

Original Research Article**DROUGHTS AND AGRICULTURAL DEVELOPMENT IN AFRICA: THE GENETICALLY MODIFIED ORGANISMS (GMOs) MITIGATION STRATEGY IN FOOD SECURITY.****Abstract**

Climate change frequent droughts cause devastating famines, hunger and economic underdevelopment to rain fed dependent agricultural systems in Africa. Researchers have fronted Genetically modified foods as the strategy to mitigate against food security in Africa. Data for the study was collected from interviews with subsistence farmers in Kenya, analyzed reports from the National Bio Safety Authority, Kenya Agricultural Livestock and Research Organization and drought scenarios since 1968-72. It was established that GMO crops are only accepted by large scale commercial farmers but not accepted by small scale subsistence farmers who consist 90% of farmers. Agricultural research should focus on improving the quality and yields of indigenous crops instead of introducing the GMOs which can not provide the solution to climate change caused food insecurity in Africa.

Keywords:- genetic engineerig, Transgenic, Brachiaria grass, Fragile ecosystem, mitigation strategy

Introduction

Droughts are the most challenging and devastating climate change indicators to moisture constrained vulnerable Africa. The frequent droughts occurring in Africa since the Sahel drought of the 1960s have impacted negatively on majority subsistence and pastoral farmers who frequently suffer from famine and starvation caused by crop failure, lack of pasture, animal losses, water scarcity and malnutrition related diseases. The 2005/2006, 2009 and the 2011 droughts were declared “ National Disasters” by the government of Kenya, there by calling for emergency response in terms of relief food and water provision to the affected families. There are various strategies such as; emergence response, mitigation, adaptation and coping mechanisms employed by scientists, researchers,

national governments and stakeholders in the agricultural sector all focused on improving food security and stimulating economic development in Africa and other arid lands located within the tropics. One such a drought mitigation strategy which has elucidated heated debate globally is the use of Genetically Modified Organisms (GMO). The main objective of the study was to investigate the assertion that droughts are the cause of agricultural underdevelopment and food insecurity in Africa and that genetically modified organisms/foods can reverse this status. In order to come up with this interesting research topic, the researcher consulted the following resources; (i) attended the policy makers workshop on GMO organized by the South African Academy of Sciences, (ii) Analyzed GMO research debates from; the ministry of agriculture, the National Bio safety Authority, the National Environment Management Authority (NEMA), the Kenya Agricultural Livestock and Research Organization (KALRO), the multinational companies such as Monsanto, (iii) Interviewed small scale subsistence farmers on the causes of food shortages and acceptability of GMOs and analyzed data on drought scenarios in the dry lands of Africa since the 1960s when climate change became a noticeable devastating phenomenon in Africa. It was established that apart from droughts, there are many other compelling factors such as inadequate research, inadequate agricultural financing, poor food distribution, pests and diseases, delayed response to early warning systems, post harvest storages and poor crop and pasture selection techniques which contribute to low yields, crop failure, post harvest wastage and general food scarcity for both human beings and livestock. The strategies to employ will definitely depend on the cause of the particular food unavailability. GMO is not one of the most compelling strategies to food security in Africa when considering the grass root causes of food shortages 60% of the small scale subsistence farmers.

The Study is based on the assumption that frequent and prolonged droughts caused by climate change is the cause of underdevelopment, food insecurity and poverty in Africa's arid and semi-arid lands which depend on rain fed agriculture for socio-economic development, and the solution to food insecurity is by use of biotechnology. Proponents of biotechnology argue that in order to increase food production and meet the food demands

of the ever growing population, biotechnology (genetically modified organisms) must replace the old methods of food production.

Key words: Genetic engineering, transgenic, Brachiaria grass, Greenhouse farming, poly cropping, fragile ecosystems, mitigation strategy

Drought effects on Agriculture in Africa

The term drought implies the absence of precipitation for a period long enough to cause moisture deficiency, crop failure, water shortages, hunger, starvation and general hardship (Ngaira, 1999). Contemporary Africa is vulnerable to floods and droughts, degradation in the dry lands and coastal zones with 60% of the total land being Arid and semi arid lands (ASAL) for example the Sahara, Kalahari, Namib and arid Northern Kenya, Northern Uganda and Tanzania, characterized by rocky grounds, thorn and scattered shrubs and highly moisture stressed (plate 1).

Plate 1: Typical moisture stressed arid Turkana County, Kenya.



Droughts in Africa are caused by increase in global temperatures due to increase in the production of greenhouse gases mainly carbon dioxide and methane from industrial activities, deforestation for

73 firewood provision, over cultivation on fragile soils, overgrazing in the arid lands and failure of the Inter
74 tropical convergence Zone (ITCZ) to move far from Equator. The persistent droughts in Africa have
75 caused devastating impacts on agriculture resulting into; collapse of rain fed agriculture, reduced grain
76 yields, diminishing food security, increased heat stress in livestock and decrease in water volume of
77 major rivers which are used for irrigation, such as; the Nile, the Zambia, the Zambezi, the Volta, the Athi
78 and the Tana (DMCN, 2005). Droughts in Africa have greatly affected pastoral farming activities of the
79 Karayu in Ethiopia, Tueregs in the Sahel, the Masaai in Kenya and Tanzania and the Karamojong in
80 Uganda (Tearfund, 2010).

81 Almost the entire continent of Africa suffered severe droughts in the last quarter of the 20th century.
82 The 1970's was seen as a decade of unusual and extreme climate conditions which caused 1968-1973
83 Sahel droughts, where an estimated 50,000 - 200,000 people died from food shortage, 1974 failure of
84 monsoon winds in India, 1975 frosts in Brazil and 1977 experienced highest rainfall and floods in the
85 semi arid lands of Kenya. Ethiopia suffered severe drought in the 1980's. Drought occurrence is not a
86 phenomenon of the tropics alone, temperate lands do suffer from droughts as well. For example,

87 Studies of tree rings in the United States of America identified droughts occurring as early as 1220. The
88 longest drought identified by tree ring method began in 1276 and lasted 38 years. Tree ring method
89 identified twenty one (21) droughts lasting five (5) or more years during the period 1220 to 1958. The
90 most well known American drought was the "Dust Bowl" which occurred on the Great Plains in the
91 years, 1931-1936.

92 Table 1: Notable drought effects on agriculture in Africa

Year	Drought Effects
1968-73	Severe phase of drought in Ethiopia and the Sahel region caused crop failure, famine, and starvation, human and animal deaths.
1980-84	Severe drought in ASAL of Kenya led to crop failure, livestock loss and 274% increase in food prices in the super markets.
1984	Severe droughts in Ethiopia and Kenya led to the introduction of "Food queues" in supermarkets and the importation of yellow maize from USA as a coping strategy in Kenya.

1990-92	Serious drought in the ASAL of Kenya caused: i) 70% of the pastoralists in Wajir, West Pokot and Mandera lost all their livestock. ii) Total crop failure caused many people to die after eating dead dog meat.
1992-1993	Severe La Nina droughts in Zimbabwe decreased agricultural production where the economy shrunk by 12%.
2000-02	Severe droughts in Ethiopia caused the pastoral Karayu community to loose 70% of their livestock's.
2005-06	Severe droughts in ASAL Kenya and Uganda led to 90% livestock loss, making the pastoral Maasai community to migrate to Nairobi city centre with their animals in search of water and pasture. Kenya declared this drought a national disaster.
2009	10 million people faced starvation while 90% of livestock were lost in Kenya due to severe drought that caused massive crop failure, water scarcity and lack of pasture (plate 2 and 3). The drought was declared a national disaster by Kenya
2011	Droughts caused 12 million people in Djibouti, Ethiopia, Kenya, Somalia and Uganda to face acute starvation and malnutrition, with food prices rising as much as 270% within the year. The drought was declared a national disaster in Kenya.

Source: Ngaira, 1999, Tearfund, 2010, UN , 2013.

Plate 2: .scramble for scarce bore hole water in the semi-arid Laikipia County in 2009



103 The 1st decade of the 21st century was seen as the driest in 100 years. The 2008-2009 failure of rains in
 104 Kenya's arid and semi-arid lands particularly the Eastern region, put 10 million Kenyans at severe risk of
 105 starvation and possible death with loss of over 90% of livestock due to acute water scarcity and lack of
 106 pasture (plate 2).

107

108 Plate 3. Effect of 2009 drought on livestock in Arid Turkana County



109

110 The 4th Assessment Report of the (IPCC) Intergovernmental panel on climate change 2007 confirmed
 111 that "Africa is one of the most vulnerable continents to climate variability and change because of
 112 multiple stresses and low adaptive capability. The diversity of the people, varying ecosystems, natural
 113 resources (minerals, plants, water availability) social and political histories (the Arab North, the "Black"
 114 South of the Saharan Africa and the "white" Southern Africa makes it difficult to find common solutions
 115 about the threats posed by the pressing "climate change and food security on the African continent."
 116 African people face serious social and economic challenges due to diseases, high poverty and poor
 117 nutrition levels with ten (10) poorest nations in the world being located in tropical and sub-tropical
 118 Africa (IPCC, 2007).

119 **Characteristics of agriculture in Africa**

120 Agriculture has great potential and holds the key to rapid job creation, improved health and
121 improved livelihoods for the majority of the poor people living in the tropics. In essence,
122 agriculture goes beyond farms and creates opportunities for growth and development in
123 health, trade, transport, education, energy and information and communication technology.

124 Agriculture within tropical Africa is rain fed, productivity is often low and it has been diminishing due to
125 rainfall fluctuations and frequent drought episodes (table 1). Most industries in the tropics are agro-
126 based, mainly processing agricultural produce for example sugarcane in Lugazi Uganda and Tea in the
127 Kenya highlands. It is practiced on extensive subsistence level in the arid and semi-arid lands.
128 Monoculture characterizes commercial farming, for example Tea and Coffee in the East African
129 highland, Cocoa in West Africa and Maize in the Maize Triangle in the Republic of South Africa. There is
130 little mechanization and is largely labour intensive, for example, tea picking, sugar cane weeding and
131 harvesting. Subsistence agriculture is practiced on highly fragile ecosystems such as hilly areas, dry
132 lands and wetlands. Frequent price fluctuation and fall due to droughts and floods lead to food crisis for
133 example, in 2017 in Kenya, due to 2016 droughts, the price of 2kg maize flour rose by 50% from kshs 85
134 to ksh 170 within six months.

135 There is duplication of cash crop farming for example, coffee in Brazil, Kenya, Tanzania and Uganda,
136 Maize in Kenya highlands and in South Africa's "Maize Triangle". This type of duplication makes
137 agricultural economies vulnerable at the slightest change in climate patterns. The tropics are
138 characterized by poor internal and external markets due to duplication and exportation of semi-
139 processed goods.

140 Agriculture constitutes about 30% of Africa's Gross Domestic Product, and provides only 60% of food
141 supply to the population, this means that food demand is higher than supply. The food balance sheet is
142 characterized by food imports and food aids from the developed countries, for example, Kenya
143 imported yellow maize from USA during the 1984 drought and white maize from Brazil in 2017 maize
144 flour crisis.

145 There is very low input investment in the agricultural sector, for example, Africa invests only 4%, and
146 Mali invests 11%, Burkina Faso 15% and Ethiopia 17%. The use of fertilizer is very low in Africa with 8

kg/ha compared to the global average of 100 kg/ha resulting in low crop yields in tons per hectare (Kalibata, 2006). In sub-Saharan Africa, agriculture employs 60% of the population (Tearfund, 2010). Women provide 80% of the labour force on farms, such as planting, harvesting, processing and responsible for both food production and food preparation for their families but, they have no land ownership rights, they receive only 5% of extension services, they are underrepresented in research, training and policy-making positions.

Rapid population growth has led to a change from traditional agricultural systems where about 7,000 plant species with varieties that could cope with changing climate were cultivated for food since agriculture began about 12,000 years ago to intensive modern agricultural systems with only about 15 plant species and 8 animal species supplying 90% of food. Many traits from wild relatives were incorporated into the modern crop varieties to improve productivity and tolerance to pests, diseases and difficult growing conditions, unfortunately, many wild races of staple food crops are endangered and are predicted to die out within the next 50 years which could make it difficult for future plant breeders to ensure that commercial varieties can cope with a changing climate (Pedulosi et al, 2011). Agriculture which is the main source of livelihood for 75% of the world's rural poor mainly in Africa is also the human activity most affected by climate change, particularly droughts, however, agricultural research and technology does not reach and benefit small scale subsistence farmers on the continent.

Though Africa has a history of extreme food shortage scenarios caused by both natural and man-made disasters in regards to food security, It is important to note that, the top most causes of food insecurity are not necessarily unfavorable weather conditions or lack of land but poverty and other causative issues such as: global warming and lack of early warning systems, Natural disasters, Poverty, Culture, Lack of farm inputs, Poor post harvest storage, Infrastructure, Civil unrest, Poor governance, Illiteracy levels, Population pressure, Pests and Rural urban Migrations (Mbofung, 2010, Lisa et al,1999).

The meaning of Genetically Modified Organisms (GMO)

Genetic modification is the artificial modification of an organisms genetic composition. This involves the transfer of genes from one organism into another organism of a different species in order to give the latter specific traits of the former organism. The resulting new organism is then called a transgenic or genetically modified organism. Examples of such organisms include plants that are resistant to certain insects, can withstand herbicides and can also survive in

moisture constrained conditions. Though genetic engineering is also being used on farm animals, so far no genetically engineered animal products have been approved by the Food and Drug Administration (FDA) for human consumption (www.investopedia.com/terms/genetically-modified-gmf.asp). Genetically modified foods, also known as genetically engineered foods or bioengineered foods are those foods produced from organisms that have had their genes engineered to introduce traits that have not been created through natural selection, but changes introduced into their DNA using genetic engineering methods. Simply put it that genetically modifying a food involves introducing a gene into a fruit or vegetable or animals from another organism. Scientists, consumers and environmental groups have cited many health and environmental risks associated with foods containing GMOs. Many countries have either passed or proposed legislations which regulate the development and use of GMOs in the food supply (Sven-Erik et al, 2013).

Methods of data collection

Data for this study was collected from the following sources; (i) The researcher attended the policy makers workshop on GMO organized by the South African Academy of Sciences, (ii) Analyzed GMO research debates from; the ministry of agriculture, the National Bio safety Authority, the National Environment Management Authority (NEMA), the Kenya Agricultural Livestock and Research Organization (KALRO), the multinational companies such as Monsanto, (iii) Interviewed small scale subsistence farmers on the causes of food shortages and acceptability of GMOs and analyzed data on drought scenarios in the dry lands of Africa since the 1960s when climate change became a noticeable devastating phenomenon in Africa, (iv) reviewed literature on GMOs from journals, text books, Newspapers and internet surveys. The analyzed data was presented in the form of critical discussions, photographs, tables and illustrating examples. The results were organized and presented under the following sub headings; the GMO strategy in food security provision, anti-GMO school of thought, negative impacts of GMO, the pro-GMO School of thought, acceptable strategies for agricultural development and food security provision, conclusion and references.

203 **Results and discussions**

204 **The GMOs as a mitigation strategy in food security in Africa.**

205 Commercial cultivation of genetically engineered crops such as soybean, maize and cotton started in the
206 early 1990s. GMO crops were commercially planted on 150 million hectares of land in 22 developed and
207 developing countries as at 2010.

208 The most popular method advanced by some agricultural scientists for mitigating food
209 insecurity in poor countries located within the tropics, is by use of Genetically Modified
210 Organisms. Koffi Annan, the chair of the board for Alliance for Green Revolution in Africa
211 (AGRA) stated that the organization will not include GMOs in its dealings with farmers, but
212 instead will work with indigenous species. He emphasized that the major causes of Food
213 insecurity in Africa were as a result of issues such as poor infrastructure, out dated farming
214 practices, Storage issues and dwindling market prices which discourage farmers from consistent
215 farming as a source of income (Mastny, 2011). Of all the challenges stated, none can be solved
216 by the introduction of GM crops (Tirado and Johnston 2010). African farmers who mostly
217 engage in subsistence farming cannot embrace food products that require purchase of seeds
218 every planting season without any allowance to replant the seeds after harvest.

219 The information made available on these new breeds courtesy of Biotechnological Companies
220 such as Sygenta and Monsanto is limited to promotional and marketing geared towards
221 stimulating purchase rather than disseminating factual information to consumers. A lot of
222 information readily available focuses on the ‘perceived benefits to farmers. Some Developing
223 countries have embraced GMO products as the solution to food insecurity without careful
224 scrutiny of the long term effects. This has been largely due to the immediate needs of the
225 people who usually are at risk of starving to death without relief food or short term sources of
226 the same. It is therefore a mix of desperation combined with the unrealistic pursuit of ‘Quick
227 fixes,’ to challenges which require long term solutions (Henk-Jan et al, 2011). The three major
228 GM seed companies; Mosanto ,Dupont and Sygenta control more than 65% of the market thus
229 exercising a great deal of control over the prices. African countries such as Rwanda, which are

230 already surviving on substantial amounts of donor funding in their development agenda may
 231 find GMO pursuit an extra burden on their strained economies (Mayet, 2004). From an
 232 economic point of view, the major agenda of GM seed companies is to expand and develop a
 233 ready market for their products in third world countries, stimulate dependence by farmers and
 234 establish territories in African countries, governments and their agricultural sectors (Tirado and
 235 Johnston, 2010). GMO research focuses mainly on producing increased yields of selected crops
 236 such as maize, cotton and sugar cane with little regard to diverse cultures and foodways of
 237 African people. Genetic modification is only one of the tools that farmers can use to boost
 238 productivity, it does not eliminate other tools such as; hybridization, spray of chemicals,
 239 mechanization and cross pollination (Micheal et al, 2012).

240 A non-profit making independent research organization established that the associated
 241 increased yields used in the promotion of GM crops are relative or non-existent. It all depends
 242 on a variety of factors beyond anyone's control such as water, market policies, cost of seeds or
 243 even the availability of cheaper alternatives. According to the report, no conclusive evidence
 244 supports the exaggerated claims purported by the GM seed companies currently (Micheal et al,
 245 2012).

246 The advent of research on Genetically Modified Organisms in agriculture has created dilemma
 247 and changed the content and nature on how the governments should respond to the persistent
 248 problem of underdevelopment and food insecurity in arid and semi-arid lands of Africa. Two
 249 extreme schools of thought pulling in different directions have emerged; the pro GMO and the
 250 anti-GMO. The pro-GM school of thought does catalogue the benefits of genetic engineering
 251 and normally dismiss all the risk concerns raised by the anti-GMO school of thought. They try to
 252 justify that genetic engineering is the solution to eradicating food insecurity and stimulating
 253 economic development in the ASALs of Africa (ASSAf, 2010). On the other hand, the anti- GMO
 254 school of thought is deeply worried about the risks and dangers that would afflict the ASALs
 255 should genetic engineering be developed, commercialized and applied (Hoban, 2004). The two
 256 schools of thought have tended to confuse many African policymakers and the public because
 257 of lack of scientifically proven reliable information. There is uncertainty, confusion and division

among governments in Africa on how best to respond to food insecurity and on how to achieve long-term agricultural growth, food security and economic development.

Anti- GMO school of thought

The anti-GMO critics argue that there is uncertainty as to the effects of GMOs on health of consumers as well as the impact on the environment. For example, GMO may squeeze out conventional fruits or vegetables from the environment which may in turn impact the animals, insects and other organisms that traditionally used those plants to survive. Other threats include genes from the GMO moving to conventional crops (out crossing) or may even be transferred from food to the consumers (Biosafety report, 2015). This school of thought is concerned that the agribusiness where a few seed varieties which need fertilizers and pesticides do well has actually eroded indigenous crop varieties and caused hunger and malnutrition to subsistence farmers (Kruff, 2001). Developed countries can help arid African countries to be food secure by supporting the revival of seed saving practices to ensure food variety at family levels. This is because GMO companies do not save seeds while 90% of subsistence farmers in Africa save their seeds for replanting, therefore, if the subsistence farmers cross pollinate their seeds with GMO or adopt GMO then, they will be exposed to hunger and food insecurity since they will not be able to protect seed varieties which they have taken generations to develop and share (Kruff, 2001). At the same time, farmers whose indigenous crops were cross pollinated by GM pollens were sued by those GM companies.

A good example of the dilemma and non acceptability of the suitability of GMOs as a recommended solution to food insecurity is the food shortage case of Southern Africa states in the spring of 2002. Due to erratic rainfall and floods, more than 15 million people were left at the mercy of donors due to acute food shortage. International concerns led to the distribution of relief food, but the then touted as 'controversial decision' by Zimbabwe, Zambia, Malawi and Mozambique to decline relief food due to inclusion of GMOs raised concerns as to the motives of such a plan (Hoban, 2004). These particular relief efforts courtesy of the United States government via USAID contained GMO maize and those African countries despite the crisis,

285 refused to accept them. The US then tried to link the entire crisis on poor governance and
 286 mismanagement in the affected countries. Research by European Union consultants and
 287 Zambian scientists concluded that the maize offered as relief had the genetic characteristics
 288 that would interfere and dominate the indigenous varieties through cross breeding. A similar
 289 scenario had been witnessed in Mexico where surplus relief maize was used as seeds by
 290 farmers and eroded the natural varieties (Zerbe, 2004, Kruff, 2001). Refusal of this brand of
 291 relief food by African governments has repeatedly been met by harsh criticisms, but one has to
 292 consider the negative long term effects of such assistance to the economies of these countries
 293 in particular from the European Union's policy on GMOs. African countries like other sovereign
 294 states are justified to protect their interests by ensuring economic stability which reduces
 295 dependence on donor funding (Vidal, 2011b). The European Union heeding to its population's
 296 pressure is yet to yield into the GMO phenomenon. EU does not engage in any form of
 297 commercial GMO based agriculture. It is known to import organic Agricultural produce paying
 298 the extra costs involved. European Union is also known to discontinue trade with countries that
 299 actively pursue biotechnological based farming; it discontinued trade with America which was
 300 one of its biggest organic producers before 1996 on bio-tech farming basis.

301 The World watch institute report established that sustainable means of combating food
 302 shortage is not dependent on the constant development of new crop varieties and breeds but
 303 on proper management of indigenous traditional crops that will be both suited for the regions
 304 climatic conditions and will also restore the biodiversity of the region (Pedulosi et al, 2011). It is
 305 important for food producers to be aware of the environmental and health consequences of
 306 GMOs. In the long-run, it has been established that the often suggested need for these
 307 biologically enhanced organisms are unnecessary in cases where indigenous alternatives are
 308 readily available especially in Africa (Makinde, 2009). The anti GMO school of thought insists
 309 that Traditional African farming systems have a diversity of seed varieties and vast amount of
 310 ecological knowledge, they have many types of seeds with better nutritional value which have
 311 evolved with resilience to local pests and diseases and are adapted to different soils and
 312 weather patterns which provide concrete resilience strategy than developing a single crop

313 which can fail to give various nutrition values and which can also fail with changes in climate
314 extremes especially droughts.

315 Therefore, GMOs do not offer solutions to Africa's peasant farmers who are better suited to
316 manage indigenous crops. The argument that GMOs will increase yields and improve food
317 production is not correct since the success and application of GM seeds does well on large
318 farms with a lot of resources while majority (90%) of African families survive on subsistence and
319 small scale farming (FAO, 2010). A controversial case documented in Kenya and which gained
320 worldwide attention was when the Monsanto backed "African Harvest group" declared after
321 extended research it had developed a new pest resistant sweet potato which would increase a
322 farmer's income by up to 39%. These claims were however exposed as lies when independent
323 research confirmed that the GM sweet potatoes not only performed poorly compared to the
324 organic counterparts but were also susceptible to the pests they were engineered to repel. The
325 capitalistic agenda of the GMO multinational companies has never been so clearly expressed.

326 Some farmers from poor nations have suffered irreversible negative impacts when the "high
327 yielding" GMO narrative failed them after heavy investment. A practical example is when
328 Monsanto which controls 95% of India's cotton seed market hiked prices that left farmers with
329 debts. 250,000 farmers were reported to have committed suicide due to debts incurred in
330 purchasing expensive seeds wrongly marketed as high yielding. When the yields failed to meet
331 the financial projections, peasant farmers resorted to suicide among other desperate acts out
332 of frustrations (Vidal, 2011, Makinde, 2009).

333 Focused research has led to specialized genetic modification and greatly reduced the
334 biodiversity of crops and livestock. A focus on the biological factors that determine crop yields
335 such as Environment and crop management need dedicated investigation as research indicate
336 they directly influence the increase in crop yields. This should be pursued with more if not
337 equal commitment to that assigned to GMOs. It is rather disturbing when the research
338 community blatantly ignores exploring other alternatives. However, when one considers that
339 the research companies are privately funded, then the capitalistic agendas of these institutions

become obvious because, there is simply no profit in traditional organic cross breeding as it cannot be patented or regulated (Fischar, 2009, Pretty, 2003).

Research communities have not allocated enough resources on organic crops while GMOs receive the bulk of research funding. Denmark for example, spent 4 million EUR in organic crop research while a whopping 20 million EUR was spent by the Danish Research Council on GMO research (European Union, 2010).

It has been established that genetic engineering benefits large Agric- business companies such as Syngenta and Monsanto of which most are researching in production technologies that respond to Global Marketplace. They do not invest in genetic engineering of indigenous crops which are not globally traded and which are the basis of food security for subsistence farmers in Africa. The biosafety laws of most African countries have serious shortfalls which must be addressed in order to convince farmers to adopt the GMO. Some of the gray areas include; (i) there is a lot of emphasis on regulating the importation and introduction of GMOs developed elsewhere into the country, but these laws are silent on measures put forward to regulate and promote domestic scientific research, (ii) the biosafety laws do not have explicit measures for promoting research on biosafety in general and risk assessment in particular

Negative Impacts of genetically modified foods

The anti-GMO School of thought has established some negative impacts associated with either consumption or application of GMOs as indicated: (i) That though the genes being transferred occur naturally in other species, there are unknown consequences to altering the natural state on an organism through **foreign gene expression**. Such alterations can change the organism's metabolism, growth rate and response to external environmental factors. These consequences may influence the GMO itself, the natural environment in which the organism is allowed to proliferate. Potential human risks include the possibility of exposure to new allergens in GMO foods and the transfer of antibiotic resistant genes to gut Flora (Ma J, 2003).

(ii) The American Academy of Environmental Science has consistently linked GM foods with infertility, weakened immune systems and insulin imbalance among human consumers. In the worst case pitted against these products, research on mice indicates that GM products when

368 consumed reduced the natural digestive enzymes thus making the mice allergic to non –GMO
369 foods. The food samples used in these researches were those already in the American market
370 targeting human consumers (Doctors health warning, 2012)

371 (iii) The “Responsible Technology” community who carried out research on the effects of the
372 consumption of GMO products established that the genetic material such as those inserted in
373 Soybean continues to survive in the human body as they get incorporated into the bacteria
374 found in the human digestive tract. In addition, the genetic advantages which enable these
375 crops to be herbicide resistant also encourage farmers to use more herbicide amounts thus
376 increasing the amount of residue from herbicide that stays within the food post harvest. An
377 even higher risk potential is the anti-biotic resistant genes that are incorporated in some GM
378 crops which may lead to super infections that are also antibiotic resistant. (Doctors health
379 warning, 2012).

380 (iv) Many ASAL countries in Africa have limited financial resources that are needed to deal with
381 emergent risk events that may be caused by adoption of GMOs or even the resources needed
382 to develop and implement effective regulations. By default, most developing countries are also
383 rich in biodiversity by virtue of their vastly unexploited natural resources which unfortunately
384 are at the highest risk of having their pure gene pool contaminated with the GMO adoption.
385 Good examples of such areas are the centres of genetic origin and biodiversity in Ethiopia and
386 the Mediterranean region which need utmost protection from gene contamination by GM
387 crops. (Bio-safety report, 2015). Either way t he researchers who are available to train local
388 researchers or offer consultancy services are all from the Multi-National companies,
389 Foundations or Research groups that are pro-GMO, therefore, limiting objective research while
390 giving opportunity for bias. (v) The Cabinet Secretary for Agriculture Mr. Willy Bett while
391 advising the Government of Kenya on GMO Research, stated that:- The National Performance
392 Trials (NPTS) which the Kenya University Biotechnology Consortium (Kubico) was advocating for
393 on Genetically Modified Organisms (GMOs) would adversely affect traditionally grown crops
394 through cross pollination and that the Kenyan Farmers were not convinced that GMO crops are
395 safe and pose no threats to Conventional Agriculture (***Daily Nation, March 27/2017***).

396 **Pro –GMO school of thought**

397 The proponents of GMOs point to many benefits of introducing desirable genetic traits into
 398 food. For example, scientists may engineer fruits and vegetables to have higher yields, resist
 399 certain diseases, pests and be able to tolerate pesticides and herbicides, they argue that
 400 biotech maize has toxic proteins that kill pests and therefore secure the plant against insect
 401 invasion. Basing on army worm invasion and destruction of thousands of acres of maize in the
 402 maize producing areas of Trans Nzoia, Uasin Gishu, Bungoma, Nakuru and Busia in Kenya, and
 403 the ministry of agriculture projected drop in maize harvests from 37.1 million bags in 2016 to
 404 32.8 million bags in 2017 representing 11.5% decline, Scientists call upon the government of
 405 Kenya to allow field trials and commercialization of bio-tech maize variety which are pest
 406 resistant (***Sunday Nation, June/11/2017***). The 20th Century Green Revolution owed much of its
 407 success to the introduction of plants that could produce higher yields in more adverse
 408 conditions such as arid lands. The GMO debate is particularly sensitive for countries that rely on
 409 Agricultural exports as the backbone of their economy such as Kenya. USAID which is pro
 410 biotechnology is also partisan in the American foreign policy which seeks to find market for its
 411 surplus GMO products, establish a market for Biotechnological corporations such as Monsanto
 412 by leveraging GMO inclusive relief food as the only option for aid to African states faced with
 413 food insecurity (Zerbe,2004). Bodies such as the Agricultural Biotechnology Support Program
 414 (ABSP) and Program for Bio-safety Systems (PBS) are both pro- GMO and are funded by USAID.
 415 They have over the years maintained the ‘GMO are safe’ narrative while labeling governments
 416 that oppose them as retrogressive thus permeating policies with great success making some
 417 countries to lower their bio-safety protocol standards. In essence these are basically GMO
 418 lobby groups and should be viewed as such.

419 African countries such as Kenya and South Africa which seem to be very pro-GMO even in
 420 official policy, hold these positions as a result of lobbying, hand –outs and smart marketing by
 421 the heavy presence of interested Parties that range from the Multinational seed producers,
 422 local Agribusiness industry players, Government based research bodies that are foreign funded
 423 or supported in GMO research and the government policies that allow adoption of these crops

(ISAAA Brief, 2011). The Kofi Annan chaired board for the Alliance for a Green Revolution in Africa (AGRA) may seem as a buffer to these campaigns by pro-GMO groups since Annan publicly declared zero tolerance policy on GMOs being a part of the program when dealing with farmers. However this landmark statement appears to have been sourced from core supporters of pro-GMO companies with the largest fertilizer manufacturer funded groups such as the Yara foundation, Syngenta, Monsanto and the Pro- GMO supporter Bill & Melinda Gates foundation. (Sven-Erik, 2013).

Acceptable Strategies for Agricultural Development and Food Security in Africa

The study established various strategies that can be applied depending on the cause of the prevailing food insecurity problem. The strategies include; emergency response in terms of food, water and pasture provision, rehabilitation through livelihood restoration, mitigation through planting drought resistant crops, adaptation and coping mechanisms.

Understanding the fact that, 60% of the farmers practice small scale subsistence crop and livestock farming in Africa and that there are many other causes of food insecurity, drought included; the study established that there are many other compelling, applicable, cheap, acceptable and readily available strategies to the 60% small scale subsistence farmers than the GMO which requires heavy financial investment and will be available to few large scale commercial farmers. Some of the readily available and acceptable strategies include the following:

(i). Evidence based conclusive research; In 2016, National Bio safety Authority (NBA) approved Water Efficient Maize for Africa (WEMA) field trials to be carried out by Kenya Agricultural Livestock Research Organization (KALRO) and African Agricultural Technology Foundation (AATF) on condition that:- The two seek a permit from NEMA. In fact NBA instructed KALRO and (AATF) to work closely with the: **“Kenya Plant Health Service (Kephis) during field trials to safeguard Public Health”**. WEMA aimed at producing a drought resistant maize variety as a way of promoting food security among Africans. By giving this condition, NBA was acknowledging the fact that GMOs pose an environmental Public Health problem to Kenyans. The National

Environmental Management Authority (NEMA) has emphatically stated that it is “taking due care to avoid GMOs entering Kenya’s Market Chain” and that NEMA must be assured that KALRO and AATF have the capacity to mitigate against cross pollination to safeguard citizens against consuming untested foodstuffs that could contain harmful toxins. ***Daily Nation, April 4/2017***. The Director General NEMA says “No License for National Field Trials on GMO will be issued before the design is scrutinized to ascertain safety of the entire research process”. As at April 2017, licensing of research and Field Trials for GMOs had not been approved. This shows how the government and anti-GMOs in Kenya have not accepted GMO crops until Scientists submit proven rehabilitation and mitigation strategies in the event that the WEMA (GMO) variety contains harmful toxins to humans and the environment.

(ii) Financial Investment: According to World Bank report, raising crop yields by 10% reduces poverty levels by about 7%. Agriculture contributes 32% of Africa’s Gross Domestic Product – GDP and employs 65% of the workforce hence the need to make it Sustainable. Africa is endowed with immense natural wealth for example; it has 10% of the Worlds renewable water resource and 60% of arable land, most of which remains uncultivated (Padulosi et al 2011). Investment in Africa should target the small scale subsistence farmers who account for 60% of the food produced in Africa in order to improve food security, drive the economic development and increase the welfare of the citizens. Banks have been reluctant to finance agriculture due to the inherent weather related risks and lack of collateral, however, banks and other financial institutions must start looking at sustainable agribusiness both as an invaluable venture and for its role in food security. In order to realize good benefits by agricultural financiers, there is need for integrated strategies approach which can lead to curtailing of costs and risks. Some of the strategies may include providing non financial products such as market intelligence using ICT and technical support in capacity building (***Daily Nation, May 10th 2017***).

The African Union by using the following development mitigation strategies tried to address the Agricultural funding which is a major factor in the agribusiness transformation and development; a) The Comprehensive African Agricultural Development Programme CAADP,(b) the Malabo and Mabuto declaration where African Countries were required to allocate 10% of

480 their national budgets to Agriculture in order to achieve a hunger free continent as stipulated in
481 African Union –AU Agenda 2063.

482 (iii) Post harvest food storage and preservation.

483 Many African countries, Kenya included do not have post harvest Policies and there is no single
484 institution of higher learning in Kenya that offers a course in post harvest management. Dr
485 Thomas Dubois, the regional director of the World Vegetable Centre for Eastern and Southern
486 Africa-WVCEA while addressing the First All Africa postharvest Congress and exhibition in
487 March 2017 in Nairobi emphasized that African Countries need to allocate more resources on
488 food preservation as mitigation strategy to avoid food losses. He noted with concern that when
489 funds are allocated to enhance food security, about 95% of these funds is directed to food
490 production. Efforts should deliberately be made to enhance food storage, market access and
491 food distribution. Africa must design right technologies which can identify the stages at which
492 value chain food losses occur and before any technology is taken to farmers, it must first be
493 tested. Re cycling of post harvest residues back to farms keeps soil nutrients and soil fertility
494 (Daily ***Nation paper, March 27th, 2017***)

495
496 (iv) Drought Resistant Animal Feed (Brachiaria grass]

497
498 Arid lands make up 80 per cent of the total land area in Kenya. This is where 90 per cent of
499 livestock is reared and livestock farmers found in these regions need resilient animal feed since
500 the land is moisture stressed. Brachiaria grass seems to be a reliable adaptation strategy. The
501 wild grass is native of Africa and has been used to transform livestock production in South
502 America. It fixes soil minerals such as nitrogen, phosphorous and carbon, which are often
503 lacking in arid areas. Brachiaria looks like Napier grass, but grows taller and produces seeds
504 which replenish the grass after harvest. The wild grass is disease and drought resistant, it
505 produces nineteen (19) tonnes of green fodder per acre and about (9) nine tones of fodder
506 after drying. ***Daily Nation Paper May 9/2017.***

507 KALRO needs to take the lead and sensitize pastoral communities to adopt, grow and feed their
 508 livestock on this grass during droughts in order to avoid the great losses incurred during
 509 drought episodes. Pastoralists need the livestock food not the GMO breed of livestock.

510



511

512 Plate 4; The Brachiaria grass farmer in Machakos County.

513

514 (v) Commercialization and value addition.

515 Commercialization and value addition to agricultural products in Africa is the strategy that will
 516 economically empower the farmer and eradicate food insecurity (Frison, 2009). For example, in
 517 2017 West Pokot County, dairy farmers' income from sale of raw milk to the processor
 518 Brookside Company rose by 10% to 330 million. The 10% increase in incomes was attributed to
 519 commercialization of dairy milk farming. Farmers in the area had formed dairy groups to
 520 enable them buy milk in bulk and transport it to the Brookside Cooling Centers in the area.
 521 Previously, most rural farmers used their milk products at subsistence level with the surplus
 522 being spoilt and thrown away. Brookside Company came in and supported Local Dairy
 523 Cooperatives by installing Cooling equipment in Lelan, Tapach and Kaptalamwa areas. Many

dairy farmers have joined cooperative societies in the region and they are getting financially empowered while having the excess milk also preserved for domestic consumption.

(vii). Greenhouse agriculture; the technology where crop diseases and water use are controlled was researched and developed by International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). It is a farming technology which ensures food security for the urban poor is spreading fast among small scale farmers near urban centers in Kenya (IGBP, 2008). The technology offers an environment in which temperature, humidity and pests are easily controlled. The greenhouses are made of wood and polythene; they measure 240 square metres and the cost of putting up such greenhouse including the installation of drip irrigation pipes ranges between Kshs 100,000-300,000. Crops grown are mainly horticultural crops such as; tomatoes, cucumbers, cabbages, spinach, carrots and capsicum (green pepper/ *pilipili hoho*), throughout the year. A combination of drought, increased food prices, growing demand from an expanding urban population and proximity to ready market is a big benefit to many greenhouse farmers in Ongata Rongai, Kitengela and Kiserian near Nairobi city. Farmers in Nyandarua, Bungoma, Machakos, Bomet, Kitale and Narok have started greenhouse agriculture.

(viii). Sustainable agriculture or agro-ecology uses ecological principles to farm. It involves maintaining the natural environment while using ecological principles for sustained farming practices, mixed cropping or poly cropping which ensures that the farm is never bare since crops are harvested at different times e.g. a farm planted with beans, maize and coffee or tea bushes, poly-cropping also increases plant diversity and attracts several other plant species and herbivores (FAO, 2010). This type of poly cropping ensures sustainable food production throughout the year (plate 5). Crop rotation and dry land farming are important farming methods which suppress pests and diseases that might attack particular crops and not others while practicing dry land farming where such crops as cassava, green grams, cow peas, sorghum and katumani maize are grown using drip irrigation (*Daily Nation paper, May 9, 2017*).



Plate 5: poly cropping of bananas, maize, cassava and vegetables in same plot ensures household food security throughout the year in semi-arid Kitengela, Kenya.

(ix) Irrigation projects, ground water resource tapping, rain water harvesting during floods and concrete irrigation plans on major rivers such as Tana and Athi in Kenya can eradicate the food security problems in Africa's drylands. The government of Kenya set aside KES 6 billion in the 2017/2018 financial budget for an irrigation project which will target 15,000 acres of land and benefit 6,000 households in the semi-arid Murang'a County. The project will use the Tana and Athi rivers, it benefit farmers from Maragua Ridge, Kamiti, Gaturi, Kirimiri and Ithanga where farmers will grow rice, onions, yams and other indigenous food crops. The irrigation project aims at solving the perennial food shortages in Murang'a within the coming three years. This was revealed by Devolution Planning Cabinet Secretary while distributing relief food supplies to effected families in lower Murang'a County (***Standard News paper, May 2nd 2017***).

(x) Prompt emergency Response to Early warning systems

Food Shortage mainly maize flour experienced in Kenya where the price of 2kg maize flour rose from ksh 90 to ksh 162 between the months of February and May 2017 would not have occurred if the agriculture ministry had promptly responded to the early warning by climate scientists and grain millers. In 2016, poor rains saw the Horn Africa experience a dry spell.

Harvests of most foods dwindled and the yields of maize, potatoes, beans and rice went down causing about four million people being affected by starvation. The Meteorological department had warned that even the 2017 March – April long rains would be suppressed and the harvests would be below average. Maize Millers had also issued an alarm, saying that there was no adequate maize in the grain reserves. It was until on March 30th when the Cabinet Secretary, National Treasury in his budget speech, removed 50 per cent duty on imported maize, allowing for importation of about 29,900 tons of maize from Mexico and South Africa to fill the deficit after the impact was beyond remedy. The crisis resulted into blame games on the political scene.

(xi) Pests and Disease control Research Mechanisms

Agricultural Scientists need to provide well researched solutions to some of the causes of food destructions which cause food insecurity in Africa. As at March to June 2017, Kenya's maize plantations were invaded by fall army worm which threatened to make the food situation worse in 2018. At least 8,000 acres of maize plantations in Trans Nzoia County and 600 acres in Uasin Gishu County were attacked by the destructive Fall Armyworm in March – June 2017, thus putting the Country's food security at high risk over the next one year. The fall army worm is a native of both North and South America. It thrives well in warm temperatures with little rains while its multiplication and spread is reduced by heavy rains and low temperatures; it has damaged maize crops in African countries of Namibia, Malawi and South Africa in the past (Lisa et al 1999). Where are agriculture scientists' and researchers in Africa to solve the food insecurity caused by pests? The solution is to eradicate the army worms on the continent in order to secure vast acres of food crops but not necessarily to plant new variety seeds which have not been tested and approved for commercialization.

A summary of The March-July causes of food Crisis in Kenya 2017

The food crisis harshly referred to as the "*Unga crisis*" could never have occurred if the relevant ministries had timely responded to the early warning systems from the meteorological forecasts and prepared for the predicted disaster by buying and filling the grain reserves.

601
 602 With maize flour shortages in retail shops, fall army worm pests having affected the staple
 603 maize crop food in the “maize granary” region and poor rainfall that could affect yields,
 604 Kenyans could still experience high food prices for more months to come. Four improved
 605 varieties of brachiaria grass have been planted in various counties to provide Livestock feed.
 606 2016 was a gloomy year for the country’s agricultural sector though the government was made
 607 aware of the worsening situation by the meteorological department. Production of maize
 608 decreased in 2016 due to below average rainfall, high costs of farm inputs and the residual
 609 effects of Maize Lethal Necrosis Disease (MLND), stated by the Kenya National Bureau of
 610 Statistics in the Economic Survey 2017.
 611 Production of the cereal reduced from 42.5 million bags in 2015 to 37.1 million bags in 2016.
 612 Both the maize produced and maize taken to the market in 2016, declined. The value of
 613 marketed maize declined by 7.2 per cent. While the value of marketed rice and wheat also
 614 went down, their poor performances were quickly compensated with increased imports of the
 615 commodities. However, maize imports declined sharply from 480,100 tonnes in 2015 to
 616 148,600 tonnes in 2016. There was no maize in Tanzania and Uganda, from where Kenya plugs
 617 its deficit. The ravaging drought had ensured that they too (Tanzania and Uganda) were as
 618 maize deficient as Kenya. Kenya’s remaining option was to import maize from overseas,
 619 particularly Mexico, which is the largest producer of white maize. *The Standard, May 23/2017.*
 620 The 2017 “Unga crisis” did not require GMO maize variety to solve, rather strategically
 621 responding to the early drought warnings by importing the maize well in advance.

623 **Conclusion and recommendation**

624
 625 The sustainable means to combat food shortages is not dependent on new crop varieties but
 626 rather further study and improved crop management of indigenous breeds better suited for
 627 Africa’s climatic conditions biodiversity (Africa’s Indigenous Crops, 2011). It is therefore
 628 important to craft solutions that target the underlying causes instead of short-cut (GMO)
 629 methods aiming only to treat the symptoms. Each African country faces a combination of

different factors such that a blanket solution such as GMO cannot cater for situations that need localized formulation of relevant policies, mitigation, adaptation and coping strategies (Ngaira, 1999)

African governments should continue to seek better understanding of what they allow into their countries. The long term benefits and losses should also be weighed at the same time sensitizing the citizen about what GMO's really are. Africa needs to use AGRA to reshape its farming practices to ensure long term food security. The time to act is now and that action means doing more research on indigenous crops which are best suited for Africa's climatic conditions, soils and are also highly nutritious. GMO's are not a sustainable strategy to food security and climatic change in Africa since they require artificial growing conditions. Lack of diversity on the other hand leads to over dependence on a few select crops and livestock which may not meet the nutritional threshold leading to health risks. This then becomes a counter-productive result, since food insecurity which GMOs are touted as combating should primarily improve the health of the consumers and not cause complications. African countries faced with multiple issues that affect developing nations must find better alternatives than those which seek to increase the rate of dependency on one commercialized crop as projected by GMO products (Frison, 2009). Agricultural investment should be channeled to improving the quality and yields of indigenous food crops which are grown by 90% of small scale subsistence farmers in Africa.

References.

- ASSAf (2010) GMOs for African agriculture: challenges and opportunities. www.assaf.org.za.
- Biosafety Report (2015) who benefits from gm crops? www.foei.org
- Doctors' Health Warning, (2012) Avoid Genetically Modified Foods. ResponsibleTechnology.org.
- DMCN (2005) The 12th Greater Horn of Africa Climate Change Outlook Forum –GHACOF 12, Nairobi, Kenya.
- European Union (2010) A decade of EU-funded GMO research. ISBN 978-92-79-16344-9. doi

662
663 FAO (2010) Genetic Considerations in ecosystem restoration using native tree species. ISBN
664 978925-1084694 pp 282, FAO, Rome.
665
666 Frison E (2009) Calls for investment in true food. www.bioversityinternational.org/
667
668
669 Fischer R (2009) Farming systems of Australia: exploiting the synergy in
670 Genetic improvement and agronomy in crop physiology. Sadras V, Calderini D (eds).
671 Elsevier: Amsterdam.
672
673 Henk-Jan Brinkman, Cullen and Hendrix. (2011) Food Insecurity and Violent Conflicts: Causes,
674 Consequences, and Addressing the Challenges. Available online at wfp.org/policy-resources.x
675
676 Hoban T, (2004) Public attitudes towards Agricultural Biotechnology. ESA working paper Nos 4-
677 9 Agriculture and Development Economics Division, Food and Agriculture Organization.
678
679 IGBP (2008) Sustainable livelihoods in a changing Earth Systems: In Global Newsletter No 71,
680 ICSU.
681
682 IPCC (2007) Fourth Assessment Report. Intergovernmental Panel on Climate Change,
683 Secretariat, Geneva, Switzerland.
684
685 ISAAA Brief, (2011) Global status of *commercialized biotech/GM crops*: International service for
686 the acquisition of agricultural Biotechnology Applications: www.isaaa.org
687
688 Kalibata A (2006) Agriculture in a changing world. Ministry of agriculture, Uganda.
689
690
691 Kruff D, (2001) Impacts of Genetically-Modified Crops and Seeds on Farmers
692 The Agricultural Law Resource and Reference Center The Dickinson School of Law of
693 the Pennsylvania State University 150 S. College Street Carlisle, PA 17013 717-241-3517.x
694
695 Lisa C, Amani, El Obeidb, Helen H. Jensen B (1999) the geography and causes of food
696 insecurity in developing countries. www.elsevier.com/locate/agecon.x
697
698 Ma J, (2003). The production of recombinant pharmaceutical proteins in plants. Nature
699 Reviews Genetics 4, 794 – 805.
700
701 Makinde D (2009) Status of Biotechnology in Africa: Challenges and opportunities. Asian
702 Biotechnology and Development Review, vol, 11 No 3, pp1-10,
703
704 Mastny E (2011) Ntp-Africa's indigenous. www.NourishingthePlanet.org.

705
706 Mayet M, (2004) Undermining Biosafety: Monsanto pushes GM wheat to secure access to
707 lucrative African markets. Briefing for the 1st Meeting of the Parties to the Cartagena Protocol
708 on Biosafety, 23rd -27th February 2004, Kuala Lumpur, Malaysia.
709
710 Michael A, Claire R, Fagan J (2012) GMO Myths and Truths: An evidence-based examination of
711 the claims made for the safety and efficacy of genetically modified crops
712 Version 1.3b© Earth Open Source. www.earthopensource.org.x
713
714 Mbofung P (2010) Composition of 13 different traditional sauces prepared from moringa
715 olifera leaves in N.Cameroon. International Journal of Innovation and Applied Studies, IJIAS.
716 Available at: ijias.issr-journals.org
717
718 Ngaira JK (1999) Environmental Impacts of rainfall variability in semi-arid areas of Kenya,
719 Unpublished PhD thesis, Moi University, Kenya.
720
721 Padulosi S, Heywood V, Hunter D, Jarvis A (2011) Underutilized species and climate change:
722 current status and outlook. Crop adaptation to climate change, 1st edition. Wiley, New York
723
724 Pretty JN (2003) Reducing food poverty by increasing agricultural sustainability in developing
725 countries. Final Report for 'SAVE World' A summary of New Evidence; Center for Environment
726 and Society, University of Essex, Wivenhoe Park, Colchester CO4, 3SQ, UK.
727 www.siteresources.worldbank.org.
728
729 Republic of Kenya (**27th March, 2017**) "Government accused of blocking GMO Research"; Daily
730 Nation News paper, pp 12; Nation Media Group Ltd, Nairobi
731
732 Republic of Kenya (**4th April, 2017**) "State's conditions for GMO trials"; Daily Nation News
733 paper, pp 39; Nation Media Group Ltd, Nairobi
734
735 Republic of Kenya (**9th April, 2017**) "State bodies lock horns over genetically modified maize";
736 Sunday Nation News paper, pp 39; Nation Media Group Ltd, Nairobi
737
738
739 Republic of Kenya (**9th May, 2017**) "Wonder grass holds key to drought-resistant animal feed";
740 Daily Nation News paper, pp 8; Nation Media Group Ltd, Nairobi
741
742
743 Republic of Kenya (**10th May, 2017**) "Small holders hold key to food security"; Daily Nation
744 News paper, pp 15; Nation Media Group Ltd, Nairobi
745
746 Republic of Kenya (**2nd May, 2017**) "Sh 6 billion irrigation project to start soon"; The Standard
747 News paper, pp 29 ; The Standard Group Centre Ltd, Nairobi

748
 749
 750 Republic of Kenya **(23rd May, 2017)** “Unga crisis”: Why Kenyans are not out of the woods yet”;
 751 The Standard News paper, pp 6; The Standard Group Centre Ltd, Nairobi
 752
 753
 754 Sven-Erik, Marten S, Søren M, Pedersen and Weiner J (2013) Feeding the world: genetically
 755 modified crops versus agricultural biodiversity: INRA and Springer-Verlag France x
 756
 757 Tirado R, Johnston P (2010) Food security: GM crops threaten biodiversity.
 758 Science 328:170–171.
 759
 760 Tearfund (2010) Caring for the environment and the people, in Footsteps 82, pp12-13, 100
 761 Church Road, Teddington, UK.
 762
 763 UN (2013) The Millenium Development Goals Report 2013. United Nations
 764
 765 Vidal J (2011b) GM crops promote super weeds, food insecurity and Pesticides. Guardian.co.uk,
 766 19 October 2011.
 767
 768 Zerbe P (2004) Small Molecules with big impact: Terpenoid phytoalexins as key factors in maize
 769 stress tolerance; Plant cell and Environment doi. Available at:
 770 www.biosci3.edu/faculty/profile/14486
 771
 772
 773
 774