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The Impact of Biotechnology and Sustainable Agricultural Practices on Rural Subsistence Farmers in Northern Nigeria

A simple definition of food security would be "living without the fear of hunger." In a prosperous, developed country like the United States, one rarely has to worry about going hungry. Sometimes it seems as if the well-stocked grocery store shelves have an endless supply of food. Unfortunately for the 852 million people on earth living without enough to eat, hunger is a very real problem. Most of these people are poor subsistence farmers living in rural areas; to them food insecurity is a vicious cycle. Low crop yields translate into low income, and low income means limited amounts of money to purchase seeds and supplies for the next growing season. This produces another low yield and the cycle continues, making it nearly impossible for farmers to improve their quality of life. The countries hardest hit by food insecurity are in sub-Saharan Africa, where the encroaching desert and tanking economies make the sting of poverty all the more painful. The most populous of these sub-Saharan countries is Nigeria. With its rich reserves of oil and status as one of the "Next Eleven" emerging economies, one would think that Nigeria is well on its way to becoming a developed country, but with an Human Development Index (a score figured by looking at a country's life expectancy, literacy rate, and GDP per capita) of only .499, it is ranked 154th out of 179. This places Nigeria among the less developed nations. The problems that face Nigeria are complex and interrelated. Rampant poverty and food insecurity caused by overpopulation is just one crisis to be addressed. The Nigerians most at risk live in the Sahel region of the country, an arid area in the north of the country populated mainly by poor subsistence farmers. Unsustainable agricultural practices like slash and burn agriculture cause soil degradation, that significantly reduces the productivity of the land. The solution to this problem lies with biotechnology and other sustainable agricultural methods. Biotechnology is defined as "any technological application that uses biological systems, dead organisms, or derivatives thereof to make or modify products or processes for a specific use." The implementation of biotechnology will improve yields and as a result boost farmers' incomes. With increased capital comes better access to resources and education, thus improving the quality of life. In order to make biotechnology accessible to these rural communities, the Nigerian government must take swift action, enact policies that support biotechnology research, and encourage foreign investment. Only after Nigeria addresses these many problems will it be able to take its place among the developed countries.

Nigeria is a melting pot of different cultures. It boasts 251 different ethnic groups, the most common being the Hausa, Yoruba, and Igbo peoples, and is home to 521 languages. The climate of the country is almost as diverse as its people, ranging from tropical rainforest in the south to desert-like Sahel region in the north. Politically, the last fifty years have been a time of turmoil for Nigeria. After achieving independence from Great Britain in 1960, control of the government passed through a succession of totalitarian military regimes that kept the country in dire economic straights. In 1998, military rule ended, and democracy was put in place. Since the advent of democracy, Nigeria has emerged as a leader among West African Nations. Industrialization has taken hold and people are flocking to the cities; Nigeria's largest city, Lagos, has a population of 7 million people, compared to just 300,000 in 1950. Also, government corruption is not as common, and in a 2003 World Values Survey, Nigerians were determined to be the happiest people on earth, considering their family and culture the most important

things in their lives. Despite being the happiest country on Earth, Nigeria still faces its fair share of problems. Ethnic and religious violence is still common, and general living conditions are poor. Health care is also mediocre, with 20 percent of children dying before five years of age and a life expectancy of only 47. Economic mismanagement is another major problem. Oil is the driving force behind Nigeria's economic boom, with 36.4 billion barrels in reserves and 2.2 million barrels being pumped per day; Nigeria is the tenth largest oil producer in the world. Currently, 85 percent of the Nigerian government's earnings come from oil. With the rise of oil as Nigeria's main source of revenue, the agricultural sector of Nigeria's economy, once it's strongest, has been neglected. This poses a serious problem for the 52 percent of the population that lives in rural areas. These people rely primarily on subsistence farming for income. With the government refusing to spend money on these traditionally unprofitable rural areas, families like the one of Habib Abdullah in Borno province are suffering.

Habib Abdullah's family is Hausa, the most common ethnic group in northern Nigeria. His family unit, like most Hausa families, is very large. It is composed of him, his three wives, his ten children, his two brothers, their wives, and their children as well. This brings the total number of people in Habib's household up to thirty-six. Large families like this help increase food security because there are more persons available to work in the fields and travel to the city to earn supplemental income. His family, like most Hausa families, is of the Islamic faith. Because northern Nigeria is a primarily Muslim area, it is divided into Muslim states, or emirates. These emirates are governed by emirs, who hold great influence with the local population. The law of the land is the Islamic Shari'a. The prominence of Islam means that the women in Habib's are limited to just a few household activities, and are not allowed to enroll in school. The boys of the family attend a local school during the winter when the fields lay fallow. The family makes their living farming a nine acre patch of land. However, they do not own this land, which gives them little incentive to invest in it. In April the planting season begins. They plant grain crops like sorghum and millet. Low soil fertility makes farming highly labor intensive, usually requiring fifty-seven man days per acre. Habib's family has little access to modern farming equipment, pesticides, or fertilizers, leaving them to resort to primitive methods that haven't changed for hundreds of years. Low rainfall is also hard on crops. The Sahel on average receives only 600 millimeters of rain per year. Droughts are also common, causing mass crop failures and skyrocketing food prices. The time a few months before harvest is the peak hunger season in the north. This is the time that the Abdullahs send their sons to the city of Kano to augment their income. Crops are harvested in early October. Yields are usually low, meaning that the Abdullahs have to spend most of their income, about $2400 yearly, on food. Many of Habib's family's problems stem from their antiquated, unsustainable agricultural practices.

The Abdullah family practices shifting cultivation, a form of agriculture that has been used for thousands of years in which plots of land are cleared of vegetation and used for farming until the soil becomes nutrient depleted. Then, the field lays fallow for a few years to replenish its nutrients, while another plot of land is cleared. Though this method may have worked well in the past, Nigeria's exploding population makes this practice impractical. With a greater population comes a greater demand for food. This puts more stress on the land to produce enough to feed a growing population. As a result, fallow periods have been shortened, giving soil less time to replace lost nutrients. Agricultural techniques like monoculture (only planting one kind of crop) further damage the soil. Also, removing natural plant life through shifting agriculture causes less moisture to be retained, making an already arid area drier. All of this overexploitation of the land causes low yields and soil degradation. Soil degradation is a major problem in Africa, where 40 percent of the land is severely degraded. Dry places like the Sahel are most

at risk. Degraded soil is more vulnerable to wind and erosion. When soil erodes, it can cause massive dust storms and draw salt near the surface. It also causes desertification, which claims 1,355 square miles of land each year and turns it into desert. Once soil is replaced by sand, biodiversity is lost and the land is virtually un-usable. Overexploitation leads to low yields, which leads to low income, which results in low quality of life. However, there is a solution to this problem: biotechnology and other sustainable agricultural methods.

The objective of a sustainable agricultural system is to make fields productive for an indefinite amount of time while causing little harm to the environment. Using biotechnology, or genetic engineering, is one way to achieve sustainable agriculture. Biotechnology embodies a broad spectrum of technologies used by a variety of different industries. The so-called "green biotechnology" is used for agriculture. Green biotechnology is used to make crops more productive by engineering their DNA to express certain desired traits. These traits can include higher yield, drought resistance, herbicide resistance, disease resistance, and increased nutritional value. Biotechnology is may be implemented in a variety of ways; selective breeding is one. Breeding only plants with the most favorable traits produces plants more likely to survive. Exposing plants to radiation is another method. The radiation mutates the plant's DNA. These mutations may prove beneficial to the plant's survival or not. Helpful mutations are passed on to the next generation of plants. One of the most common methods is using recombinant DNA, which is created by injecting foreign DNA into the plant's natural DNA. For example, *Bacillus turgenensis* corn, commonly referred to as Bt corn, has been given the gene to naturally produce a certain insecticide, thus reducing the amount of insectide needed to be sprayed on fields. Also, the *At-DBFZ thale cress gene* for resisting certain environmental stresses like salt and drought has been inserted into tomato plants, resulting in tomatoes being grown in harsher environments. Plants have also been engineered to produce other kinds of products, such as edible vaccines and acids for detergents. Using biotechnology opens the door for the implementation of other sustainable agricultural methods. To prevent desertification, the most urgent environmental issue in the Sahel, conservation and soil protection are key to improving agricultural productivity. Planting a variety of crops at once, called polyculture, is one way to prevent soil erosion and nutrient loss. Cultivating legumes, like beans, not only converts nitrogen into a usable form, but it also enriches the soil. Using irrigation with proper drainage prevents increased soil salinity. To prevent the encroachment of sand dunes, shrubs can be planted near them as a form of stabilization. Planting rows of trees to act as windbreaks has also proved very effective in preventing soil erosion. There is no doubt implementing these methods will improve the Abdullah family's quality of life.

Genetically engineered crops are already benefiting 8.5 million farmers in 21 countries. It has allowed farmers in the United States to increase their yields of corn from about 2.5 tons per hectare in 1900 to 9.4 tons per hectare in 2001. That almost a four-fold increase. Though Africa has yet to feel the full effects of the revolution caused by green biotechnology, some countries, like Egypt and Burkina Faso, are beginning to plant high yield varieties of corn and cotton. The benefits of biotechnology and sustainable agriculture reach far beyond just higher yields. With pesticide and herbicide resistant varieties less money needs to be spent on herbicide and pesticide. Also, with greater yields comes greater incomes, and greater food security. This means more capital with which to invest in improved technology. Higher productivity also means inexpensive, locally grown food, and an all-around healthier diet. This translates into people living longer, healthier lives. Using sustainable methods will help stop environmental degradation so fields will stay productive, and the Abdullah family can abandon their unsustainable slash and burn agricultural practices. Despite all of these benefits, there is still some controversy surrounding

the use of biotechnology. The hotbed of this debate lies in Western Europe, where adequate food production is usually not an issue. Some countries have gone so far as to completely banned GMO's (genetically modified organisms) due to safety and ethical issues. These nations are concerned that genetically engineered plants could impact biodiversity because local varieties of plants may not be able to compete with genetically engineered varieties. Thus, local varieties of plants may die out. However, in the words of scientist Dr. Florence Wambago of Kenya, the European concerns are irrelevant to Africa because they "do not have anything to do with safety, just mistrust and misinformation." A major obstacle for implementing biotechnology in Nigeria is that most of the Nigerian staple crops, like sorghum, don't even have their genetic codes sequenced, making biotechnological research into these crops very difficult. Also, Nigeria does not have the research infrastructure, such as labs and lab equipment, to support biotechnological research. This stems from Nigeria's "brain drain" problem. Most Nigerians with advanced degrees move out of the country, leaving no one in Nigeria to conduct research. This poses the problem that Nigeria may be exploited as a "dumping ground" for unproven biotechnology from profit-hungry companies. There is also the problem of "intellectual copyright" laws which make it difficult for biotechnology to be accessible to developing nations. Scientists patent their genetically engineered plants so farmers who wish to use them must pay a fee. It is obvious that there must be cooperation between the Nigerian government, the developed world, and farmers in order for the country to fix these problems and reap the benefits of biotechnology and sustainable agriculture.

To achieve food security, the Nigerian government must take action and enact policies and programs that stimulate rural growth by spending money on programs that improve rural areas and make biotechnology more accessible. The government must start with programs that improve rural infrastructure. Better irrigation systems, roads, and farming equipment will help make agriculture more productive and sustainable. Rural land ownership must also be made easily available. With ownership readily obtainable, there is more incentive for farmers, like the Abdullahs to invest in and improve their land. Unfortunately many farmers have limited access to credit. The Nigerian government could provide incentives to banks to give loans to poor people. Nigeria also must enact resource management policies. Policies that regulate water and land usage will help prevent soil degradation. To make biotechnology widely available, Nigeria must invest in research. This means Nigeria must offer incentives to stop its few educated people from leaving the country and encourage foreign scientists to research in Nigeria. Also, if biotechnology is going to become common place, there must be bio-safety regulations put in place, so that the technology is not misused. This means that rural farmers must be educated on how to farm sustainably. In order to finance these programs, Nigeria must encourage foreign investment. This means Nigeria must invest in improving its infrastructure, economic regulations, and curbing government corruption as these factors can hinder investment. Nigeria could also partner with international aid organizations and companies that share biotechnology with the developing world. Nigeria receives 250 million dollars in aid each year. A portion of this could be used to finance the agricultural sector. Organizations like the International Fund for Agricultural Development and the Food and Agriculture Organization both have programs that advocate for the rural poor and educate them on ways to improve food security. The developing world also must soften the regulations on intellectual property rights in order to make biotechnology more accessible. When all of these policies and programs come together the life of the Abdullah family will be better, and perhaps one day they will not have to worry about food security.

Nigeria is a land facing many dire problems. One of them is rampant food insecurity. Millions of Nigerians are living without enough to eat. Families who live in the desert-like Sahel region of the country, like the Abdullahs, are most severely affected. The Abdullahs make their living by farming sorghum on a fairly unproductive plot of land, that they don't even own. Their access to resources like irrigation, herbicide, and pesticide is severely limited due to lack of infrastructure and low income. The factor that reduces their yields the most is their use of shifting cultivation, a form of agriculture that is becoming unsustainable for Nigeria's booming population. The land is being overworked, which reduces nutrients, and eventually leads to desertification. However, there are ways to stop environmental degradation and improve yields. To prevent soil erosion, it is vital to restore nutrients to the soil. This can be done by planting a variety of crops, and using proper irrigation techniques which reduce soil salinity. Genetic engineering, or biotechnology, uses genetic manipulation techniques to create plants which express specific traits like high yield, herbicide resistance, and disease resistance. Planting genetically modified crops will increase yields and augment the Abdullah family's income. Having more money will make it easier for the Abdullah to improve their situation in life. However, there are some obstacles in making widespread biotechnology use a reality. Limited research capability and intellectual property rights, plus concerns over safety make biotechnology all the more inaccessible to families like the Abdullahs. This makes it imperative that the government, farmers, and developed countries cooperate and make policies on biotechnology and sustainable agriculture. Things like land ownership, credit, and education must be readily available to *all* farmers. There must also be investment in rural infrastructure and biotechnology research. To finance new policies, the Nigerian government must finance foreign investment. Partnerships with international aid organizations and companies will also help provide capital. Biotechnology and sustainable agriculture have the potential to revolutionize Nigerian agriculture and improve the lives of many Nigerians, including the Abdullah family. With an abundance of food and a sustainable agricultural system in place, food insecurity in Nigeria will finally become a thing of the past. With problems like hunger gone, Nigeria can look forward to a very bright future.

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