TWN

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GMO Options in Agriculture for Climate Change Adaptation

Table of Contents

Summary

Global warming will affect world agriculture with implications for food supply at both local and international levels. African countries are vulnerable to climate change and especially the African countries that are in the hot tropical regions since they are heavily reliant on climate-sensitive sectors, such as agriculture, forestry, and tourism. In the coming years, many African countries are likely to experience more severe droughts and declines in water supply. This has drawn an interest into how new options for agriculture practice and breeding can contribute to reduce crop loss and declining yields due to drought.

The Julius Nyerere Professorial Chair in climate change and environment at the University of Dar es Salaam in collaboration with the Vice Presidents Office – Division of Environment, GenØk-Centre for Biosafety and Third World Network hosted a workshop and public meeting back to back from 6th – 8th December 2012 in Dar es Salaam, Tanzania. Scientists, academicians, researchers, regulators, non-governmental organisations, farmers' groups representatives and policy makers from East, South and Central Africa attended the meeting to discuss the theme 'GMO options in agriculture to address climate change adaptation'. In this report, the different chapters provide an introduction followed by a summary of the presentations given by the invited experts as well as key issues that came up in the plenary discussions. The workshop offered group work on specific and important questions, and the summaries from the group work are also included in this report. The report is the organizers´ summary of the presentations, panel discussions and group work.

The broad theme of the workshop offered an avenue for discussion on the challenges of adopting genetically modified (GM) plants, of inclusion of non-GM alternatives, intellectual property rights, socio-economic issues as well as benefits and risks associated with GM crops.

1 Background

Climate change is a potentially catastrophic global externality and one of the world's greatest collective action problem. Causes and effects of climate change are distributed highly unevenly across countries, with developed countries accounting for most of the current stock of greenhouse gas emissions resulting from the burning of fossil fuels. The emerging and developing countries are expected to be hit harder by the impacts of climate change and variability. Estimates of future damages that may result from climate change are highly uncertain, but may be catastrophic if global warming is unchecked. The costs of abating climate change are also uncertain. They are contingent on a number of factors, including the rate at which individual countries and the global economy as a whole grow over the long term and the pace at which clean technologies emerge and diffuse across the world.

Climate change, food security and poverty challenges should not be considered separately but holistically, particularly as they all affect 75 percent of the world’s poor. Agricultural production needs to increase by 70 percent by 2050 in order to feed the projected 9 billion people and climate models predict a much more uncertain climate for world agriculture, with potentially devastating down-side possibilities. Thus, countries' efforts to adapt to climate change must fit in with their broad development agendas. Economic and social development is one of the most powerful ways to increase the capacity to adapt to climate change. To enhance economic growth and improve capacity to deal with climate change, developing countries must remove impediments to domestic agricultural production. This is also important in light of the current food crisis. This means improving infrastructure and distribution and storage systems, increasing competition, expanding irrigation systems, and removing barriers to trade.

Among the potential problems with global warming, are the risks to the world agriculture and, therefore, food supply stands out as one of the most important. Above a certain range of temperatures, warming tends to reduce yields. Recent estimates suggest that the effects will be greater in countries located closer to the equator, with potentially large losses in Africa. In some of the poorest countries, the damage—when measured as a reduction in agricultural productivity—could reach devastating levels of greater than 50 percent.

African countries are more vulnerable to climate change because most of them are located in already hot tropical regions and are more heavily reliant on climate-sensitive sectors, such as agriculture, forestry, and tourism. They also have a more limited capacity to adapt to climate change, given their lower income levels and weaker institutional frameworks. Africa is the continent that is most vulnerable to climate change. In the coming years, many African countries are likely to experience more severe droughts and declines in water supply, which would further aggravate food shortages on the continent, where 95 percent of population depend on agriculture for their livelihood. Health and water systems of African countries may also come under increased stress in the coming decades from more intense and possibly more frequent natural disasters. Coasts may be flooded, and populations may seek to migrate, raising the risk of social conflicts.

The negative effects of climate change on crop production are especially pronounced in Sub-Saharan Africa, as the agriculture sector accounts for a large share of GDP, export earnings, and employment in most African countries. Furthermore, the vast majority of the poor reside in rural areas and depend on agriculture for their livelihoods.

Crop modelling indicates that in 2050 in Sub-Saharan Africa (SSA), average rice, wheat, and maize yields will decline by up to 14 percent, 22 percent, and 5 percent respectively, as a result of climate change. Irrigation water supply reliability, the ratio of water consumption to requirements, is expected to worsen in SSA due to climate change.

In a no-climate change scenario, only SSA sees an increase in the number of malnourished children between 2000 and 2050, from 33 to 42 million. Climate change will further increase this number by over 10 million, resulting in 52 million malnourished children in 2050. Furthermore, SSA is the most vulnerable region to climate change due to low adaptive capacity, high exposure to drought and floods, high population growth and heavy dependence on agriculture. Over 200 million people face drought each year. This number is expected to rise to 600 million by 2050. Unfortunately, more than 90 percent of SSA agriculture is rain fed. Increased crop loss and declining yields are occurring due to drought. About 50 percent yield loss is expected in rain-fed agriculture by 2020. Since most African countries depend heavily on agriculture, the effects of climate change on croplands are likely to threaten both the welfare of the population and the economic development of the countries. Tropical regions in the developing world are particularly vulnerable to potential damage from environmental changes because of the poor soils that cover large areas of these regions; and already have made much of the land unusable for agriculture. Agronomic models of climate sensitivity indicate that higher temperatures are likely to be harmful in many developing countries where the climate is marginal, water is inadequate, and temperatures are high. A further increase in temperatures will make many agricultural areas less productive and some completely unsuitable for agriculture.

While the agronomic literature provides different insights on climate change implications on crop production, they all conclude that climatic factors most affecting crops are the intensity and duration of rainfall, the relationship between annual rainfall and potential evapo-transpiration, and the year-to-year variation in rainfall. For instance, the length of the growing season depends partly on rainfall, evaporation and temperature, partly on soil factors (mainly how much moisture gets into the soil and is retained) and partly on crop factors (the most important being the plant's rooting and maturing characteristics). In addition, processes that determine crop yield under climate change are estimated to be the response of crops to mean temperature, the interaction between water stress and CO_2, and the interaction between ozone and a range of environmental variables.

The major parameters that have been cited to be significant in the climate change dimension include the changes in temperature and rainfall patterns (both to averages and to the variability of rainfall), with many semi-arid parts of the developing world likely to become even hotter and dryer with even less predictable rainfall. These changes will both directly affect crop yields and ecosystem distributions and species ranges. This will dramatically affect the livelihoods of many poor people, particularly through declining food security. Secondary impacts will likely include increases in urban food prices.

Direct and indirect effects of climate change on agriculture are estimated to be negative. Studies show that the overall predictability of weather and climate would decrease, making the day-to-day and medium-term planning of farm operations more difficult. Likewise, incidences of diseases and pests, especially alien ones, could increase, and present (agro) ecological zones could shift in some cases over hundreds of kilometres horizontally, and hundreds of metres altitudinally. In this regard, some plants, especially trees, and animal species cannot follow in time, and thus farming systems cannot adjust themselves in time. Other impacts include higher temperatures that would allow seasonally longer plant growth and crop growing in cool and mountainous areas, thus leading to increased cropping and production. In contrast, in already warm areas climate change can cause reduced productivity, and hence the imbalance of food production particularly in the developing countries. In addition to changes in precipitation and total water availability for irrigation, that directly affect agricultural production, changes in the pattern of water use by crop plants throughout the season may affect the outcome. Of special concern is the change in the physiological functioning of the vegetation as a consequence of the changed atmospheric composition. According to IPCC (2007), increased temperature would also affect the crop calendar in tropical regions. In semi-arid regions and other agro-ecological zones where there is wide diurnal temperature variation, relatively small changes in mean annual temperatures could markedly increase the frequency of highest temperature injury.

Agronomic models of climate sensitivity indicate that higher temperatures are likely to be harmful in many developing countries where the climate is marginal, water is inadequate, and temperatures are high. A further increase in temperatures will make many agricultural areas less productive and some completely unsuitable for agriculture. Fostering the ability to adapt to a changing climate will involve improving the ability of agricultural systems to respond to generally changing and uncertain conditions largely through existing policy instruments such as support for agricultural research, trade policy, water management, and commodity programs and pricing. In agro-ecosystems the choice of longer-duration cultivars or changes in cropping pattern could eliminate unproductive periods that might arise because of the shorter growth cycle of the main crop.

The sustainable use of genetic resources for food and agriculture will be the foundation for many of the adaptation strategies required in food and agriculture. In order to adapt to climate change, plants and animals important for food security will need to adjust to abiotic changes such as in heat, drought, floods and salinity. As climate change brings new pest and diseases, new resistances will be required for animal breeds, fish breeds and crop and forest varieties. Genetic diversity which is currently underutilized may become more attractive to farmers as a result of climate change.

Adoption of crop varieties that tolerate drought, pest and disease, as well as having improved nutrient composition is one of the adaptation strategies suggested by IPCC (2007). Some important African crops are difficult to improve using traditional breeding methods. Techniques for developing genetically modified organisms (GMOs) may broaden opportunities for crop improvement. There is increasing adoption of genetically modified (GM) crops globally, although these remain confined largely to two traits – herbicide tolerance and insect resistance.

However, there have been a number of challenges for GM adoption in SSA. Such challenges include:

- Lack of a clear national policy and legislation on GMOs.

- Decline in public funding of agricultural research, which is necessary to develop products for local needs and priorities.
- Limited capacity in intellectual property rights management, particularly in relation to agricultural products.
- Inadequate capacity for risk assessment, management and risk communication, given the risks associated with GMOs.
- Trade issues with some European countries who are major importers of agricultural products, and are opposed to GMOs.
- Advocacy for organic agriculture by many donors, although some concerns remain with critics as to whether organic agriculture alone can meet the future food needs of a growing population.
- Diffusion of GMOs into the social system. For wide adoption, GMO products must be superior, yet compatible with existing farming systems, and affordable.

In this context of evaluating GMOs as an option for addressing climate change in agriculture, the University of Dar es Salaam, the Vice Presidents Office – Division of Environment, Third World Network and GenØk-Center for Biosafety partnered to host a meeting for the East African region. Participants and speakers were drawn from a pool of regulators, scientists, technology developers and non-governmental organisations.

2 Climate change impacts on the agricultural sector in Africa

The IPCC (2007) suggests that Africa will be the region most affected by climate change, due to both changes in mean temperatures and rainfall, as well as increased variability. The continent has warmed by about half a degree (0.5) Celsius over the last century, and average annual temperatures are expected to continue to rise. In Africa 70 percent of agricultural land is considered degraded by the Food and Agriculture Organisation (FAO) – due to unsustainable farming practices and expansion into marginal lands such as is seen in plate 3.1 below.

September: Residues raked up and burnt. Soil totally exposed to early storms and erosion. **b)** November: The first heavy rain falls on the bare ground and takes the soil with it.

Countries are increasingly being forced to consider "Smart Agriculture" where there is sustainable increase of productivity, increased resilience (adaptation) of existing practises whilst enhancing achievement of national food security and development goals.

Initiatives to ensure national food security and to meet development goals, need to be based on approaches that put an emphasis on how to design and implement research and development strategies by focusing on livelihoods, the value chain and landscape management. They must in all aspects ensure that vulnerable groups and/ or areas benefit from the adaptation and/ or resilience development for sustainability. In so doing the type of crop, varieties, technologies including biotechnology, accessibility of seed, water resources, land biotic and abiotic stresses and cultural practises need to be incorporated holistically in planning.

2.1 Drought as a challenge for crop production, Dr Richard Oduor

There is increasing interest in addressing climate change challenges using biotechnology in Africa, and significant ground has been covered with regards to developing products and building capacity. In particular, genetic engineering is considered an important technology to address climate change challenges such as drought. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has identified the Plant Transformation Laboratory in Kenyatta University, Nairobi, Kenya as a centre of excellence for advancing the technology through genetic improvement of key crops, including maize, against drought stress. The project aims at building a database of knowledge and competence for genetic engineering and product development through training and local generation of knowledge using a network of scientists in Sub-Saharan Africa where the organisation operates.

The ASARECA project considers genetic engineering to be a crucial complement to conventional breeding as the latter is limited when traits to be transferred, such as drought tolerance, are complex and polygenic; making the breeding process longer and causing products not to reach the market in some cases. In transforming maize, the project uses genes and transcription factors isolated from various sources including the resurrection plant (*Xerophyta viscosa*). Further, the project embraces the use of the selectable marker IPT to enhance commercialization of the resulting products. This effort has borne a number of international publications as well as has resulted in the training of several PhD students drawn from Kenya, Tanzania, Ethiopia and Sudan.

2.2 Drought tolerant breeding in maize – CIMMYT, Dr Dan Makumbi

Non-GM initiatives to addressing drought include the Drought Tolerant Maize for development and delivery in Africa (DTMA) initiative. Maize is an important staple for Africa grown by both small and large farmers, but yields are erratic due to the fluctuating price of inputs, limited variability in cultivars, climate change impacts particularly drought and low investment. Africa is rapidly becoming a net importer of maize as the population growth rates increase whilst production remains low.

The DTMA initiative is focused on managing drought stress through screening for tolerant maize lines, by targeting stress sensitive organs such as flowers. The initiative measures success by contributing a broad genetic base, developing tools that reduce the breeding process time and providing stress tolerant material for improved yield to farmers. To date, DTMA has successfully released 51 drought tolerant hybrids and open pollinated varieties of maize.

2.3 Pest and diseases as challenges for crop production, Dr Angelika Hilbeck

Biotic stresses such as pests and diseases pose a significant challenge to crop production and these are influenced by abiotic stresses such as drought. There are several non-biotech approaches to control pests and the push-pull technology is only one of many effective control mechanisms. The technology works by using repellent "push" plants and trap "pull" plants and in East Africa where stem borers infest most cereals this technology has demonstrated relative success. Grasses planted around the perimeter of the crop attract and trap the pests, whereas other plants, like *Desmodium* (another crop), planted between the rows of maize repel the pests and control the parasitic plant *Striga*. The push–pull technology was developed at the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya in collaboration with other partners and is widely used even on non-cereal crops.

3 Strategies to address climate change

New initiatives and strategies for plant breeding to address climate change are at present attracting great interest from both private and public funded institutions. During the workshop there were four presentations that informed the participants about some of the strategies involved. The presentations concerned initiatives within conventional breeding and some by using GM where a special emphasis was put on the Water Efficient Maize for Africa project. In addition, a presentation was given on issues related to the challenges raised by intellectual property rights associated with genetically modified crops.

3.1 Plant breeding options for increased drought tolerance, Dr. Angelika Hilbeck

To date, there is only one transgenic trait that has been deregulated by US authorities for which the developer (Monsanto Company) claims that it confers approximately 6% yield protection under moderate water-limited conditions. This ‘drought tolerance’ trait is conferred by the *csp* transgene. However, the conferred drought tolerance has not yet been independently confirmed. In all other claimed transgenic drought tolerant crops, the drought tolerance has been bred through non-transgenic, modern breeding methods (e.g. marker assisted selection), hence, non-patentable. They only become ‘transgenic’ and patentable by adding the old Bt and

HR transgenes. Thus, as a business model, non-transgenic, non-patented drought tolerant varieties are not marketed as such but only with the added Bt and HR trait that endows these crop varieties with patent protection and property rights. Moreover, the global problem with climate change is not moderate drought but severe, recurring or protracted drought followed by flooding rain events. None of the current drought-tolerant varieties addresses this problem sufficiently, regardless of whether they are transgenic or not.

3.2 Developing more climate change-ready maize for Africa via WEMA partnership, Dr Sylvester Oikeh

In Sub-Saharan Africa, food production has been stagnant for decades, thus one-third of the population is starving. The Water Efficient Maize for Africa (WEMA) project is a public-private partnership (PPP) initiative to develop and deploy African drought-tolerant and insect-pest protected royalty-free maize varieties. The initiative is a dual approach of biotechnology and conventional breeding to maximize yield under low moisture conditions. The approach is projected to enable a 20-35 percent increase in yield over year 2008 varieties, which would potentially translate into an additional 2 million metric tonnes during drought years that can feed 14-21 million people. The initiative is being piloted in five African countries and has achieved significant success.

It is hoped that the conventional WEMA drought-tolerant white hybrids (non-GMO) will be available to farmers from 2013 through the national seed companies; and the GMO products, including transgenic (*Bt*) insect-pest protected white hybrids, will be available from 2016, while stacked transgenic drought-tolerant and *Bt* hybrids from 2017, provided the necessary biosafety regulations are in place. Challenges faced are the regulatory frameworks in some of the countries and the low levels of awareness.

3.3 Issues of intellectual property rights, Mariam Mayet

The WEMA project is framed within a charitable objective to bring drought tolerant hybrid and GM maize varieties to smallholder farmers in Africa. This raises intellectual property (IP) issues. It was noted that outside the charitable objective one of the partners (Monsanto) is a commercial enterprise linked to the promotion and kick starting of a hybrid maize market and supply chain to also include transgenic varieties later on. The key issues focused on in the discussion were ownership issues; issues regarding confidentiality, liability and the role of key actors. WEMA is a public-private partnership between AATF, CIMMYT, Monsanto, and the

National Agriculture Research Systems of Uganda, Kenya, Mozambique, South Africa and Tanzania. The aim of the partnership is to deliver hybrid germplasm of maize with improved drought tolerance through molecular breeding and biotechnology to smallholder farmers in South Africa and all farmers in the rest of sub-Saharan Africa. Large-scale farmers in South Africa are expressly excluded.

Ownership of the WEMA project's technology and IP is to be determined by US law on 'inventorship' and the IP law of the country where the protection is sought. The drought tolerant trait is to be delivered royalty free to small farmers in Africa and expressly not to large farmers in South Africa. It is not clear whether the seeds were to be given free of charge to farmers and if not, what the cost structure of the seeds entailed. The principle is that each party in the project owns the IP on their materials (germplasm) but that this is licensed to other partners. In other words, the WEMA project partners have a free license to access and use the germplasm brought into the project. It was not clear whether the project will seek IP protection for the drought tolerant trait and associated technology and thus it is an open question if the seeds will be truly royalty free if IP is being sought on the drought tolerant trait. Further clarification on whether farmers will receive IP protected seed subject to national laws based on UPOV 1991 and whether they would be able to freely re-use, sell, exchange seed and or harvested material would be needed.

Other IP issues important to consider as part of such projects are where partners wish to seek IP protection for any discoveries and creations made during the project under mechanisms such as PVP, patents, etc. As each partner in the project has their own breeding programs, understanding on ownership of discoveries or creations made during the project is of concern (e.g. the state in the case where one or more of the national research system was involved). Clear exceptions include: the germplasm that is owned by the part whose breeding program developed it, regardless of the source of the starting germplasm used to develop it. The partner with superior technology (advanced breeding technology) should not be able to get free access to germplasm brought into the project and own the new varieties developed.

One of the main aims of the WEMA project is to kick-start the hybrid market and supply chain, moving to an exclusive license environment; one of the partners, AATF, was to organize a lottery for this. In order to obtain an exclusive license, companies much show that they have reached a maximum sales target after the hybrid's third year in which event the companies will then get exclusive rights to market the transgenic varieties and this may be of economic concern for smallholder farmers.

IP issues in seed production and multiplication and the different roles of the various players in this process including confidentiality and liability with regard to the project were discussed. Other matters raised that would need clarity are the relationship between introducing GM drought tolerant varieties to the market and the current Bt crops.

3.4 Plenary discussion: Climate change impacts on the agricultural sector in Africa and strategies to address climate change

Following the presentations, a plenary that allowed the participants to provide comments and questions to the presentations on day 1 was held. The discussions were as follows:

Push-pull strategy – it was commented that the push-pull strategy gives additional control to other IPM strategies. It doesn't involve intellectual property rights and it includes control of germplasm by the farmers. Genetic modification on the other hand reduces germplasm control by the farmers. However, the push-pull strategy requires some input to educate farmers but once they understand the system they can modify it to suit their needs.

GM approaches to drought – Drought is more than the lack of water for plants, in Tanzania for example, the problem is more of erratic weather patterns than just lack of water. Coping with drought is a complex challenge for plants requiring complex, multi-gene regulated adjustments. Solutions, therefore, must be holistic and address the problem at the proper level of complexity as it presents itself.

It was queried how far the ASARECA funded projects were from a product that would be available to farmers. The meeting was informed that they had recently received approval for the field trials and thus it would take at least 10 years for a product to reach the market.

Another query was to what other products were the ASARECA team interested in apart from food crops. The meeting was informed that Africa has several medicinal plants and this was an area of interest. The reason being that several of the therapeutic agents in the plants are not high enough in concentration and thus some improvement may be done genetically. However, the interest initially is to develop a library for medicinal plants, the products and the pathways and later enhance product production.

Experience from outside Africa to combat drought – It was queried what success did the USA have in dealing with the recent drought considering that they are the largest cultivators of GM crops. The meeting was informed that the USA has not focused on drought in the genetic engineering of most crops grown in the US. Most of the GM crops grown in the USA are modified for herbicide resistance. It may be possible that now after the drought experienced in summer 2012 that they are going to give drought resistance more consideration.

WEMA – The price of the seeds was queried and it was said that the market would determine this. It was pointed out that the EU's apparent unwillingness to adopt GM in agriculture is due to issues such as regulatory and farmers' rejection and not only the priority issues alone.

4 Climate change adaptation initiatives

The first day of the workshop included a description of the challenges to agriculture posed by climate change, especially focusing on drought. Different strategies including GM options were presented. The problem solving nature of the strategies as well as issues of relevance related to intellectual property was discussed. The second day of the workshop was dedicated to presentations on possibilities of adapting agriculture practices and to whether alternative approaches to traditional agriculture practices can be used to for adaptation to climate change.

4.1 Conservation agriculture to meet climate change challenges, Mr Said Mkomwa

While global population is projected to increase by 50 percent to 9 billion people by 2050, Sub-Saharan Africa's population is projected to increase by 150 percent (from 0.8 to 2 billion) by the same date. This will require 70 percent more food globally to feed the growing population, and more for Africa. But Africa's food production has been stagnant at one tonne per hectare of cereals over the last 50 years. Expanding crop production by the majority of smallholders requires adoption of improved technologies not only to increase yields and productivity but also to reduce production costs and labour demands (especially for women), to improve the resilience of production and reduced risks and improve the long-term environmental sustainability of farming. GMOs have the potential to strengthen resilience through genetic improvement. They are, however, not a sufficient solution to the problem, as they require the right/undegraded natural resource soil production habitat for optimal performance of the inputs and resilience of the production system.

A major paradigm shift, a transformation, is required in the way farming is done, to reverse the decreasing per capita crop yield trends. Conservation agriculture (CA) is defined by FAO as a concept for ecological resource efficient agricultural crop production and is based on an integrated management of soil, water and biological resources combined with external inputs. CA holds the promise for delivering on the triple win goals of food security, adaptation and mitigation to climate change.

Now implemented in over 125 million hectares worldwide, CA is expanding at the average rate of six million hectares per year globally. Highest adoption levels are found in Canada and the southern parts of South America. Fast adoption rates are now being seen in Central Asia and China, while early large-scale adoption is taking place across Africa such as that undertaken by the African Conservation Tillage Network (ACT). The major drivers for CA adoption include soil erosion, drought and cost of production. Knowledge and innovation support are the major limitations for small-scale farmers. This calls for interventions at the policy level, to enhance capacity of smallholder farmers not only as producers but also as stewards of the environment. It was recommended that policy interventions should cater for infrastructure in rural Africa so that access to inputs (including GMOs) and output markets are unlocked. To enhance wide scale adoption of CA, governments were encouraged to ensure that national agricultural policies focus on sustainable intensification, appropriate nation-wide programmes, financing and political commitment and strong international support policies in their agricultural production systems. Site-specific research and advisory/extension is needed to assist farmers in responding to new challenges.

4.2 Ecological agriculture approaches to meet climate change challenges, Lim Li Ching

Given the climate change challenge, the emerging consensus is that the world needs to move away from conventional, energy- and input-intensive agriculture, which has been the dominant model to date. The ecological model of agricultural production, which is based on principles that create healthy soils and cultivate biological diversity and which prioritizes farmers and traditional knowledge, is climate-resilient as well as productive. Ecological agriculture practices and technologies can be the bases for the adaptation efforts so urgently needed by developing-country farmers.

Ecological agriculture practices improve and sustain soil quality and fertility, enhance agricultural biodiversity and emphasize water management and harvesting techniques. Practices such as using compost, green manures, cover crops, mulching and crop rotation increase soil fertility and organic matter, which reduce negative effects of drought, enhance soil water-holding capacity and increase water infiltration capacity, providing resilience under unpredictable conditions. Moreover, cultivating a high degree of diversity allows farmers to respond better to climate change, pest and diseases and encourages the use of traditional and locally-adapted drought and heat-tolerant varieties and species.

There is also increasing evidence showing that ecological agriculture can increase yields where they matter most – in small farmers' fields – with low-cost readily adoptable and accessible technologies that build on farmers' knowledge. A review of 286 ecological agriculture projects in 57 countries showed 116 percent increase in yields for African projects, and 128 percent increase for East Africa.

While there is great potential in ecological agriculture, there has been little attention to it in terms of research, investment, training and policy focus. The challenge is to reorient agriculture policies and significantly increase funding to support climate-resilient ecological agricultural technologies. Research and development efforts should be refocused towards ecological agriculture in the context of climate change, while at the same time strengthening existing farmer knowledge and innovation.

4.3 Experience from climate change adaptations in ecological agriculture, Michael Farelly

From a conservation perspective it is noted that Africa has had little to do with creating climate change but will suffer most from its effects. Traditional smallholder farming in Tanzania is NOT organic, nor organic by default, nor ecological, it is just traditional, typically *kuberega* slash and burn shifting agriculture. Ecological organic agriculture is a production system that sustains the health of soils, ecosystems and people. It combines tradition, innovation and modern science. Organic farmers take responsibility for the fertility of the soil, applying the four principles of organic agriculture, health, ecology, fairness and care.

Chololo Ecovillage is a partnership project to test agriculture innovations in a community in semi-arid Dodoma region. Benefits of ecological agriculture in climate change adaptation include building soil structure and soil fertility, bringing degraded soils back to productivity, reducing erosion caused by wind and water, reducing financial risk through less external inputs, increasing biodiversity and resilience to pests, storms and diseases. The type of agriculture innovations being tested include:

1. *Good agricultural practices*: improved open pollinated varieties, spacing, thinning, weeding, community seed production, post harvest handling and storage.

2. *Soil erosion control*: *fanya Juu*, contour farming, grass strips, trash lines. Soil fertility management: use of crop rotation, intercropping legumes, farm yard manure, composting.

3. *Soil moisture management*: Magoye ripper, Ox ridger, cover crops, contour farming.

First year results from Chololo Ecovillge show that these approaches have more than doubled yields of food crops (sorghum, pearl millet) and trebled yields of cash crops (sunflower), and increased food security.

With this evidence it is contended that GMOs fail to address the challenges faced by smallholder farmers, including: post harvest losses which waste around 40 percent of Tanzanian agricultural production; market access; lack of money for inputs, access to credit, farm machinery, roads, energy, and extension services.

In a recent statement by Christopher Chiza, Minister of Agriculture defending the New Plant Breeders Act to Parliament, when questioned on the security of farmer seeds in the event of GM introduction, he stated that “The country is not ready for GMOs” and that “The government is committed in preserving local seeds and we will not let them be replaced by foreign seed as we would not like to put the future of our country in doubt.” He noted that FAO recognises the value of ecological approaches: “In developing countries, organic agricultural systems achieve equal or even higher yields, as compared to the current conventional practices, which translate into a potentially important option for food security and sustainable livelihoods for the rural poor in times of climate change.” FAO reports that while it dominates in the world’s food production "industrialized food systems have environmental and social costs that threaten food security, e.g., occupational deaths through pesticide poisoning, farmers’ suicides due to debts, and loss of millions of jobs in rural areas." The FAO also expressed concern about the impact of industrial agriculture on vulnerable populations, the environment and climate change issues.

A new report by UNEP and the UN Conference on Trade and the Development (UNCTAD) recently assessed 114 projects in 24 African countries. It found that yields had more than doubled where organic, or near-organic practices had been used. That increase in yield jumped to 128 per cent in East Africa. It also found strong environmental benefits such as improved soil fertility, better retention of water and resistance to drought. The UNEP conclusion is that organic agriculture may have a potentially significant role to play in climate change adaptation and in meeting many of the Millennium Development Goals - an assumption that is discounted in many development models.

4.3 Mobile-phone based methodology for self-documentation and sharing of smallholder farmer´s coping strategies with environmental challenges, Eugenio Tiselli

Mobile phone based methodology for self-documentation and sharing of smallholder farmer's coping strategies with environmental challenges is an initiative coordinated at the Swiss Federal Institute of Technology (ETH) by Angelika Hilbeck. The project is located at Chambezi, Bagamoyo, Tanzania where there is – as everywhere in Tanzania - a growing need to gather local data related to the effects of climate change. The framework and development of the e-agriculture project “The farmers’ voice” or “*Sauti ya wakulima*” in Kiswahili, is based on building a community through sharing of experiences by using mobile technology. Science today acknowledges that in order to find sustainable means to producing food in the future, it is necessary to understand agriculture as a complex, multifunctional system which, besides economic and ecological factors, also includes the social context of rural farming communities. *Sauti ya wakulima* adopts this approach by establishing an open and participative research process, in which a group of farmers living near Bagamoyo, Tanzania, use smartphones and a web platform to document their environment, share their experiences and create, thus, a collaborative knowledge base of how to identify and address challenges.

4.4 Climate change impacts on ecosystem services and food security in Eastern Africa (CHIESA), Prof. P. Mushi

Prof. Mushi presented on the topic of Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA). He emphasized that climate change has impacts on ecosystem services and food security in East Africa. Data collected from 1950 to 2007 show that rainfall trends vary location-wise. Rainfall has decreased in southern Tanzania while it has increased around Lake Victoria and is stable in the central regions. Temperature is on the rise countrywide. The growing season has shrunk as the rain comes late but leaves early. River basins have experienced a decrease in runoff by 5–11 percent.

4.5 Plenary discussion: Climate change adaptation initiatives

The cost effectiveness of using the ecological agriculture approach was discussed. According to FAO, the use of compost not only increases yield, but is also cost effective since the biomass comes from the farm and farmers themselves provide the labour needed. And in most cases it depends on farmers' own creativity. The ecological agriculture approach is not a short-term fix. It is an issue of sustainability. It is important to go to the rural areas and talk to the farmers. In most cases the issue that farmers are facing is not GMOs or hybrid drought resistance. It could be something else like access to markets.

5 Group work

During the workshop the participants could choose the following topics for group work;

- IPR challenges
- Comparative assessment of different approaches to meet climate change challenges – biotechnology vs. conventional vs. ecological approaches
- Socio-economic aspects of drought tolerant plants
- Public awareness: How to communicate and generate interest on these issues?

5.1 IPR challenges

There were no participants that chose to discuss IPR challenges.

5.2 Comparative assessment of different approaches to meet climate change challenges – biotechnology vs. conventional vs. ecological approaches

The discussion focused on how to conduct a Problem Formulation & Options Assessment, as one approach to compare technologies, whether conventional, biotechnology or ecological. In this approach a number of steps that are guided by responding to a set of questions are recommended as part of the process. The process is best done through brainstorming with stakeholders from diverse backgrounds. Bt maize was used as an example of a technology to solve the problem of pests.

1. Step 1 Problem formulation:

- What needs of the people are not met by the present situation? This implies there is information of the current situation.
- Whose need is addressed? The characteristics of the intended target population are to be delineated, and how the problem affects them that would justify how important it is.
- What is the cause of the problem? Sources of the problem are important in determining potential solutions.
- How do the causes rank in their influence? It may be so that there are several interrelated problems and so ranking these to determine the importance is necessary.
- What are the effects of the problem? How the various problems effect the current situation in case of no intervention is important.
- What must be changed to meet the needs?

2. Step 2 Prioritization and scale:

- Is the problem a core problem for people identified?
- Do people recognize the problem as important for their lives?
- What are the potentially competing needs of these people?
- How do the needs identified rank in importance to these other competing needs?
- How many people are affected?
- In what part of a country are these people located?
- How large an area is affected by the problem?
- How severe is the problem?
- What is the local distribution of the problem?

3. Problem statement – This is to be clearly defined as a step synthesizing the outcomes of the first two steps and in some cases the initially perceived problem may not seem the priority issue to address, depending on the information discussed.

4. Move forward – Following the synthesis in step 3 and its problem formulation, a decision to move on with addressing the problem is made dependent on the existing capacities and urgency of the matter. Moving forward could also mean looking for other options.

5. Option identification – Various options are to be presented and discussed, pros and cons identified and ranked, including how they would affect existing and/or future practices.

- Local technical knowledge (LTK)/ indigenous knowledge
- Technology
- Management

6. Assessment in relation to the technology and the problem technology attributes – this is to be done for each of the options identified in step 5.

- What are the characteristics of the technology?
- What are social/ political attributes?
- What is the efficacy of technology of the target?
- What law, regulation or policies apply?
- What are production attributes?
- What current advantage do we have for implementation?
- How confident are we?

7. Changes required and anticipated – The necessary changes in behaviour and otherwise to effectively implement the selected option also need to be assessed.

- Management practice
- Local communities
- Government support
- Production structure

5.3 Socio-economic considerations of drought tolerant plants

New technology and new products may besides the intended benefits also provide risks. Technologies may also change in both positive and negative ways our behaviour as individuals and as communities, as well as our relationship with food systems and the environment. This is why there has been an increased interest in the socio-economic aspects of GM plants. The importance of socio-economic considerations is also found in the Cartagena Protocol on Biosafety where it is stated that the parties to the Protocol may take into account, consistent with their international obligations, socio-economic considerations arising from the impact of living modified organisms on the conservation and sustainable use of biological diversity, especially with regard to the value of biological diversity to indigenous and local communities.

During the group work, various issues related to socio-economic considerations were discussed. Especially what could be included within the term socio-economics and if these should be related to both benefits and risks or only be related to adverse effects. It was for example argued that here should be an analysis of the trade off between utility and risk, and between short term and long term benefits. It should include the dynamics of seed and farming systems, household and communities. The issue of cultural aspects was especially raised, and the importance of protecting indigenous plant varieties and cooking traditions was emphasised. Other issues were related to the ethics behind GM and gene technology, and the importance of avoiding taboo genes.

How to assess socio-economic considerations was raised during the group discussion and several questions of relevance came up. A new product, as for example a drought tolerant plant or a change in agriculture practice, needs to be assessed in relation to:

- How it contributes to the improvement of health and nutrition
- How it provides a benefit for local conditions (as for example semi-arid conditions)
- If it is adopted to local growing seasons
- If it is strengthening job security
- If there are adequate extension services
- If it affects the market and consumers (as creating division of social classes)
- If there are impacts on agricultural biodiversity and organic agriculture goals
- If there are impacts on co-existence and resilience of farming systems
- If introduction caused a loss of traditional landraces
- If the transition affects seed sovereignty

5.4 Public awareness: How to communicate and generate interest on these issues?

It were acknowledged that the public needs to be aware and relatively knowledgeable of GMOs and their global marketing strategies to enable them to effectively participate in discussions. One of the concerns is that the release of information to the public in some cases is restricted as confidential business information (CBI) and generally withheld. Information that is designated as CBI is filed as part of the application to the respective authorities, but is not released to the public.

It was noted that information has to be released in such a way that it is easily accessible by the public. The language has to be simplified for mass consumption. There are many ways to reach the public such as drama and social media. Efforts should be made to exhaust all these in informing the public. Regulators and technology promoters/ developers must work together to reach out to the public to ensure that unbiased information is given to the public. Workshops have to be conducted for local governments, media and members of parliament, and capacity building is necessary to curb misconceptions.

It is important to communicate not only to curb misconceptions but also to build trust between stakeholders. Communication is not about giving information to the public but also getting feedback from them. The public should be heard. In some cases the issue is not the science of GM per se as it may be issues of control, profits, politics, etc. Gathering information from the public is very important. Social auditing must be conducted to know which areas need to be addressed in public awareness activities. Opposing views are important and have to be there. It helps to guide the technology such that things move in a good direction.

6.0 Reflections from the organizers

From the discussions and presentations it is evident that the debate on the use of GMOs as a strategy for addressing climate change adaptation is far from being closed. However, clear messages from the workshop are that the different players in the debate are not only listening to the concerns and recommendations, but are also taking action. An example being the removal of antibiotic resistance markers in GM crops in response to concerns raised about resistance development; albeit the situation is far from perfect and that the diversity of options, vastness of information and access to the same for countries in Africa is still a challenge.

The following statements are the perspectives of the editorial team derived from the discussion and thus are not to provide a bias or recieved consensus from the meeting, but are intended to highlight key messages from the workshop that may serve as a basis for next steps:

- Agricultural production needs to increase in order to feed the projected population rise. Current climate models predict uncertain scenarios for agriculture, with potentially devastating down-side possibilities. Countries are increasingly being forced to consider

"Smart Agriculture" to enhance achievement of national food security and development goals.

- African countries are more vulnerable to climate change due to their geographic location, socio-economic status and reliance on climate-sensitive sectors, such as agriculture, forestry, and tourism.

- Climate change, food security and poverty challenges should not be considered separately but holistically. The diversity of strategies in addressing these likewise need to be holistic and transparent with all parties responsible having access to similar information and opportunities for decision-making.

- The sustainable use of genetic resources for food and agriculture is recognized as being critical for many of the adaptation strategies. GMOs present one option but are not a panacea and clear national policy and legislation is necessary among others. In Africa, more so than the other continents, the capacity for risk assessment, management and risk communication is limited, affecting decisions on adoption of GMO technology. Additional challenges are limited understanding and capacity for intellectual property rights management and external trade agreements that may not be supportive.

- Problem formulation options assessment provides a useful information tool for decision making for identifying which strategy would benefit agricultural development. The tool serves to guide risk assessment on GMOs and allows for the inclusion of other strategies such as conservation agriculture and ecological agriculture presenting challenges and opportunities of these.

- The role of ICT in agriculture is increasingly more important particularly with access to mobile technology where Africa features the 3rd largest coverage globally. It provides an important platform for raising awareness and linking farmers to markets and technical solutions.

Annexes

1.1 Participants list

GMOs WORKSHOP PARTCIPANTS AT GIRRAFFE HOTEL – DECEMBER, 06th – 08th 2012

S/N	Country	Name	Institution	Sex	Background	Contact
1.	**Kenya**	Said S. Mkomwa	ACT	**M**	NGO	Info.tz@act-africa.org
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5.	**South Africa**	Mariam Mayet	African, Centre for Biosafety (ACB)	**F**	Scientist	mariammayet@mweb.co.za
6.	**Kenya**	Sylvester O. Oikeh	WEMA, Project manager	**M**	Scientist	s.oikeh@aatf-africa.org
7.	**Tanzania**	Michael Farrelly	Tanzania Organic Agriculture Movement,	**M**	NGO	mrfarrelly@gmail.com
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9.	**Tanzania**	Alloysius Kullaya	WEMA - Project Coordinator Tanzania	**M**	Scientist	akkullaya@yahoo.co.uk
10.	**Tanzania**	Masoud Muruke	CoNAS – UDSM	**M**	Scientist	muruke@udsm.ac.tz, muruke@amu.udsm.ac.tz
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20.	**Tanzania**	Msafiri Mwaikusa	Rapporteur	**M**	Rapporteur	
21.	**Tanzania**	Prosper Raymond	Rapporteur	**M**	Rapporteur	

22.	**Tanzania**	Neema Mshigeni	MJNPC – ECC	**F**	Logistics	neemamshigeni@yahoo.com
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33.	**Mexico**	Eugeino Tiselli	GENØK	**M**	Science communication	cubo23@yahoo.com

1.2 Program for workshop

Venue: ***GIRAFFE OCEAN VIEW HOTEL – DAR ES SALAAM***

Day 1 – Thursday, 06th December 2012

TIME	EVENT	RESPONSIBLE
08:30 – 09:00	Participants Registration	*Secretariat*
09:00 – 09:10	Welcoming Remarks	*Mr Piniel Yonazi*
09:10 – 09:25	Overview of Climate Change impacts and Adaptation on Agricultural Sector	*Prof. Pius Z. Yanda - The Chair holder of Mwalimu Julius Nyerere Professorial Chair - Environment and Climate Change (MJNPC- ECC)*
09:25 – 09:35	Remarks from the Donor - GenØk-Centre for Biosafety	*Anne Ingeborg Myhr – Ag. Deputy Director,* GenØk-Centre for Biosafety
09:35 – 09:45	Remarks from the Royal Norwegian Ambassador	*Counsellor Inger G. Næss*
09:45 – 09:55	Remarks and Welcoming the Guest of Honour	*Prof. P. Z. Yanda – Chair Holder MJNPC – ECC*
09:55 – 10:15	Official Opening Remarks	*Prof. Rwekaza S. Mukandala (VC – University of Dar es Salaam)*
10:15 – 10:20	Vote of Thanks	*Dr. Adolphine G. Kateka*
10:20 – 10:50	PHOTO SESSION/ HEALTH BREAK	ALL

Abiotic and Biotic stress: impact on crop production **-** *Chairperson*: *Dr. Masoud Muruke*		
10:50 - 11:15	Drought as a challenge for crop production	*Dr. Richard Oduor - Representative from ASARECA project*
11:15 – 11:40	Pest and diseases as challenges for crop production	*Dr. Angelika Hilbeck – ETH*
11:40 – 12:30	Plenary Discussion; Questions and Answer Session on the presentations	*ALL*
12:30 – 13:30	*LUNCH*	*ALL*
Responses to Climate Change - *Chairperson*: *Dr. Mugassa Rubindamayugi*		
13:30 – 14:00	Plant breeding options for increased drought tolerance	*Angelika Hilbeck – ETH*
14:00 – 14:20	Developing More Climate Change – Ready Maize for Africa via WEMA Partnership	*Sylvester Oikeh - WEMA Representative*
14:20 – 14:40	Drought tolerant breeding in Maize - CIMMYT	*Dr. Francis Maideni/ Dr Dan Makumbi (Maize breeding, partner in DMTA Project, Malawi/ CIMMYT Nairobi)*
14:40 – 15:00	Issues of Intellectual property rights	*Mariam Mayet (African Centre for Biosafety)*
15:00 – 15:30	Plenary Discussion, Questions and Answer Session	*ALL*
15:30 – 15:50	HEALTH BREAK	*ALL*

15:50 – 17:00	Group work: Participant can choose between three topics: • Challenges related to intellectual property rights	*Maryam Mayet*
	• Topics for risk assessment of drought tolerant GM plants	*Angelika Hilbeck*
	• Socio economic issues related to drought tolerant GM plants	*Anne Myhr*
17:00 – 17:30	Plenary Session	*ALL*
17:30 – 17:40	Closing Remarks for Day 1	*Session's Chairperson*

Day 2 - Friday, 07th December 2012

Climate Change Adaptation Initiatives - Chairperson: *Dr. Roshan Abdallah*		
08:30 – 09:00	Recap of the Day ONE	*Dr. Flora Tibarazwa*
09:00 – 09:30	Conservation agriculture to meet climate change challenges	*Said Mkomwa - Representative from African conservation tillage Network (ACT)*
09:30 – 10:00	Ecological agriculture approaches to meet climate change challenges	*Lim Li Ching*
10:00 – 10:30	HEALTH BREAK	*ALL*
10:30 – 11:00	Experiences from climate change adaptations in ecological agriculture	*Michael Farelly – Representative from Tanzania organic agriculture movement*
11:00 – 11:30	Mobile-phone based methodology for self-documentation and sharing of small holder	*Eugenio Tiselli - Z-Node candidate*

	farmer's coping strategies with environmental challenges	
11:30 – 12:00	Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA)	*Prof. P. Munishi - Representative from CHIESA*
12:00 – 13:00	Plenary Discussion, Questions and Answer Session	*ALL*
13:00 – 14:00	LUNCH	*ALL*
14:00 – 15:30	*Group work: Participant chooses one among the three topics to attend.*	
	• Environmental impacts from conservation agriculture and the role of herbicide tolerant GM crops	*Dr. Flora Tibazarwa*
	• Comparative assessment of different approaches to meet climate change challenges – biotech vs conventional vs ecological approaches	*Dr. Angelika Hilbeck*
	• Public awareness: how to communicate and generate interest on these issues?	*Lim Li Ching*
15:30 – 16:00	Plenary Discussion, Questions and Answer Session	*ALL*
16:00 – 16:10	Workshop Evaluation	*ALL*
16:10 - 16:30	Closure of the Workshop	*Prof. Pius Z. Yanda - The Chair holder of Mwalimu Julius Nyerere Professorial Chair - Environment and Climate Change (MJNPC- ECC)*
16:30 – 17:00	*HEALTH BREAK*	*ALL*
17:00	*DEPARTURE*	*Participants from Tanzania*

1.3 Program for public meeting

VENUE: NKRUMAH HALL – UNIVERSITY OF DAR ES SALAAM

MUWEZESHAJI – Ndg. YONAZI, R. P.		
MUDA	TUKIO	MHUSIKA
14:00 – 14:30	Introductory remarks on the challenges of climate change in Agriculture – use of products of biotechnology/ genetically engineered crops as options to address climate change in agriculture	*Profesa P. Z. Yanda – Chair holder Mwalimu Julius Nyerere Professorial Chair - Environment and Climate Change – University of Dar es Salaam*
14:30 – 15:30	Panel presentations (10mins @)	• *Dr. M. Rubindamayugi - Molecular Biologist* • *Dr. G. Ndosi – Retired Food Scientist* • *Lim Li Ching – TWN Malaysia* • *Anne Ingeborg Myhr - GENØK* • *Mr. R. Mgamba (Weekend editor – The Guardian)*
15:30 – 17:40	Discussion, question and answers	*ALL*
17:40 – 17:50	Summary	*Facilitator – Ndg. Yonazi, R. P.*
17:50 – 18:00	Closing	*Profesa P. Z. Yanda – Chair holder Mwalimu Julius Nyerere Professorial Chair - Environment and Climate Change – University of Dar es Salaam*

1.4 Photo gallery

Day one of the meeting, guest speakers' presentations and the opening ceremony

A relaxing moment after a long day of discussions and presentations, cocktails by the pool at Giraffe Ocean View Hotel

Second day of the meeting, presentations and discussions from the floor and panelists

1.5 Comments from public meeting (8 December 2012)

The public meeting was arranged after the workshop with its own program that included presentations. After the presentations by the panel the floor was opened for discussion. There were several questions and comments that are listed below together with responses from the panel.

Professor Majule

This is a breeding technology of some kind. The challenge is acceptability of the technology to farmers, how are they going take it?
Key stakeholders are research centers and breeding should rely strictly on specific conditions, how is this to be addressed before we adopt the technology?

Response: there has been lack of transparency in particular from large companies dealing with GM issues e.g. Monsanto. This dialogue has not been funded for campaigning for GM issues, but has been given resources to facilitate a technical workshop for GM discussion and to facilitate public dialogues like this. The issue of breeding is very specific and ecological options also exist.

Yona Maro

Stakeholders in agriculture should come up with a strategy on how to educate the society through social networks.

Janeth (Sokoine University of Agriculture)

Experience with small farmers suggests there are environmental friendly methods such as sustainable agriculture, which help to restore soil fertility and increase soil water holding capacity. These are cheaper techniques and use local seeds, which are better than GM.

Mwaka Mbiu

Why do political leaders make important treaties/protocols instead of technical personnel?

Response: Technical personnel are responsible for formulation and discussions about treaties/protocols, political leaders finalize these by negotiating depending on advice from technical personnel. In these meetings all nations have equal power in decisions even though levels of negotiations differ. They normally discuss nations that contribute to climate change, their compensations and how are they going to reduce emission of these gases. All parties must ratify the protocol before its implementation.

John Laizer
GMOs are not a conclusive solution for climate change; we should not solely depend on ideas from developed countries.

Response: It is true that GM is not the only solution for this problem that's why we are having public dialogue like this to discuss alternative methods and to get stakeholders' views and opinion. This panel is neutral.

Christopher Singa (Zambian)
Why are we adopting very risky technologies to solve problems and not adopting beneficial ones?
How sure are we going to control farmers in using the seeds?
Herbicides have been found to have short residual span, GMOs will become part of our genes, they can mutate and change the organisms that we cannot control.

Obadiah Msaki (Kilimo Hai)
Consumers should be given a chance to make their views heard in public dialogues like this one instead of government making their decisions.
Safe agriculture (Kilimo Hai) can be used as an alternative in solving this problem; GMOs should be given priority in the medical and not in the food sector.

Roshan Abdallah
Universities have well-educated young people who can make significant contributions in dialogues like this, they have to use this opportunities instead of waiting for others' decisions. A good example is Zanzibar where the use of plastic bags was banned due to environmental concerns.

Dr. Kullaya
Providing the public with proper and correct information is very important; terminator gene technology is no longer accepted or in use and this was done in order to allow germplasm

exchange. It has been mentioned here that there is GM cotton in Shinyanga but the truth is there is no GM cotton anywhere in Tanzania. There is on-going research in the laboratory for cassava where the only possible control for the virus that is being addressed is by silencing the gene to produce resistant plant material. Furthermore, there are number of companies dealing with GM not only Monsanto. Debates like this are highly required for authorities to disseminate information.

Dr. Sylvester Oikeh

It is good to enlighten ourselves, we have been debating whether biotechnology is good or not. This technology is highly required, what we need are regulations to mitigate the risks because in every technology there is a risk.

Leodgar Kiwia

This technology is good and highly needed but we need to be conscious about it. For example in Karagwe where banana trees were infected, and a single company were selling insecticides, this kind of monopoly in business is not acceptable.

Dr. Nicholas Nyange (COSTECH)

The aim of science and technology is to provide solutions and proper services for emerging challenges; we need to improve the standard of living of small peasants. The use of GM technology is among the available solutions if used in a proper way. Recently a delegation from the Tanzanian government visited Burkina Faso to study the cultivation of Bt cotton and how this has benefited small farmers. The observations were that Bt cotton is indeed of benefit to smallholders and can be contained with minimal risk to the environment and human health. In Tanzania 5 regions are involved in cotton production over an area of about 400,000 hectares, which produces only 350,000 tonnes per year while in 2011 Burkina Faso Bt cotton was cultivated over an area of 247,000 hectares that produced 700,000 tonnes of cotton.
In Tanzania we have a National Biosafety Policy, with all regulations, yet we are unable to introduce such technologies that would change the lives of smallholder farmers and our economy.

Chagula Mwita

My current research is on imported maize and soybean products to determine whether they have GM events or not. The pressure to adopt GM and its products is high. For the past 5 years it was not easy to identify the effect on the GM products, it took time for anti GM activists to express their concerns but now the effects are obvious. GM technology is a problem and its effect is similar to that of climate change; what are being done are just comparative safety assessments and not a thorough safety assessment. Therefore, this GM technology should be abandoned.

Bruno Allyson

GM has no benefit to our country, it has got a lot of problems compared to those imposed by climate change. Solutions to climate change should focus on policies in those countries responsible for climate change. Also, reforestation should be emphasized.

Alfred Mwalembe

How have local technologies been of benefit to farmers?

How will this new technology be of benefit to farmers?

Luga (Citizens/Mwananchi newspapers)

What is the Government stand about GMOs?

If TFDA has no capacity to handle GMO issues, what is the way forward?

Government must show concern in terms of law and policy.

Response: TFDA is in the process of capacity building, but one can access expertise in the Universities. There is nothing to worry about because GM products have been consumed in other countries for some time now and no health effects reported. The most important is labelling the products.

Christine Muki (Majira newspaper)

How will this technology help local farmers who know nothing about GMO?

Dr. Riaz Heider

All possible questions have been raised and answered during this debate.

The problem of Tanzanian farmers is production, their capacity needs to be built in this area.

The extension services in agricultural sector are also a major problem requiring improvement.

Contamination starts when GMOs are in the field so whatever we decide we should know that at this level in this country, it would be difficult to solve this problem. Pollination occurs in the field so GMOs can contaminate non-GM seeds. We have to consider smaller farmers as their local seeds would be wiped out and it would be difficult to recover them.

Abdallah Ramadhani (ENVIROCARE)

We are not supposed to take this GM technology as a solution to our problems. A good example is that of local seed versus hybrid ones. Local seeds are currently no longer available in the market while hybrids dominate. We have to make sure we obtain patents for our local seeds.

Response: Risk assessment and food analysis of GM products iare done in most countries, biosafety assessment is well addressed in biosafety regulations and other cultivars are not prohibited, these can be used as well.

Frank

We are not supposed to rush into GM technology, Why did Kenya ban the importation of GM products?

Richard Oduor

GM technology is not the only alternative, but is one that can be adopted to solve agricultural problems. National strategic planning to combat climate change is under way, let's wait and see its content. During this time of market competition, with other countries experimenting and engaging in the technology, Tanzania can end up as a dumping place; we need to be prepared to avoid such effects.

Shaaban Kassuwi

GM technology is required for solving particular problems; the issue of gene flow has been there even before GM technology. This technology has been supported in the medical industry but is highly feared in agriculture. Precautions must be taken into consideration by doing a lot of research.

Dr. Richard Oduor

The import of GM products has been banned in Kenya but GM related research is still underway in the field. GM technology is growing fast, started with research, laboratory containment then release of material. We are not supposed to wait for it because we will be left out.

Joseph Swilla

Genetic modifications have been occurring in nature for a long time though it is a slow process; it is less precise as GM technology. GM technology is more precise and faster.

Is Norway commercializing transgenic salmon? At which stage is this process, have products been released? We are supposed to do more research about GM because with time GM will come in.

Response: GM salmon has been developed in the USA not Norway, it is yet to be approved in Norway. Combining GM technology with other technologies can solve the problem. There is no proof if genetic modifications occur in nature all the time.

Leucadia Kingamkono

Is there any effect of GM products on soil?

Response: Yes, GM products have impacts on the soil. If we want to get back into traditional ways after using GM technology is there any chance of getting more products as we used to?

Kamkuru (VPO)

The team from the Vice President's Office attended this debate in order to listen to public views about GM technology.

Elizabeth Mpofu (Zimbambwe)

Both scientists and researchers are focused on getting all the necessary information about GMOs; it would be wise to get information from farmers too.

Nicodemus Munisi

GM technology is required and must be adopted even though it should be run simultaneously with other methods.

Nancy (Uganda)

Farmers have innovations, which cannot be picked. The concern is on the extension services and on how information is delivered to farmers. GM technology is a part of solution but it should be used in a positive way.