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An Ethical Perspective of Genetically Modified Organism (GMO) and Food Security in Africa

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Abstract

Ethicists and other philosophers have raised opinions concerning GM technology that influenced greatly acceptance of GMO by various stakeholders. Achieving food security in African nations continues to be a challenge. In order to reduce this dilemma stakeholders in developed nations have introduced GMO. However, GM technology is more widely practiced by developed countries than developing countries of Africa and Asia. Despite the strong efforts made by different countries of the world to ensure food security through GM technology, African Countries are still lagging behind due to health and environmental concerns. Therefore, this paper seeks to identify the strength, weaknesses, opportunities and threats/risks and establishing safety and ethical measures on the adoption, use and implementation of GMO technology in Africa. Based on the review of the GM technology, it can be seen that, the technology has been surrounded with controversies and these have warranted the authors to support the adoption and use of the technology in Africa on ethical and safety grounds, such as involving the actors who may be affected by the potential impacts of GMOs, public awareness sensitization and active participation underlying the role of government and civil society in providing a balance information to the public are necessary in the hope that these measures may have the potential to consolidate the gains made from the technology while at the same time mitigating the potential risks associated with such technology.

Keywords: Genetically Modified Organism, Poverty and Hunger, Food Security, Ethics and Africa

Introduction

Food insecurity in Africa remains a persistent and daunting challenge in which 230 million Africans constitute 20 percent of the continent's population are classified as hungry. The challenges will intensify in the coming decades, as Africa's population, currently growing at 2.5 percent annually, and is set to double to two billion by 2050.To date; many countries

around the world have adopted the use of GMO as a means to respond to the current food insecurity problems (Liao et al. 2013, Chambers 2013). Food insecurity is a situation in which people live without reliable access to a sufficient quantity or affordable, safe and nutritious food. The urgency of immediate needs and increasing awareness of the looming challenge have led a number of African governments to consider the potential benefits of biotechnology and in particular genetically modified (GM) crops[1] in order to increase yields, decrease reliance on costly inputs, reduce labor, and provide resistance against specific diseases and pest. Over the last two decades, debates around the world with regards to GMO technologies have been mired in controversy. For instance, the technology is faced with low willingness of the society in accepting GM products due to safety, ethical and environmental reasons.

The global planted area of GM crops has increased from 1.7 million hectares in 1996 to 170 million hectares in the year 2012 (Chambers 2013). James (2011) reported that the United States of America is the leading producer of GM crops in the world, while Brazil is the second producer of GM crops covering an area of about 4.9 million hectares. The majority of African countries are still lagging behind compared to other countries of the world in accepting GM technology (Phillips and Doggart 2011, Wei et al. 2013).

The African science and research community have difficulties to adequately disseminate the potential benefits of the new technologies underlying GMO, meaning that these discussions have been, to a large extent, driven and dominated by non-African interest with exaggerated claims on both the benefits and risks of the technology. The African countries are still at the early stage in the adoption of GM technology whereby South Africa, Burkina Faso, Egypt and Sudan are the only countries that commercially produced in GM crops. To date, South Africa is the eighth worlds' largest GMO producer, with 2.9 million hectares of GM maize, soybeans, and cotton (Stieber 2013).

A number of African governments have looked into a number of research that pointed potential benefits of GM technology and the growing number of emerging markets like Brazil, India, China, Argentina, South Africa, Chile and Mexico are growing commercially genetically engineered (GE) crops. As the promises of GMO technologies gain profile, and as African economies diversify their trade partner beyond Europe and the United States, a growing number of African countries have invested scientifically, financially and politically to investigate how the GM technology addresses their unique food security needs (James 2012).

[1] Genetic modified Foods (GM) are foods obtained from organisms that have been genetically modified with (DNA) in a way that does not occur naturally (e.g. the introduction of gene from different species).GM foods stem mostly available in plants, but in future GM animals are likely to be introduced on the market. Genetically modified crops have been developed to improve yield, resistance to pest, increased tolerance of herbicides and nutritional value. World Health Organization, http://www.who.int/topics/food_genetically_modified/en/.

Research on the ethical perspective regarding GM technology and food security in Africa are scant, and given the potential consideration of the technology to address food insecurity concerns in Africa, we investigate the ethical perspective of such technology with a view to create a balance between the adoption and use of GM technology and its potential effects. To this end crucial questions arises (i) Are there any ethical relationships between GMO and Food Security in Africa? (ii) Can the adoption and the use of the technology, while mitigating its potential effect promote food security in Africa? This paper therefore aims at investigating the ethical perspective and establishing the basis to inform policy makers on the adoption, use and the associated potential risks of the technology. Specifically, the study seeks to identify the strength, weaknesses, opportunities and threats/risks with a view to establishing safety and ethical considerations on the adoption, use and implementation of GMO technology in Africa.

The rest of the work is organized as follows: section 2 the Institutional background, section 3 is perceived strength and weaknesses, section 4 is authors assessment/evaluation of GMO technology and Food Security in Africa and finally section 5 is conclusion.

2 Institutional Background

This section reviews the poverty and food security in Africa, the economic and political conditions and the state of GMO and food security in Africa. The analysis of these indicators (Poverty and Food Security, Economic, the Overall GMO capacity and Political Realities) provides the basis for the authors to evaluate the state of GMO in Africa from an ethical stand point.

2.1 Poverty and Food Security Profile in Africa

In the recent years, there have been mounting concerns regarding the world's ability to feed its population, not to mention the projected population of nine billion people in 2050.These figures implies food production will have to increase by as much as 70% to keep the world nourished. Africa is one of the few regions in the world with vast ranges of land suitable for agricultural activity still unutilized. Its geographical locations across the equator imply that there are adequate water resources, adding to the continent's allure. It is estimated that more than 60% of the globe's available and unexploited cropland is located in Sub Saharan Africa (SSA). In the Democratic Republic of Congo (DRC), 0.8 million hectares (ha) of land suited for agricultural has been cultivated. In (the unified) Sudan, Only 16% of available land have been cultivated by 2009- the majority of which now falls in South Sudan, a country that still imports almost all its food (Rabiei et al. 2013, Chaouachi et al. 2013).

In addition many of the agricultural efficiency gains that have already been made in emerging market economies such as China and India almost 30 years ago have still not been made in Africa. Although this implies large losses in terms of where Africa's agricultural sector's development could have been by now, it also suggests that the sector has incredible growth potential which is still untapped.

The African continents as a whole remain a food importing – and according to the World Bank, just 5% of Africa's cereal imports come from other African Countries. It is mainly through volatile food prices that the shortcomings of the current state of the continent's

agricultural sectors are especially visible. When harvests fail, domestic food prices rise as a result of supply shortages and high transport or import costs. In 2008, a global rise in the cost of food saw more than 100 million worldwide people being pushed into poverty- and the majority of these were living on the African continent. (World Bank Development Indicators, 2008)

Africa has the lowest growth-poverty elasticity in the World. That is a 1% increase in growth reduces poverty by only 1.6%. Africa has unfortunately not been marched with a significant reduction in unemployment and poverty. More worrisome is the fact that inequality persists. The Gini Index of income inequality measurement ranged from 30% in Ethiopia to 74% in Namibia. The Continent's average Gini Index currently stands at 45% in view of the high inequality, Africa's impressive economic growth results in limited progress in poverty reduction. Thus between 2000 and 2008, the proportion of people living on less than USD 1.25 a day declined slightly from 57% to 48%. This slow pace of extreme poverty to meet the MDGs to get to 29% by end 2015 is doubtful (Kanu et al, 2014).

Agriculture contributes an estimated 32% to Africa's overall economic activity. Considering that approximately 65% of the African working population is employed in the agricultural industry, it is certain that the sector has the ability to influence the lives of literally millions of people. It has also been found that GDP growth originating from the agricultural sector is to be two to four times more effective in raising incomes of extremely poor people than growth in other sectors of the economy. Adding this to the role, the continent will have to play a big role in global food production in the decades to come, the prospect of increasing agricultural production and growth becomes increasingly important, both for Africa and the World.

The condition of extreme poverty and hunger in the world have attracted global dimensions in the 21st century and have gain the foremost priority in the Millennium Development Goals (United Nations 2006). This hunger is critical in low-income and food-deficient countries in Sub- Saharan Africa whereby about 70% of the population comprises small scale farmers. The soils in these areas have become impoverished such that the environments are prone to drought, soil erosion, famine and epidemics of diseases. The advent of modern technologies, especially GM technology was perceived to be potential for resolving the major agricultural constraints ranging from low crop yields to stress-related issues that arise from pests, diseases and drought. GMO food offers African an opportunity to increase food security and address agricultural production constraints (Lewis et al, 2010).

Therefore, the adoption of GMO could be an important tool for sustainable development in Africa and could benefit most of the resource poor farmers (Azadi and Ho 2010). Many African countries, such as Angola, Ethiopia, Lesotho, Zimbabwe, Tanzania, Mozambique, and Malawi are still at the early stage in the use of GMO products. Chamber (2010) reported that these countries are conducting field trials to ascertain the possibility of adopting GM crops.

2.2 Economic Conditions

In the broader sense, Economic Growth is directly concerns with the aims of distribution, high and sustainable development on the quality of life of a country, which are now recognized as overriding national objectives. Economic Growth performance of least developed countries in general and that of Africa in particular has been unsatisfactory since the 1980s. Source of the instability are partly blamed by external conditions. For example terms of trade shocks, reverse capital flows, natural disaster, etc. on the other hand, if the sources are endogenous such as inappropriate domestic policies reflected in high inflation rates, high budget deficit, overvalued real exchange rate, interest rate, inadequate human capital accumulation (broadly defined) and education (narrowly defined) the quality of labour productivity, agricultural producers price are at the heart of the region's poor growth performance (Abata et.al, 2012).

The underdeveloped state of African agriculture has a lot to do with the low average level of income per capita, in Africa; the general population is poor and lives in rural areas. It is estimated that 85% of farmers in Africa are smallholders farmers, with the average piece of farmland spanning approximately 1.6 hectares(ha).This is only a fraction of the size of 121 ha (Nagayet, 2005). As a result, it is often not possible to buy modern forms of technology as the scale of their farming operations is too small for this to be a financially viable option. This means that many farmers are still dependent on traditional methods of working on their field, making the sector less productive than it could potentially be.With the economic environment driven by incentive, farmers will leave agriculture if the reward (or quality of life) from their efforts in the sector is greater in non –agriculture than in agriculture. It should also be noted that young people, the future farmers and food suppliers of the continent- will only become farmers if they are given the opportunity to enhance the rewards offered by the sector. In Africa, farmer's low level of income does not allow farmers to cultivate larger plot of land, nor make use of newer (and costlier) technology and developments which would make it a reasonable investment. This makes it more difficult for farmers to expand their activities to emerging commercial farming scale, as obtaining finance for such expansions will be hard. It is however; here the government can play a role in the industry, by helping farmers over the initial hurdle of boosting yields and expanding cultivated land, thereby increasing income from farming activities (Von Braun, 2005).

Over the last ten years, Africa has experienced a relatively strong economic growth, inspite of the setback occasioned by the food and financial crises, political tensions, as well as natural disasters in some African countries. The continent's economy grew at an average of 5.3 percent; far above the global average between 2001 and 2010, and even higher than that of developing East Asia and the pacific, which was at 3.8 percent average. However, Africa's GDP growth declined to 3.4 percent in 2011 primarily due to the conflicts in Sudan, and North Africa, and the Eurozone debt crisis. Nevertheless, GDP accelerated to 4.5 percent in 2012 and is projected to rise further as the political and economic situation stabilizes (Kanu et al, 2014).

Table 2.2.1: Shows the Economic wide indicators[2] in the surveyed Africa countries:

Country	GDP per capita (constant 2000 US$)	GDP per capita growth (annual %)	GDP per capita, PPP (constant 2005 international $)	Industry, value added (% of GDP)	Industry, value added (annual % growth)	Agriculture, value added (% of GDP)	Agriculture, value added (annual % growth)	Agriculture, value added (millions, constant 2000 US$)
Algeria	1,882.20	2.4	5,378.80	53.5	4.1	10.4	5.6	5260.9
Angola	734.3	6.5	2,950.70	67.1	10.5	8.2	11.3	671.6
Benin	311.4	1.3	1,175.90	13.8	4.5	35.3	5.6	840.6
Botswana	3,680.30	4.8	10,086.00	54.7	7.3	2.7	-1.6	142.8
Burkina	228.6	3.3	957.4	20.4	9.1	32.6	5.9	832.9
Burundi	106.2	-1.6	337.4	17.7	-2.3	43.2	-0.9	255.2
Comoros	379.4	-0.2	1,109.40	11.8	1.5	46.4	2.7	100.4
Congo, Dem. rep.	91.4	-2.1	274.2	23.3	4.4	48.4	-0.7	2213.3
Congo Republic	1,036.40	1.1	3,055.10	62.3	1.6	6.9	4.9	n.a.
Côte D'ivoire	599.8	-0.6	1,728.00	23.6	2.3	23.9	2.5	2430.1
Egypt	1,511.90	2.8	4,209.30	33.9	4.6	16.3	3.4	16121.6

Source: Zepeda F, and Sengupta G, (2010).

Table 2.2.1 above indicates that most of the surveyed African Countries (Algeria, Angola, Botswana, Comoros, Congo Republic, Cote D'ivoire and Egypt) have exhibited high GDP per Capita constant 2000 (US$) . However, when percent rank are taken into considerations in table 2.2.2 below, on average Algeria, Angola, Comoros, and Egypt registered strong overall economic status to adopt and use the GM technology, while the rest of the countries on the list have demonstrated an average economic position.

It is important to note that, Congo Democratic Republic has zero GDP per capita constant 2000 (US$) and also zero GDP purchasing power parity (PPP) constant 2005 but overall registered an average economic status, as evident with (++) to mean average/medium. A similar situation is observed for Botswana regarding Agricultural value added (% GDP) and

[2] GDP per capita (Constant 2000US$) is the growth domestics product divided by the population with 2000 as constant US $ prices.

Agricultural value added (annual % Growth). Burundi is the only country found to have low overall economic conditions to adopt and use the technology. The overall economic classifications are provided in table 2.2.2 below:

Table 2.2.2 below Shows the Economic classification based on the average percent rank

Country	Percent rank								Average	Classification
	GDP per capita (constant 2000 US$)	GDP per capita growth (annual %)	GDP per capita, PPP (constant 2005 international $)	Industry, value added (% of GDP)	Industry, value added (annual % growth)	Agriculture, value added (% of GDP)	Agriculture, value added (annual % growth)	Agriculture, value added (millions, constant 2000 US$)		
Algeria	0.816	0.6	0.836	0.897	0.425	0.163	0.851	0.934	0.69025	+++
Angola	0.693	0.96	0.714	0.979	0.914	0.122	1	0.478	0.7325	+++
Benin	0.428	0.38	0.489	0.102	0.553	0.653	0.829	0.586	0.5025	++
Botswana	0.897	0.9	0.918	0.938	0.765	0	0	0.195	0.576625	++
Burkina	0.204	0.76	0.346	0.367	0.893	0.612	0.893	0.565	0.58	++
Burundi	0.02	0.06	0.04	0.224	0.021	0.836	0.042	0.239	0.18525	+
Comoros	0.673	0.48	0.673	0.755	0.51	0.448	0.744	0.739	0.62775	+++
Congo, Dem. Rep.	0	0.04	0	0.469	0.489	0.918	0.063	0.76	0.342375	++
Congo Republic	0.714	0.32	0.734	0.959	0.127	0.081	0.68	N.A[3].	0.516429	++
Côte D'ivoire	0.653	0.14	0.653	0.51	0.148	0.469	0.297	0.804	0.45925	++
Egypt	0.795	0.72	0.795	0.816	0.617	0.265	0.446	1	0.68175	+++

Source: Zepeda F, and Sengupta G, (2010). + = low: ++=Average/Medium: +++ Strong: The average for each country is obtained by summing the values of all the economic wide indications divided by the number of economic wide indicators;

2.3 The State of GMO and Food Security in Africa.

Though African countries are paying great efforts towards the adoption of GM technology, yet they are faced with low willingness of the society in accepting GM products due to safety, ethical and environmental reasons (Molinelli and Ciliberti 2005). In addition, it was noted that GM technology has substantial benefits depending on how it is used (e.g., ethical production of GM crops) or dissemination of the information concerning benefit - costs of GMO to the society mainly for food security reasons. Personal attitudinal differences in terms of opinions and ethical standards (e.g., consumers right for selection of products, believes that it is unethical to treat nature in an industrial fashion or tampering with nature and arguments like playing with God and so on), have greatly discouraged the acceptance of GM technology in various countries of Africa (Daño 2007, Burkhardt 2000).

[3] N.A=Not Available

Africa's approach to agriculture biotechnology has been cautious. Only four African countries are growing Genetically Modified (GM) crops. The technology suggests that the process of genetic modification, by itself, poses are not free from risk of human health or the environment. The transformation of Africa's agriculture system will require new approaches, new technologies, new efficiencies, and the accompanying political focus needed to effect changes. Biotechnologies are one of the tools that can be used to achieve this, based on the experience from other countries. The relatively small-scale and heterogeneous nature of most African farms poses some issues with respect to stewardship, management and ownership of bio-tech crops. But various concerns and factors could potentially be managed in ways that will allow technology optimization with socially and culturally acceptable parameters. Savings in terms of increased gross margins, reduced pesticides, beneficial human and environmental effects and improved yields over conventional crops in the presence of pest pressure have been documented for small-scale Africa farmers growing commercial GM crops, despite high variation among crops, time and geographies.

The key issues related to the use of biotechnology in Africa include but not limited to the following;

(i) The capacity of Africa to innovate, create, adapt and transform its agriculture sector using the new tools of biotechnology is presently highly deficient

(ii) Most existing regulatory systems in Africa are inefficient, costly, lack transparency, and as very risk averse, which is not supported by an accumulating record of scientific evidence about the safety of the process.

(iii) On Intellectual property rights, while African countries have a number of options at their disposal to protect indigenous or external intellectual property assets, while simultaneously protecting the inventive step, few have made productive step forward . Overall there is a need for much education on the topic at senior political levels as well as the level of practitioners.

(iv) On trade and markets, the irregular adoption of genetically modified products throughout the world and their limited acceptance in the European Union, in particular, pose a number of trade-related issues for Africa and;

(v) The natural resource management and bio-diversity in terms of the risks posed for gene flow, non-target organism or threat to biodiversity (International Food Policy Research Institute 2012).

According to the International Food Policy Research Institute, Program For Biosafety Systems, study conducted on the determinants of national GM Biotechnology innovative capacity and policy and political reality in Africa (2012), the indicators used in the study are provided below:

The Overall Innovative Capacity Indicators-includes the scientific and technical Journal Articles (average), the scientific and technical Journal Articles (sum 1990–2005), personal computers and public spending on education, total (percent of GDP).

Intellectual Property Management Situation Indications- are the number of patent applications, non-residents (1987–2005, total, WBDI, 2008), the number of patents applications, residents (1987–2005, total, WBDI, 2008), total number of patent applications

(1987–2005, total, calculated) and the patent applications per million inhabitants (estimated by calculation)

Strength of the Private Sector Determinants includes -the domestic credit provided by they banking sector (% of GDP, average 1996-2006, WBDI, 2008), the ease of doing business index (ranking, 1=most business-friendly Regulations, average 2005-2007, WBDI, 2008); cost of business start-up procedures (% of GNI per capita, average 2003-2007, WBDI, 2008) and the time required to enforce a contract (days, average 2002-2007, WBDI, 2008).

The market size indicators involves- the land area (1,000 hectares, average 2000–2008), arable Land (hectares and percent of total average calculated from land and arable land) , crop production Index (Average 1997–2004,1999 –2001 = 100, WBDI,2008), Population Millions (average 1997–2006, WBDI, 2008) , the population growth rates percentage average 1997–2006, WBDI, 2008) and the aggregate value of agriculture percent of GDP 1997–2006 WBDI,2008).

For the Biotech capacity subjective classification-were the non-selective importers of tools, methods, and technologies, selective importers of tools, methods, and technologies, users of Biotechnology tools developers of Biotechnology tools, methods, and technologies were applied and;

Finally, for the Biosafety capacity achieved milestones- the completed national Biosafety framework, use of interim laws, policies regulations, confined or extended field trials and allowed for commercialization were used. The overall GM Biotechnology capacity for the surveyed African Countries is provided in Table 2.3.1

Table 2.3 1 below shows the Overall GM Biotechnology Capacity in the surveyed African Countries

	Common Innovation Infrastructure			Links, Networks and Technology Transfer Capacity		Cluster Specific Environment		Overall Classifications
Country	Overall Innovative Capacity	IP[4] Situation	Economy Wide Status	Market Size	Strength Of The Private Sector	Biotechnology Technical Capacity	Biosafety Regulatory Capacity	
Algeria	+++	+++	+++	++	++	+++	+	+++
Angola	++	++	+++	++	++	+	+	+
Burundi	++	++	+	++	+++	+	+	+

[4] IP= Intellectual Property

Côte D'ivoire	+++	+	++	++	++	+	+	+
Egypt	+++	+++	+++	++	+++	+++	++	+++
Ethiopia	+++	++	++	+++	++	++	++	++
Ghana	+++	++	++	+++	++	+	+	++
Kenya	+++	+++	++	++	++	++	++	++
Malawi	++	+++	++	++	++	+	+	+
Namibia	+++	+++	++	++	++	+	+	++
Nigeria	+++	++	+++	+++	++	++	++	+++
Rwanda	++	++	++	+++	++	+	+	+
Senegal	+++	+	++	++	++	++	+	+
South Africa	+++	+++	++	++	++	+++	++	+++
Tanzania	+++	++	++	+++	++	++	+	++
Uganda	+++	++	++	+++	++	++	++	++
Zambia	++	+++	++	++	++	++	++	++
Zimbabwe	+++	+++	++	++	+++	++	++	+++

Source: IFPRI (2012), World Bank Development Indicators (2002-2008), Food and Agriculture Organization Statistics (2000-2008) + = low: ++=Average/Medium: +++ Strong

Table 2.3.1 indicates that Algeria, Egypt, Nigeria, South Africa and Zimbabwe have strong overall capacity to adopt, use and innovate GM technology. Six countries including Angola, Cote D'Ivoire, Burundi, Malawi, Rwanda and Senegal have shown low overall capacity with the remaining countries exhibiting average capacity to adopt, innovate and use the GM Bio-technology.

Table 2.3 2 shows the Political realities of GMO in the surveyed African Countries:

Country	Ban/ Moratorium[5]	Limits on use	Year introduced/ reported
Algeria[6]	Yes	All GM crop	2000
Angola	Yes	No GM imports (maize)	2004
Benin	Maize	Two five year moratoria-in place until 2013.	2002
Botswana	Yes	No GM imports, milled GM food aid	2004
Lesotho	Yes	Government advisory that grains to be used only for food not cultivation	2003
Malawi	Yes	Un-milled products food aid; no GM imports	2002
Mozambique	Yes	Un-milled products food aid	2005
Namibia	Yes	Received wheat instead of maize for food; no GM imports	2002
Nigeria	Yes	Un-milled products food aid	2005
Sudan	Yes	Allowed import of GM food aid through temporary waivers	2003
Swaziland	Yes	Government advisory that grains to be used only for food not cultivation; changing GM acceptance/rejection for food aid	2002
Zambia	Yes	No GM imports, no GM food aid in 2002, milled GM food aid in emergency after	2002
Zimbabwe	Yes	No GM imports (1%) tolerance for maize and soybeans), identity preserved requirements for non-GM, milled GM food aid in 2002, no GM food aid after	2002

Source: Gruere and Sengupta (2010)

[5] The ban/moratorium was still in effect as per the study period (2000-2012) for this countries

[6] Algeria has a ban on distribution and commercialization of GM products and is still in force.

Table 2.3.2 revealed that most of the African countries surveyed have not adopted and used the GM technology, the importation of GM crops have been banned or moratorium declared by the governments of these countries. The implication is that most of the African countries have been lagging behind to adopt the technology percieved to protect their citizen against health and environmental concerns.

Table 2.3.3 shows the Mapping countries to policy situation of GMO for the surveyed African Countries:

Policy Situation	Objective to develop Bio-technology Capacity	Small Market	Medium Market	Large Market
Non selective bio-technology importers	Develop the framework for using bio-technology products	Seychelles, Sao –tome, Cape Verde, Comoros, Mauritius, Equatorial Guinea, Swaziland, Gambia, Bissau, Gabon, Lesotho, Botswana and Liberia	Angola, Benin, Burkina Faso, Burundi, Central Africa Republic, Congo Republic, Chad, Cote d'Ivoire, Eretria, Guinea, Libya, Mozambique, Mali, Rwanda, Mauritania, Senegal, Sierra Leone, Somalia, Togo and Zimbabwe	Cameroon, Congo, Democratic Republic of Sudan, Niger
Selective bio-technology importers	Improve the efficiency of agricultural research through the use of bio-technology tools	none	Namibia, Ghana and Tunisia	Uganda, Ethiopia, Tanzania, Algeria, Morocco, Zambia and Kenya
Bio-technology tools users	Improve the efficiency and R&D products	None	None	Nigeria, South Africa and Egypt
Bio-technology innovators	Take advantage of the development of innovation capacity based on bio-technology applications and the development of innovation	None	None	None

Source: James, C (2010)

Table 2.3.3 shows that the surveyed African countries have been classified into small, medium and large markets on the adoption, use and innovation of the GM technology. Nigeria, South Africa and Egypt are large markets and have got the potential to use the technology. However, no county in all of the various markets demonstrates the innovative capacity of GM technology. Majority of the countries are small and medium markets regarding the non-selective bio-technology and selective bio-technology importers.

3. Percieved Strength of GM Technology

Morris (2011), Orr and Parr (2012) , Bazuin et al. (2011) argued that African society would be in a good chance of food security and increased export of crops if they adopt GM technology. Ledermann and Novy (2012) developed that use of GM crops by farmers result into higher crops productivity and presence of various nutritious food (plants improvement) including soybeans, vegetables, rice etc that grows in different environmental conditions e.g., drought and infertile soils. The GM maize is more advantageous to naturally grown maize due to their high resistance to viruses, insects, and the African dry weather (Weale 2010). Thus, with GM technology smallholder farmers in Africa can use the insect resistant crop varieties to prevent their agricultural crops from fungal infections that in most cases originate from the moist and warm storage of crops. This has been possible because GM crops can withstand heat and drought that lead to enhanced nutritional and medicinal values and alleviation of the poverty in some Africa households. The potential benefits of GMO to consumers and farmers include decreased application of farming chemical inputs (pesticides) leading to reduced human health risks and reduced crops cultivation costs due to low application of chemical inputs because of the pest resistance of some GM crops with transgenic pesticides (Schnurr 2012). Another benefit is reduced food prices that increase the possibilities of the poor African's to feed their people such that the food insecurity and poverty (increased individual income) can be reduced significantly.

Qaim (2010) argued that substantial developments of GM crops were noticed including crop enrichment that is achieved by adjustments of nutritional elements of organisms. Usually the most famous crop enrichment can be seen from the golden rice. The rice contains some extra vitamin A which can protect people from blindness. For example (Bazuin et.al 2011) contended that about 30 to 40% of preschool children in South of Sub- Saharan Africa were suffering from vitamin A deficiency. Thus nutrients enrichment via GM technologies might solve the deficiency of micronutrients in the region. GM crops have been proven to potentially enrich the soil texture (fertility); GM crops are engineered in a way that they prosper not only in areas that are prone to drought, disease and pests, but also GM crops offer large biomass post-harvest compared to natural crops (Aerni 2005).

However, the increased GM crop production in the area can face challenges in terms of food distribution in various regions and farmers knowledge on how to sell their products. Therefore, policy makers have the major role to play on decision making. Through GM technology, some African countries were able to improve crops resistance against pests, diseases and drought, such that the agricultural productions increase significantly. For example Precise understanding of the benefits and costs of GM technology to civil society by Nigerian government Okeno et al. (2013) has documented that Nigeria, Kenya and Uganda are increasingly on field testing of GM crops with the view to commercialize them because

policy makers have succeeded to understand the benefits of GM technology while other countries of Africa are now investing in GM technology to find innovative solutions for future challenges of food insecurity.

Furthermore, the developed biosafety frameworks for GMO in East Africa Community (EAC) recommended common procedures for the EAC regional policy, trade and regulations on GMO in terms of food security, public health and environmental concerns. For example in Kenya, Uganda, and Tanzania great efforts have been made by respective governments to create awareness to the community on the benefits of GM technology such that safety and ethical issues of GMO were addressed (Wedding and Tuttle 2013). The EA community report of 2006 showed that EA countries ratified the Cartagena Protocol on Biosafety in September, 2003 such that they joined the 133 world countries which have significant contribution to the prevention of possible health risks that ensures safe transfer, handling and use of GM crops and animals (Okigbo et al 2011).

For the safety and ethical considerations of GMO, researchers have reported that, legal system has been introduced to handle all matters concerning GMO for example, the recognition of the Convention on Biological Diversity (CBD) as an international commitment to conserve biological diversity, sustainable use biological resources and equitable sharing of the benefits of the genetic resources, is a responsibility of all nations worldwide e.g., African countries (IUCN, 1994). This was explained by the speed with which the convention received signatures of ratification by contracting parties and come into force since 1993. To date, all countries in South of Saharan Africa except Somalia are parties to the Convention on Biological Diversity (CBD). For other EAC countries i.e., Kenya and Uganda the National focal points for biosafety of GMO products are controlled by the Council for Science and Technology, Vice President's office and the Ministry of Land Water and Natural Resources of each country (Cooke and Downie 2010). In Tanzania, safety aspects of GM crops and animals are clearly described in various regulations like the Tanzania Environmental Management Act (EMA) of 2004, Wildlife Act 2009 and the Forest Act 2002 (URT 2004, Phillips and Doggart 2011).

3.1 Percieved Weaknesses/Risks of GM Technology

Many scholars have reported arguments which indicate potential losses of GM technology to consumers as follows: Black et.al. (2011), Molinelli and Ciliberti (2005) argued that, poor understanding of the potential risks of GMO to human health and environment and mismanagement of GMO use and production might be the reason for the coward acceptance of GM technology in African countries. For example in Tanzania, the planned introduction of two GM crops including maize and cotton has raised challenging questions such as the right of choices and access of the information about safety (e.g., possibility of body cancer, diabetes or heart problems) and environmental aspects (e.g., accumulation of toxic substances in the food chain causing secondary poisoning to consumers) (Ledermann and Novy 2012). Furthermore, a recent study to explore consumer's knowledge and attitude to GM crops in Tanzania documented that, majority of Tanzanians are not aware of GMO and respondents shared the opinion that it is important to eat a healthy diet food, which they considered to be one which have enough calories and nutritious to prevent hunger (Lewis at al 2010).

According to Gregorowius et al. (2012) the use of GM technology transgenes might escape into wild populations during GMO production and the increased use of herbicides will cause toxins to enter the food supply chain and affect non-targeted organisms. It was further developed by researchers that, GM crops might cause a significant loss in genetic diversity of crops, since farmers would rely on producing a certain type of GM crops only as a result the risk of epidemics and soil degradation (loss of micro-organisms) will increase due to lack of genetic diversity in agriculture. Other opponents have publicized that there is a high risk of gene transfer from one GM crop to the non-GM crops whereby the modified genes were evidenced to move beyond the intended destinations such that they can contaminate other proximate non-GM crops easily (Jacobson and Myhr 2012). Normally this cross-pollination has serious negative impacts to the non-GM crop growers as GM characters in cash crops that are meant for export are not acceptable (e.g., in European market).

In addition, doubts have been raised with respect to the socio-economic implications of GMO in developing countries. Some consider high-tech applications as inappropriate for smallholder farmers and disruptive for traditional cultivation systems (Bawa and Anilakumar 2013). Also, there was a fear that, the dominance of multinational companies in GM technology and the international proliferation of intellectual property rights (IPRs) would lead to the exploitation of the local agricultural producers (Black et al. 2011). Hence, in this view, GM crops are rather counter-productive for food security and human development. Qaim (2010) argued that, the Golden rice for example which promises to reduce nutritional deficiencies and health problems among the poor through improving the vitamin A status of rice consumer's literatures revealed that, golden rice is not yet available in the market for most of the African countries. Bazuin (2011) argued that, the biotech companies have often remain silent in response to the public debates such that only a few companies have taken appropriate measures to develop tools that can manage the potential risks and uncertainties of GM crops. This cause many stakeholders to have dilemma on GMO products as most of their questions remain unanswered.

On the other hand, policy makers have also found themselves in an uncertain condition in the decision making because the criteria of risk acceptance have to be judged in a political process that includes broader issues such as ethical, social and cultural matters that lacks the scientific objectivity. However, increasing public skepticism towards GM crops is an example of a problem being complex in African countries in which experts, scientists and the general public disagrees. For example in the European Union (EU), the political solution to this problem has involved the adoption of precautionary principle for deliberate release of GMO. This principle is a political and value-laden instrument that withholds the implementation of the technology until its uncertainties are understood and has led to a de facto moratorium on GM crops within the EU (Borch and Rasmussen 2002).

The Amartya Sen capability approach can be related to the concept of GMO and food security in African based on how the main alternative resources of food are related with the utility. Resources e.g. food security is considered as an input, but their value depends upon individuals' ability to convert them into valuable functioning (i.e., the adaptations of GM technology and GMO uses), which depends on the side effects such as health problems, social norms, and environment impacts. Moreover Sen added that assessing capability is

more informational demanding than other accounts of advantage since it not only takes a much broader view of what well-being achievement consists of, but also tries to assess the freedom people actually have to choose high quality options. This is not a purely procedural matter of adding up the number of options available, since the option to use GMO has a rather different significance than the option to secure food. For example, Sen argues that the eradication of hunger from an area enhances the capability of individuals living there even though it does not increase the number of options those individuals have (since they do not have the option to live in poverty area anymore). Because the value of a capability set represents a person's effective freedom to live a valuable life in terms of the value of the functioning available to that individual, when the available functioning are improved, so is the person's effective freedom.

4. Authors Assessment/Evaluation of GMO and Food Security in Africa:-(Ethical Perspective)

Ethicist ideas on GMO is mainly emphasizing about consideration of equity, fairness and justice within the countries, in this vain the author's supports the GM technology on the grounds of assesing the specific needs of African countries on a case by case basis. Transparency, accountability, and decision making is another issue which need to be emphasized for the adoption of GM technology in Africa, for example decisions about when and how to use GM technology are driven by the individual interests of developers, distributors, and users, not by considerations of public good or general welfare, hence for safety and ethical consideration a balance should be created by policy makers to devise policies for the good of the general welfare of society in a sequential manner.

Lack of clear information about the possibility of human health problems (e.g., heart problems and cancer) after consumption of GM products is a serious issue for the low adaption of GM technology in Africa. Also, stakeholders might be in fear of producing more environmental problems (soil, air and water pollution) due to lack of GM based herbicides and insect resistant. Stakeholders and consumers would be convinced and change their mindset if convinced and assured that GMO are produced following the ethical principles such that no perceived risk to human-being line with Thiroux (2005), Daño (2007), Degeorge (2014) the basic ethical principles need to be adhered by GMO producers and are require of doing good for the welfare of people and understand the benefits of new technology, fidelity and responsibility of Governments and other stakeholders, value of life, dignity and respect for people's rights.

Given the unsatisfactory situation and negative attitude towards GMO of large parts of the population in African countries, what is highly needed is a new approach to deal with the authorization and use of GMO in agriculture. Though Africans' need food but the most important thing is provision of knowledge and technology to consumers as also argued by Amartya Sen (1987) that, no matter how the reality is complicated, it should reflect that complexity rather than take a shortcut by excluding all sorts of information from consideration in advance. The author's therefore, holds the view that evaluation of how well people are doing must seek to be as open-minded as possible to people. For example in areas that face climate change impacts and food insecurity in African, the priority should be on

research and development by introduction of modern technology (i.e., on a broad set of agricultural issues). This should be driven by the most pressing needs of smallholder farmers and educate citizens about potential opportunities and innovations towards adoption of the GM technology. However, Governments must seek for the transparency, accountability, obedience of rules and regulation in food labeling and transfer the information to consumers to ensure monitoring of the safety of GM products as Amartya Sen argued that whether or not people take up the options they have, the fact that they do have valuable options is significant. Therefore, evaluation must be sensitive to both actual achievements (functioning) and effective freedom (capability).

Based on the safety and ethical issues, most of the Southern and Eastern African (EA) countries have regularly placed restrictions on the importation of GM food. Hence, following the current condition of GM technology adoption in Africa, the question whether acceptance of GM technology has fulfilled the objectives of food security, or when GMO will be fully commercialized is still hidden. This can be explained by the condition that most African countries have not commercialized the GMO and the adoption is lagging behind compared to other countries of the world, the argument is that, the adverse effects of GM products are unclear (Cooke and Downie 2010). With consideration of these principles, all unnecessary risks of GM products could be avoided and consumers are assured of safe consumption. From the authors point of view most ethical issues to be followed in the introduction of GM technology in Africa should comprise the autonomy principle which suggest that, for new technology to be adopted each person should be given self-rule, respect and protect the rights of individuals, basic level of health is necessary for people to make decisions and obtain informed consent from all relevant parties for an action. Justice, right of choice, access to and dissemination of information and safety (i.e., potential health and environmental impacts) must be considered.

While food security concerns remain a great challenge for majority of Africa countries and in order to give meaning to the issue, the authors argued that socio-economic impact assessment considerations should be vigorously pursued by developers and regulators. This is because a technology should aim at contributing to sustainable development and is therefore hinged on the inter-generational responsibility of developers of the technology and regulators. From an ethical stand point, assessing the socio-economic impacts of GMOs would not only ensure that adverse effects are avoided or at least reduced but may also protect the interest and needs of the present as well as those of the future generations. To this end, a bottom-top approach is essential, involving the actors who may be affected by the potential impacts of GMOs, public awareness sensitization and active participation underlying the role of government and civil society in providing balance information to the public.

Given that GMOs technology has its merits and drawbacks, for example over the past 15 years GM crops producing countries have benefited from adoption of this new technology in the form of improved crop productivity, food security and the quality of life. Despite, these benefits to countries and farmers who grown GMOs many people are concerned about the suspected potential risks associated with the technology, this spike debate as to whether GM technology should be adopted or not. Given this scenario, a call for the need to raise the level of public awareness, prudent scientific investigation of safe application of the technology is

required to establish the reality, scope and other potential environmental risks due to the technology.

The fact that GM crops potentially benefit Africa countries towards poverty and hunger, improving agricultural productivity, health, food security and creating a friendly environment cannot be overemphasized. However, the adoption of the technology is at the initial stages in Africa and is currently faced with several constraints including poor infrastructural facilities, poor education, bio-safety regulations, intellectual property rights and many other concerns. On this basis, and given also that the technology is surrounded by a lot of controversies and it is at the initial stages in Africa. In the views of the authors, ethical concerns relating to the concerted efforts from developed countries including international organization should be put in place to ensure that Africa benefits from the technology, and Africa governments in turn should also be involved in solving the problem of the technology themselves by developing a coherent strategy to adopt modern bio-technology including educating the public, farmers, government institutions, the media and private companies to increase the scope and level of understanding of the GM technology. Hence common policies and regional platform through which Africa governments can engage in dialogue and develop a common bio-technology regulatory approach are necessary to poverty reduction, hunger and food security drive in Africa.

5. Conclusion

The study aims at investigating the ethical perspectives of GM technology and establishing the basis to inform policy makers on the adoption, use and the associated potential risks of the technology in addressing the concerns of hunger and food security problem in Africa. Specifically, the study seeks to identify the strength, weaknesses, opportunities and threats/risks on the implementation of GMO technology in Africa. A comprehensive review about adoption of GM technology in many countries around the world, specifically African countries have been performed. Based on this review, it can be established that, utilization of GM technology by various countries is still a long debate, due to the reluctance of the community especially Africa towards acceptance of GMO. The main concern is about ethics, human health and environmental concerns. Despite the fact that, some countries have strongly believes in the benefits of GM crops yet others have hesitated to use GM technology either by fearing of the risks of GM products to consumers believes that it is an unethical practice. In order to avoid these elements transpired through the development GMO all over the world, the Government and other stakeholders should adhere to the rules, policies and regulations in place before taking any action.

The study recognized the fact that South Africa, Egypt, Sudan and Burkina Faso have demonstrated the technical capacity to adopt and use the technology. However, majority of Africa countries do not have the capacity to adopt the technology although the potential exist. Additionally, no country in the surveyed Africa countries has the innovative capacity for the technology. The implication is that to innovate such technology may require financial and technical resources and the state of Africa weak economic capacity and poverty poses a serious problem. From an ethical consideration, for Africa to innovate and use the technology requires financial and technical support from the government, the private sector and donors

including the international financial institutions such as the United Nations and the World Bank.

The study noted that the state of GMO adoption and use particularly for commercialization purpose is by far lagging behind in Africa due to a number of factors including political, economic, social, financial and regulatory conditions and the difficulty experienced in intellectual property right, the long term period requires to get the innovation ready to be tested for commercialization could have cost implication to sustain the process. However to overcome these challenges, the political, economic, social financial and regulatory environment of Africa countries should be assessed on a case by case basis, and to also incorporate strong partnership with the public and the private sector with a view to proffer guidance for a robust approach on the adoption and use of the technology to address the concerns of hunger and food security in Africa.

Given the controversies that surround the GMO technology, the authors argued that for such technology to be adopted and used in Africa ethical issues such as involving the actors who may be affected by the potential impacts of GMOs, public awareness sensitization and active participation underlying the role of government and civil society in providing a balance information to the public on the technology are necessary in the hope that these measures may have the potential to consolidate the gains made from the technology to overcome hunger and food security problems in Africa, while at the same time mitigating the potential risks associated with such technology. Hence the need to create a balance between the use and adoption and overcoming the challenges and the hazards associated with the technology, with a view to increase the scope of research and development(R &D), prudent trade links, bilateral and multilateral cooperation among African countries and the rest of the world on the implementation of GMO technology.

Following the statistical data for the areas grown by GM crops, a possible inference could be that, until now there are no strong efforts in place by African governments to ensure adoption of GM technology with the exception of South Africa. The question is whether this reluctance of the governments towards adoption of GM technology is really caused by ethical issues, management, technical, or financial is still not clear. The existed difference in views and perceptions of ethicists and other professionals have also caused some hardships for the governments to enforce laws and regulations pertaining to GM technology. Similarly, for the African countries, especially East Africa it has been documented that GMO is on testing stage, i.e., they have not started to commercialize GMO crops and animals as other countries in the developed world. On this note, a more robust future study on the topic with a view to further provoke policy discourse is necessary to be carried. An interesting area worth researching on is an assessment of the right, justice, freedom and commercialization capacity of African countries to adopt, use and innovate the GM technology.

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