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Optimizing the Instrument of Biotechnology in Reducing Climate Change Induced Food Insecurity in Nigeria

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Abstract

This paper reviews inhibiting factors which climate change places on Nigerian agricultural productivity and food security. Nigeria's agriculture and food security is more than 90 percent dependent on weather and climate elements, especially precipitation (rainfall), humidity, wind and evapo-transpiration. Climate change and climate variability are now happening, and they tend to exacerbate such extreme meteorological events as droughts, floods, heat waves and storms. These extreme weather events are not only intensifying but are also occurring more frequently in many parts of Nigeria. These extreme events are very inimical to agriculture and the food security of Nigeria. For example, droughts now persist in many parts of Nigeria and farmers have constantly recurring stories of losses in their agricultural productivity. In the more humid southern part of Nigeria, floods and destructive storms now occur more frequently, wreaking havoc; farmers count their losses whenever these events strike. Both the on-set and cessation of rains fall outside the routines long established and taken for granted by farmers for decades. Consequently, climate change has now emerged as one of the key obstacles to the attainment of food security in Nigeria. The good news is that the field, of biotechnology, which is an applied form of biology, has many techniques and processes which can be explored, exploited, optimized and widely adopted for improving Nigeria's agriculture and enhancing her food security, especially in this era of climate variability and change. This paper discusses these processes and techniques in full.

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1. Introduction

Climate change is now recognized as the greatest and most serious environmental challenge facing the world in the 21st century, to the extent that global warming and climate change issues now top the global agenda [1].

Annan [2] has observed that it is one of the main pillars of our fight against poverty and is thus essential for the achievement of the Millennium Development Goals. Indeed, an unstable climate can lead to economic instability which can in turn threaten investment, growth and economic development. Brown [3] notes that climate change is not just on environmental issue, but most definitely an economic issue, whose risks are not evenly spread, but will affect the poorest countries most. Climate change is caused principally by the industrialized countries, but its effect is disproportionately felt by the developing countries; this is the paradox of the cause and effect of climate change.

The impact of climate on human development and human livelihood is multi-faceted, but the Human Development Report [4] identified five at least major effects:

- Loss of agricultural productivity and food insecurity
- Water resources insecurity
- Extreme weather events
- The collapse of ecosystems that support human development
- Increased health risks

Oladipo [5] in his own contribution on the impact of climate change on sustainable development, reported that climate change is a serious threat to poverty eradication and sustainable development in general, and Nigeria is no exception. This is so because the country has a large rural population directly dependent on such climate-sensitive economic factors as water, biodiversity and grasslands for their subsistence and livelihoods.

In Nigeria at least four critical happenings have strong finger prints of climate change:

- The Savannah and Sahel zones of the country have both recorded deficits in rainfall since 1980;
- Changes in patterns of land cover between 1976 and 1995 indicated loss of prime arable land;
- The cereal producing Sudan savannah ecological zone has begun to transit to pure Sahel as the influence of the Sahara desert increases southwards; and
- The root and tuber production technology of the Guinea savannah is gradually giving way to Sudan savanna grassland with dire consequences, especially in increasingly frequent and violent clashes between herders and farmers, with associated loss of lives, farmlands and burning of homes the bone of contention being access to grassland.

Three developments related to climate change that can affect Nigeria's agricultural productivity and food security have been high1ighted by Cramer [6]

- Increased coastal and riverine erosion and flooding, as well as storm damage, in the south and middle belt of Nigeria.
- Strong rainfall in the-south and middle belt with changes in agricultural patterns, river erosion and flooding, as well as an increased rate of disease.
- Reduced rainfall in the north, with diminished agricultural fields and water scarcity. The truth is that climate change is already having strong negative impact on Nigerian agriculture and her food security. This impact calls for sound and efficient mitigation and adaptation measures that can significantly minimize Nigeria's increasing vulnerability to climate change-induced food insecurity. It is the position of this paper that exploration and utilization of the various techniques and processes now readily available and adoptable in the field of biotechnology represent one of the sure strategies that can be exploited to boost Nigerian agricultural productivity and, by extension, contribute immensely towards enhancing her food security and improved livelihoods. These strategies provided by biotechnology are reviewed and discussed in this paper

1.1. What is Climate Change? And what is Biotechnology?

1.1.1. Climate change

Many definitions of climate change are available in the literature but this work limits itself to those by two known authorities on the subject, The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCC).

IPCC depicts climate change as any change of in climate over time whether due to natural variability or as a result of human activity

UNFCCC [7] on the other hand, sees climate change as any change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is m addition to natural climate variability observed over comparable time periods. The above two definitions are thus similar in many respects except that UNFCC clearly discriminates between natural and human factors while IPCC does not.

Biotechnology is a field of applied biology that involves the use of living organisms and bioprocesses in engineering, technology, medicine and other fields requiring byproducts. In other words, biotechnology is any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific outcomes.

The field of biotechnology is very diverse and draws a great deal from some other fields, especially such pure biological sciences as genetics, microbiology, animal cell culture, molecular biology, biochemistry, embryology. In many instances it also depends on knowledge and methods from outside the sphere of biology (chemical engineering, bioprocess engineering, information technology and biorobotics).

Agriculture and food processing have benefited greatly from biotechnology. Through early biotechnology farmers were able to select the most suitable crops for their environment with the highest yields, so as to produce enough food to support a growing population (www.accessexcellence.org).

Brewing of beer, which is a process derived from biotechnology, was used in many ancient cultures, such as Mesopotamia, Egypt and India: This process, which involves the use of malted grains (containing enzymes) to covert starch from grain into sugar and then adds specific yeast to stimulate fermentation, is still being practiced in breweries around the world.

For thousands of years, humans have used selective breeding to improve the production of crops and livestock for food. In selective breeding, organisms with desirable characteristics are mated to produce offspring with the same characteristics. For example, this technique was used with com to produce the largest

and sweetest ear (www, accessexcellence.org).

Though man has harnessed many of the processes made available by the field of biotechnology, many uncertainties and risks still remain. This paper will highlight some of these risks as challenges that could hinder the wholesome use of biotechnology in Nigeria.

1.2. The Links between Climate and Agriculture

It is still generally accepted that weather is the most important variable in agricultural production, even though technological advances and improvements in forecasting have made possible minor adjustments in planting and harvesting schedules [8]. The main climatic elements upon which crop growth depends are solar radiation, temperature and moisture. According to the World Climate News [9] the main determinants of agricultural production is seasonal variation in such weather elements as temperature, precipitation and sunshine. Droughts, floods, frost and heat waves stress both crops and livestock.

It is the changing frequency of the above events due to climate change that is the major reason for concern. Many studies and field reports have established these determinants of agricultural productivity and associated food security in various parts of the world. Though there are many uncertainties, certain facts have been fairly well established. For example, Rosenzweig and Parry [10] and Akeh, et al. [11] have noted that climate affects several aspects of plant growth and yield. Climatic elements and their extremes alter crop productivity.

Light and moisture availability affect crop growth, while the rate of crop development is generally determined by temperature. Sivakumar concludes that throughout history, extremes of heat and cold, drought and floods and various forms of violent weather have wrought hovoc on agricultural systems.

This section has highlighted the link between climate and agriculture. It is expected that any major change in climate, such as is currently being experienced, will affect agriculture and food security in various ways, especially for those nations in the third world that still practice subsistence agriculture, which is essentially rain-fed.

1.3. The Impact on Sub-Saharan Africa

Poor countries will be hardest hit by climate change through a combination of droughts, failing agricultural yields, more severe hurricanes, flooding and storm surges [12].

Some effects of climate change are already very visible in sub-Saharan Africa. These include changing weather patterns resulting in crop-failures, increased starvation, dwindling access to water, increasing food shortages and malnutrition leading to stunted growth of children, especially in poorer families with limited access to formal insurance. Climate change shocks have negatively affected food security and have resulted in food shortages, high food prices and the choice of unsustainable survival option [4].The Human Development Report [4] Report supports the thesis that Africa is highly vulnerable to the shocks that are associated with climate change, especially as the continent lacks both the technologies and resources necessary to build requisite adaptation responses to the impact of climate change. For example, the IPCC [13] has clearly noted that such extreme weather events as drought and floods are projected to affect local crop production negatively, especially in the subsistence scale at the low latitudes. At low latitudes of the seasonally dry and tropical regions, productivity is projected to decrease even with a small local temperature increase (1- 2°C). This would increase the risk of hunger [9].

As a result of climate change, agricultural production and thus access to food in many countries of the continent is projected to be severely compromised. This is so because many areas suitable for agriculture may be profoundly altered by climate change. The length of the growing season and the yield potential, particularly along marginal semi-arid and arid areas, are expected to decrease. In some countries of the continent, yields from rain-fed agriculture could be reduced by up to 50 per cent *by* 2020. Low-lying coastal areas such, as the mangroves, coral reefs and wetlands, are projected to be further degraded by floods and storm surges, with additional risks and consequences for fishermen and tourism.

Agronomic models of climate sensitivity also indicate that high temperatures associated with climate change are likely to be harmful in many developing countries, especially where land is marginal, water inadequate and temperatures high [10, 14]. The models clearly predict that increasing temperatures will make many agricultural areas less productive and some completely unsustainable. Mendelsohn and Dinar [14] in their various reviews of the implications of climate change for agriculture, particularly in developing countries, reported that adaption can significantly reduce the effects of climate change. Reilly [15] also reported that, without adaptation, average cereal production yields fell roughly 20-30 percent, but through various channels of adaptation, losses attributed to climate change were reversed resulting to small increases in production (0-1%t) worldwide, as the adaptations included modification of crops, application of new techniques to existing farmlands, shifting crops to new land and responding to changing market price.

In all, Africa is the most vulnerable continent; climate change threatens to roll back years of development gains. The near future will see increased pressure on water, food and land and exacerbated poverty [16].

1.4. The impact on Nigeria

In Nigeria, climate change is no longer a fairytale phenomenon. Concrete evidence and impact are here. Many sectors of Nigeria's economy are very vulnerable. Agriculture, however, is one sector that would be very significantly affected. This is so because Nigeria's agriculture is predominantly rain-fed, very seasonal, employing very low technologies and inputs and usually at subsistence level. According to Ajadike [17] all aspects of Nigeria's agriculture will be significantly affected by climate change.

The timing of different agricultural activities may be completely altered. Agro-climatic zones as presently constituted may undergo significant changes. Some Nigerian researchers have established that Nigeria's climate is undergoing discernible changes. For example, Udoeka and Iso [18] reported variations of rainfall and pan evaporation over catchment in the various climate zones of Nigeria within the last thirty-five years. The trend is that water availability index in Nigeria is decreasing. Gakahu [19] in his review of the impact of climate change on the Nigerian savanna, noted that climate change could expand the arid and semi-arid savanna, eating up arable land and hence depressing agricultural production. Intensification of agriculture would lead to over use of land and to its ultimate degradation.

Another strong piece of evidence that climate change is now being experienced in Nigeria's landscape is the increasing stormy weather characterized by the frequent disastrous floods that wreak havoc on farmlands and livestock, These major flood disasters are presented in Table 1.

Table-1. Major Flood Disasters that Affecting Nigeria's Agriculture and Food Security, 1998-2007.

Date	Place	Occurrence	Agriculture and other Loss
October 7, 1998	Many villages in Niger and Kwara State	Floods from Kainji Dam	3.2 hectare rice plantation belonging to Lower Niger River Basin and Rural Development Authority destroyed.
August 1999	7 LGAs in Borno State	Widespread erosion	Farmlands lost About 300 farmsteads submerged.
August, 1999	Parts of Jigawa and Yobe State	Floods	Rice and maize, farms destroyed
September 1999	Ikere, Ado, Aramoko Efon, Moba Ileje-Meje and Emure LGAs of Ekiti State	Floods and erosion	Farmlands washed away
Between July 8 and August, 24, 2007	11 Local Government Areas, 108 villages	Devastating floods with about 24 deaths	About 5, 787 farmsteads and 13,609 houses worth over N717.3 million destroyed.
No clear date	Gwoza, Bama, Konduga and Kaga, Borno State	River Yezeram overflowed its banks	Farmlands ravaged and houses destroyed along the river banks.
No clear date	Lokoja, Ibaji, Ida, Bassa and part of West Yagba, Kogi State	Worst flood in 20 years.	More than 1,110 hectares of farmlands lost to floods
September, 2007	Lapai LGA of Niger State	Worst flood in 100 years	Five persons died, 1,000 houses destroyed

Table Compiled by Ajadike [20] partly by the data provided by the News Agency of Nigeria in their Survey titled: "Farmers Concern over Incessant Flooding," reported by The Guardian [21] and data provided by the Nigerian Meteorological Society publication Effects of Climate Change in 1999.

2. Strategies for the Application of Biotechnology

2.1. To Increase Agriculture Productivity and Enhance Food Security

There are many uncertainties concerning the extent and likely impact of current prevailing climate variability and climate change. Nevertheless, some agronomic and field studies have at least established some trends in the relationship between climate change and agriculture in the tropical and developing countries of the world.

Fakorede [22] in a field study of the correlation between the impact of climate change and the yield of maize in Ife, reported an increased incidence in the delayed on-set of rain, false starts of the rainy season and reduced rainfall in March, April and May. These factors combined to lead to delay in planting of maize as well as the reduction in the length of growing season.

Apart from rainfall, whose many characteristics have been profoundly altered, other weather elements that determine agricultural yields such as temperature, light, humidity, evapo-transportation have also been

observed to be changing as well. In addition, extreme weather events such as floods, droughts, soil erosion, heat waves and ocean surges are not only being strengthened, their frequencies are also increasing. Pests and disease are increasing because climate change creates favourable conditions for the rapid multiplication of organisms resistant to currently available insecticides and herbicides. At the same time, with the application of some biotechnological techniques and processes, such as crossbreeding, hybridization and crop improvement, many desirable agronomic characteristics, such as tolerance or multiple resistance to identified production hazards, like drought, disease, soil aridity, mineral deficiency, maturing varieties, etc., can be achieved [23].

Recombinant DNA technology is now possible. This process can be exploited to transfer disease resistance from non-cultivated species into cultivated species. This technique should be expanded and promoted for wider adaptation using publicity channels and agriculture extension services, so that ordinary farmers benefit maximally from this novel technique.

Another biotechnological process that will benefit Nigeria's quest for increasing food security is the use of protoplast fusion and cell cultures to obtain hybrids from the crosses of quite unrelated species [24]. These techniques of genetic engineering can ensure that certain desirable traits, such as early maturity, drought resistant, increased salinity, pest resistant and nutrition enhancement and reinforcement, are enhanced. Nwokeocha and Fluyi [25] in their study of the genetics of dwarfness, were, for example, able to segregate a number of desirable characteristics in rice. Such characteristics include dwarfness (D), heavy tillering (T), dense panicle (P), early maturity at 110 days maximum (M) and tolerance of low iron in the soil (Fet). The resulting rice variety is coded DTP MFet, and this variety has long grains early and maturing period, with dense panicle.

It is now possible to exploit some desirable traits in wild grass and incorporate them in cultivable plants. For example, wild grass can be crossbred with barley, wheat, sorghum, etc. to achieve resistance to drought, wild fires, etc.

One of the latest developments in genetic engineering that can help greatly in achieving food security in Nigeria is the discovery of gene at-DBF2 from Arabido psis Ihatiana (a tiny weed which has been used extensively in research). When At-DBT2 genes were inserted into tomatoes and tobacco cells, they were able to withstand many environmental stresses, like salt, drought, cold and heat, far more than ordinary plants. If these preliminary results are sustained in large trials, then At-DBF2 can really help in engineering crops that can withstand harsh environments, including those that have been introduced by the prevailing climate change in Nigeria [25].

There is little doubt that the massive introduction of genetically modified food in Nigeria would help significantly in fighting food insecurity and responding to climate change, but this technology should be applied with great caution. This is so because the technology has many environmental, moral, legal and health challenges, For example, it has not been determined whether products of biotechnology can harm humans and the environment. Environmentalists fear that biotechnology could alter and transform nature and profoundly change the many-century-old relationships between species and their ecosystems. Already such fish as carp have been genetically altered to grow faster. Theoretically, scientists could implant into salmon genes that would alter their migration patterns, making it easier to catch the species in the oceans. Rivers, lakes and even oceans might become aquatic corrals in which once-wild species are spawned, raised and harvested like cattle [26].

The various uncertainties associated with wholesome application of biotechnology throw up many questions which are still begging for answers: How can we be sure that a genetically altered organism, though beneficial to humans, will not have disastrous consequences when released into the environment? What trade--offs between ensuring public safely and continuing scientific progress are reasonable? There are many questions, but few answers [26].

3. Discussion

The truth is that Nigeria is currently experiencing a very viable climate. The harmattan winds that used to prevail between November and December may now come between February and March. The unset of rain, which usually comes in mid-March in the south and mid-May in the far north is totally altered. The end of the rains, previously very predictable in both northern and southern Nigeria, is now very erratic.

Climate change is already exacerbating other factors, such as primitive implements, inefficient small holdings and little or no access to resources like irrigation facilities and fertilizer causing Nigeria to be classified among the countries suffering from acute food insecurity. This classification is supported by the 2008 surveys jointly conducted by the Federal Government and the United Nations Children's Fund (UNICEF), in which about 65%, or 91 million Nigerians, were identified as being at risk of food insecurity. Kano State was adjudged the state facing the worst food insecurity in the country.

Nigeria had the highest prevalence of stunted or chronically undernourished children under the age of five, [27]. Agriculture is one sector that is very sensitive to climate change. Under the "business as usual" scenario, agricultural productivity in general could decline by between 10 and 25 percent by 2080. Rain-fed agriculture is projected to be reduced by as much as 50% [5].

4. Conclusion

The good news is that food insecurity in Nigeria can be mitigated by the application of various techniques that are now available and adaptable in the field of biotechnology. For example, traditional methods of cross breeding crops have been extended by the genetic insertion of desirable genes to produce crops that are resistant to the environmental stresses associated with climate change.

However desirable, the biotechnological modification of food must nevertheless be received with great caution, because of the many uncertainties that still trail many genetically modified foods.

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