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Assessing the Conflict Perspectives and Acceptability of Genetically Modified Foods (GMOs) for African Agriculture

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Abstract

Genetically Modified Food means any food containing or derived from genetically modified organisms (GMOs). Genetically modified foods as a need in Africa has been generating polarizing debates among stakeholders. Africa is confronted with the motivations and concerns of GMOs. Some African countries had adopted genetically modified foods (GMOs) with a view to improving and increasing productivity in the agricultural sector. The expectation is to improve the socio-economic status of African farmers; enhanced national and continental economic prosperity, and achieve foreign investments and earnings from safe modern biotechnology sector. However, there are concerns among the public that the adoption of genetically modified food in Africa may be harmful to man's health and the environment. This paper discusses the motivational factors for GMOs into the agricultural sector in Africa. The paper also identifies prospective environmental and health concerns raised against the introduction of GMOs in Africa. The paper concludes with suggestions that will enable the continent explore the potentials of biotechnology and douse the attendant apprehensions.

Keywords; Genetically Modified Foods (GMOs), Environmental Conflicts, Economy and Africa

1. Introduction

The concept of "perceptions" is a puzzle. While some would agree on the importance of obtaining African standpoints on the topic, it also involves challenges which cannot be easily dismissed with a wave of the hand. This may require a country-by-country approach, thus translating to nationals collect opinions about impact of this technology in their own country. Nevertheless, this is still open to debate, whether such national opinions are comparable among each other.

In the world, the continent of Africa is positioned as the second largest and second most-populous continent after Asia with about 30.3 million km^2 (11.7 million square miles) surface area including adjacent islands, and it occupies 6% of Earth's total surface area and 20% of its land area. The population of about 1.2 billion people as at 2016, which represents about 16% of the world's human population (Sayre and Pulley 1999). Africa is ranked as the hottest continent on earth with 60% of the total land mass comprises of dry lands and deserts. The climate of Africa varies from tropical to subarctic on its peak. While its central and southern parts contain both rainforest and savanna plains regions Its northern zone is predominantly desert. There is a convergence In in the middle, dominated by Sahel and steppe vegetation patterns. (Africa Environmental Atlas, 2008).

Africa is embroiled in a deep socio-economic and agrarian crisis. Agriculture is pivotal to the African economy despite its widely varied economic significance across African countries. The agricultural sector stands as the main source of revenue for Africa's rural population—projected to represent 64% of the total and contributes about 15% of GDP for the continent (Adamopoulos and Restuccia, 2014). The agricultural sector remains the largest and main source of food security in the continent as farming in the African region contributes meaningfully to the populations' income and sustenance (Machuka, 2001). The sector generates employment opportunities for 50 percent of the critical labor force and women are 47 percent of these workers (Adewunmi, 2012).

The continent of Africa is a constant mention in the rearward progression. Africa records the lowest production of crop per unit area of land in the world. This is evident from the production of sweet potatoes, which is a staple food that is 6 tons per hectare as compared to the global average of 14 tons per hectare representing one-third China's average production (Wambugu, 1999). About one third population of Africa is recurrently hungry and undernourished resulting in ill health and abysmal decline of productive capacity thereby undermining the GDP (Arcand, 2011). Crop yields have grown slowest in Africa. Despite the use of fertilizers, pesticides and irrigation, crop yields are insufficient (Machuka, 2001). This contributed to the failure to supply enough food to satisfy the prevalent hunger, malnutrition and poverty ensuing from the food crisis (Abah et al, 2010). The malnutrition continues to increase proportionally with the population, thus, making it extremely difficult to maintain adequate food consumption levels (Thomson, 2008).

Despite her abundant natural resources, Africa remains the poorest and most underdeveloped continent in the world bedeviled with inept and corrupt government, mass illiteracy, gross violation of human rights, political instability, terrorism, poor central planning and impeding access to foreign investments and capital (Sandbrook, 1985). As a matter of fact, the 2003 United Nations' Human Development Report showed the bottom 24 ranked nations (15^{th} – 175^{th}) were African (UNDP, 2003). Comparatively, 80 per cent of the sub-Saharan Africa population lived on less than $2.50 (PPP) per day in 2005 as against 85.7 per cent of India (World Bank, 2009). Africa is characterized by poverty, ill-health, malnutrition, illiteracy, and acute shortage of water supply in spite of of the abundant water resources and deplorable sanitation as evident by the August 2008 World Bank revised global poverty estimates of $1.25 per day versus the previous measure of $1,00 (World Bank, 2008).

Apart from oxygen and water, the place of food as the third most important life's sustenance cannot be underestimated. Countries within the continent have long been confronted with protracted food insecurity, lack of distribution and dearth of higher crop yields due to a combination of overlapping environmental, economic and social challenges (Messmore et al., 2007). Prolong and extreme drought conditions due to global climate change, increased temperatures, Soil nutrient depletion, rampant pest and disease cases are but a few of the environmental challenges that have placed considerable limitations on agriculture (Drechsel et al., 2001). The ever-growing population, which seemingly put considerable pressure on the continent's agricultural sector, described the common unsustainable nexus between population, agriculture and the natural environment (Drechsel et al. (2001).

Genetic modification (GM) is one of the fastest crop technologies to be embraced and adopted within the historical context of modern agriculture (James, 2010). Like a drowning man that will clutch at a straw, Africa is clutching at the production of genetically modified organisms (GMOs) as a tool that has the potential to address the myriad of socio-economic and environmental challenges that bedeviled the continent agricultural sector. (Wambugu,1999). It is expected that in the event of encountering malnutrition, biotechnology will make it easier to maintain traditional diets while improving their nutritional values. There are no indications that genetically modified crops are more dangerous than traditionally bred varieties (Cook, 2000).

The Dawn of the Gene Revolution in Africa

The GM technology in Africa had so far been deployed only in South Africa, Malawi, Egypt, Kenya, Burkina Faso, Uganda, Zimbabwe, and Mauritius. But only the following countries; South Africa, Egypt and Burkina Faso have commercialized their crops (Eicher et al., 2006; ASSAF, 2010). Genetically modified (GM) crops have been approved for commercial release in Burkina Faso, Egypt, and South Africa, while contained and confined testing of them has been performed in Kenya and Nigeria (Falck-Zepeda, 2013), In 2010, three African countries such as Burkina Faso, South Africa and Egypt benefited immensely from the adoption of GM crops (James, 2010).

Notwithstanding the slight success stories about biosafety legislation in Africa, progress has been a bit slow, with just only seven countries (Burkina Faso, Mali, Mauritius, South Africa, Sudan, Zimbabwe, Kenya) having developed functional national biosafety frameworks. Other 13 countries (Ethiopia, Ghana, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Uganda, Tanzania, Zambia, and Egypt) are at various stages in the development of biosafety frameworks (James, 2010). Seemingly, the intense debate on GM crops has sent mixed signals, hence impelling decision-making at policy level and slowing progress. Presently, Nigeria is at the cross- fire of the heated debate on the application of biotechnology.

The leading and fastest adopters in the continent remains South Africa (James, 2009), and GM cotton was first cultivated in the year 1997. In GMO production, South Africa ranks the leader in the African context and ranks amongst the top eight countries in the world, with a total of 2.1 million hectares cultivated of GM crops; 78% of both white and yellow maize grown are genetically modified, 98% of cotton and 85% is soybean (ISAAA, 2009 Report). Egypt was the second country in the continent from North Africa to embrace GM crops with several GM crops under field trials, such as maize, melon, potato, wheat and sugar cane (Adenle, 2011). Nonetheless, the country is yet to pass a biosafety law even despite the fact that some of the tested crops (potato, squash, maize and cotton) are approaching commercialization.

The percentage of hungry people ranks highest in East, Central and Southern Africa as hunger and poverty claim 25,000 lives every day (FAO & The State of Food Insecurity in the World, 2003). In 2002, six million people suffered from starvation in Zimbabwe resulting from poor rains in the previous two years, while a drop in the rate of plantings in the large-scale commercial sector, caused by the land reform disturbances, also contributed to the food shortage. Previously Zimbabwe disallowed the GM food for fear of negative reactions in human beings but later made a U-turn and recognized it. Malawi and Mozambique were the two more southern African countries, that followed Zimbabwe's example and also accepted the GM food as starvation took its toll in the region. In Zambia, hungry villagers in the southern province unlawfully helped themselves to the GM food (Bote, 2002).

Mozambicans have been suffering from devastating famines and intervention in the economy with a view to consolidating power and sovereignty has been the central government's goal ever since Mozambique acquired its name (Joao, 1998). The Mozambican government had requested that "GM seeds be milled before distribution with a view to preventing their cross-breeding with local flora" (Michael, 2002). However, many farmers are afraid that they'll lose their space in the European market if they cannot differentiate between natural crops and GM crops, and they also worry that biotech companies could introduce a 'terminator' gene in their seeds, which would prevent small farmers from replanting them after harvest, thus making farmers virtually dependent on big companies that control the price of seeds. (Michael, 2002).

There is polarized debate on GM crops in Mozambique. Mozambique heightened concerns about accepting GM maize aid based on biosafety and human health grounds and chose to ban its import. (Miller, 2007) a school of thought argues that Africa needs all the food that they can get –and fast. Mozambique cannot indulge in debate and delay... GM foods might avert further famine while also protecting the environment by reducing the need for pesticides and herbicides" (Michael, 2002). This school of thought insists that preventing the peasants of Mozambique access to genetically modified food, the government is depriving citizens from getting enough food to eat. Starving people are concerned with their everyday survival, not about debating the ethics of altering the plant genome.

Kenya is rethinking the 2012 GMO crop ban to sustain support food security (Verenardo, 2019). Three years after the government established the National Biosafety Authority (NBA), tasked with exercising general supervision and control of the transfer, handling and use of GMOs the government placed a ban on the importation of genetically modified organisms (GMOs)due to insufficient information on the public health impact of such foods (Otieno, 2012).The ban was to remain in effect until there was sufficient information, data and knowledge indicating that GMO foods are not a danger to public health. However, Scientists feared that Kenya's ban on the import of genetically modified organisms (GMOs) may be a substantial blow to progress on biotechnology research and development in the country (Otieno, 2012).

Nigeria the giant of Africa is grappling with the reality of expanding her economy from crude petroleum reliance (Nwajiuba, 2013). Nigeria used to be a key food producer and exporter. Before the reliance on oil resources, the country was noted for providing 95 percent of her domestic food requirement (**Cerier**, 2016). Consequently, the nation is faced with the burden of heavy reliance on food imports to feed its growing population as an aftermath of abandoning farming for oil production and exportation (**Cerier,** 2016). Due to poor governance, the successive government failed to transform the agricultural sector and identify elements that inform modern agriculture (Sanusi, 2010; Assessment of Nigeria Agricultural Policy, ANAP, 2005).

Ironically, Nigeria's economy that was traditionally based on agriculture and trade changed severely at the beginning of the late nineteenth century. The petroleum industry which increased export earnings and allowing massive investments in the 1960s declined productively thus ranking the country among the lowest in the world and well below the average for sub – Saharan Africa with a GDP per capita was only $481.1 billion in 2005 (World Bank, 2016). In addition, currency devaluations, which make basic imported goods, such as food to be more expensive made the poor vulnerable.

The decline is due to low productivity resulting from the dominance of subsistence nature of farming and dependence on crude farm equipment and low technology (Apata, 2006). Another hydra-headed challenge of the agricultural sector was undercapitalization which resulted in low yield and diminishing output (Central Bank of Nigeria, CBN, 2008). However, if agriculture was well managed it would have provided an opportunity to upturn rural poverty and stagnation into development (Alston and Pardey, 2014). The government had decided that one of the strategies to address food security crisis in the country is the introduction of genetically engineered foods (Barrows et al., 2014).

Skepticism abounds that this biotechnological product is risky but it is a fact that human life is full of risks. The urge to deal with risks remains a basic condition of human existence (Adrian, 2017). Science and Technology not only ease some hardships of life but can be used to mitigate the impact of some of the most threatening risks of nature (UN, 2006). Recent history provides ample examples of beneficial effects of technological and scientific developments (UN, 2006). For example, life expectancy has gone up significantly in most countries during the last century, and many hardships of human life now belong to history (UN, 2006). Crops are genetically engineered to improve appearance, nutritional quality, and tolerance to drought. Achieving food security is more than fulfilling yield deficits, it also requires sufficient physical, socio-economic access to healthy and safe, nutritious and culturally acceptable food at the household level (Witcombe and Sanchez, 2004), without resorting to emergency supplies. This demands either adequate food production or food importation to meet the expected shortfalls.

Genetic modification technology is essentially advocated to address some aspects of inadequate food production and yield deficits (UNEP, 2002) to enhance food sufficiency and profitability in Nigeria. However, the potential of such technologies is laced up with controversies at the national level. There are arguements about its impact on human health and environment, and doubts on whether the products will provide the sustainable solution to food challenges (UNEP, 2002). The risks and benefits associated with GM technologies are hard to quantify (Berg, 2009). Despite the claims that the consumption of GMOs is harmless (Winter et al., 2006; Key et al., 2008), it is being argued that the danger associated with the degradation of the environment (ecosystem) and human health is a threat to humanity (Rinkesh, 2009).

The GMOs debate in Nigeria generates conflict between the Government, Agri-biotech investors and their affiliated scientists who consider agricultural biotechnology as a solution to food shortage, scarcity of environmental resources and weeds and pests infestations; and independent scientists, environmentalists, farmers and consumers who warn that genetically modified food introduces new risks to human health, food security and the environment in terms of environmental pollution, gene flow and biodiversity loss (Kaplan, 2004).

2.0 The Drive for Genetically Engineered Foods in Africa.

2.1 Nutritional Benefits

Genetically modified crops may provide better quality food, higher nutritional yields, inexpensive and nutritious food, crops and produce that require less chemical application, such as herbicide-resistant maize (Singh et al., 2014)**.** The GMO technology involves the application of genetic engineering to improve crop productivity in order to respond to the needs of more than one billion people in the world facing starvation and two billion people suffering from one or more micronutrient deficiencies which include vitamin A, iron, and, iodine often lumped as hidden hunger (Alnwick, 1996). GM crops are also used for food security purpose (Chondie and Kebede, 2015).

GM crops were first cultivated commercially worldwide in 1996 (James, 2007). Since then, a number of GM or transgenic crops carrying novel traits have been developed and released for commercial purpose due to the advancement of biotechnology (Arthur, 2011). An example is seen in the GM maize crops technology where the desired traits were inserted into a plant, unlike the conventional breeding methods, where traits from two crops were combined (James, 2013; Chondie and Kebede, 2015). GM maize is now useful for livestock and human consumption (Clive, 2008).

Despite the controversy about GM agriculture in Europe, the transgenic crops have the ability to generate more nutritious varieties, which opens a window of opportunities for developing countries with lowest malnutrition levels to tap into the clear benefits to all sectors of the population (Buiatti et al., 2012). This promotes GMOs as having the prospect of providing nutritional advantages for wealthy population groups. Like in Europe, there is a surprisingly large malnourished population in Africa which has arisen not only through the impact of poverty but also through ignorance and poor lifestyle choices (Buiatti et al., 2012). Malnourishment is prevalent in the elderly population because of the distresses of aging which is a progressive loss of the capacity to absorb nutrients (Ljungqvist et al. 2010).

The benefits of the enrichment of transgenic maize in specific alimentary products makes such maize foods to frequently have higher utility value than traditional food products due to the group of nutraceutics containing, first of all, vitamins A, C, E, plant pigments, alimentary cellulose, and pre- and probiotics (Kosicka-Gębska et al., 2009). The leading examples of cultivable edible vaccines are typified by varieties of rice, maize, soybean or potato, capable of producing antigens against various infections, including the effects of *Escherichia coli* toxins, rabies, infections of *Helicobacter pylori bacteria*, and viral type B hepatitis (Kramkowska et al., 2013).

However, the perceptual stance of anti-GM activism and the resulting political expediency holding back the deployment of newer first-generation GM crops that are protected from drought, salinity and better suited to grow in hostile environments, as well as second-generation GM crops that have enhanced output traits such as better nutritional composition (Farre et al. 2011b). While the industrialized world may have a choice on GMOs, but it is perceived as an elixir in Africa in a sense that GM crops could turn the tide against plant diseases and pests, eliminate damaging agricultural practices, reduce hunger and malnutrition and produce cheap medicines in response to some of the world's most demanding socioeconomic concerns (Farre et al. 2010; Gómez-Galera et al. 2010).

2.2 Socio-Economy Benefits.

The International Service for the Acquisition of Agri-biotech Applications cited that farmers grew 16.7 million biotech crops in 2011 of which over 90 % were from small resource farmers in developing countries (Seven million in China and Seven million in India) when they jointly planted 14.5 million hectares of genetically modified crops (James, 2011). GM crops are becoming prominent in world crop production owing to the fact that since 2011, the cultivation of GM crops in the world has gotten to 160 million hectares (+8 % with respect to 2010, a ninety-four fold increase with respect to 1996) in twenty-nine countries worldwide (Buiatti et al., 2012).

The US is currently the world leading producer of GM crops with 69.0 million hectares (maize, cotton soybean, canola, sugarbeet, papaya, alfalfa, and squash) follow on by Brazil (30.3 million hectares, maize, soybean, cotton), Argentina (23.7 million hectares, maize, soybean, cotton) **(**James, 2011**)**, India (10.6 million hectares, cotton), Canada (10.4 million hectares, canola, maize, soybean, sugarbeet) and China (3.9 million hectares, cotton, papaya, poplar, tomato, sweet pepper) **(**James, 2011**)**, in this connection, six EU countries comprising of Spain, Portugal, Czechia, Poland, Slovakia, and Romania planted 114.490 hectares of Bt maize (+26 % as respect to 2010), with Spain growing 85 % of the total in the EU (James, 2011),

The potentials of GM crops are diverse. It has the propensity to guarantee sufficient availability of food, raw materials for a growing population and increased productivity in global agriculture (FAO 2004, von Braun 2007). Transgenic crops have played an important role in rural income growth and poverty alleviation in developing countries. Inferentially, GM crops can also bring about environmental benefits (Hazell & Ramasamy 1991, Fan et al. 2005). Crops that are nutritionally enhanced could help boost the health status of consumers (Bouis 2007, Unnevehr et al. 2007). These effects are also expected to be replicated for GM crops in Nigeria.

GM food's economic value to farmers in developing nations is one of its major benefits (Areal et al., 2012). Taking a cue from a study of 2010, it was found that Bt corn generated economic benefits of $6.9 billion over the previous 14 years in 5 European states with a chunk of $4.3 billion accrued to farmers producing non-Bt corn (Hutchison et al., 2010). This was adduced to European corn borer populations reduction by exposure to Bt corn (Hutchison et al., 2010). It was the conclusion of PG Economics comprehensive 2012 study that GM crops increased farm incomes worldwide by $14 billion in 2010, with more than half of this total going to farmers in developing countries (Falck et al., 2000).

In a socio-economic context, the higher margins generated by GM crops help the efforts to alleviate poverty by providing better access to food, medicine, and education, enhancing the social dimension of sustainability (Yuan et al. 2011). The first-generation of GM crops have indirectly led to increasing the profitability of farms and empowering the smallholders in a socioeconomically. While reducing exposure to pesticides, GM agriculture brings health benefits. The Second and third generation GM crops have been produced to address these issues directly by improving nutrition or providing inexpensive drugs (Brimner et al. 2005; Knox et al. 2006),

It is generally acknowledged that first-generation GM crops have the ability to provide higher yields with fewer inputs (principally fuel and pesticides), which has important economic benefits for the agricultural industry in the industrialized world, but the more significant positive effects are seen in the developing world where GM crops allow subsistence farmers not only to survive but to take surplus produce to market thus providing additional wealth that supports education, improves access to medicines, and leads to the empowerment of women (Christou and Twyman 2004; Yuan et al. 2011).

Nevertheless, the available evidence confirms that in both developed and developing countries, the adoption of GM crops can increase the farmer's income (Bennett et al, 2006). A key component of sustainable development is the marginal increment in income to small-scale farmers in developing countries can have a direct impact on poverty alleviation and quality of life (Bennett et al, 2006).This is likened to the performance of *Bt* and non-*Bt* cotton in resource-poor smallholder cotton farm plots in South Africa and South India. Their results demonstrated that in many agricultural environments the adopters of *Bt* cotton benefitted in terms of higher yields, reduced labor and pesticide use, and ultimately higher gross margins per hectare, leading them to conclude that 'the smallest producers are presented to have benefited from adoption of the variety of *Bt* as much as, if not more than, larger producers."

Critics challenged the claimed benefits to farmers over the prevalence of biased observers and by the absence of randomized controlled trials. The main Bt crop grown by small farmers in developing countries is cotton. A 2006 review of Bt cotton findings by agricultural economists concluded, "the overall balance sheet, though promising, is mixed. Economic returns are highly variable over years, farm type, and geographical location" (Smale et al., 2006). Mark Lynas, an environmental activist said that complete rejection of genetic engineering may not be logical and may be harmful to the interests of poorer peoples and the environment (Lynas, 2010). What is obvious is that without “approval” by society at large, GM crops will surely fail in the marketplace. It is expected that the forthcoming years may be crucial for the economically and commercially viable application of GMOs in food production and food agriculture (Nap et al. 2003).

In 2013 the European Academy of Science Advisory Council (EASAC) asked the EU to allow the development of agricultural GM technologies to stimulate sustainable agriculture, by employing fewer land, water, and nutrient resources. EASAC also criticizes the EU's "time consuming and expensive regulatory framework" and emphasizing that the EU had fallen behind in the adoption of GM technologies. (EASAC, 2013) Mostly, GMFs are expected to be cheaper to produce than their natural counterparts because the procedure of genetic modification is cost effective especially on pest control on the field and during storage. Since GMFs are produced by farmers at cheaper rates, the relief will be passed on to the consumers who will purchase the produce at cheaper rates (Carpenter and Gianessi, 2001). Another benefit associated with genetically modified plants is the reduction in the price of certain medicines that are produced from them.

South Africa, is not only the first and biggest producer of GM crops in Africa but the only African country among the five principal countries (also India, Argentina, Brazil and China) producing GM crops, with 63 million hectares planted in 2010 alone. South Africa’s economy has benefited significantly from the adoption of GM technology. It has been reported that this technology enhanced farm income from GM maize, GM soybean and GM cotton by US$156 million in the period 1998 to 2006, with 2006 alone estimated to be US$67 million (James, 2007). In 2010, Burkina Faso recorded about 100,000 farmers who cultivated GM cotton on an expanse of 260,000 hectares with 126% increase from 115,000 hectares planted in 2009. Going by its impact to the economy of Burkina Faso, it was estimated that a benefit of over US$100 million per year could be generated premised on almost 30% increase in yield (Vitale et al, 2008b). In addition, about 50% reduction in insecticides sprays could be realized, thus saving fossil fuels and lowering greenhouse gases emission, therefore fighting against climate change. Egypt remained the first North African country to grow GM crops on a commercial scale in 2008 with 700 hectares of GM maize planted with the prospect of the Egyptian government planning to increase the hectarage of GM crops in future (James, 2008).

2.3 Higher Yields

GM crops are engineered to increase yield thus becoming a more direct solution to chronic hunger involve. (McGrath, 2014)**.** GM crops play an importnt role in intensive crop farming, involving monoculture, use of pesticides and herbicides, use of equipment requiring large amounts of fuel and irrigation. Opponents such as Jonathan Latham of the *Bioscience Resource Project* and Vandana Silva treat industrial agriculture and modified crops as the same and thereby called for government to adopt practices drastically reducing disruptions to the environment (Miguel, 1998). Proponents of commercial agriculture point to its High yields, low prices, and wider choices and the potential of the claim that technology is necessary to feed a growing population (William, 2010). Commercial GM crops have traits that reduce yield loss from insect pressure or weed interference (Wesseler, 2005). Average US maize yields were 174.2 bushels per acre in 2014 (Nielsen, 2012).

A popular strategy that scientists use to increase this metric is to insert a gene that confers resistance to commonly used weed killers Farmers that adopt these herbicide-resistant crops are able to weed off unwanted plants without tilling the soil; this allows them to plant higher densities of crops. Geneticists have also developed pest-resistant crops that are poisonous to hungry insects, greatly reducing farmers' reliance on chemical pesticides. More importantly, genetic engineering can produce crops that are resistant to microbial infections, such as the potato blight that triggered the Irish Potato Famine in the mid-19th century (McGrath, 2014)

Moreover, there is clear evidence that GM maize is not easily contaminated by mycotoxins such as fumonisin and aflatoxin, toxins produced by fungi that infest maize cobs and which may cause serious illnesses in man and animals (DeVilliers and Hoisington, 2011). With the exception of GM cotton, soybean and maize, only a limited number of commercially available GM crops are currently suitable for conditions in developing countries. Even though GM maize crop is promoted for high yield worldwide, Gurian-Sherman (2009) indicated that there is a strong market to cultivate non-GMO corn for the premiums in Kentucky compared to GM maize product. GM maize crop has contributed to lower production in the United States (Gurian-Sherman, 2009). In contrast, Lee and Halich (2008) argued that farmers are concerned that they may be losing yield without using GMO hybrids because their finding showed that GMO hybrid yield was higher than the non-GMO sister at a range of 2.5 to 25.5 ratios.

Large chemical companies like DuPont and Monsanto have been using the GM technology for over two decades on a wide variety of plants, many of which may alleviate world hunger. In 1994, Calgene introduced the first GM crop to be sold in the United States, the Flavr Savr tomato, which ripened slowly and had an extended shelf-life but eventually disappeared from grocery stores because of high production costs that prevented them from becoming profitable (Bruening and Lyons, 2000). In 2003, GM technology crept into Africa through *Bt* maize introduced into South Africa. Wanyama *et al*., (2004) reports that since its introduction, the technology has been found to reduce losses of maize incurred through damage by stem borers. GM maize in South Africa offers a grain yield advantage of 11% and increased revenue of US$35 per ha (James, 2008).

In South Africa, higher yield was one of the numerous reasons why these crops were embraced. Upon adoption, the yields increased farm profitability for both small scale and large scale farms by up to $506.9 million (Kirsten and Gouse, 2006; Keetch et al., 2005;). This mean s a lot to the country as agriculture represents 4.5% to the country's GDP (www.nda.agric.za). The reason for the higher yield was because of minimal damage to the crops which also contributes to increase the quality of the food which is largely useful to the consumers (Keetch et al., 2005; Brookes and Barfoot, 2010). The high rate of adoption of genetically engineered foods in South Africa yielded gains to smallholders and contributed immensely to food security (Godfray et al, 2010). Burkina Faso, was the third African country to adopt GM crops after South Africa and Egypt by commercializing *Bt* cotton in 2008 (Kerumbu *et al*., 2009). In Burkina Faso, the technology has produced 15% higher yields and reduced insecticide sprays by two thirds, thereby reducing labour costs and environmental pollution. In 2008, 15 102 ha were planted for cotton seed production and this resulted in 163 265 ha of *Bt* cotton in 2009 (Vitale *et al*. 2008a).

2.4 Hunger Reduction

Geneticists have also developed pest-resistant crops that are poisonous to hungry insects, greatly reducing farmers' reliance on chemical pesticides. (McGrath, 2014). However, what remains a controversy is how these scientific ideas actually translate to the fields but a recent review of almost 150 studies has validated that GM technology has significantly increased crop yields and farmer profits over the past 20 years (Klumper et al, 2014). GM soybeans, maize, and cotton were associated with a 22% overall increase in yield, 37% decrease in pesticide use, and 68% increase in farmer profits, despite the higher cost of GM seeds (Klumper et al, 2014). Furthermore, farmers in developing countries experienced yield and profit gains that were 14% and 60% higher, respectively, than those observed by their counterparts in industrialized countries. This is particularly encouraging because food shortages often take their most severe toll in underdeveloped regions. Even with these new crops, however, some areas of the world have seen their agricultural output begin to plateau (Grassini et. al, 2013). Therefore, increases in yield alone will likely not be able to sustain our ever-growing populace.

GM maize was grown for commercial purpose in 11 countries, including United States, Brazil, Argentina, South Africa, Canada, Philippines, and Spain (Singh et al., 2014). From the African perspective, GM technology so far has been deployed only in South Africa, Zimbabwe, Egypt, Kenya, Burkina Faso, Uganda, Malawi, and Mauritius. Of these, few countries, South Africa, Egypt, and Burkina Faso have commercialized their crops (Arthur, 2011). The US Senate is considering a bill that would overhaul the way Americans distribute foreign aid. With more people going hungry than ever before, the bill's attention to global hunger could not come at a better time. This bill includes a mandate that we spend foreign aid dollars developing genetically modified (GM) crops. No other kind of agricultural technology is mentioned.

Opposition to GMO claims that the trouble with a mandate for GM crops is this: it won't work. A recent document by the Union of Concerned Scientists establishes that GM crops don't increase crop yields (Hans and Marcia, 2010). They accused USAID of spending millions of taxpayer dollars developing Genetic Modified crops over the past two decades, without a single success story to show for it, and plenty of failures. A highly touted partnership between USAID and Monsanto to develop a virus-resistant sweet potato in Kenya failed to bring anything useful for farmers. After 14 years and $6 million, local varieties vastly outperformed their genetically modified cousins in field trials. Also, a 10-year USAID project for GM eggplant in India lately met with such outcry — from scientists and Indian farmers alike — that the government put a moratorium on its release. Growing insect resistance to GM cotton and corn shows that the technology is already failing farmers and will continue to fail over the long term. Sadly, today's GM obsession shows every indication of duplicating the first ill-fated "Green Revolution" that trapped millions of farmers on a pesticide treadmill while devastating the functioning of the ecosystems on which we depend (Hans and Marcia, 2010).

3.0 Result / Discussion

Genetically modified food (GMOs) Arguments.

The performance and the impacts of GM crop releases around the world since 1996 has been thoroughly evaluated on a global level by Civil society groups in Africa and around the world **(**FoEN, 2004**)**, These efforts have been aimed at providing an accurate picture of the global spread and impacts of these crops and organisms, and to help separate the hype from reality (FoEN, 2014). Genetic engineering of crops has been generating a tirade of debate in Africa questioning the potential risk in the areas not limited to the followings;

3.1 Health Risk

Nestle (Nestle, 1996) and (Margulis, 2006) reported the possibility of genetically modified foods being toxic and allergenic. Hiefle and Taylor (Hiefle, 1999) noted that one of the theoretical challenges raised about food derived from genetically modified plants is that consumers might experience allergic reactions to them. Fears are generated that live genetically modified foods could transfer antibiotic-resistant genes to people (Environmental news network, 2002). When this occurs, people could become resistant to commonly used antibiotics and may lead to the loss of ability to treat illnesses with antibiotic drugs (Jarvis 1999). The nature of genetic engineering is essentially imprecise and unpredictable. There is a concern for allergic reactions or other health-related effects (ERA/FoE, 2003). Given the uncertainty over the heath risks associated with GMOs, it is not surprising that strong and often polarized opinions are held around issues of food safety and human health **(**Spinney 1999, Cox 1995)**.** Consumer and environmental organizations alongside several governments have embraced cautious approaches to Genetic Modified -derived foods, choosing to err on the side of safety rather than take risks (Soil Association, 2003).

3.2 Environmental Risk

Carpenter and Gianessi, 2001 reported that the opponents of biotechnology argued that the adoption of genetically modified crops may lead to the emergence of super weeds and decrease in plant biodiversity, thereby affecting the planet sustainability. Thus, it is possible that if insect-resistant plants cause rise in death of one particular pest, it may decrease competition and invite minor pests to become a major problem (Haliweli, 1999). In addition, it could cause the pest population to shift to another plant population that was once unthreatened. GM herbicide-tolerant crops allow farmers to apply "broad spectrum" weed killers to their field, which kill other plants. (ERA/FoE, 1996-2006). The crop plants that were engineered for herbicide tolerance and weeds may cross-breed, thereby resulting in the transfer of the herbicide resistance genes from the crops into the weeds is another concern. These "super weeds" would then be herbicide tolerant as well (Whitman, 2000). Other introduced genes may cross over into non-modified crops planted next to GM crops. Another negative impact of GM food on the environment adduced by environmentalists is the possibility of residues from herbicides or pest-resistant crops to harm key groups of organisms found in surrounding soil, such as bacteria, fungi, nematodes and other microorganisms (Snow, 1997).

3.3 Patenting Life: Intellectual Property Rights

Increased investment and unprecedented returns on these investments in agricultural biotechnology have brought issues of IP protection to the forefront. Agricultural biotechnology is a technique used by scientists to create, improve, or modify plants. Genetic engineering is one example of a biotechnological technique. For centuries, Recent advances in science and technology now allow genetic engineers to easily and precisely move genes to improve plants and seeds as compared to farmers who are used to selective breeding to improve seed production. over the years (USDA, 2005). IP rights are likewise at the forefront of the United States' trade agenda, just as they are priorities on the private seed industry's agenda (USTR, 2005). The United States is seen as having the strongest protections for IP rights world-wide. In the United States, agribusinesses exercise an enormous amount of power in influencing IP biotechnology policies, as recent trade agreements reveal (Susan, 2002).

Recent dramatic developments in technology have opened new doors for seed developers and marketers. Rapid consolidation created a global industry primarily controlled by a few large corporations. As a result, the seed industry is now a global $15 billion industry with a strong monopoly (Jeremy, 1998). The private seed industry has made tremendous commercial gains as a result of strong Intellectual Property (IP) protections on its products. Subsequently, as a result of the innovation, ingenuity, and research for new and improved products fostered by these protections, the public also benefits (Spectar, 2002).

Biotechnology issues related to intellectual property rights are associated with concerns that are associated with the moral and ethical implication of patenting living organisms. These concerns are borne out of fears that biotechnology will transfer resources from the public domain to private ownership through the enforcement of intellectual property rights. It is imperative that, firms that have invested in the development of genetically modified varieties want to protect their proprietary knowledge. Consequently, many farmer groups have protested that enforcing intellectual property rights will make them depend perpetually on the company for seedlings. Farmers are not inclined to buying seeds as they have been accustomed to harvesting and replanting their seeds conventionally. The controversial TRIPs Article 27.3(b) which exempts certain life forms from patentability but requires countries to establish some form of protection for plant varieties is gaining attention to this debate (Grain, 2000), The high level of investment needed in Genetically Modified research and its application has constrained African contribution and has led to research that primarily focuses on developed country needs. Transgenic research is very expensive when compared to more traditional biotechnology techniques (Odame et al, 2003). It is noteworthy that the companies producing genetically modified plants have a monopoly over the products (Carpenter and Gianessi, 2001). Many new plant genetic engineering technologies and GM plants have been patented, and infringement on the patent is considered a big concern of agri-business (Whitman, 2010). Yet consumer advocates are worried that patenting these new plant varieties may increase the price of seeds and make it unaffordable by farmers thus widening the gap between the wealthy and the poor (McGloughlin, 1999).

There is also a concern that the access and intellectual property issues related to “terminator gene” technologies may lead to increasing dependence on industrialized countries by African countries, and domination of world food production by a few multinational companies. Biopiracy is becoming growing concern, particularly as many African countries lack the legislative and enforcement systems to control illegal extraction of genetic resources. Additionally, the benefit sharing systems for the use of these assets and of traditional knowledge are poorly developed (ERA, 2005).

The absence of a legal framworks and supportive policy is often cited as an inhibiting factor in the development of biotechnology. On the one hand, biotechnology companies may be reluctant to invest in costly research without the legal guarantee enabling them to recoup their investments (Seshia 2002) Supportive legislative frameworks for research is required for intellectual property rights (IPR) and not limited to include only clear rules for risk assessment and commercialization (Yamin 2003). Although the IPR standards have been developed through the World Trade Organization’s (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), domestic IPR legislation in many African countries remains weak. Many countries struggle with how to reconcile IPRs with farmers’ rights and other local interests. There are fears that strong IPRs will entrench global domination of world food production by a few companies and increased dependence on industrialized nations. IPR may place limitations on farmers, including on their prevailing rights to store and exchange seed. (Glover 2003a).

3.4 Ethics

In Africa, many communities and consumers have expressed ethical concerns that GM Technology is akin to "playing god" as plants are transformed in unnatural ways and about the implications for traditional beliefs and values. Social inequity could be promoted and institutionalized if gene patents are not properly managed (Portfolio 21 2005, ERA 2005). Patenting genetic material conventionally available to a community, without letting the community have free access to use of the material or making provision for any return to the community, affects the fair and equitable distribution of resources which is a necessity in the development of a sustainable society (ERA 2005).

The issues of proprietary science have complicated the ethical and safety issues of GM technology. In particular, there are challenges around reconciling the rights of product developers with those of consumers. Many public protests have centered on ethical or ecological grounds, the uncertainty about the impacts of the technology, and the public right-to-know and to have access to information, including through labeling. In several countries, concerns have been raised as to whether "the technology is tantamount to playing god, interfering with nature, contrary to local ethics and also whether gene insertion would be disastrous to life and environment (Mohamed-Katerere 2003).

3.5 Policy Frameworks for Genetically Engineered Foods.

Two major influences drive the risk-averse regulatory approach of many African countries (Chambers et al. 2014, pp. 42-45). The first approach is the Cartagena Protocol on Biodiversity, which endorses the precautionary approach, it states that countries exporting GMOs for food and feed use must notify importing countries that products "may contain living GMOs (Paarlberg 2013)." The second approach is the African Union Model Law on Safety in Biotechnology (formerly the African Model Law on Safety in Biotechnology), which is designed to shape biosafety legislation across the continent. It emphasizes the precautionary principle and calls for regional harmonization of policies on imports, exports, and marketing (Chambers et al. 2014, p. 45).

Several Sub-Saharan African countries being influenced by these policies in 2000 imposed bans on GMOs, such as cultivation and imports for food, feed, and industrial use. Countries like

Zambia took an extreme decision to impose bans even for food aid. Other countries like Malawi and Tanzania, made exceptions for imports of milled grains (Chambers et al. 2014, p. 45). Apart from Angola and Kenya, these bans have been lifted in 2016. Shipments that may contain GMOs remain unregulated in some in countries like Ethiopia and Ghana where cotton, soybean meal, and soybean oil are imported from the large GM producing countries such as United States, Argentina, and Brazil (USDA, 2015).

3.5.1 The Cartagena Protocol on Biosafety

The BioSafety Protocol is a Multinational Environmental Agreement (MEA) that is charged with devising a comprehensive international regulatory approach to the protection of biodiversity.

The Cartagena Protocol, concluded in negotiations in Montreal on January 29, 2000, establishes rules to manage the environmental risks of trans-boundary movements of genetically modified living organisms. Although the BSP has an environmental orientation, it also has provisions that have significant potential implications for trade in GMOs. The preamble to the protocol acknowledges this and emphasizes that it shall not be interpreted as changing the rights and obligations of countries under other international pacts, such as the WTO. The Cartagena protocol on Biosafety finally came into force, after years of negotiation, on 11th September 2003. This protocol regulates trade in GMOs based on the precautionary principle. This internationally binding environmental agreement is explicitly intended to protect human health, the environment and biodiversity from the risk posed by GMOs. (Cartagena Protocol, 2000).

In accordance with the precautionary approach, contained in Principle 15 of the Rio Declaration on Environment and Development, the objective of the Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of 'living modified organisms resulting from modern biotechnology' that may portend adverse effects on the conservation and sustainable use of biological diversity, taking cognizance of risks to human health, and explicitly focusing on transboundary movements (SCBD, 2000).

3.5.2 The Precautionary Principle

Precaution means taking action to protect human health and the environment against possible danger of severe damage. The emergence of the Precautionary Principle has marked a shift from *post damage* control (civil liability as a curative tool) to the level of a pre-damage control (anticipatory measures) of risks. The Precautionary Principle (PP) has been introduced as an approach to scientific uncertainty (Freestone and Hey, 1996).

At present, scientific uncertainty concerning the ecological impact of GMP utilization hinders consensus with regard to importance of hypothetical, but possible threats (Clark and Lehman, 2001). References to “science based” and “scientific evidence” are open to interpretation, which may influence the framework and scope of risk and safety assessments. In particular, since decisions concerning the framework affect the design, implementation of methods, choice of variables/indicators, and time scales of the study, it contends that the current framework for GMP regulation is inadequate; it does not cope efficiently with the present scientific uncertainty and public concern. Application of the Precautionary Principle requires robust scientific responses with focus on scientific uncertainty, the importance of evidence, and the framing of hypotheses (Buhl-Mortensen and Welin, 1998; O’Riordan and Jordan, 1995). Over the past decades, the Precautionary Principle has become an underlying rationale for a large and increasing number of international treaties and declarations in the fields of sustainable development, environmental protection, health, trade and food safety. In its most basic form, the

Precautionary Principle is a strategy to cope with scientific uncertainties in the assessment and management of risks. It is about the wisdom of action under uncertainty: ‘Look before you leap’, ‘better safe than sorry’. However, in the international arena, different views exist of what precaution is and the Precautionary Principle has different interpretations. The Precautionary Principle is often seen as an integral principle of sustainable development that is development that meets the needs of the present without compromising the abilities of future generations to meet their needs. By safeguarding against serious and, particularly, irreversible harm to the natural resource base that might jeopardize the capacity of future generations to provide for their own needs, it builds on ethical notions of intra- and inter-generational equity.

Some people fear that a more precautionary approach to forestalling potential hazards of a morally unacceptable nature may stifle innovation or hamper scientific progress. They point to the fact that new technologies typically introduce new risks. The Precautionary Principle is not based on 'zero risks' but aims to achieve lower or more acceptable risks or hazards. However, there are immense challenges to, and opportunities in, understanding complex and emergent systems while meeting human needs with lower health costs and lower ecological damages. Wider use of the Precautionary Principle can help stimulate both innovation and science by replacing 19^{th} century technologies and simple science of the 1^{st} industrial revolution with the "eco-efficient technologies" and systems science of the third." (Poul, 2002)

3.5.3 Substantial Equivalence

The concept of substantial equivalence was introduced by OECD in 1993, and later affirmed by FAO in 1996 for the purposes of assessing the safety of GM foods (OECD, 1993; FAO, 1996). The concept is considered a guiding principle to risk assessment with the purpose of determining whether a GM food product is as safe as the traditionally bred counterpart (non-GM). If a GMO is characterized as "substantial equivalent," it is considered to represent no new health risk and will then be approved for commercial use. Conclusions concerning substantial equivalence are based on chemical analyses. There are controversies on whether the use of the concept deals adequately with important risk factors, or limits the scope of investigation (Gasson and Burke, 2001; Millstone et al., 1999; Trewavas and Leaver, 1999). The issue of novelty has been pivotal in the ensued discussions (The Royal Society of Canada, 2001).

Proponents claiming no reason to expect different effects of genetically modified than conventional agricultural products seem to overlook that the present methods for genetic modification entail lack of precision and control with respect to transgene integration.

However, it has been argued that the use of substantial equivalence in safety assessment provides neither the means to detect changes in gene expression patterns of endogenous genes (up/down regulation or epigenetic silencing of genes) nor to determine whether the inserted constructs or parts of it move within the recipient genome. Pleiotropic plant effects may border on changes in level of constituents such as anti-nutrients, allergens, and toxins (Novak and Haslberger, 2000).

To get adequate understanding, it will be imperative to initiate research with the purpose to detect changes in expression of gene products in GM foods and to reveal whether such changes have adverse effects on consumers. Consequently, an assessment of safety should involve more comprehensive investigations based on biochemical and toxicological tests (Millstone et al., 1999).

The use of the concept substantial equivalence may be considered an attempt to use conventional science to resolve the intricacy of the problem.to scale down the complexity of the risk to manageable proportions (Clark and Lehman, 2001). For instance, GM products are assessed by analogy to products from chemically intensive farming. More stringent benchmark baselines for comparison of GM products would, for instance, be products from organic agriculture. The decision thresholds for extrapolation of safety to ensure that adverse effects do not exceed those of the non-GM counterpart will be quite different depending on what is their subject, i.e., organic versus chemically intensive agriculture (Clark and Lehman, 2001).

3.5.4 Nigerian National Biosafety Management Agency Act, 2015

Nigeria is party to the Convention on Biological Diversity and has ratified the Cartagena Protocol on Biosafety. The general objective of the policy on modern biotechnology is to provide a regulatory regime and guidance for the sustainable development of the science of modern biotechnology, its application and safe use of its products without prejudice and risk to public health, environmental health, national sovereignty, human dignity and fundamental human rights (Nang'ayo , 2006). This Act establishes the National Biosafety Management Agency charged with the responsibility for providing regulatory framework, institutional and administrative mechanism for safety measures in the application of modern bio-technology in Nigeria with the view to preventing any adverse effect on human health, animals, plants and environment (NBMA Act, 2015).

In Nigeria, the National Biosafety Management Agency Act, 2015, was signed into law in May, 2015. In spite of the far-reaching importance of biosafety matters to citizens of Nigeria, the process that led to the passage of the Biosafety Bill and its eventual signing into law was trailed by controversies and complaints from key stakeholders including farmers, consumers and civil society groups. They alleged that GM crop proponents including the USDA urged Nigeria to double its "efforts to fast-track the creation of an enabling environment for biotechnology" in other words accelerate the development of their biosafety laws" to allow the introduction of GM products in our country (Bassey-Orovwuje, 2016).

They advocated that Government should take a critical look at the current Act and to act as necessary, to comprehensively review it and ensure that Nigeria does not become a laboratory for the testing of unproven technologies and/or a dumping ground without recourse to the precautionary principle. The bottom line is that the interest of Nigerians must be uppermost on issues of biosafety and corporations and multinational companies should not be allowed to dictate corporate-driven food and agricultural policies that undermine sustainable agriculture and our food future. However, the National Biosafety Management Agency (NABMA) has allayed the fears of Nigerians about genetically modified (GM) crops, saying every genetically modified organism (GMO) in the country is properly analysed and approved by the agency (Ebegba, 2017).

4. Suggestions

1. A joint problem-solving approach is suggested encompassing all the stakeholders to take a holistic approach for the adoption of genetically modified food in Africa. This will open a broad window of opportunities to ventilate the reservations hitherto trailing the implementation of this technology in the continent with a view to making Africa benefit from its potentials.
2. The continent should adopt a strong precautionary principle that is context specific to safeguard the adoption of genetically modified food in each country.
3. The African version suitable for our own nutritional requirement and environment should be developed so that the GMO's benefits may not elude the continent.

5. Conclusion

There is a lack of consensus in Africa on the safety of GMOs to health and environment; hence, there are controversies, disagreements and hesitations heralding this technology in the continent. These diverse opinions are not yet harmonized as different stakeholders are holding to their perspectives from activism, science and professionalism on this technology without shifting ground thus creating a conflict begging for resolution.

References

Adamopoulos, T. and D. Restuccia. 2014. *"Land Reforms and Productivity: A Quantitative Analysis with Micro Data." Working Paper* 525. Toronto: University of Toronto, Department of Economics.

Adenle AA: Global capture of crop biotechnology in developing world over a decade. Journal of Genetic Engineering and Biotechnology 2011. Adenle BMC Research Notes 2011, 4:388 http://www.biomedcentral.com/1756-0500/4/388 Page 5 of 6

Adewunmi, F. 2012. *"Four Ways How Technology Can Boost African Farming."* Available at http://www.howwemadeitinafrica.com/four-ways-how-technology-can-boost-african-farming/22908/.

Adrian Barbu Ilie. *Precautionary Principle - too Vague to be a Viable Policy*? Original Paper. RSP • No. 53 • 2017: 34-44 34

Africa: Environmental Atlas, 2011. " Archived 2012-01-05 at the Wayback Machine. African Studies Center, University of Pennsylvania. Accessed June 2011. 06/17/08.

Alnwick D (1996). Significance of micronutrient deficiencies in developing and industrialize countries. In: Combs GF, Welch RM, Duxbury JM, Uphoff NT, Nesheim MC (eds) Food-based approaches to preventing micronutrient malnutrition. An international research agenda. Cornell University, Ithaca, NY, USA.

Alston, J. M. and Pardey, P. G. (2014). *"Agriculture in the Global Economy"*. Journal of Economic Perspectives—Volume 28, Number 1—Winter 2014—Pages 121–146.

American Medical Association (2012). Report 2 of the Council on Science and Public Health:

Labeling of Bioengineered Foods. page 7

Apata, T.G., 2006. *Income and Livelihood Diversification Strategies of Farming Households In Crude-oil Polluted Areas of Ondo State, Nigeria*. Unpublished PhD Thesis in the Department of Agricultural Economics, University of Ibadan, Nigeria xi + 255 pages

Arcand. J. L, 2011. *Undernourishment and Economic Growth: the efficiency cost of hunger*, Economic and Social Development Paper No. 147, Rome. FAO. 2001.

Areal, F. J.; Riesgo, L.; Rodríguez-Cerezo, E. (2012).*"Economic and agronomic impact of commercialized GM crops: A meta-analysis".* The Journal of Agricultural Science 151: 733.doi:10.1017/S0021859612000111

Arthur GD (2011). *Benefits and concerns surrounding the cultivation of genetically modified crops in Africa:* The debate. Afr. J. Biotechnol. 10(77):17663-17677.

ASSAF Academy of Science of South Africa (2010). GMO's for African agriculture: challenges and opportunities. Workshop proceedings report

Assessment of Nigeria Agricultural Policy (ANAP) study, 2005. *Agriculture in Nigeria: Identifying Opportunities for increased commercialization and investment.* IITA press, IITA Ibadan.

Barrows, G. Sexton, S. and Zilberman, D. (2014*). "The Impact of Agricultural Biotechnology on Supply and Land-Use. Environment and Development Economics*''. Journal of Economic Perspectives 19, 676-703.—Volume 28, Number 1—Winter 2014—Pages 99–120.

Bassey-Orovwuje. M. (2016). *National Conference on Just Governance; The Nigerian Biosafety Act, and GMOs- Implication for Nigerians and Africa*.

Bennett, R.M., Y. Ismael, U. Kambhampati, and S. Morse (2005-01-26).*"Economic Impact of Genetically Modified Cotton in India"*.Agbioforum.org.Retrieved 2013-05-30.

Berg, J. V. (2009) *"Insect-plant interactions, genetically modified crops and integrated pest management"*: what does the future hold? Available at dspace.nwu.ac.za/bitstream/handle/10394/4967/VandenBerg_J.pdf?

Bote T (2002) *Mozambique, Malawi accept GM Food as Hunger Bites.* The Daily News (Harare) October4, 2002.

Bouis H. (2007). *The potential of genetically modified food crops to improve human nutrition in developing countries*. J. Dev. Stud. 43:79–96.

Brookes G. and Barfoot P. (2010) GM crops: global socio-economic and environmental impacts 1996-2008.

Buhl-Mortensen, L. and S. Welin, "The ethics of Doing Policy Relevant Science: "*The Precautionary Principle and the Significance of Non-Significant Results*," *Science and Engineering Ethics* 4 (1998), 401–412.

Buiatti, M, Christou, P. and Pastor, G. (2012). The application of GMOs in agriculture and in food production for a better nutrition: two different scientific points of view. *Genes & Nutrition* Studying the relationship between genetics and nutrition in the improvement of human health https://doi.org/10.1007/s12263-012-0316-4

Brimner TA, Gallivan GJ, Stephenson GR. *Influence of herbicide-resistant canola on the environmental impact of weed management. Pest*Manag Sci. 2005;61:47–52. doi:

10.1002/ps.967. [PubMed] [Cross Ref].

Bruening G and Lyons JM.*"The case of the FLAVR SAVR tomato"*. University of California: California Agriculture (2000), 54, 6-

Canadian Association of Physicians for the Environment (2013) Statement on Genetically Modified Organisms in the Environment and the Marketplace. October, 2013.

Carpenter J, Gianessi L. *Why US farmers have adopted genetically modified crops and the impact on US agriculture*. AgBiotechNet. 2001;3:ABN 063 1.

Cartagena Protocol on Biosafety to the Convention on Biological Diversity Concerning the Safe Transfer, Handling and Use of Living Modified Organisms Resulting from Modern Biotechnology, art. 10, Jan. 29 2000, http://www.cbd.int/doc/legal/cartagena-protocol-en.pdf

Central Bank of Nigeria (CBN), 2008: Statistical Bulletin

Cerier Steven E. *"Nigeria poised to become Africa's GMO superpower, overcoming NGO scare campaign"*. November 18, 2016 | Genetic Literacy Project

Chambers, J. et al. 2014. *GM Agricultural Technologies for Africa: A State of Affairs*. Report of a study commissioned by the African Development Bank (AfDB). Washington: International Food Policy Research Institute and AfDB.

Chondie YG, Kebede M (2015). *Genetically Modified Crops and Food Security*. Food Sci. Qual. Manage. 42:41-49

Christou P, Twyman RM.*The potential of genetically enhanced plants to address food insecurity*. Nutr Res Rev. 2004;17:23–42. doi: 10.1079/NRR200373. [PubMed] [Cross Ref].

Clark, E. A. and H. Lehman, "*Assessment of GM Crops in Commercial Agriculture*," *J. of Agricultural and Environmental Ethics* 14(1) (2001), 3–28.

Cox, C. (1995). Glyphosate, Part 1: Toxicology. Journal of Pesticide Reform. 15 (3). http://www.panna.org/resources/pestis/PESTIS.1996. 16.html . html Soil Association ; www. Soilassociation.org.

DeVilliers SM, Hoisington DA (2011). *The trends and future of biotechnology crops for insect pest control.* Afr. J. Biotechnol. 10(23):4677-4681.

EASAC policy report 21, 27.06.13. "*Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture*",

Ebegba Rufus,2017. Director-General/CEO, Welcome Message on the website of National Biosafety.

Eicher CK, Maredia K, Sithole-Niang I (2006). *Crop biotechnology and the African farmer.* Food Policy. 31: 504-527.

Emily Marden, *Risk and Regulation: U.S. Regulatory Policy on Genetically Modified Food and Agriculture* 44 B.C.L. Rev. 733 (2000).

Environmental news network.(Internet). 2002 [accessed 2015 Dec 11]. Available from: http://enn.com/indepth/gmfood/index.asp.

Environmental Rights Actions/Friends of the earth Nigeria. *Who benefits from Gm crops? An analysis of the global performance of gm crops* (1996-2006). [Internet]. 2007 [access 2006 dec11]. Available from: Issue 111:4-

Environmental Rights Actions/Friends of the earth Nigeria. Briefing: *Genetically Modified*

Crops and food. [Internet]. 2003 [access 2006 dec 11]. Available from: http://www.foe.co.uk.

Environmental Rights Action/ Friends of the Earth, Nigeria. 2005. "*Genetically Modified Crops: The African Challenge*" Environmental Rights Action (Friends of the Earth, Nigeria). GMO Campaign- FoE, (2005). http://www.eraction.org/modules/Publications/docs/eragmoreport.pdf.

Ewepu Gabriel. 2017. HOMEF, scientists call for repeal of National Biosafety Act. Vanguard MAY 22, 2017. https://www.vanguardngr.com/2017/05/homef-scientists-call-repeal-national-biosafety-act/

Falck-Zepeda, José Benjamin; Traxler, Greg; Nelson, Robert G. (2000).*"Surplus Distribution from the Introduction of a Biotechnology Innovation"*.American Journal of Agricultural Economics 82 (2): 360–9. doi:10.1111/0002-9092.00031. JSTOR 1244657.

Fan S, Chan-Kang C, Qian K, Krishnaiah K. 2005. *National and international agricultural research and rural poverty: the case of rice research in India and China*. Agric. Econ. 33:36979.

FAO and The State of Food Insecurity in the World (2003). *The State of Food Insecurity in the World: monitoring progress towards the world food summit target. Food and Agricultural Organization of the United Nations*, Rome, Italy. p. 7.

FAO. 2004. *The State of Food and Agriculture 2003-04; Agricultural Biotechnology: Meeting the Needs of the Poor?* Rome: FAO.

FAO, *1996*. The State of Food and Agriculture. Food Security: Some. Macroeconomic. Dimensions.

Farre G, Bai C, Twyman RM, Capell C, Christou P, Zhu C. *Nutritious crops producing multiple* *carotenoids—a metabolic balancing act*. Trends Plant Sci. 2011;16:532–540. doi: 10.1016/j.tplants.2011.08.001.[PubMed] [Cross Ref].

Farre G, Twyman RM, Zhu C, Capell T, Christou P. *Nutritionally enhanced crops and food security: scientific achievements versus political expediency*. CurrOpinBiotechnol. 2011;22:245 251. doi: 10.1016/j.copbio.2010.11.002. [PubMed] [Cross Ref].

FDA News Release 7 July 2009 Noted Food Safety Expert Michael R. Taylor Named Advisor to FDA Commissioner.

FoEN. (Friends of the Earth International), 2004. Genetically Modified Crops a decade of failure [1994 - 2004] Corn growing in the Garcia Rovira province, Colombia. gmos issue 105 10

FoEN. Who benefits from genecally modified crops? 30 April 2014. www.foeeurope.org/whobenefits- gm-crops-industry-myths-240414.

Freestone, D. and E. Hey, "*Origins and Development of the Precautionary Principle,*" in D. Freestone and E. Hey (eds.), *The Precautionary Principle and International Law* (Kluwer Law International, Netherlands, 1996), pp. 3–15.

Gasson, M. and D. Burke, "*Scientific Perspectives on Regulating the Safety of Genetically Modified Foods*," *Nature Reviews* 2 (2001), 217–222.

Glover, D. (2003a). "*Biotechnology for Africa"?*Democratising Biotechnology Series: Genetically Modified Crops in Developing Countries Briefing Series, Briefing 10.Institute of Development Studies, Brighton.http://www.eldis.org/cache/DOC14356.pdf GM Watch: www.gmwatch.org.

Gómez-Galera S, Rojas E, Sudhakar D, Zhu C, Pelacho AM, Capell T, Christou P. *Critical evaluation of strategies for mineral fortification of staple food crops.* Transgenic Res. 2010;19:165–180. doi: 10.1007/s11248-009-9311-y. [PubMed] [Cross Ref].

Grain, 2000.For a full review of TRIPS 27.3(b). GRAIN | 15 March 2000 |Reports

Grassini P, Eskridge KM, and Cassman KG.*"Distinguishing between yield advances and yield* plateaus in historical crop production trends". Nature Communications (2013), 4, Article number: 2918.

Gurian-Sherman D (2009). *Failure to Yield, Evaluating the Performance of Genetically Engineered Crops.* In: Union of Concerned Scientists. Available at http://www.ucsusa.org/food_and_agriculture/our-failing-food-system/genetic engineering/failure-to-yield.html.

Haliweli B. *Unintended effects of Bt crops*. World Watch. 1999;12(1):9-10.

Hammer M *Writing nature: discourses of ecology. the economics of genetically modified foods*. CSA. UK: Routledge; 2003.

Hans Herrenand Marcia Ishii-Eiteman.Genetically modified crops are not the answer- 04/22/10 10:18 PM EDT 32.

Hutchison WD, Burkness EC, Mitchell PD, Moon RD, Leslie TW, Fleischer SJ, Abrahamson M, Hamilton KL, Steffey KL, Gray ME, Hellmich RL, Kaster LV, Hunt TE, Wright RJ, Pecinovsky K, Rabaey TL, Flood BR, Raun ES (October 2010). *"Areawidesuppression of European corn borer with Bt maize reaps savings to non-Bt maize growers"*. Science 330 (6001): 222–5. Bibcode:2010Sci...330..222H. doi:10.1126/science.1190242. PMID 20929774.

Hazell P, Ramasamy C. 1991. *The Green Revolution Reconsidered: The Impact of High-Yielding Rice Varieties in South India*. Baltimore, MD: Johns Hopkins Univ. Press.

Hiefle SL, Taylor SL. *Allergenic foods*. Crit Rev Food SciNutr. 1999;36:69-89.

James, C. 2007. Global Status of Commercialized Biotech/GM Crops: 2007 (ISAAA Brief No. 37) International Service for the Acquisition of Agribiotech Applications. Ithaca, NY; 2007.

James, Clive. 2008. *Global Status of Commercialized Biotech/GM Crops*: 2008. ISAAA Brief No. 39. ISAAA: Ithaca, NY.ISBN; 978-1-892456-4. New York: ISAAA. (International Service for the Acquisition of Agri Biotech Applications). Availableat:http://www.isaaa.org/resources/publications/briefs/39/executive summary/default.html [Accessed: 12 January 2010].

James, C. 2009. Global status of Commercialised Biotech/GM Crops, 2009. ISAAA Briefs No 41-
2009

James C: Global Status of Commercialized Biotech/GM Crops: 2010 (ISAAA Brief No.42) International Service for the Acquisition of Agribiotech Applications. Ithaca, NY; 2010.

James, C (2011). *"ISAAA Brief 43, Global Status of Commercialized Biotech/GM Crops: 2011"*. ISAAA Briefs. Ithaca, New York: International Service for the Acquisition of Agri Biotech Applications (ISAAA). Retrieved 2 June 2012.

Jarvis S, Hickford J. (1999). *Gene Technology*. Christchurch: NZ Institute for crop and food research.

Jeremy Rifkin, *Harvesting the Gene and Remaking the World:* The Biotech Century 68 (1998).

Joao, Cravinho. (1991). *"Frelimo and the Politics of Agricultural Marketing in Mozambique."* Journal of Southern African Studies 24 (1998). Academic Search Premier. EBSCO. Upper Arlington Public Library, Columbus. 17 Sept. 2007.

Kaplan, D. M. (2004). *"What's Wrong with Genetically Modified Food"?*in Frederick Adams, ed. Ethical Issues of the 21st Century (Charlottesville: Philosophy Documentation Center Press).

Karembu, M., Nguthi, F. & Ismail, H. 2009. Biotech crops in Africa: The final frontier. ISAAA AfriCenter, Nairobi, Kenya.

Keetch D.P., Webster J.W., Ngqaka A., Akanbi R. and Mahlanga P. (2005) Bt maize for small scale farmers: a case study. African Journal of Biotechnology,4: 1505-1509.

Key S, Ma JK, Drake PM (June 2008).*"Genetically modified plants and human health"*.J R Soc Med 101 (6): 290–8. doi:10.1258/jrsm.2008.070372. pp 292-293.

Kirsten j. and Gouse M. (2006)Bt cotton in South Africa: Adoption and impact on farm incomes amongst small- and large-scale farmers. http://croplife.intraspin.com/Biotech/papers/22article.pdf

Klumper W and Qaim M. *"A Meta-Analysis of the Impacts of Genetically Modified Crops"*.PLoS ONE (2014), 9.

Knox OGG, Vadakattu GVSR, Gordon K, Lardner R, Hicks M. *Environmental impact of conventional and Bt insecticidal cotton expressing one and two Cry genes in Australia*. Aust J Agr Res. 2006;57:501–509. doi: 10.1071/AR05366. [Cross Ref].

Kosicka-Gębska M, Gębski J (2009). *Oczekiwania i obawyzwiązane z wprowadzaniem do* *obrotuproduktow żywnościpochodzących genetycznychmodyfikacj*i. ProblemyRolnictwaŚwiatowego.ZeszytyNaukowe SGGW w Warszawie. 9:65-76.

Kramkowska M, Grzelak T, Czyżewska K (2013). *Benefits and risks associated with genetically modified food products.* Ann. Agric. Environ. Med. 20(3):413-419.

Kuiper, H. A, H. P. J. M. Noteborn, E. J. Kok, and G. A. Kleter, "*Safety Aspects of Novel Food,*" Food Research International35 (2002), 267–270.

Lee C, Halich G (2008). Corn and Soybean News. Volume 8, Issue 4. Available online at: www.uky.edu/Ag/CornSoy/

Ljungqvist O, Gossum AV, Sanz ML, Man F. *The European fight against malnutrition*. ClinNutr. 2010;29:149–150. doi:10.1016/j.clnu.2009.10.004. [PubMed] [Cross Ref].

Lynas, Mark (4 November 2010). *"What the Green Movement Got Wrong: A turncoat explains"*. Telegraph. Retrieved 5 November 2010.

McGloughlin M. *Ten reasons why biotechnology will be important to the developing world*. Ag Bio Forum. 1999;2:(3)163-174.

McGrath M. "*Genetically modified potatoes 'resist late blight'*". BBC News. 17 February 2014. http://www.bbc.com/news/science-environment-26189722.

Margulis C. *The hazards of genetically engineered foods*. Environ Health Perspect. 2006;114:146.

Michael, Meron T. "Africa Bites the Bullet on Genetically Modified Food Aid." (2002). 21 Sept. 2007 <www.Worldpress.org>.

Miguel A. Altieri (1998) *“Modern Agriculture: Ecological impacts and the possibilities for truly sustainable farming”* Monthly Review 50(3).

Miller, Michelle. "Genetically Modified Crops in Africa." United Nations Environment Programme (2007). 21 Sept. 2007. <http://www.eoearth.org/article/Genetically_modified_crops_in_Africa>.

Millstone, E., E. Brunner, and S. Mayer, “*Beyond Substantial Equivalence,*” *Nature* 401 (1999), 525–526.

Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C., Daniel J. (4 March 2014). *"California Reenters the Genetically Modified Organism (GMO) Food Labeling Arena; This Time Through the Legislature". The National Law Review*.Retrieved 6 March 2014.

Mohamed- Katerere (2013). *“Africa Environment Outlook 2: Our Environment, Our Wealth.”*

Nang’ayo Francis. The *status of Regulations for Genetically modified crops in countries of Sub-Saharan Africa*. 2006.

Nap JP, Metz PLJ, Escaler M, Conner AJ.*The release of genetically modified crops into the environment* part I. Plant J. 2003;33:1–18. doi: 10.1046/j.0960 7412.2003.01602.x. [PubMed] [Cross Ref]. Nestle M. *Allergies to transgenic foods.*Questions of policy. N Engl J Med. 1996; 334:726-8. Newbury Park, CA: Sage.

National Biosafety Management Agency Act, 2015

Newswire PR *Genetically Modified Maize: Doctors' Chamber Warns of "Unpredictable Results" to Humans*.November 11, 2013.

Nielsen, R.L. (Bob) (August 2012). *"Historical Corn Grain Yields for Indiana and the U.S."*. Corny News Network.PurdueUniversity.Retrieved October 2014.

Novak,W. K. and A. G. Haslberger, "*Substantial Equivalence of Antineutrinos and Inherent Plant Toxins in Genetically Modified Foods*," Food and Chemical Toxicol. 38 (2000), 473–483.

Nwajiuba, C. (2 013). "*Nigeria's Agriculture and Food Security Challenges*".Agriculture& Food Security.available at http://ng.boell.org/sites/default/files/uploads/2013/10/agriculture_ green_deal_nigeria_study.pdf .

Nyiam, 2016. Nigeria deploys genetically modified cotton, maize despite safety concerns. Premium Times. Jan. 25. Abuja.

Obadina Tunde. "*Using GM technology to feed Africa*". Africa Economic Analysis. www.AfricaEconomicAnalysis.org. First published Vanguard Newspaper May 2003. Copyright Africa Economic Analysis 2005.

Odame, H., Kameri-Mbote, P. and Wafula, D. (2003)."*Governing Modern Agricultural Biotechnology in Kenya: Implications forFood Security*".IDSWorking Paper 199.Institute of Development Studies, Brighton.http://www.ids.ac.uk/ids/bookshop/wp/wp199.pdf.

OECD, "*Safety Evaluation of Foods Produced by Modern Biotechnology: Concepts andprinciples*" (OECD, Paris, 1993).

O'Riordan, Timothy, and Andrew *Jordan*. "The Precautionary Principle in Contemporary Environmental Politics." Environmental Values 4, no. 3 (*1995*): 191–312

Otieno Owino, 2012. Scientists torn over Kenya's recent GM food ban. Nature International weekly journal of science. 03 December 2012. Nairobi.

Paarlberg, Robert. 2006. "Are genetically modified (GM) crops a commercial risk for Africa?" *International Journal of Technology and Globalisation*, vol. 2 no. 1/2: 81-92.

Prakash, D. Verma, S. Bhatia, R. and B. N. Tiwary.(2011). "*Risks and Precautions of*

Genetically Modified Organisms".International Scholarly Research Network, ISRN Ecology, Volume 2011, Article ID 369573, 13 pages.

Portfolio 21 (2005)."*Biotechnology Policy for Portfolio21*".http://www.portfolio21.com/Biotech-main.html.

Potrykus I. *Lessons from the 'Humanitarian Golden Rice' project: regulation prevents development of public good genetically engineered crop products*. Nat Biotechnol. 2010;27:466472. [PubMed].

Poul, N. R. 2002. "the rise of the far right," 16 october 2002 at lse. imagelibrary/871 persistent url: archives.lse.ac.uk/dserve.exe?dsqserver=lib-4.lse.ac.uk&a.

Rice Biotechnology: Rockefeller to End Network After 15 Years of Success (Science, Vol 286, No 5444, pp 1468-1469, Nov 1999).

Richard Sandbrook, 1985. *The Politics of Africa's Economic Stagnation*, Cambridge University Press, 1985 passim

Rinkesh Kukreja. *Conserve Energy Future. Be green, Stay green*. 2009.

Ronald, Pamela, 2011. *"Plant Genetics, Sustainable Agriculture and Global Food Security". Genetics 188 (1): 11–20. doi:10.1534/genetics.111.128553. PMC 3120150. PMID 21546547.*

Sanusi, L.S, 2010: *Growth Prospects for the Nigerian Economy*. Paper presented at the eight convocation lecture of Igbinedion University, Okada, Edo State, Nigeria, November, 20, 37pp

Sayre, April Pulley, 1999. *Africa*, Twenty-First Century Books. ISBN 0-7613-1367-2.

SCBD, 2000. Protocol. on. Biosafety. to the. Convention. on. Biological. Diversity. Text and Annexes. Cartagena ***Protocol*** on Biosafety. Montreal, ***2000.***

https://www.cbd.int/doc/legal/cartagena-protocol-en.pdf.

Seshia, S. (2002). “Plant Variety Protection and Farmers’ Rights in India: Law-Making and the Cultivation of Varietal Control”. *Economic and Political Weekly*.37 (27), 2741-7.

Singh A, Kumar V, Poonam, Gupta HR, 2014. *Genetically Modified Food: A Review on Mechanism of Production and Labeling Concern.* Adv. Plants Agric. Res. 1:4.

Smale, M., P. Zambrano, and M. Cartel, 2006. *"Bales and balance: A review of the methods used to assess the economic impact of Bt cotton on farmers in developing economies"*(PDF). AgBioForum9 (3): 195–212.

Snow A, Pedro MP, 1997. *Commercialization of transgenic plants: potential ecological risks. Bioscience.* 1997;47:86-96.

Soil Association, 2003b.” *Key Concerns about GM. Press Statement*”, 6 May. http://www.soilassociation.org/web/sa/saweb.nsf/librarytitles/05062003

Spectar J.M, *Patent Necessity: Intellectual Property Dilemmas in the Biotech Domain & Treatment Equity for Developing Countries*, 24 HOUS. J. INT’L L 227, 234 (2002).

Spinney,L, 1999. *Biotechnology in Crops: Issues for the developing world.* A report compiled for Oxfam GB by Laura Spinney.Oxfam GB,Oxford. http://www.oxfam.org.uk/what_we_do/issues/livelihoods/biotech_gm.htm

Susan K. Sell, *Industry Strategies for Intellectual Property and Trade: The Quest for TRIPS, and Post-TRIPS Strategies*, 10 CARDOZO J. INT’L & COMP. L. 79 (2002).

Terri Hallenbeck, 2014. *Past, Present and Future Perspectives*”, The Burlington Free Press. May 8, 2014 UNEP, 2002. “*Africa Environment Outlook:*UNEP,Nairobi, pp 422.

The Royal Society of Canada, “*Elements of Precaution, Recommendations for the Regulationof Food Biotechnology in Canada*” (http://www.rsc.ca, 2001).

Trewavas, A. and C. J. Leaver, "*Conventional Crops are the Test of GM Prejudice*," *Nature*401 (1999), 640.

The TRIPS Agreement and Convention on Biological Diversity. Paper IP/C/W/368/Rev.1, revised 8 February 2006.

United Nations, 2006. *The world food situation: new driving forces and required actions*. The Millennium Development Goals Report 2006.Von Braun J. 2007. Food Policy Rep. 18, Int. Food Policy Res. Inst., Washington, DC.

United Nations Development Programme, 2003. *"Human Development Reports'' – hdr.undp.org.2003.*

United States Department of Agriculture, Agriculture. 2005. Biotechnology FAQ's. Available at http://www.nal.usda.gov/bic/ (last visited April 20, 2005).

United States Trade Representative, USTR's Role in Trade Policy, available at http://www.ustr.gov/Who_We_Are/Mission_of_the_USTR.html (last visited April 20, 2005).

Unnevehr L, Pray C, Paarlberg R. 2007. *Addressing micronutrient deficiencies: alternative interventions and technologies*.AgBioForum 10:124–34.

USDA Agricultural Biotechnology Annual Reports for 2015 for Ethiopia and Ghana are available at http://1.usa.gov/1Sksfl2 and http://1.usa.gov/1UAbsRf.

Verenardo Meeme. '*Kenya reconsidering GMO crop ban to support food security'* Cornell Alliance for Science. April 30, 2019.

Vitale, J., Harvey, G., Greenplate, J., Abdennadher, M. & Traoré, O. 2008a. Second-generation Bt cotton field trials in Burkina Faso: analyzing the potential benefits to West African farmers. *Crop Science***,** 48: 1958-1966.

Vitale J, Glick H, Greenplate J, Traore O. 2008b : The Economic Impact of Second Generation Bt Cotton in West Africa: Emperical Evidence from Burkina Faso. International Journal of Biotechnology 2008, 10(2-3):167-183.

Von Braun J. 2007. *The world food situation: new driving forces and required actions*. Food Policy Rep. 18, Int. Food Policy Res. Inst., Washington, DC.

Wanyama, J. M., de Groote, H. Mose, L., Odendo, O., Ouma, M., Owuor G., Lutta, M., Ndung'u, J. & Mutoko, M. 2004. Economics of insecticide use and potential for *Bt* maize varieties in the control of stalkborer in Kenya. Proceedings, African Association of Agricultural Economists. Inaugural Symposium, 6–8 December 2004, Nairobi, Kenya.

Wesseler, J, 2005. (ed.): *"Environmental Costs and Benefits of Transgenic Crops"*. Dordrecht, NL: Springer Press.

Whitman B. Deborah, 2010. Genetically Modified Foods: Harmful or Helpful? CSA Discovery Guides http://www.csa.com/discoveryguides/discoveryguides-main.php Released April 2000

William C. Motes March 2010. *"Modern Agriculture and Its Benefits – Trends, Implications and Outlook"*.

Winter CK, Gallegos LK, 2006. "Safety of Genetically Engineered Food" (PDF). University of California Agricultural and Natural Resource Service. ANR Publication 8180.

Witcombe, J and Sanchez, J, 2004. Food systems and security helping the poor cope. ID21 health. http://www.id21.org/health/InsightsHealth 5art3.htm

World Bank, 2008. *"World Bank Updates Poverty Estimates for the Developing World". World Bank. 26 August 2008. Archived from the original on 19 May 2010. Retrieved 18 May 2010.*

World Bank, 2009. "The developing world is poorer than we thought, but no less successful in the fight against poverty". World Bank. Archived from the original on 2009-03-23. Retrieved 2009-04-16.

World Bank, 2015. *Nigeria from the World Bank:* Data. ... Annual GDP Growth (%). 2005 2010 2015 -1.62 . World Bank data Group. General Household Survey, Panel 2015-2016, Wave 3. data.worldbank.org/country/Nigeria.

World Economic Forum's Africa Competitiveness Report 2015. www.nda.agric.za

Yamin, F. (2003)."*Intellectual property rights, biotechnology and food security"y*. IDS Working Paper 203.http://www.ids.ac.uk/ids/bookshop/wp/wp203.pdf.

Yuan D, Bassie L, Sabalza M, Miralpeix B, Dashevskaya S, Farre G, Rivera SM, Subhasappa RB, Bai C, Sanahuja G, Arjo G, Avilla E, Zorrilla-Lopez U, Ugido N, Lopez A, Almacellas D, Zhu C, Capell T, Hahne G, Twyman RM, Christou P, 2011. *The potential impact of plant biotechnology on the millennium development goals.* Plant Cell Rep. 2011;30:249–265. doi:10.1007/s00299-010-0987-5. [PubMed] [Cross Ref]