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A Review on Agricultural Biotechnology in Africa, Current State and the Future Prospects

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Abstract: The exploding global population is presenting a new challenge of providing food for further billions of people against the backdrop of the challenges of already existing hunger and malnutrition, climate change, emerging destructive crop and animal diseases and the pressure being exerted on arable lands by several other anthropological demands. Providing food for the world in the faceable future, therefore, require the revolutionization of the agricultural sector as it stands today. Agricultural biotechnology has evolved over three decades and has presented itself as a critical avenue for addressing the perennial food production insecurity situations; particularly in Africa and other food-insecure regions of the world. This study sought to review the agricultural biotechnology in Africa by assessing its current state and the future prospects of the technology on the African continent. The adoption and utilization of biotechnology in African has been faced with serious challenges of ethical, religious, environmental contamination and health risks issues. Adoption of the biotechnology and genetically modified (GM) products has only been achieved in few countries in Africa on small-scale basis and under few selected crops. Inadequate legislation, unenhanced public education and the spread of misconceptions by anti-GM technology activists, remains a strong challenge to navigate around for the smooth adoption of the technology on the African continent. Smallholder farmers in Africa also habour serious apprehension over seed monopoly and erosion of the traditional seed quality with neo-colonial intensions by the developers of the technology. Anti-GM sentiments based on misconceptions are deeply rooted in many African countries, heightening fear for its adoption. Stronger and an elaborate public education strategy that highlights the benefits of biotechnology and assures the people of the risk levels of the technology, and further research to alleviate public anxiety is critical for the adoption of biotechnology and GM products in African.

Keywords: Agricultural biotechnology, Africa, GMO.

1. INTRODUCTION

The world population growth is increasing at a faster rate, and it is expected to surpass 9 billion people by 2050 (Tripathi *et al.*, 2019). The trend of the global population growth reveals that, the highest growth rate is expected to occur in Africa where hunger and food insecurity are already major contending challenge (Gu *et al.*, 2021: Ritson, 2020: Tripathi *et al.*, 2019). Pivotal to achieving the goal of economic income generation and food security of Africa, is the strong performance of the agriculture sector, which contributes to nearly, three quarters of the economic income and sustenance of the region's population (Machuka, 2001). However, depleting soil nutrient levels, rising global temperatures, extended drought conditions, climate change and the high incidence of pest and disease challenges has become a major debacle to the efficient delivery of the sector (Drechsel *et al.*, 2001). Machuka (2001), reported that, the traditional agriculture practices and the green revolution methods; fertilizer use, irrigation and pesticides application are failing to achieve the desired crop yields needed to keep-up with the rate of global population growth. The situation has called into sharp focus the unsustainable dynamism between population, agriculture and the environment, requiring suitable alternatives to meet the global food needs without further harming and dis-stabilizing the environment and the natural ecosystems, respectively (Abah *et al.*, 2010).

Emerging as an efficient alternative means of achieving food production and food security needs of the world (particularly in the third world) is to embrace the advent of agricultural biotechnology. This is a branch of agricultural science that utilizes scientific tools and techniques of genetic engineering, molecular markers, molecular diagnostics, vaccines, and tissue culture, to modify living organisms; thus, plants and animals (Bunders and Broerse, 1991). Agricultural biotechnology is a **set of scientific techniques which can improve plants, micro-organisms, and animals based on DNA and its concepts**. This technology involves the utilization of variety of scientific tools that include breeding techniques to alter parts or a whole living organism to modify its products, improve plants or animals or develop

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microorganisms for specific agricultural purposes (Gonzalez, 2007). Through the use of biotechnology, desired traits of a particular species could be transferred to an entirely different species to achieve a desired positive outcome. Biotechnologically transgene crops, will therefore, possess the desired traits of flavour, flower colour, fruit size, yield and pests and disease resistance of the original crop (Ahteensuu, 2012).

The prospect of biotechnology to solving hunger and food insecurity challenges of Africa is enormous; however, acceptability of the technology has faced several challenges. This paper sought to review the agricultural biotechnology in Africa by assessing its current state and the future prospects of the technology on the African continent.

2. HISTORICAL DEVELOPMENT OF GM CROPS

The use of biotechnology has evolved over decades, however, lingering doubts about the issues of environmental sustainability and human health risks upon the consumption of products of the technology (e.g. GMO foods) has impaired its smooth adoption (Peterson *et al.*, 2000). Historical background of the Genetically Modified (GM) Crops is presented in (Table 1).

Table 1: Historical timeline of GM Crops

No.	Year	Activity
1	1985	Production of the 1st transgenic plants
2	1988	Development of particle bombardment
3	1992	GM crops was considered substantially equivalent to hybrid varieties
4	1994	Flavr-Savr tomato was released
5	1996	▪ Herbicide- and insect-resistant crops approved for cultivation in maize, soybean, cotton. ▪ 4.3 million acres of GM crops planted
6	1998	▪ UK TV reports that GM food is dangerous ▪ Monarch butterfly paper causes uproar
7	1999	▪ GM corn is excluded from baby foods ▪ Green-Peace starts anti-GMO campaign
8	2000	▪ 75 million acres of GM crops planted ▪ Golden rice with ß-carotene developed ▪ McDonald's rejects GM potatoes
9	2002	*Bacillus thuringiensis* (*Bt*) cotton released in India grown in 50,000 ha
10	2006	GM crops cultivation reached 100m ha world wide
11	2014	181.5 million hectares of GM crops planted world wide

(Shahanaz, 2014)

3. GLOBAL OUTLOOK AND IMPACT OF AGRICULTURAL BIOTECHNOLOGY

Issues of food insecurity and famine had been a thorny topic that has been for discussion around the world in the face of global changes in climatic- conditions. Drought prone crops, pests attacks on crops on the field and storage, and the ineffeicient minerals and water use efficiency of available crops, occasioned the scientific search into alternative crops that could provide the right yields (Braun, 2002). The introduction of GM crops in the late 1970s and the adoption of biotechnology in the world as an alternative, has yielded some positve results with over 181.5 million hectares of various GM crops planted world-wide. A metastudy on the global impact of agricultural biotechnology revealed that biotechnology adoption has led to the reduction of pesticide usage by

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37%, improved yield by 22% and has helped in the inrease of farmer income by 68% (Shahanaz, 2014). In the face of global sentiments on the residual effect of pesticides on food crops and their associated health and environmental risks as well as ecosystem distabilzation, the use of GM crops with resistant properties against certain insects is a healthy alternate to enhance public health, environmental and ecosystem restoration. Improved farmer income through the use of biotechnology could potentially inhance the efforts poverty alleviation among farmers.

4. APPLICATION AND ROLE OF BIOTECHNOLOGY IN AGRICULTURE

Biotechnology, over the years have permiated through several fields of science including medicine, agriculture, genetic engineering., etc. The following highlights some of the areas in which biotechnology has found its way in agriculture.

a. Genetic Engineering/rDNA Technology

Genetic engineering is a technology in which one or more genes are delibrately modified in the laboratory. Its is achieved by the process of using recombinant DNA (rDNA) technology, thereby altering the genetic makeup of an organism. Genetic engineering using rDNA has been an improvement program in agriculture which has enhanced the efficiency of crop improvement compared to the conventional phenotypic slection by changing the regime of identifying superior combinations of genetic regions and management systems (Bengna, 2000). The application of rDNA technology and nanotechnology induces direct interaction of transgene and nanoparticles with the components of the agroecosystem, whereby the escaping transgenes from transgenic plants invades wild plant types, leading to enhanced evasiveness (Guleria and Kumar, 2018).

b. Tissue Culture

Tissue culture involves nuturing fragments of plant or animal tissue in a controlled environment where they survive and continue to grow on nutrient medium. For this, tissue has to be isolated first. Plant tissue culture offers remarkable opportunities in in-vitro propagations, plant quality improvement and production of plants with desirable agronomical quality and quantity. It’s now possible to develop virus-free plant regeneration, herbicide resistance, salinity tolerance, disease resistance, incorporation of high protein content and genetically engineered plants for desirable traits. (Jyoti and Kumar, 2020)

c. Embryo Rescue

Embryo rescue is a form of in-vitro culture technique for plants. In this technique, an immature embryo is nurtured in a controlled environment to ensure its survival. This technique can be used for the preservation of species of seeds that are nearing extinction, heritage seeds, local grains of cultural significance, etc. The embryo rescue technique has been widely and efficiently used in plant breeding procedures for the production of seedless grapes and the presevation of crops at the potential point of extinction (Li *et al.*, 2020).

d. Somatic Hybridization

Somatic Hybridization is a process through which the cellular genome is manipulated by way of protoplast fusion. Somatic hybridization aims to strengthen the gene pool by introducing genes from wild species (Helgeson *et al.*, 1993). However, challenges have existed in the past with regards to harnessing several useful genes of wild sources through conventional breeding due to sexual barriers caused by the differences in ploidy level and endosperm balance number (Spooner and Salas 2006). Through somatic hybridization and other genetic manipulations, such as the manipulation of ploidy and endosperm balance number, embryo rescue, hormone treatment and reciprocal crosses, this challenge has now been overcome (Jansky 2006) to the advantage of improved crop production.

e. Molecular Gene Markers

Genetic markers are very important developments in plant breeding 3. In genetic engineering, molecular-gene markers are specific segments of DNA that are associated with a particuplar location within the genome. Molecular marker may be defined as any site (locus) in the genome of an organism at which the DNA base sequence varies among the different individuals of a population. According to Lincoln *et al.* (2018), molecular markers are widely used in crop improvement due to its simplicity, reproducibility and precise location. Molecular markers are used for:

- **The detection of plant evolution and phylogeny:** Past evolutionary studies of plants have relied heavily on their geographical and morphological changes. However, with advancement in molecular genetics, molecular markers have been used for the reconstruction of genetic maps in order to obtain full information about the phylogeny and evolution of plants (Wang *et al.*, 2017; Peng *et al.*, 2015).

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- **Investigation of heterosis:** Heterosis refers to the superior performance of a progeny (F_1) over the mean of the crossed parents (114). Studies have been conducted in crops such as wheat, maize and rape seeds (Betran *et al.*, 2003; Yu *et al.*, 2005) using molecular markers to investigate genetic diversity and heterosis.

- **Genetic diversity assessment:** This is very useful in the study of plant evolution and for the comparing of their genomics, to help to understand structure of different populations (Nawaz *et al.,* 2017). Genetic markers has been helpful in this regard for the successful determination of genetic diversity and classification of genetic materials (Naeem *et al.*, 2015; Yin*et al.,* 2015)

f. Molecular Diagnostics

Molecular diagnostics is a set of techniques used to analyze biological markers in the genome and proteome. It helps in determining how their cells express their genes as proteins. Molecular diagnostics is essential in agricultural biosecurity for the monitoring od diseases in animals and crops and for the assessment of disease risks (ITP, 2019).

g. Vaccines

Vaccines are biological preparations improves the immunity to a specific disease. These biological formulations are injected into a host body to stimulate a desired immune response, otensibily as a disease preevention measure. Vaccines stimulate the body's immune system to recognize the antigens. Through the agency of modern biotechnology methods, vaccines are being produced from genetically modified plants through gene-encoding of bacteria or viral disease-causing agent being incorporated in plants without losing its immunogenic property in what is known as the "edible vaccines" (Kurup and Thomas, 2020). The main mechanism of action is to activate the systemic immunity response against foreign disease-causing organism through the incorporation of transgene into the selected plant cell (Racioc, 2022). Currently, edible vaccines are developed for veterinary. Comparatively, edible vaccines are seen as cost effective and efficient, and promise a better prevention option from diseases. However, acceptability of this innovate technology by the populace has been a major challenge (Kurup and Thomas, 2020).

h. Micropropagation

Micropropagation is an in-vitro technique of tissue culture in which, high quality, clone plants are developed on large scale. This biotechnology technique has benefited agriculture immensely, through the production of disease-free planting materials for cultivation. Banana production, which serves as a source of employment and income to several people in Africa and Asia, has been the major beneficiary of this revolutionary, inexpensive and easy to use technique, through the regeneration of disease-free plantlets from healthy banana plants (Ranjha *et al.*, 2020). This biotechnology technique has a higher potential to reduce the disease incidence in crop production.

5. AGRICULTURAL BIOTECHNOLOGY IN AFRICA

The birth of biotechnology was hailed as a major breakthrough for solving the food need challenges of the poorest countries of the world; majority of which are in Africa. However, the euphoria that greeted its birth has thinned with the emergence of varied challenges that have held its mass implementation hostage in many African countries. A series of road-blocks have impeded the smooth adoption of genetically modified (GM) seeds from most of the poor countries of the world. The challenges are varied and include lack of locale-appropriate seeds and the institutions of biosafety and plant patent laws (Kent, 2004).

To be able to address these challenges, several large development donors in the world such as the Bill & Melinda Gates Foundation, the US Agency for International Development (USAID) and the Rockefeller Foundation partnered the private industry with several millions of dollars to develop GM crops for Africa (Schnurr, 2013), and to build capacity on biotechnology regulation and safety assessment on the African continent[3] in an effort to garner support for the acceptance of agricultural biotechnology (Harsh, 2014). Their efforts were also in the direction of establishing acceptable policy environment for the production and delivery of GM crops (Schnurr, 2013). However, the efforts have yielded minimal fruit with just six African countries (Burkina Faso, Nigeria, South Africa, Sudan, Zambia, and Swaziland) having approved GM crops (mostly one crop, and commonly; insect resistant cotton) with Nigeria being the African country with the biggest embrace of the technology (Rock & Schurman, 2020).

Argument has been advanced to the effect that, these efforts have failed to achieve the desired impact in Africa as a result of the spread of lies, misconceptions, misinformation and the preposterous exaggeration of the risks of GM crops by anti-GM activists, whiles ignoring

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the benefits of the technology (Schnurr & Gore, 2015). This has compelled many African governments to be overly wary of biotechnology, thereby, stalling efforts to institute legislations to permit the introduction and dissemination of GM crops.

Other literary arguments have also focused on the practices of some powerful corporate involvements in the development of the technology as a major reason for the skeptical adoption by many African countries. Some of these critically minded scholars have called attention to the problematic merger of ‘biocapital’ and ‘philanthrocapital’ and see the collective efforts of firms, donors, and biotech advocacy groups as an attempt to establish ‘bio-hegemony’ on the continent (Ignatova, 2017).

South Africa, in 1996 becomes the first country on the continent to plant *Bt* cotton (ISAAA, 2012). Since then, countries such as Burkina Faso, Nigeria, and Mali have entered into commercial production of GM cowpea. Currently, Ghana has developed *Bt* cowpea with the objective of controlling the larger legume pod borer (*Maruca*), a major pest in cowpea production. The product is awaiting approval from national biosafety authority to conduct filed trials before commercialization of the crops. Several products in Africa which include insect resistance plants (plant incorporated protectants), example *Bt* corn & cotton, herbicide tolerance crops (e.g. glyphosate resistant corn & soybeans), stress tolerance plants (e.g. drought, salt resistant varieties), “value added” crops (e.g. Golden rice containing vitamin A), biopharming (e.g. production of drugs, chemicals on agricultural scales) has been adopted for cultivation with significant success and improved productivity.

6. POLITICO-ECONOMIC STRUCTURE OF AGRICULTURAL BIOTECHNOLOGY

The early age of recombinant DNA in the late 1970s, politico-economic inclined scholars started to study the ‘bio-revolution’ and its consequences for Africa. These studies which focused on the actors involved in the development and promotion of the new technologies revealed that, even though early research into biotechnology was led by academia. However, the later involvement of a group of large multinational corporations (MNCs) from the agrochemical and pharmaceutical industries took the lead in the research work with huge investment by either partnering academic institutions or hiring away scientists from academia to build a new ‘life sciences’ industries (Buttel *et al.*, 1985; Juma, 1989; Kenney, 1986), eventually, becoming the main leaders in the research, which was seen as privatizing science to the interests of these large MNCs (Buttel *et al.*, 1984).
Analysis of early literature on the activities of the MNS revealed the trend that, corporations were acquiring seed companies to take advantage of the ‘increasingly evident synergies among biotechnology, seeds and agrichemicals’ (Buttel *et al.*, 1991) which could lead to the concentration and absolute control over the world’s seed supply by a handful of ‘gene giants’ industries. (Buttel *et al.*, 1984). These casted doubts in the minds of anti-GM activists over the behavior and the true intentions of these companies as being driven by greed.

7. ADOPTION OF AGRICULTURAL BIOTECHNOLOGY IN GHANA

In the face of the challenges of growing population and changing climate, financiers who are funding to facilitate research and commercialization of GM crops in Ghana and across Africa, are of the strong believe that, GMOs would rapidly increase crop yields to mitigate the challenges of farming and food insecurity on the continent. In 2013, the Council for Scientific and Industrial Research (CSIR) test-planted genetically modified cowpea, cotton and rice at various research stations in the country with seeds from the African Agricultural Technology Foundation (AATF). The Attorney General and Minister of Justice, in the same year, tabled a bill known as the Plant Breeders Bill at the parliament with the bill extending intellectual property rights and exclusive patenting rights to plant breeders of new and novel varieties (Plant Breeders Bill 2013).

This generated a mixed public discourse in Ghana over GM crops, with issues of health risks (safety), environmental contamination and integrity questions of the technology being strongly asked by anti-GM activists. Proponents of biotechnology on the other hand, argued that, crops such as the *Bacillus thuringiensis (Bt)* cotton, *Bt* cowpea, and nitrogen and water efficient, salt tolerant new rice varieties that have been hailed over their impact on productivity have been gained through the effort of efficient scientific studies (Gakpo 2017). Such achievements which are hinged on scientific technology as interventions adopted to raise productivity were propagated as ample evidence of the efficiency of biotechnology to revolutionize crop productivity in Ghana.

The attempts to institute legislations on GM crops in 2013, were, therefore, vehemently opposed by several local anti-

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GM activists, Civil Society Organizations (CSOs) and smallholder farmers. General sentiments and apprehension over seed monopolization and the potential erosion of the purity of local seeds, health risk implications of GM crops and ethics were strongly expressed.

8. REASONS FOR REJECTION GMO IN AFRICAN

The foremost argument advanced against the adoption of GMOs has principally, been on health and environmental grounds. The potential risks of biotechnology to the environment has been considered to include horizontal gene transfer (i.e. the movement of genetic information between organisms) or vertical gene transfer (i.e. gene transfer form parent to an offspring), hybridization (i.e. interbreed of genetically distinct populations to produce hybrids), persistence (thus the ability of genetically modified organisms to remain in the environment over a long period), allergenicity (the potential of a genetically modified organisms to induce immune response), higher order effects (the tendency of materials entering into food-webs and the ecosystem) and non-target effects (thus the effect of modified organism introduced on other organisms other than the target organism) (Breckling *et al.*, 2011). Besides these established risks, several scholarly works have brought into sharp focus the potential for unknown risks and the need for precautious and pre-emptive measures as a caution to scientific uncertainty (de-Vendomois *et al.*, 2010; Morris, 2011; Varzakas *et al.*, 2007). According to de-Vendomois *et al.*, (2010), the potential for human health risks from the consumption of GMOs (biotech products) is more of a theoretical assumption, and the general information derived from experiments in mammals that were fed on GMOs. However, the existence of strength of association and consistency between genetically modified foods and diseases in several animal studies have been reported (Ewen and Pusztai, 1999; Finamore *et al.*, 2008; Kiliç and Akay, 2008; Kroghsbo *et al.*, 2008; Malatesta *et al.*, 2008).

Surprisingly, study findings of “no adverse human health risks” for the consumption of GMOs have been observed in research works commissioned by biotech industry whiles studies commissioned by environmentalists have found the contrary (Kangmennaang *et al.*, 2016). A study by Diels *et al.*, (2010), found statistical significance of financial and or professional conflict of interest in biotech commissioned research outcomes on health risk assessment of GMOs. Such phenomenon tends to generate public mistrust towards GM products and further deepen the debate.

Myhr, (2007), emphasized that, the possibility of breaking the rejection of GMOs, substantially, hinges on the offer a trustworthy consumer benefit. This has been further highlighted by some scholars that, a major role in this regard is to be played by science to offer the needed trustworthy benefit to shape the public acceptance of GMOs.

9. THE NEED FOR THE ACCEPTANCE OF GMO IN AFRICAN

Ample documentations abound on the critical role that scientific advances in biotechnology could play in sustainable food production and economic transformation in Africa (Figure 1). The technology has, however, attracted several conversations due to the rise in GMO food commercialization, increasing global food insecurity, increases in global food prices, and the roles of anti-GMOs and environmental activism (Makinde *et al*., 2009). Acceptance of the products of biotechnology has been mixed with strong arguments; both for and against the technology. Decades after the advent of commercial GMOs, global debate on the technology still continue over its acceptance. At the center of the raging debate on GMOs are the topical issues of the environment and particularly, the perceived health risks associated with the consumption of GMO food (Peterson *et al.*, 2000). Despite these issues, James (2007), put forward compelling case for genetically engineered crops, emphasizing the contributions it could bring to humanity and the environment which such as:

a. Increased crop productivity, which will enhance global food and fuel security, and ultimately improve upon producer’s income and benefit consumers.
b. Conserving biodiversity, thus; achieving increased productivity on the 1.5 billion hectares under arable cultivation, and effectively minimizing the deforestation and protecting biodiversity.
c. Mitigating climate change through the reduction in the emission of greenhouse gases by using ‘speeding breeding’ in crop and livestock improvement programmes and optimizing Carbon sequestration.
d. Increase stable productivity to avoid perennial food shortages due to environmental and biotic stress factors that are associated with drought.
e. To reduce the footprints of agriculture’s impact on the environment to achieve safe environment and sustainable agricultural systems.

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f. To improve upon the economic, health and alleviate poverty and malnutrition of rural populations that mainly depends on agriculture for sustenance.

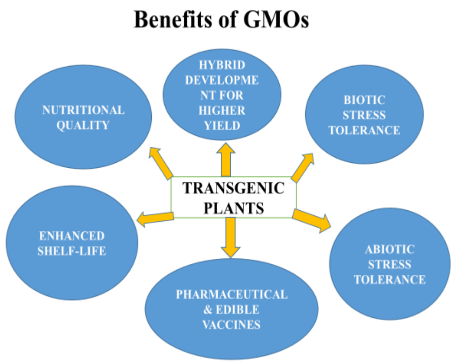

Figure 1: Benefits of GMO

10. FACTORS INFLUENCING MISCONCEPTIONS OF GMOS

The call for rejection of GM crops has been influenced by the creation of several misconceptions about the technology by anti-GM activists. Ethical and religious questions of adulterating the purity of the DNA of one natural organism with genes from other species have been asked about biotechnology and GM products with religious sentiments of a challenge to creation purity been expressed. Socio-economic and political sides, also embrace the overview anxiety. These include issues relating to human health as allergies and toxins, as well as environmental impacts from gene escape, altering the balance in living organisms, and ethical concerns based on religious and cultural values.

There is also the general apprehension by several peasant farmers in African about a neo-colonial agender to adulterate local seeds by the lager cooperate organizations who are funding the technology with the hidden interest of monopolizing the seed industry at the detriment of the poor smallholder farmers who cannot afford the GM seeds. Low confidence in the research institutions and the doubt about the competency and infrastructural capability on the African continent to manage setbacks of the technology is a major concern that has influenced perception about the technology. Public misinformation by anti-GM activists and some NGOs peddling falsehood on the safety of GM products and the rejection of GM products by conglomerates such as McDonald Foods cause several people to establish doubts about the safety of GMOs tagging them as dangerous with health risks.

11. ETHICAL ISSUES ON GMOS

Ethical questions have been asked on GMOs from the angles of integrity of the produce and from religion. The threat of environmental impacts from gene escape that may alter genetic imbalance in living organisms have been expressed by environmental activists and people of religious persuasions.Cultural concerns based on the values such as the transfer of animal genes into plants raises ethical issues for vegetarians and religious groups who finds the condition highly repugnant and unacceptable (Asante, 2008). Passion on ethical questions has been as high as people in questioning the integrity of feeding on crops with human genes as more or less practicing cannibalism since humans are the ultimate users of such crops and their products. In many communities Africa, consumers have express ethical religious concerns about playing God, as plants are transformed in unnatural ways, and about the implications for traditional beliefs and values (Asante, 2008; UNEP, 2007).

12. THINGS NEEDED TO DEVELOP BIOTECHNOLOGY IN AFRICA

The development of biotech is essential to the food and economic security of Africa. There is the greater need for biotechnology to be developed on the continent to advance economic growth and development. Among the things that must be done to take advantage of the biotechnology include the enhancement of coordination between strategic policy making in sustainable agriculture, and agricultural research. There is also the need to establish the political willingness and commitment to the use of the biotechnological tools. To fully benefit from the modern trends of the technology, adequate resources must be committed to the area of human resource development and the infrastructural capacity building/strengthening. Furthermore, there is the need to institute a stronger regulatory framework to ensure the successful implementation of the technology at all levels of agriculture. All stakeholders should also be involved. The promotion of intra-Africa trade through harmonized biosafety regulation and the removal of trade barriers among trading partners is necessary to achieving a successful implementation of biotechnology in Africa. Public education for the acceptance of GM products should be enhanced.

13. CONCLUSION

Biotechnology has evolved over three decades and has shown itself as a major avenue for addressing the perennial food production insecurity associated with pest attacks, effects of climate change and drought, particularly

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in Africa and other food-insecure regions of the world. However, the adoption and utilization of the technology in the African region has faced several with serious challenges with the questions on ethical issues, religious passions, environmental contamination risks and health risks among many others having been raised. Although few countries in Africa have adopted the technology on small-scale basis, challenges of inadequate legislation, unenhanced public education and the spread of misconceptions by the narratives of anti-GM technology activists, remains a strong challenge to navigate around for the smooth adoption of the technology on the African continent. There exists also, a major apprehension by smallholder farmers in Africa, over seed monopoly and erosion of the traditional seed quality with neo-colonial intensions. Misconceptions spread by anti-GM technology activists have been deeply rooted in many African countries, heightening fear for the adoption of the technology. Defects observed in research works on animals fed with GM products have equally raised doubts about the biosafety of GMOs. Further research into the technology to alleviate public anxiety of anti-GM sentiments expressed by activists against the technology as well as the institution of stronger public education system on biotechnology, with respect to the risk and benefit analysis of the technology is critical for it's the adoption of products of biotechnology in the African.

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