losses in sub-Saharan Africa across the value chain for different types of crops



Source: FAO, 2011

Widening the applicability of innovative solutions to post-harvest loss, a number of recent examples demonstrate various approaches to minimize the losses that smallholder farmers often experienced. The six-year project, which started in 2011, provides improved rice-threshing technologies (ASI and NARO Lightweight Rice threshers) to smallholder rice farmers, particularly women and youth; farmer cooperatives; rice millers; traders and local agro machinery manufacturers. Technology transfer and dissemination are facilitated by the adoption of a business model, training of the beneficiaries on the use of the technologies and business skills, training of local private agro-machinery fabricators, and field days and radio announcements in the local languages for creating awareness. The threshers are expected to reduce post-harvest grain loss from 4.87 per cent to 0.01 per cent, translating to a savings of $12 million. The threshers should also improve the grain quality, labour productivity (saving up to 59 per cent threshing labour) and employment opportunities. Other projects include meat, dairy and fishery agro processing in Cuba and recent efforts to create mobile processing units for cassava in Nigeria.

Furthermore, genetically improved varieties can also limit (post-) harvest losses and preserve foods for transport to local, national, and international markets. Nanotechnology is being used in a number of projects to improve the preservation of crops. It aims to increase environmentally sustainable food security for poor people, especially small-scale farmers and women, through applied, collaborative, results-oriented research that informs development practice. A key part of the project involves

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hexanal, an affordable and naturally occurring compound produced by all plants to slow the ripening of soft fruits and extend their storage life. The use of hexanal spray has increased fruit retention time by up to two weeks in mango and five to seven days in peaches and nectarines. A nanotechnology smart packaging system was also developed with hexanal-impregnated packaging and coatings made from banana stems and other agriculture waste to keep fruit fresh. The technologies are transferred using different mechanisms, including through technology transfer workshops, field days, seminars and public–private model centers. A significant number of smallholder farmers in tropical areas do not have access to affordable harvest equipment. The cost, size, energy needs and maintenance requirements of imported threshers can create a burden for such smallholder farmers. In such cases, investing in the creation of local talent to fabricate and repair small to medium sized threshers can address the affordability and availability of such technologies. Initiatives such as Soybean Innovation Lab supported by the United States Agency for International Development offer training workshops and have been recently piloted in Ghana.

There is a need to better link smallholder farmers to local, regional, and international markets. Because many developing countries face regulatory costs related to international trade, investments should be made in sanitary and phytosanitary standards that can not only ensure compliance with trade regulations but also address national food and animal safety (IAASTD, 2009). Improving the capabilities of smallholder farmers to produce for regional and international markets could potentially create the economic and financial stimulus to escape smallholder farming status. In particular, low levels of intraregional trade among African LDCs (compared with other regions) may be an unexploited opportunity for increasing regional agricultural exports, harmonizing product standards within regional trading blocs and promoting regional agricultural innovation (Juma,2015; UNCTAD, 2015d;). Knowledge aid, where international donors promote the intensification of knowledge for development, could potentially support standards compliance in addition to the development of specific agricultural technologies (UNCTAD, 2007).

Food stability: New ways to combat acute and chronic food insecurity

Sustainable food systems deliver food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised. The effects of climate change will require sustainable and climate-compatible agriculture practices, including diversifying production.

Adapting food production to climate change

Integrating technology in physics should focus on re-integrating crop and livestock production and related closed nutrient cycles. In relation to this, the mitigation potential of carbon sequestration in optimally managed agricultural crop- and grasslands should be exploited more deeply. This potential is of the same order of magnitude as total agricultural emissions at the beginning (Smith et al., 2008; Bellary et al., 2008), but declines over time while approaching a new, higher soil carbon equilibrium level in soils, generally reaching zero sequestration rates after few decades. Soil carbon losses can be reduced by protecting existing permanent grassland, and soil carbon sequestration can be increased in arable land by the application of organic fertilizers, minimal soil disturbance, agroforestry, mixed cropping and the planting of legumes. When addressing climate change mitigation and adaptation in agriculture, it becomes evident that this is less about developing new practices than about making the available knowledge and skills widely available and supporting sustained implementation in the field. In particular, Physics for climate change mitigation and adaptation should focus on information provision and knowledge transfer and should include social, as well as technical, innovations. Many practices, however, deliver both, and many of the effective adaptation, resilience and mitigation approaches to a changing climate offer important ecological, agronomic, economic and social co-benefits. In addition, locally adapted breeding for drought or heat-tolerant crop varieties, with a focus on underutilized crops, has great potential to support climate change adaptation in agriculture.

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Conclusion

Physics discoveries convergences a number of emerging technologies, such as synthetic biology, artificial intelligence, tissue engineering, three-dimensional printing, drones and robotics, may have profound impacts on the future of food production and food security. Many of these applications are currently in the research and development or demonstration phase in developed countries. However, such technologies have the potential to reshape the future of food production, either individually or as part of converged applications. Recent advances in biotechnology have created a new approach to genome editing, based on CRISPR/Cas9. Some companies are using novel genetic sequencing, along with machine learning, to detect soil quality and help increase crop quality. Machine learning is being applied to drone and satellite imagery to build detailed weather models that help farmers make more informed decisions to maximize their yield. It is also being used with plant genomic and phenotypic data to predict the performance of new plant hybrids. Robots are increasingly automating farming through the ecological and economical weeding of row crops. A number of these technologies (sensors, artificial intelligence, imaging, and robotics) can be combined for automated precision farming.

Recommendations

If Nigerian government can dare to invest in physics and what it does as applied I science and technology in biology and agriculture there will be abundant quality food for healthy living that leads national development because agriculture is the main stay of any nation that must develop when the adequate principles of science and technology are applied.

References

Abari, A. O. (2019). Towards an optimal climate and a dynamic culture in functional educational research for sustainable national development. *Academic Journal of Research and Development,* 11(1), 1 – 11.

Abdani Nasiri, A., Mortazaeinezhad, F. & Taheri, R. (2018). Seed germination of medicinal sage is affected by gibberellic acid, magnetic field and laser irradiation. *Electromagnetic Biology and Medicine*, 37(1): 50-56.

Afzal, I., Mukhtar, K., Qasim, M., Basra, S.M.A., & Shahid, M. (2012). Magnetic stimulation of marigold seed. *International Agrophysics*, 26(4): 335-339.

Akinyemi, I. A. & Mohammed, M. O. B. (2023). Achieving National Sustainable Development through Educational Planning and Administration in Nigeria: The Harsh Reality. *African Journal of Educational Management, Teaching and Entrepreneurship Studies,* 9(1), 60- 75

Aladjadjiyan, A. (2006). Alternative Solutions for the Treatment of Food Produce. In: Case Studies in Food Safety and Environmental Health Ed: Peter Ho and Margarida Vieira. Springer, 69-75.

Aladjadjiyan, A. (2012). Physical factors for plant growth stimulation improve food quality, Food Production – Approaches, Challenges and Tasks, Anna Aladjadjiyan, (Ed.), ISBN: 978-953-307-887-888, In Tech.

Aladjadjiyan, A. (2018). The role of physics in food quality. BAOJ Biotech 4: 056.

Asseng, S., Ewert, F., Martre, P., Rötter, RP., Lobell, DB., Cammarano D, Kimball BA, Ottman MJ., Wall, GW., White, JW. & Reynolds, MP. (2014). Rising temperatures reduce global wheat production. Nature Climate Change, 5(2):143–147.

Bawa, B. (2019). National development: Meaning and problems. https://www.yourarticlelibrary.com

Bellarby, J., Foereid, B., Hastings, A. & Smith, P. (2008). Cool Farming: Climate impacts of agriculture and mitigation potential. Amsterdam, Greenpeace International: Available at http://www.greenpeace.org/international/Global/international/planet-2/report/2008/1/cool-farming-full-

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report.pdf.

Challinor, A., Watson, J., Lobell, D., Howden, S., Smith, D. & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change*, 4: 287–291.

Defries, R., Fanzo, J., Remans, R., Palm, C., Wood, S. & Anderman, TL. (2015). Metrics for land-scarce agriculture Science, 349: 238–240.

FAO (2006) World agriculture: towards 2030/2050 – Interim report FAO, Rome.

FAO (2015). The State of Food Insecurity in the World Meeting the 2015 international hunger targets: taking stock of uneven progress. FAO, Rome.

Godefroid, S., Van De Vyver, A., Stoffelen, P. & Vanderborght, T. (2016). Effectiveness of dry heat as a seed sterilization technique: Implications forexsitu conservation, Plant Bio- systems - *An International Journal Dealing with all Aspects of Plant Biology*, 1054-1061.

Hasan, S. & Mehmet, Y. (2017). Using Electric Current as a Weed Control Method EJERS, European Journal of Engineering Research and Science, 2(6)

ITPS (2015). Status of the World's Soil Resources (SWSR): FAO Intergovernmental Technical Panel on Soils, Rome

Juma, C (2015). The New Harvest: Agricultural Innovation in Africa Second Edition. Oxford University Press, New York.

Juma, C. & Yee-Cheong, L. (2005). Innovation: Applying knowledge in development. Report of the United Nations Millennium Project Task Force on Science, Technology, and Innovation Earthscan, London

Kartalska, Y., Dimitrova, K., Aladjadjiyan, A. & Zheleva, I. v. (2013). Study on the development of lactic acid bacteria in cow 'sand sheep's milk treated with ultrasound. App. Sci. Report 4 (3): 229-233.

Lobell, D., Schlenker, W. & Costa-Roberts, J. (2011). Climate Trends and Global Crop Production since 1980: Science, 333,616–620

Mahajan, TS. & Pandey, OP. (2014). Effect of Electric field (at different temperatures) on Germination of Chickpea Seeds. *African Journal of Biotechnology* 13 (1), 61-67.

Müller, C. & Robertson, RD. (2014). Projecting future crop productivity for global economic modeling. *Agricultural Economics*, 45, 37–50.

Müller, C., Bondeau, A., Popp, A., Waha, K. & Fader, M. (2010). Climate Change Impacts on Agricultural Yields in World Development Report 2010, Background Note (Potsdam Institute for Climate Impact Research)

Poghosyan, G. H. & Mukhaelyan, Zh. H. (2018). The Influence of Low-Intensity EMI Treatment on Seed Germination and Early Growth of WeatProc. of the Yerevan State Univ. *Chemistry and Biology*, 52(2), 110-115.

Porter, JR., Xie, L., Challinor, AJ., Cochrane, K., Howden, SM., Iqbal, MM., Lobell, DB. & Travasso, MI., (2014). Chapter 7: Food Security and Food Production Systems. In: Climate Change 2014, Contribution of the WG II to the 5th Assessment Report of the IPCC. Cambridge University Press, Cambridge, UK

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L., Wetterstrand, H., DeClerck, F., Shah, M., Steduto, P. & de Fraiture, C. (2016). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio* 46(1), 1–14.

Smith, P., Martino, D.Z, Cai, D., Gwary, H., Janzen, P., Kumar, B., McCarl, S., Ogle, F., O'Mara, C., Rice, B., Scholes, O., Sirotenko, M., Howden, T., McAllister, G., Pan, V., Romanenko, U., Schneider, S., Towprayoon, M., Watteenbach & Smith, J.U. (2008). Greenhouse gas mitigation in Agriculture. Phil. Trans. R Soc London. *B Biol Sci*. 363(1492):789-813

ISSN: 1117-6350

Society for International Development (2021). What is Development? https://www.sid-israel.org/en/what-isdevelopment/

Statsyuk, K., Thakur, TI., Smetanina, MA. & Kuznetsova. (2016). Effect of a pre-planting treatment of seed tubers with low-frequency pulse electric field on the growth of potato plants of different varieties. *Agricultural Biology*, 51(3), 360-366.

Steffen, W., Richardson, K., Rockström, J., Cornell, SE., Fetzer, I., Bennett, EM., Biggs R., Carpenter, SR., de Vries, W., de Wit, CA. & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 1259855.

Sudsiria, C.J., Jumpa, N., Kongchanab, P. & Ritchiec, R.J. (2017). Stimulation of oilpalm (Elaeisguineensis) seed germination by exposure to electromagnetic fields 220, 66-77

Sujayadi, R., Supyani, S. & Purwanto, E. (2017). Micro wave Application to Control Seed borne Fungal Pathogens of Soybean. *J Fitopatol Indones*, 13 (6), 191-198.

Tamara, B., Bulak, P., Nosalewicz, M., Pietruszewski, S. & Wlodarczyk, T. (2015). The influence of wheat Triticumaestivum L. seed pre-sowing treatment with magnetic fields on germination, seedling growth, and antioxidant potential under optimal soil watering and flooding. *Acta Physiological Plantarum*, 37(3), 1-10.

UN (2015b). Agricultural Technology for Development: Report of the Secretary-General United Nations.

UNCTAD (2010). Technology and Innovation Report 2010: Enhancing food security in Africa through science, technology and innovation: United Nations, New York and Geneva.

UNCTAD (2012). Information Economy Report 2012: United Nations, New York and Geneva.

UNCTAD (2013). Trade and Environment Review 2013: Wake up before it is too late: Make agriculture truly sustainable now for food security in a changing climate: United Nations, New York and Geneva.

UNCTAD (2015). UNCTAD Handbook of Statistics: United Nations, New York and Geneva.

UNCTAD (2015d). The Least Developed Countries Report 2015: Transforming Rural Economies: United Nations, New York and Geneva.

UNESCO (2013). Education for sustainable development: Sourcebook; Education for sustainable development in action. learning & training tools, 4; 216-383. Education for sustainable development: sourcebook; Education for sustainable development in action: learning & training tools; Vol.:4; 2013 - 216383eng.pdf (unesco.org)

Valderrama-Bravo, C., Dominguez-Pacheco, F.A., Hernandez-Aguilar, C., Sanchez-Hernandez, G. & Perez-Reyes, C. et al. (2018). Changesinmasa and tortill as obtained from maize irradiated and nixtamalizedwith nejayote. *International Agrophysics* 32(3), 387-394.

Vora, N.C. & Jasrai, Y.T. (2012). Microwave Oven Based Sterilization of Media for Micro Propagation of Banana. *Cibtech Journal of Biotechnology*, 1(2-3), 1821.

Wang, S., Wang, J. & Guo, Y. (2018). Microwave Irradiation Enhances the Germination Rate of Tartary Buckwheat and Content of Some Compounds in Its Sprouts: *Pol. J. Food Nutr Sci.* 68 (3), 195-205.

World Bank (2008). World Development Report 2008: Agriculture for Development: World Bank, Washington, D.C.

Zareh, H. & Mohsenzadeh, S. (2015). Electromagnetic Waves from GSM Mobile Phone Simulator Increase Germination and Abiotic Stress in Zeamays L. *J Nutr Food Sci*. 5: 382.