International Environmental
Law Research Centre

Globalisation and the International Governance of Modern Biotechnology:

The Implications for Food Security in Kenya

Final report prepared for the FIELD/IDS Project on Globalisation and the International Governance of Modern Biotechnology funded by DFID

Hannington Odame, Patricia Kameri-Mbote & David Wafula

IELRC WORKING PAPER
2003 - 2

International Environmental Law Research Centre
International Environmental House
Chemin de Balexert 7 & 9
1219 Châtelaine
Geneva, Switzerland
E-mail: info@ielrc.org

Table of Content

I. Introduction

Kenya is faced with the twin problems of declining production and distribution of available food. The country's leading agricultural research institute, the Kenya Agricultural research Institute (KARI) has been responding to such agriculture and food production constraints by seeking to harness the potential of modern biotechnology through public and private partnerships and commercialisation of its services. But the progress has been slow.

Agricultural biotechnology in Kenya is characterised by low-technology applications such as biofertilisers, micropropagation and use of molecular assisted selection (MAS), however, and the country is experiencing an increased number of agricultural R&D activities in high-tech biotechnology options. These include work on transgenic sweet potato, Bt maize and recombinant DNA livestock vaccines and diagnostics. The introduction of these applications in Kenya has stimulated debate on globalisation issues (including equity and governance of IPRs, biosafety, investments and trade) and their potential impacts on food security in the country.

This study uses secondary literature and a case study approach to review elements of globalisation and international governance of modern agricultural biotechnology and to assess their potential impact on the local and national food security in Kenya. The report provides some background to the agriculture and food production trends in Kenya in Section 2. This is followed by an analysis of the policy and institutional context for agricultural biotechnology in Kenya. Section 4, reviews some of biotechnology programmes and regulations that have recently been introduced into Kenya, or are being considered as means of alleviating food insecurity in the country. Section 5 briefly describes two case studies of agricultural biotechnology introductions, namely transgenic sweet potato and Bt Maize. The cases were selected because they represent biotechnology R&D-inspired innovation process, which challenges the traditional role of the state and the rural livelihoods, as we know them today. In Section 6, we examine the how the transfer of transgenic sweet potato and Bt Maize to Kenya have contributed to the national agricultural biotechnology policy and regulations, and their potential impacts on food security in the country. The report concludes with a summary of key issues and lessons learned in Section 7.

II. Agricultural Production in Kenya

A. Overview of agriculture production

Agriculture is an important sector in Kenya's economy. It contributes 26 per cent of GDP and generates 60 per cent of total foreign exchange earnings. Agriculture provides seventy per cent of Kenya's employment. Consequently, agriculture creates jobs and increases incomes. As such, it has, and is expected to have for many years to come, an important and direct relationship with respect to development efforts to eliminate poverty and food insecurity. Furthermore, agriculture in Kenya provides 70 per cent of the raw materials for agro-based industries, which in turn account for 70 per cent of all the industries in the country. Agricultural production can therefore stimulate growth in other sectors. With an estimated growth multiplier of 1.6, compared to 1.23 in non-agriculture, it is likely to also maintain a strong indirect effect on Kenya's overall economic development.

However, agricultural production has gradually declined since mid 1980s and more rapidly in the past five years. It declined from 4.6 per cent in 1960 to less than 1 per cent in the 1990s. Further, the sector's contribution to GNP dropped from 35 per cent to 28 per cent during the same period (Republic of Kenya, 2000). Notably, the production of major food crops, such as maize, rice, wheat and sorghum dropped significantly.

This has resulted in more public expenditure on food imports. Maize production declined from 2.2 m. metric tons (from here abbreviated as MT (24 m. bags)[1] in 1996 to 1.98 million MT (22 million bags) in 2000, forcing the government to import 360,000 MT (4 m. bags) at Sh4.7 billion. In the same period, 636, 000 MT (7.1 million bags) of wheat were imported at Sh7 billion. Wheat is the second most important crop after maize, but its production levels fall far below that of its consumption. Kenya produces 270,000 MT (3 million bags) against the national demand of 540,000 MT (6 million bags) per year.

The production decline is not limited to major cereals but also extends to traditional food crops such as sorghum, millet, beans, cowpeas, pigeon peas and grams. Sorghum and millet are indigenous cereals to Africa with Sudan as their Centre of Diversity (CoD). They are adaptable to agro-ecological zones of Kenya because of their drought-resistance and good performance on a range of poor soils with low rainfall. Sorghum production has declined from 175,000 ha with an output of 108,000 MT (1.2 m. bags) in 1994 to 123,184 ha with an output of 90,000 MT (1 m. bags) in 1999.

The production of pulses (including beans, cowpeas, pigeon peas and grams) is also on a downward trend in terms of area and output. For instance, bean production in 1993 was 405,000 MT (4.5 million bags) from an area of 628,000 ha. But it declined to 135,000 MT (1.5 m. bags) from an area of 647,000 ha in 1997. In part, the decline in the production of pulses is attributed to adverse weather conditions, especially the *El Niňo* rains in late 1997. Whereas the production of cereals and pulses has declined, the production of roots and tubers such as potatoes and sweet potatoes has gradually increased in the past decade. However, cassava experienced a drastic production decline .

Overall, agricultural growth in Kenya has declined substantially in the past decade. Only the horticultural industry has experienced reasonable growth over the same period. Horticulture production in Kenya includes vegetables, fruits, nuts, cut flower, herbs and spices. Analysis of Ministry of Agriculture and Regional Development (MOARD) data suggests that 92 per cent of horticulture produce is consumed locally, thus contributing to food security and employment. Horticulture also provides raw materials for agro-food processing industries and is a key export sub-sector. At an annual growth rate of 15-20 per cent, the sub-sector has grown rapidly in two decades. Indeed, the foreign exchange earnings from horticulture have grown at an annual rate of 20 per cent and now stand at Ksh.14 billion. This rapid growth has been attributed to high global demand and appropriate policies (or lack of government intervention), which have encouraged private sector participation.

B. Factors affecting food production

At the macro-level, the Government of Kenya's policy on agriculture has proven ineffective, despite the fact that this sector is central to the country's economy. Some analysts argue that the government stresses the issue of food self-sufficiency in policy but in practice, the agricultural sector has not been given the attention it deserves in raising domestic food production and contributing to national accounts (Institute of Economic Affairs et al., 2001). The weak implementation of newly formulated policies on natural resources (including master plans for environment, water and forestry) exacerbates poverty in Kenya. The rural poor, and particularly women, often have no access to land and security of tenure. The numbers of men, women and youth who are landless squatters make up the poorest of the rural and peri-urban population. As Bates (1989) suggests, inequitable access to and rights over land reflect historical factors and weaknesses in land administration as much as failure of the market.

At the micro-level in Kenya, the high prices of inputs including labour, and lack of access to credit, by the majority of small holder farmers, has impacted negatively on investments in food crop production. For instance, the high cost of farm inputs, especially fertilisers, pesticides, spray equipment militates against smallholder farmers' ability to procure these inputs in quantities required for the hybrid seeds (Institute of Economic Affairs et al., 2001).

The distribution of stockists of these inputs is also inadequate, leading to high prices and scarcity in certain food-producing areas of the country. This is in part due to the poor provision of physical infrastructure such good road network and maintenance of the existing roads to link agricultural areas and markets. The result is high transport costs for agricultural inputs and outputs (Omamo, 1998).

C. Implications for agricultural research and extension

There are problems of inadequate research results, non-availability of quality seeds and inappropriate production technologies especially for smallholder farmers. The quality of seed, if available, is poor and susceptible to pests and diseases. The seeds also have low germination rates and are often adulterated and of low product quality, yielding low prices. At the same time, this category of farmers lack capable organisations to demand adequate quality research as well as efficiently distribute available seeds and other inputs among resource-poor farmers. Inadequate and low levels of research also result in the lack of high yielding varieties, and disease free planting materials to compensate the farmers' labour efforts.

Dry weather conditions also predispose the crops to high incidence of infestation.[2] Some diseases are common, and could, with the appropriate support to smallholders, be controlled by improved agronomic practices such as integrated pest management. Yet, most often the associated costs are prohibitive. Under these circumstances, small farmers are often faced with total crop failure or reduced yields.

Another cause of low agricultural production is the inefficient rural extension systems. In the past, small farmers relied on the government extension service, which was free, although in Kenya, as in many developing countries, agricultural extension was rarely universally accessible to all farmers, and especially to women (Poats et al.,1988). Structural adjustment programmes and the associated partial or fully privatised extension services recently instituted in Kenya have not increased resource-poor farmers' access to agricultural inputs. While not yet sufficiently investigated, the current transition in rural extension services in Kenya is believed to have contributed to decline in food production over the past few years, especially in more marginal areas of the country (Nyariki and Thirtle, 2000).

According to sources at the Ministry of Agriculture, the country's new National Extension Policy (NEP) has acknowledged these gaps and attempted to shift from prescriptive to educational methods in providing technical advice to farmers, typically through farmers' organizations and women's groups. The NEP puts emphasis on providing farmers with the necessary skills and ability to identify opportunities for improving farm productivity and to seek out, test and ultimately adopt technologies appropriate to their particular social and agro-ecological conditions. It remains to be seen however, how this policy will be able to respond to the challenges confronting Kenyan agriculture, especially those associated with biotechnology.

III. Policy and Institutional Environment

A. Science and technology policy

The government of Kenya had, since the mid 1980s, embarked on structural adjustment programmes, which sought to spur economic growth through export orientation, and investment in modern science and technology and public management practices for reviving the country's agricultural economy. Although Kenya has a broad S&T policy constituency, it lacks a specific national policy and legal framework on biotechnology. The National Council for Science and Technology is in the process of drafting a national biotechnology policy but this is yet to be finalised. While biotechnology R&D is evolving rapidly in a policy vacuum, no consideration has been made to mainstream the technology into national planning and development instruments. For example, biotechnology is not mentioned in the current Development Plan (2002-2008), although it was mentioned for the first time, as a specific policy for agricultural development, in Kenya's Seventh Development Plan (1994-1996):

> *The application of biotechnology in agriculture and livestock production will be nurtured and developed " (GOK, Development Plan, 1994-6:127).*

A certain level of political will has been demonstrated. For instance, in 2000, President Moi wrote a letter of request to President Clinton for technical assistance to Kenya in the area of biotechnology capacity building. This has been read to imply that at the highest level, the Kenyan State appreciates and supports the role of biotechnology in the country's development. Political commitment in terms of increased allocation of financial resources to biotechnology R&D is however uncertain, and some analysts believe inadequate (ISNAR, 2000).

Policy makers often make *ad hoc* policy-related statements on biotechnology during national or international events or meetings. This has led to fragmentation and poor communication of the biotechnology R&D agenda among various actors in the National Agricultural Research System (NARS). For instance, many of the recent biotechnology initiatives in the public research sector reflect the interests of the concerned individuals or particular institutions– with minimum inter-organisational interactions or synergy. Therefore, modern biotechnology activities in the country are influenced by institutional preferences and donor funding, which is not necessarily guided by or aligned to national priorities (Anyango and Shiundu, 1999).

B. The National Agricultural Research System of Kenya

Biotechnology applications in Kenya have occurred within an existing historical and structured system of national agricultural research. The system is characterised mainly by conventional technology, public goods research, multiple internal and external stakeholders and centralised and hierarchical organisations including national research institutes like the Kenya Agricultural Research Institute (KARI), several universities, numerous NGOs, producer associations and very many community based organizations representing resource-poor smallholder farmers.

It is argued that the legacy of using "technological fixes" to achieve national development makes top-down approaches a persistent feature in Kenya's agriculture research system (Mwangi, 1999). This tendency disregards the livelihoods of rural communities whose own institutions are rendered invisible. With respect to the emergence of modern agricultural biotechnology in Kenya weak governance structures and processes and ambiguity about the existence of a clear and comprehensive policy for the efficient and effective co-ordination of biotechnology research in the country further exacerbate the situation. This in turn affects the capacity of Kenya to participate effectively in regional, as well as international biotechnology collaborative efforts.

In Table 1, a survey of organisations conducted by Odame and Mbote in 2000 summarises the organizational synergy or productive (not nominal) inter-organisational interactions within the Kenyan NARS with respect to modern biotechnology. This study reveals that the highest number of ties between organizations involves international agricultural research institutes (IARCs) having their head offices in Nairobi. These include the International Livestock Research Institute (ILRI), International Centre on Research and Agroforestry (ICRAF), International Centre for Insect Pest and Ecology (ICIPE) or having regional offices (CIMMYT, CIP and ISAAA) in Nairobi. Of second level importance were inter-organisational interactions involving NARIs (including KARI), which account for 32 of the estimated 52 ties. There are 50 ties to the universities, with 19 and 14 ties to NGOs and the private sector respectively.

About 158 (70%) of all the ties are linked to the three organisational categories namely, international agencies, NARIs and universities. Ties to other organisational categories were 36 (16%) and 33 (14%) for the government agencies and NGOs/private sector respectively. This demonstrates the dominance of research networks in S&T policy. It further confirms the prominence of upstream institutional linkages in the production of public goods research. In terms of tie performance, with the exception of ties to the government agencies (which are rated fair at 2.83), most of the scores fall within the range of good (3.04 to 3.37).

The ties to KARI are rated fair at 2.96 and to the other NARIs are rated good (at 3.15). A large number of ties are reported to be informal (inter-personal relationships). Even where respondents indicated existence of Memoranda of Understanding (MOUs), they were not sure about the contents of these linkage agreements.

Table 1: Organisational Synergy in Kenyan Biotechnology

Organisation category	Number of ties to sector	Average score of tie performance [b]
University	50	3.20
NARIs[a]	52	3.04
NGOs	19	3.37
Private	14	3.37
International	56	3.37
Government	36	2.83
Total	227	

Note: a: KARI (ties =32 and score = 2.96), Other NARIs (ties =20 and score = 3.15); b: 1= poor; 2= fair; 3= good; 4=very good; 5=excellent

Source: Odame and Mbote, 2000

Notably, farmers' organizations and agencies whose members are resource-poor farmers are absent or silent in the networks of S&T policy. Integrating biotechnology into existing structures may not necessarily result in the generation and retention of appropriate or profitable innovations for smallholders suggests Bunders et al. (1991). A more interactive, bottom-up approach is recommended, but such an approach is primarily concerned with methodological issues in needs assessment and priority-setting phases of biotechnological innovation process. There is still little work in the Kenyan context that analyses farmers' experiences and local-level consequences of biotechnology innovations. Given the uncertainty surrounding biotechnology, there are persistent concerns over farmer representation and participation in terms of type and level of decision-making. As we shall see in the next section, the extent to which institutions might influence interactions between researchers and farmers further adds to this uncertainty.

IV. Agricultural Biotechnology in Kenya

A. Traditional to modern biotechnology

Biotechnology in Kenya is taking place within the context of an established agricultural R & D system. The advent of traditional biotechnology applications such as biofertilisation, tissue culture and molecular markers, and their ease of integration into existing conventional plant and animal breeding have provided an opportunity for addressing the problems of poverty, hunger and malnutrition. These applications do not require advanced laboratory facilities and specially trained scientists. In particular, the use of traditional biological processes, such as fermentation and biological nitrogen fixation (BNF) in Kenya is a long-standing practice. Since the early 1960s, European farmers in Kenya, through the Kenya Farmers Association (KFA), were importing BNF for production of soya bean and fodder legumes in the country. The use of tissue culture began in the early 1980s with its incorporation into the production of pyrethrum and citrus by KARI and the University of Nairobi respectively. But these projects were simply added on to conventional breeding programmes.

A systematic evaluation of biotechnology in the country was initiated 1990, when the government appointed a National Advisory Committee on Biotechnology Advances and Their Applications (NACBAA). The objectives of NACBAA were to:

1. Identify national priorities on the basis of comparative advantage and ability to implement traditional methods in small scale agriculture;
2. Facilitate rapid access to new germplasm;
3. Reduce high costs of agricultural inputs; and
4. Gain access to cheaper and more environmentally friendly alternative.

The Committee completed the study and reported its findings to the government towards the end of 1990. Among its key findings, NACBAA identified immediate applications in tissue culture for mass propagation and disease elimination, development of disease diagnostic kits, and the use of biological inoculates as priorities. The committee further identified and recommended some areas of plant genetic transformation for various biotic and abiotic stress and at capacity building needs at various levels. It recommended that without technical and regulatory capacity, the viability of modern biotechnology in Kenya was uncertain. But the findings and recommendations of NACBAA were not implemented due to lack of funding.

In 1993, the Biotechnology Program of the Netherlands Directorate-General for International Co-operation (DGIS) took a different approach to biotechnology policy and programme development by implementing on a pilot basis a special social science research project in four countries: Kenya, Zimbabwe, India and Colombia. The overall aim of the programme was to help alleviate poverty through biotechnology research and implementation in a way that takes grassroots interests into account. (Wekundah, 2000) It is one of the few development programs that are directed exclusively towards biotechnology and poverty alleviation. Like NACBAA, this programme also prioritised policy developments in biosafety and capacity building.

Table 2: Selected Biotechnology Projects and Funding

Organisation	Commodity/policy	Objective	Technique	Funding source	Level of funding (US$)
UoN-Soils Botany	Beans, soy bean	Nitrogen Fixation	Biofertilisers.	Various	na
JKUAT -Biotech	Bananas, sweet potato, cassava	Micro-propagation	Tissue culture	BTA/DGIS	250,000
KEFRI	Multi-purpose tree species	Micro-propagation	Tissue culture	EU	382,000
TRF, Oserian co.	Tea, cut flowers	Micro-propagation	Tissue culture	Company	na
KARI, KEPHIS	Pyrethrum, potato, sweetpotato	Micro-propagation	Tissue culture	Government	Na
KARI-Katumani	Maize	Drought-tolerance	Marker techno.	BTA/DGIS	1100,000
KARI-Katumani	Bt. Maize	Insect-resistance	Bt. Technology	Norvatis Found.	4,000,000
KARI	Transgenic sweet potato	Disease-resistance	DNA Technology	Monsanto/others	2.000.000
KARI-NVRC	Livestock	Disease control			
KETRI	Livestock	Disease control Tryps. -resistance		IAEA DFID	2570,000 100,000
TRF	Tea	Gene Mapping	Marker techno	Brooke Bond Ltd.	
ICRAF	Priority tree species	Biodiversity	Marker techno.	CGIAR	na
ILRI	Livestock	Biodiv./diseases	DNA Technology	CGIAR	6,000,000
KIPI	IPRs	Training	Short courses	WIPO	na
NCST	Biosafety Guidelines	Training	Short courses	BTA/DGIS UNEP-GEF	120,000 na

Source: Odame and Mbote, 2000

Unlike the NACBAA priorities which were not implemented by the government due lack of funding, KABP received US$4.2 m from Netherlands Directorate-General for International Co-operation (DGIS). The programme has since the mid 1990s supported eight biotechnology research projects: potato, cassava and sweet potato, citrus, macadamia, banana, marker assisted breeding (MAB) in maize, biopesticides, animal health and institutional support.

At US$1.1 MAB in maize received the most funding within the programme. The average funding for each of the other projects was US$300,000 (Odame and Mbote, 2000). At US$ 2 million, the transgenic sweet potato project represents the largest single biotechnology research contribution by the private sector (Monsanto). The implementation of the Bt. Maize project by KARI, CIMMYT and Norvatis Foundation, under the auspices of the Insect Resistance Maize for Africa (IRMA), is estimated to cost US$4 million.

Kenya Trypanosomiasis Research Institute (KETRI) has since the early 1990s, received public funding of US$ 2,570,000 from IAEA for livestock disease control and US$100,000 from DFID for trypanosomiasis tolerance research. Due to geographical proximity, Kenya also benefits from research activities of supranational organisations such as ICRAF, ILRI, ICIPE and ISAAA. For instance, ILRI spends approximately US$6 million per year on biotechnology-related livestock research. Some research organisations and farmers in Kenya may benefit through their collaborations with ILRI and other centres.

Excluding the international organisations, over US$ 15 million has been spent on tree, crop and Livestock biotechnology-related research in Kenya –in the last 10 years. All agricultural biotechnology research projects are donor-funded for a period of five years. This raises the question of their sustainability. Apparently, donors as political actors are unlikely to operate without and direction of priorities and interests of their own countries.

B. Key developments in modern biotechnology

The controversial image of agricultural biotechnology industry in developed countries has driven a series of initiatives by the corporate sector in their activities in modern biotechnology transfer to developing countries. The discourse now includes a strong basis for how biotechnology can be harnessed to address the problems of poverty, hunger and malnutrition in developing countries. In Kenya, some scientists such as Dr. Cyrus Ndiritu (the former Director of KARI) were aware that the public sector could not afford to access modern biotechnology because of its proprietary nature. They also learnt that making the private sector controlled biotechnology work for the benefit of society was almost impossible. As a result KARI sought to access the proprietary technology from the private sector through negotiation of licensing agreements for public goods research. The transfer of transgenic sweet potato and Bt. Maize to KARI involved proprietary technologies donated by international organisations.

The main modern biotechnology programme and policy-related initiatives include:

(1) Transgenic sweet potato for virus resistance, a collaborative public-private research project involving Kenya Agricultural Research Institute (KARI), Monsanto, Agricultural Biotechnology for Sustainable Productivity (ABSP) project, International Service for Acquisition of Agbiotech Applications (ISAAA) and Michigan State University (MSU).

(2) The Insect Resistant Maize for Africa (IRMA) project, a Bt. Maize project involving public and private partnerships among KARI, CIMMYT, Norvatis (now, Syngenta) Foundation for Sustainable Development and Rockefeller Foundation.

(3) The National Biosafety Framework Development Project by the National Council of Science and Technology (NCST), mainly publicly financed by various international agencies including the Dutch Ministry of International Cooperation (DGIS) and UNEP-GEF to establish a framework for the safe development and introduction of modern biotechnology in the country.

While conceding that these initiatives contributed to the technical and legal capacity of national institutions such as KARI and placed them on the technology-frontier, some critics were concerned about the threat of weakening public research. In particular, they observed that, the use of proprietary technology threatened to replace free exchange of knowledge and undermine the public goods produced through national research programmes. Furthermore, much of the effort was confined to capacity building for transgenic sweet potato and Bt. Maize research at the national level, and not extended to the local level.

Apart from these donated technologies, no examples of private-public research initiatives in the country. This has led critics, particularly through local print media to argue that these token technologies were used by the private sector as market openers for many of their GM crops in Kenya and elsewhere in Africa (Kenya Daily Nation, 2000-2001).

C. Human resource development

Without comprehensive strategic research focus and definite objectives, developments in modern biotechnology to benefit resource-poor smallholders remain a mirage. Equally important is the effective communication and implementation of the development strategy with the relevant scientists and stakeholders. To this end, the management of modern biotechnology research initiatives in Kenya often seek to strengthen the country's legal, scientific and management capacities. This requires strong scientific knowledge and linkages in technology generation –which were undeveloped in traditional biotechnology innovations.

Wafula and Falconi (1998) estimated that by 1996 about 56 scientists were involved in biotechnology research activities in Kenya. These scientists accounted for 80 per cent of agricultural biotechnology research in the country. Scientists in international organisations located in the country performed the remainder.

Of the 56 Kenyan scientists, 21 (or 38 per cent) were located in public universities. The public university scientists spent less than 10 per cent of their time on agricultural biotechnology-related research. Public university policy sought to ensure that scientists spent most of their work-time on teaching and other related activities. This implies that only 35 full-time equivalent research in the entire national biotechnology research programme.

The problem of building capacity is exacerbated by the deficiency of both quantity and quality of personnel in the relevant disciplines of modern biotechnology. In particular, the government and research institutions do not have specific training strategies for building national capacity in biotechnology, IPRs and biosafety regulations. Rather the research institutions have incorporated their training needs within the framework of individual research projects/programmes (KARI Training Masterplan, 1997). To date, our research suggests that there are more than 60 scientists and technicians who have received training on basic and applied tissue, molecular biology, recombinant DNA and other aspects of biosafety and biopolicy.

Over the years, capacity building in agricultural research has tended to focus on hardware (physical facilities) and post-graduate training in MSc and PhD. However, the rapid expansion of physical facilities implied a low proportion of scientists to total employees in a given research organisation. A large number of non-scientific staff relative to scientific staff were required to maintain the physical facilities (Table 3). Table 4 shows the quality of staff available in terms of ratio of Ph.D.s, MSc. and BSc/other technicians. It is difficult to determine the optimum proportion of scientific staff. But agricultural research institutions often aim to achieve a target ratio of 30:30:60 for Ph.D.s, MSc. and BSc./other technicians (*ibid*).

According to sources at the CGIAR centres in Nairobi, a majority of scientists in Kenya may have basic scientific knowledge in genetics and molecular biology, but lack practical experience to effectively apply their existing knowledge to modern biotechnology. For instance, universities produce scientists with BSc and MSc --without practical training in modern biotechnology. The capacity of available scientists is also under-utilised due to low levels of funding in terms of scientific infrastructure and actual research grants and staff salaries (Odame and Mbote, 2000).

Table 3: The proportion of scientific staff to total employees

Organisation	Number of Employees	Number of Scientific staff	Per cent (%) of Scientist
JKUAT –Biotech centre	8	6	75
Plant Pathology –UoN	30	10	33
KARI-NVRC	342	35	10
KEFRI	1200	8	1
KETRI	690	10	8
TRF	165	5	3
Oserian Development Co.	4000[a]	9	0.2
KEPHIS	315	80	25
KIPO	85	21	25

Note: A large number of these employees are casual labourers –working in the flower industry. *Source*: Odame and Mbote, 2000

Table 4: The ratio of scientific staff in selected research organisations

Organisation	Number of Ph.D. staff	Number of MSc. staff	Number of BSc./ other staff	**Total**
JKUAT –Biotech centre	1	1	4	6
Plant Pathology –UoN	3	1	6	10
KARI-NVRC	8	8	19	35
KEFRI	1	1	6	8
KETRI	1	1	8	10
TRF	1	1	3	5
Oserian Development Co.	0	0	9	9

Source: Odame and Mbote, 2000

Of the 11 laboratories surveyed, the majority are using tissue culture techniques. With the exception of international centres such as and ILRI and ICRAF, it appears that funding and reagents and relevant personnel are acute and serious constraints for laboratory capacity in Kenya. Universities, national agricultural research institutes (NARIs) and government regulatory agencies are particularly affected. These agencies are also face the problem of finding suitable organisational and personal collaborators.

While traditional biotechnology capacity building involved plant breeding and soil science, modern biotechnology has since the early 1990s focused research training in areas related to law, science and bureaucracy. At the same time, the role of the public research sector in modern biotechnology was limited due to declines in public investment and consequently R&D-inspired innovations are increasingly funded by the private sector.

With increasing proprietary knowledge, the public research sector can only access the technology and the relevant human resource capacity training through collaboration with the private sector and donor funding. Some respondents pointed out that the approach was limited to a few scientists and short courses. There is thus limited contribution to the long-term strategy for achieving a critical mass of human resources needed to effectively engage in modern biotechnology. The country is currently facing a crisis of training and retaining scientists. The few scientists that are highly trained leave the country for better career opportunities in Europe, North America and Southern Africa. For instance, Kenya's national newspaper the Daily Nation reported recently that 1 out of 14 scientists who had qualified with Ph.D. in molecular biology and genomics was still in the country by the end of 2001. This may be attributable to under-utilisation of existing capacity as a result of poor scientific infrastructure. Much of the deficiency in modern biotechnology capacity is also related to intensification of science and costs. Therefore, effort is still needed to develop agricultural biotechnology strategies that work with diverse social groups and their particular constraints, and not against or around them.

IV. Case Studies

A. Basis for selection of case studies

Transgenic sweet potato and Bt. maize were selected as case studies because they highlight the impacts of globalisation on science and technology (S&T) policy. They also reflect international and national governance issues underpinning access to modern biotechnology for food and agricultural production in sub-Saharan Africa. In Kenya, the two case studies complement each other. Sweet potato is an important food security crop for the poor, small-scale and women farmers. Meanwhile, maize is an important national food crop in the country. There is also a large body of secondary data on it and it has been the subject of lively debate among various stakeholders.

Therefore, a comparison between a nationally important strategic crop like maize and a minor crop like sweet potato is likely to reveal some interesting lessons about who is setting the research agenda and its relation to national-level policy and globalisation factors. Furthermore, a comparison of the different ways in which policy treats for maize and sweet potato is interesting given the centrality of maize and in light of debates about price support mechanisms and subsidies, trade liberalisation, WTO obligations and the production fluctuations being experienced in the country currently.

B. Sweet potato production in Kenya

Sweet potato is cultivated on about 75, 000 hectares spread over various agro ecological zones in marginal and high potential areas (Qaim, 1999, Gibbons, 2000). While it is a versatile crop for meeting food security needs at the household level, its production has been declining due to high losses caused by diseases and lack of adequate planting materials (see Figure 2). In particular, a combination of viruses including the sweet potato feathery mottle virus (SPFMV) and the sweet potato chlorotic stunt virus account for losses amounting to about 80% of the yields (KARI, 2000). Kenya's average sweet potato yield stands at 6 tha^{-1}, less than half the world's average of 14 tha^{-1} (Mungai, 2000). China has, for instance, realised yields of 18 tha^{-1} (Hinchee, 1998). The advent of modern biotechnology motivated researchers to conceive a collaborative programme to address the low yields of African sweet potato.

1. Transgenic sweet potato project

The development of the virus resistant sweet potato began in 1991 with financial support from the USAID. The project was designed to address production problems and losses emanating from SPFMV. The key actors in the project were Monsanto and KARI scientists, who developed suitable biotransformation and plant regeneration protocols. Technical backstopping and additional support came from the ABSP and ISAAA.[3] Monsanto donated (free-of-charge) the gene of interest and initial research support on genetic transformation of six Kenyan sweet potato varieties against SPFMV at Monsanto laboratories in the US. At the initial stages of the project, only one of the six local sweet potato varieties, CPT 560, was successfully transformed using the donated coat protein gene. But by 1997, over 195 lines of CPT 560 had been transformed (Gibbons, 2000).

Source: FAO database

The actual transfer of the transgenic sweet potato technology from Monsanto to KARI only took place in the year 2000, after a delay of at least two years. Under-developed biosafety guidelines and regulations and inadequate human resources and infrastructure for risk assessment caused this. It was also the first introduction of a genetically modified crop into the country and it coincided with heightened global concern and debate over GMOs. The National Biosafety Committee (NBC) gave KARI an approval in December 1999 and this was followed by issuance of a plant importation permit by the Kenya Plant Health Inspectorate Services (KEPHIS). At present, on-farm trials are being conducted in various parts of the country before the technology is diffused to farmers (Odhiambo 2000).

2. Lessons from the transgenic sweet potato project

One of the limitations of this project is that it will only address a specific production constraint. In other words, it does not address multiple problems leading to low yields of sweet potato in Kenya. This raises the question of the extent to which the technology will meet the farmers' preferred agronomic and other characteristics. A user-relevant technology should be able to cater and satisfy the diverse needs of farmers in terms of cultural preferences, varied tastes and nutritional qualities. These are important determinants for its adoption. According to sources at the International Potato Centre (CIP) based in Nairobi, there is need for at least two sweet potato clones per each agro ecological zone.

An *ex ante* economic analysis of the potential gains from transgenic sweet potato introduction in Kenya conducted in 1999 shows significant returns for small-scale farmers. It is estimated that by using transgenic virus-resistant varieties farmers will be able to increase their sweet potato yields by 18 percent. According to results of model simulations, the virus-resistant varieties are estimated to produce an aggregate annual benefit of 5.4 million US dollars. However, the main challenge in the project could be establishing a system for distribution of disease-free sweet potato planting materials. It is worth noting that the *ex ante* economic analysis assumes an efficient seed potato system to serve the farmers. This however does not currently exist. Indeed a system whereby farmers regularly purchase clean planting materials may be more demanding compared to the traditional and informal one where farmers reproduce and exchange the materials among themselves (Qaim, 1999).

In countries that have already experimented with transgenic sweet potato, for instance, the Mexico, experience shows that farmers do not use commercial seed potato because of the high cost of the seed (Qaim, 1999). In Kenya, a study commissioned by GTZ to address the consumption characteristics of sweet potato in Kenya shows that the supply of certified seed by KARI and other parastatal organisations has not been efficient. Furthermore, efforts by institutions such as CIP, have focussed more on technical aspects such as flour processing and post-harvest protection as opposed to delivery of extension services and distribution of seeds (GTZ, 1998). Therefore, the project is faced with the challenge of linking R & D generally and science particularly, to production.

C. Maize production in Kenya

Maize is grown in 90 per cent of all Kenyan farms. Its importance to the Kenyan economy ranges from food provision, income generation to creation of employment both directly and indirectly (Person et al., 1995).

In particular, maize is an important food crop that shortages and famine in the country are usually linked to its poor yields. In the 1970s and early 1980s, the performance of the maize-sub sector in Kenya's economy was impressive. This period was characterised by expansion in the area under maize and increase in the yields of the crop (see Figure 3).

Source: FAO database

Government intervention in maize production was mainly handled through the National Cereals and Produce Board (NCPB). The Board was involved in the marketing of maize and other cereals with the objective of achieving price stabilisation and food security (Nyangito and Okello, 1998). The early success and growth spearheaded by technical change and enabling government policies began to decline in mid 1980s and worsened in 1990s. During the 1990s, maize production has been affected by a combination of factors including unprecedented demographic trends leading to massive sub-division of land, and market distortions resulting from the implementation of liberalisation policies. Other problems include harsh climatic conditions, scarcity of good agricultural land for expansion, and a high incidence of pests and diseases. Major diseases include maize streak virus, the stem borer and the grain borer, which account for heavy losses.

The area under maize cultivation has stabilised at around 1.4 million hectares with an average maize yield is about 2 tonnes per hectare, but potential exists for increasing the yield to over 6 tonnes per hectare through increased use of improved seeds, fertilisers and good crop management (Government of Kenya, 1997). While efforts have been put in place to increase maize production, the demand has been high and occasionally outstrips supply. The deficit has in most cases been partly met through commercial importation and food relief from international agencies like the World Food Programme.

Analysis of the major problems facing maize production shows that for the past 30-40 years, maize research in Kenya, maize research in Kenya has been concentrated around breeding for higher yields, while ignoring breeding for pest and disease tolerance. As a result, small-scale farmers grow maize under very poor pest and disease management conditions. Stem borers pose one of the most serious threats to the production of maize with losses estimated at about 15 % of the harvest. This is equivalent to 400, 000 tons of maize valued at US$ 90 million (De Groote, 2000). This problem has continued to intensify as most subsistence farmers are resource-constrained and cannot meet crop protection costs. Climatic factors such as drought combine with the virus to aggravate production losses. In years of surplus production, post-harvest losses are high mainly due to poor and limited storage facilities.

1. Insect Resistant Maize for Africa Project

In response to the above concerns, the International Maize and Wheat Improvement Centre (CIMMYT) and the Kenya Agricultural Research Institute (KARI) launched the Insect Resistant Maize for Africa (IRMA) project in 1999, with financial support from the Norvatis Foundation. The overall objective of project is to increase maize production and food security through the development and deployment of insect resistant maize that is adapted to various agro ecological zones in Kenya. The new maize variety will be developed with Bt. genes that are harmful to local populations of stem borers. Maize leaves with Bt. toxins were introduced from Mexico and these are undergoing trials at various KARI research stations. Other components of the project include procedures for diffusing the technology to farmers and assessment of the socio-economic impacts of the new maize variety in the entire Kenyan agricultural system (IRMA, 2000).

2. Lessons learned from Bt Maize project

Like the case of transgenic sweet potato project, this project has a number of limitations. While Bt. gene offers resistance against the stem-borers, they will not solve problems posed by other pests and diseases such as maize streak virus. Further, Bt. maize does not have genes of resistance to weeds such as striga. This implies that technology will only partially help farmers in reducing crop protection costs. In essence, the two projects have contributed to the technical capacity building for KARI scientists, but they are yet to show a shift in the behaviour of these scientists towards closer interaction with user groups in priority setting in agricultural biotechnology.

V. Policy and Regulations

A. Intellectual Property Rights and Trade

1. Adopting IP-related laws

International forces and interests have influenced the development of intellectual property laws in Kenya. Kenya has a long history of IP protection with the first patent registered in the country in 1912. Like other laws in Kenya, IP laws are a heritage of the colonial past. Indeed until 1989, Kenya had a dependent patent system. In 1990 however, the Kenya Industrial Property Office (KIPO) was created with the enactment of the Industrial Property Act. Cap. 509 of the Laws of Kenya. KIPO was given the mandate of examining, granting and registering industrial property rights under the provisions of the Industrial Property Act and the Trade marks Act

Cap. 506. this signified a major shift from the prior system where Kenyan authorities merely re-registered IPRs granted in the United Kingdom.

With the creation of World Trade Organization (WTO) in 1995, and the coming into force of the TRIPS agreement, all members of WTO were required to revise their national patent laws to conform to the requirements of TRIPS and WIPO guidelines. Kenya as a member of WTO and a signatory to TRIPS, was obligated to amend the Industrial Property Act. This came into effect when the Industrial Property Act was passed by the parliament on 13th June 2001.[4] The process led to institutional transition. KIPO, initially a Government department under the Ministry of Tourism, Trade and Industry was transformed into a more autonomous and independent patent office, the Kenya Intellectual Property Institute (KIPI). The autonomy gave KIPI a wider decision-making mandate in the screening and granting of industrial property rights. It is also mandated to carry out training courses. The institute is expected to shift from financial reliance on the government and raise its own funds (Aluoko, n.d.). There is no doubt that the government and some international bodies meet part of KIPI's financial needs. In the past KIPO (now KIPI) has received support from WIPO in areas such as human resources capacity training and IP-related computer hardware and software.

Although KIPI is positioned as one of the best intellectual property institutions in Sub-Saharan Africa, the organization is faced with many challenges such as drafting of suitable laws such as the *sui generis system,* and managing day to day issues related to enforcement and policing of IPRs. One area that needs urgent intervention of KIPI, is the strengthening of IPR regimes at the institutional level. Many Kenyan institutions lack or have underdeveloped IPR regimes and policies (BIO-EARN 2001). KIPI is also confronted with the daunting challenge of developing appropriate policies and laws to harmonize the apparent conflict between TRIPS and the CBD, in particular on issues revolving around Article 8 (j) of the CBD. It appears that the Industrial Property Act (2001) was swiftly enacted to conform to standards set by TRIPS. From a national development perspective however, the Act is silent on a number of crucial concerns. For instance, it does not address issues such as protection of genetic resources and knowledge held by local communities. While Kenya is a signatory to a number of binding international conventions and agreements that touch on these issues and is participating in discussions on appropriate mechanisms at that level, majority of Kenyans, including farmers, researchers, manufacturers and other actors are unaware of these developments and little effort is made to help them understand the relevant implications of these policies (Omiti, 2002). Foreigners account for most of the applicants to KIPI. Kenyans have for instance, filed very few patents because the various players are not aware of their rights as inventors and the procedures for getting their rights protected.

2. IPRs, research and product development

Article 27 of TRIPS requires that patents be granted in all areas of technology including biotechnology. The Industrial Property Act, 2001 provides for the grant of patents for biotechnology innovations. For a biotechnological invention to be patentable, it must be "new, involve an inventive step and is industrially applicable" (Section 7). The Act excludes plant and animal varieties from patentability. Under TRIPS, plant varieties are required to be protected either by patents or an effective *sui generis* system or a combination of both. Kenya has not yet developed a *sui generis* system. Kenya has had a plant variety protection legislation, which until the mid-1990s was characterised as largely dormant in terms of variety protection. The Seeds and Plant Varieties legislation (Cap 326 of the Laws of Kenya) became functional in 1975 but was confined to seed certification. The Act was revised in 1978 and 1991 to respond to shifting developments in international trade and the seed industry. The revised Act was to a large extent in conformity with the requirements of the 1978 version of UPOV convention. This enabled Kenya to accede to convention in 1999. As per the stipulations of the convention, new plant varieties in Kenya had to be protected by Plant Breeders' Rights (PBRs) granted for plant varieties that distinct, homogenous and stable. The Kenya Plant Health Inspectorate Services (KEPHIS) was established in 1996 to regulate importation and exportation of plant materials and the trade in bio-safety control organisms in accordance with the International Plant Protection Convention (IPPC). KEPHIS administers plant breeders' rights in Kenya and is the liaison office for the UPOV convention. A Plant Breeders Rights office was created in 1997 under KEPHIS to handle matters related to PBRs (BIOEARN, 2001a).

3. Application of IPRs to the transgenic sweet potato and Bt. maize

The transgenic sweet potato and Bt. maize were introduced into Kenya as 'technology donations' by international organizations and as crops directed towards enhancing food security. KARI is, for instance, permitted by Monsanto to protect the transformed transgenic sweet potato varieties under plant breeders' rights or any other appropriate IPR instrument. The non-exclusive, royalty-free licensing agreement signed between KARI and Monsanto allows KARI to use the technology and share it with other African countries in future. Syngenta Foundation donated Bt. maize technology as a corporate contribution to sustainable development in Kenya. After the technology had been transferred, legal problems arose between Syngenta Company and Syngenta Foundation due to lack of communication and prior consultation. Apparently, KARI and CIMMYT scientists were working with a technology without being aware of its of IPR implications. Given that the researchers involved lacked the requisite negotiating skills in IPRs, CIMMYT commissioned a study to investigate IPRs implications of releasing Bt. maize in Kenya as a public good.

The Strategic World Initiative for Technology Transfer (SWIFTT), Cornell University undertook the study known as "freedom to operate". The study revealed that unlike other projects involving transgenic crops, Bt. maize would be subject to fewer intellectual property restrictions. What is implied by fewer intellectual property restrictions is not clear. However, the report states that KARI may have to negotiate with IPRs of third parties like commercial ventures before Bt. maize is commercialised (IRMA 2001). According to some sources at Syngenta Company, there were some problems with the proprietary technology donated by Syngenta Foundation for Sustainable Development. While sweet potato and Bt maize are meant to be public goods, it can be seen that they are entangled in some IPR protection. This implies that ultimately, farmers may have to pay for increased transaction costs of accessing certified seeds and planting materials. Access to the technology by farmers is vital and related to this issue is how the distribution of seeds of Bt. maize and sweet potato are going to be organized.

In transforming transgenic sweet potato and Bt. maize germplasm to come up with varieties adapted to various agro-ecological zones in Kenya, KARI scientists will draw on the knowledge of farmers and the landraces grown in various parts of the country. For many years these farmers have been custodians of traditional varieties adapted to various climatic conditions and suitable for meeting food security needs. Unfortunately, PBRs exclude the rights and traditional knowledge of farmers and do not recognize them as key players and part and parcel of the breeding process. PBRs fail to appreciate the fact that the breeding process begins at the farmer's level before moving to the laboratories. This contradicts the notion of farmers' rights and protection of traditional knowledge as indicated in article 8 (j) of the Convention on Biological Diversity (CBD). It will be interesting to see what approach Kenya takes to the domestication of the International Treaty on Plant Genetic Resources for Food and Agriculture which has provisions on farmers' rights which are distinct from breeders' rights.

4. Implications of IPRs for public research and farmers' access to biotechnology

Before the introduction of PBRs, KARI as a public research organization was involved in breeding crop varieties that were exclusively treated as public goods. This is likely to change with the liberalization of the seed industry, which requires farmers to pay royalties for the varieties that they purchase. Given that plant breeding is a long and expensive affair, and financial support from the government is declining, even KARI may be compelled to charge royalty fees to help fund further variety development and provide rewards and incentives to researchers involved in breeding (BIOEARN, 2001a). Farmers will start paying for varieties that they have been involved in nurturing instead of sharing benefits accruing from them.[5]

By December 2001, about 541 applications of PBR had been received with 259 applications originating from Kenyan breeders. Most of the applications covered horticultural crops as opposed to key food security crops (Figure 2). More than half of the applications came from industrialized countries. These were mainly companies or individuals who wanted to protect certain varieties for the export market. Some critics point out that the pressure to put in place PBRs came from breeders in the horticultural industry, especially with the enforcement of plant breeders' rights in the international markets. This could be true as roses for export accounted for 39% of PBRs applications in Kenya by December 2001. Applications originated from France, the Netherlands, Germany, New Zealand, Spain, Israel, U.S.A, Italy and Ecuador. Other horticultural crops accounted for 37% while key food crops such as maize, sweet potato, beans, Irish potato, wheat, millet and sorghum accounted for only 24% of the applications.

Before the coming into force of PBRs, new plant varieties were breed exclusively as public goods (not attracting royalties) by public research institutions such as KARI (Sikinyi 2001). This clearly shows that PBRs are tailored towards strengthening commercial crops and not food security crops. Indeed the development of PBRs under UPOV was geared towards providing incentives to commercial farmers (Kameri-Mbote & Cullet, 1999). The introduction of PBRs in Kenya's context can be described as a way of encouraging monoculture leading to erosion of genetic diversity and concentrating benefits of 'new' varieties in the hands of commercial companies, all at the expense of poor farmers (Cullet, 2001). According to KEPHIS, farmers who depended on old varieties and recycling of seeds suffered when PBRs were fully enforced.

B. Globalisation and trade

Measures to alleviate poverty and curb food insecurity in Kenya should be viewed within the broader scope of liberalization and the impacts of regional and international trade regimes such as Common Market for Eastern and Southern Africa (COMESA), the East African Community and WTO respectively. WTO as an international governance regime for trade is and will be a major determinant of the extent to which new agricultural technologies can contribute to poverty eradication and increased food security in developing countries. Since inception, WTO has advocated for liberalization reforms through removal of market barriers and opening up of markets for increased movement of goods and services.

The Agreement on Agriculture (AoA) of the WTO places emphasis on minimizing domestic support for agriculture. It requires countries to withdraw subsidies, decontrol market prices, and other kinds of support directed towards agricultural sectors. Liberalization of the already weak agricultural economy has impacted negatively on the production, processing and marketing of agricultural produce in Kenya. Smallholder farmers are feeling the impact of AoA because their means of production are limited and yet they are being forced to compete globally. Farmers in the grain sector have been affected severely by the escalating costs of inputs such as fertilizers, seeds and chemicals on one end and poor and discouraging market prices for their produce on the other hand. The environment in which farmers operate has become difficult taking into account the fact that they have no access to credit facilities and the government extension system has collapsed.

Before implementation of liberalization reforms started in Kenya, the National Cereals and Produce Board (NCPB) was charged with the responsibility of regulating movement of maize and stabilizing prices. NCPB ensured movement of maize produce from the surplus producing regions to the deficit areas therefore equalizing maize supply in various parts of the country (Nyangito and Okello, 1998). When the reform process intensified the role of NCPB was marginally reduced to that of maintaining strategic national food reserves (Nyoro and Nugyo, n.d.). Since then, uncertainty has dominated the maize market with prices fluctuating widely in response to both seasonal and political forces.

Introduction of Bt. maize comes at a time when the maize sector in Kenya faces imminent collapse because of problems related to high prices of inputs and meagre and fluctuating market prices for maize. While one of the potential benefits of Bt. maize is increased yields per unit area, this may be counterproductive if there is increased surplus produce leading to more serious marketing problems. Since the government no longer controls the market prices for maize, traders are at liberty to fix them. The regulatory and monitoring vacuum created by the pulling out of NCPB, has attracted middlemen and millers in the market place leading to exploitation of farmers. The prices offered to farmers are far much below the costs incurred in production. For instance, in April 2002, maize was retailing at Kshs 400 per bag. At the same time a bag of maize seed was going for Kshs 3, 300 while a bag of fertilizer was going for about Kshs 1, 500 (Daily Nation, 2002).

This scenario has occasionally triggered demonstrations by farmers threatening to boycott production of maize (Daily Nation 2001). In seasons of surplus maize produce NCPB, comes under pressure to buy maize at prices proposed by farmers. NCPB finds itself in a disadvantaged position to respond to the demands of farmers due to inadequate budgetary allocation from the government to buy maize or lack of storage facilities to accommodate the surplus. These problems have been exacerbated by influx of cheap maize from neighbouring countries and massive imports by powerful and money-minded politicians.

On overall, an increase in supply of maize from both domestic and external sources leads to sharp and significant decreases in the prices for maize. During times of acute shortages import taxes on maize are reduced or waived altogether. This leads to hefty imports that exceed the actual deficit. Farmers find themselves on the loosing end because imported maize is usually cheaper than local maize. This is due to the fact that some neighbouring countries such as Uganda are members of COMESA, which allows them to trade with partner countries like Kenya without any trade barriers.

Additionally, WTO categorises countries as either developing or least developed. Some of the poorest developing countries have been exempted from reduction commitments. This implies that they can continue subsidizing and supporting their agricultural sectors. Kenya is classified as a developing country and therefore obligated to reduce subsidies and other forms of support. This has led to dumping of subsidized food to the Kenyan market leading to suppression of prices. For a country whose lifeline and economy depends on agriculture in terms of food security, employment, economic growth and poverty reduction, this constitutes narrowing of livelihood options both directly and indirectly. In this regard, there have been proposals that Kenya should withdraw its membership from COMESA to save the local agricultural sector (Daily Nation, 2002). Going by the current trends and high level of uncertainty, one can argue that biotechnology is not a magic bullet. While productivity will be increased, high yields will be of no consequence if the various diverse and complex structural constraints are not mitigated.

C. Biosafety Guidelines and Regulations

There is an inexorable link between the development of biotechnology and the existence of a biosafety system. Debates about the safety of biotechnological products and processes, specifically genetically modified organisms, have raised countries' concerns to establish risk assessment and management systems as a necessary function of biotechnology development. This is the case in Kenya where the research on the transgenic sweet potato and Bt maize have spurred and accelerated biopolicy development.

1. The National Biosafety System

Kenya was the first member of the CBD to sign the Biosafety Protocol when it was opened for signature in Nairobi on 24th May 2000. Less than two years later, Kenya ratified the Protocol on 24th January 2002. This demonstrates the country's intention and willingness to engage in safe handling, use and transboundary movement of living modified organisms, effectively engaging in modern biotechnology. Kenya was however already working on a biosafety system prior to the conclusion of the Biosafety Protocol. Indeed the increasing application of biotechnology in Kenya had raised the need to formulate appropriate biosafety regulations and guidelines to streamline biotechnology R and D. The National Council for Science and Technology (NCST) played the role of co-ordinating the formulation of the guidelines as part of the UNEP-GEF Pilot Project on the development of biosafety frameworks and regulations. Kenya's guidelines were published in 1998. The guidelines cover various aspects of risk assessment and management of modern biotechnology including the release of genetically modified organisms into the environment (NCST 1998). The need to establish a National Biosafety Committee (NBC) was recommended in the guidelines and the NCST was designated by the government to form the Committee.

The NBC was constituted and charged with the mandate of handling technical and policy issues involved in introducing genetically modified organisms (GMOs) into the country. Institutions represented on the Committee include NCST, KARI, KIPI, KEPHIS, KEMRI, ILRI, Ministry of Agriculture and Rural Development (MOA&RD), Ministry of Education Science and Technology, Department of Resource Surveys and Remote Sensing (DRSRS), University of Nairobi (UON), Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenyatta University (KU), Office of the President (OP), Kenya Bureau of Standards (KEBS) and the National Environment Secretariat (NES).

In spite of the progress made so far, the guidelines and regulations have not yet been promulgated into law. This implies that the legal instrument for enforcing them is lacking. The process of enacting biosafety law has been dragging due to lack of political commitment and little understanding of biotechnology and biosafety concerns among the policy makers and legislators. This seems to be the prevailing situation although the Africa Biotechnology Stakeholders Forum (ABSF) and other institutions have organized a number of meetings to improve the level of understanding on the various aspects of biotechnology and biosafety. NBC is also faced with financial difficulties and lack of a permanent secretariat with a critical mass of experts. NBC does not have a budgetary allocation from the government and an adequate number of in-house scientists who are competent in diverse areas of biotechnology. The two aspects are vital for strengthening the operations of the Committee.

Kenya's biosafety regulations and guidelines were prepared before adoption of the Cartagena Protocol on Biosafety as such, revision is required to bring the guidelines into conformity with the various provisions of the Protocol. On another level, the Protocol has taken a lot of time before coming into force due to the slow rate of ratification. Currently, only thirty-seven countries have ratified the Protocol, yet fifty ratifications are required before the Protocol comes into force. It is expected that the requisite number of ratifications will be attained in 2003.

Kenya's guidelines do not give direction on the labelling GMOs and modalities of handling movement of GM crops from the laboratories to the farms should be handled. The movement of transgenic sweet potato and Bt. maize from KARI stations to farmers' fields is drawing closer but the level of awareness of biotechnology and biosafety issues at the farmers' level is lacking. Once the Protocol comes into force, Kenya is going to be under an obligation to have in place a risk assessment and management regime in congruence with the Protocol. This calls for diligence in getting the mechanisms put in place and operationalised. While appreciating that NGOs such the (ABSF) have been instrumental in raising the level of awareness on biosafety and biotechnology, such efforts are currently confined among policy makers, scientists and to a lesser extent the media circles. Adequate and balanced information is yet to reach the resource poor farmers who are the final users beneficiaries of the technologies being developed. Public awareness at the grass roots level is crucial and should be enhanced to point out clearly and objectively the benefits and risks of adopting the technologies developed, so far. Indeed Article 23 of the Protocol requires that the public be made aware and participate indecision-making on living modified organisms. Inadequacy of information creates uncertainties and this may act as a barrier to technology adoption. But this is hardly an inevitable outcome. Kenya is among countries that are benefiting from the second phase of UNEP-GEF enabling biosafety project aimed at supporting countries to implement the already existing frameworks. While it is certain that various implementation issues at the national level will be covered, it is not clear whether capacity building needs at the local level (farmers) will be addressed.

2. Food Safety

With regard to food safety, Kenya's system based on the Food and Drugs Act has been largely concerned with wholesomeness of food and procedures against pest infestation. Food standards are the responsibility of the Kenya Bureau of Standards (KEBS). KEBS is charged with the responsibility of ascertaining quality standards of food and non-food products. The Biosafety guidelines and regulations are silent on the issue of labelling of genetically modified products or products containing GMO ingredients but the Kenya Bureau of Standards (KEBS) is a member of the NBC. The mandate of NBC that is relevant for food safety, is the development of relevant standards and mechanisms for assessing the safety of genetically modified foods. This has not yet been done. According to senior officers of the Bureau, Kenya is still implementing (KS 05-40) Kenya Standard Labelling of Pre-packed Foods established in line with the requirements of Codex Alimentarius

Commission. The existing standards do not contain any information on mechanisms and systems for handling GMOs (BIOEARN, 2001b).

D. Potential impacts on food security

1. IPRs, trade and food security

The impact of IPRs on food security in Kenya is at the moment negligible. Farmers can grow their own food with minimal IPRs restrictions. For many years the common practice among Kenyan farmers has been that of saving and exchanging seeds season after season. While some farmers used improved varieties before the liberalization period, they were mostly commercial farmers and to a larger extent their motivation was subsidised costs and a good public research and extension system. Following the removal of subsidies and decontrol of input prices, farmers are reverting to the use of local seed varieties. But with increased IP protection and liberalization of the seed industry, this is not likely to last for long. The section on IPRs has highlighted some of the difficulties that farmers are likely to encounter.

Concerning issues of trade, maize is both a food and cash crop while sweet potato is mainly a food crop at the household level. In some parts of Kenya, food security is achieved by selling maize to earn income to buy food, while in others maize is grown as a staple food crop for subsistence consumption. Over the years, the area under maize production has reduced significantly. Annual national yields have declined as well. It is in this context that biotechnology is seen as a promising technology for increasing yields at the national level. However, it should be noted that biotechnology is not a quick solution to problems of food security in Kenya. Achieving food security requires a multi-dimensional approach. It is not just about increasing yields per unit area. It also entails the way food is distributed or availability of income to purchase it. At the same time, increasing food production at the national level does not necessarily translate to food security at the household level. Food security is situational and context specific. In some areas food insecurity is not due to lack of food but lack of income to buy food (CIDSE 2000). In some years, depending on erratic climatic conditions, Kenya realizes surplus production of maize. While at such times the national food security situation is usually favorable, in other parts of the country, household food security goals are never realized due to a complex web of factors. Poor infrastructure and insecurity curtails distribution in hardship areas such as the arid and semi-arid regions. Political proclivity and exclusion often leads to unavailability of food in some areas. In areas where food is available in the markets, problems related to access arise. Families living below the poverty line are too poor to buy food.

Issues related to marketing of maize produce will determine the extent to which biotechnology can contribute to food security. Unless such issues are addressed accordingly, poor and fluctuating prices of maize on one side and the high cost of inputs on the other, are likely to stifle production. If it turns out that producing maize is not rewarding, farmers who depend on maize as a cash crop may shift to other crops.

2. Biosafety, food- safety and security

Issues of biosafety in general and food safety in particular surround the introduction of Bt maize and transgenic sweet potato in Kenya. The section on biosafety guidelines and regulations has clearly shown the weak and strong points of Kenya's biosafety system. A major food safety concern is the issue of relief food that is donated to the country during years of acute famine and food shortages and in particular, the possible health and environmental risks that may have come along with such shipments. For example in the year 2000, Kenya received 21,000 tons of corn from the US government to relieve 3 million Kenyans that were threatened with starvation. The 'humanitarian' assistance came in response to several appeals by President Moi to the international community to assist the government in meeting food requirements of the famine victims. Surprisingly, this food was not subjected to the biosafety system. While it is not documented that a Presidential appeal can supersede the existing biosafety mechanisms and procedures, Kenya's biosafety guidelines and regulations were not invoked in assessing the safety of the relief food. The lack of capacity and facilities on the part of KEBS to inspect and screen the relief food donated determined how the food was handled. Furthermore, liberalization has led to a large influx of food products from various parts of the world to the Kenyan markets. KEBS lacks the requisite capacity to test and detect presence or absence of GMOs in food products entering the country or those already on the market shelves.

What is happening in other parts of the world testifies to the fact that genetically modified products can easily find their way into the country without the knowledge of the relevant authorities. In October 2001, in Japan, StarLink[6] was found in food products where it had not been approved even for animal feed (Hur 2001, n.d.). In mid 2002, the government of Zimbabwe rejected an offer of 10,000 metric tonnes of corn from the US on grounds of fear and uncertainty. The shipment was meant to salvage the lives of over three million people that were faced with starvation. The consignment was rejected on the basis that some farmers may end up planting part of the genetically modified corn leading to massive irreversible consequences. Zambia has similarly rejected GM food aid on the grounds of fear and uncertainty. These concerns have policy implications for Kenya as a country that has been depending on relief food for a number of years. There are possibilities that some farmers in the country may have re-planted part of the yellow maize received.

The issue of risk assessment and management of transgenic sweet potato and Bt. maize in farms is another concern that the NBC has to grapple with. For the two technologies to generate the anticipated results while minimizing potential risks, the capacity of farmers to conduct risk assessment and management at the local level has to be enhanced. For instance, farmers ought to understand the dynamics of gene flow in maize cropping systems and adjust their cultivation practices to suit such dynamics. Unless appropriate resistance management strategies are developed, it may not take long before the stem borers develop resistance against the Bt. gene (Mwangi and Ely 2001). There may be possibilities of the transgenic sweet potato developing resistance against the mottle virus and other closely related viruses. The average land holding size in Kenya is very small and therefore the possibility of gene flow from Bt. maize or transgenic sweet potato to adjacent conventional varieties may affect the adoption rate of farmers aiming to preserve non-GM identity.

On the other hand, the genetically modified varieties are likely to erode the genetic diversity of local varieties and make farmers dependent on a few commercial varieties. Should either the sweet potato or Bt. maize become super weeds, farmers will have to pay for increased crop protection costs. In fact this will dampen prospects of increasing yields and achieving food security. Therefore, breakdown of resistance has to be reported early enough and handled promptly to retard negative consequences (Songa 2002). Given that the government extension system has collapsed and NGOs at the grassroots level lack the scientific and technological capacity to work with farmers, these are likely to be major challenges.

VII. Summary and Conclusions

This paper has demonstrated that for modern biotechnology research to have long-term and wider positive social impact in Kenya, changes in policies and institutions are mandatory to ensure that it benefits the majority of Kenya's population who are dependent on smallholder farming. For instance, critical issues such as biosafety and food safety, loss of biodiversity and IPRs need to be given attention to allow safe development and transfer of the relevant agricultural biotechnology applications. These complex issues require institutional and national capacity building through regional and international collaboration. However, new R&D policy and legal frameworks alone may not be sufficient, unless there is change towards multi-disciplinary approaches, leadership/supervisory training and problem-solving skills, especially for research and extension personnel, linkages with private sector and meaningful participation of farmers and their organisations.

Given the declining public spending, institutions in Kenya are under pressure to generate revenue. Already some private firms are gradually becoming involved in funding biotechnology research projects through contract research with KARI. It is also important to note that despite serious policy and institutional constraints, there is enthusiasm, although sometimes guarded, among many Kenyan scholars and practitioners concerning modern biotechnology for food security. Ensuring clarity about biotechnology in national agricultural development policy is definitely a critical factor.

In conclusion, there are five key points to summarize from this paper. *First*, alleviating rural poverty and food insecurity in Kenya requires changes at the local, national and international levels because of the inter-connectedness of agricultural systems and development in general. *Second*, developments in agricultural biotechnology will require slow and careful policy formulation, planning and implementation in order to improve food security of smallholders and reduce possible negative and socio-economic impacts such as loss of biodiversity, food safety and further marginalisation of smallholders. *Third,* the Kenyan public sector will continue to play an important role in the biotechnology development because this area of research is crucial to the national interests and the survival of rural communities.

Fourth, the development and transfer of agricultural biotechnology as advocated by international agencies and their national collaborators in the developing countries are risky undertakings particularly, when they proceed faster than the capacity of the state and its institutions to cope with the emergent technologies. Ensuring that effective policy and institutional mechanisms not only exist but also are enforced in Kenya is especially critical to the capacity of the public research sector to respond to national and local food security needs. This has to move in tandem with capacity to manage risk, which is critical to engagement in safe handling, use and transboundary movement of LMOs. *Fifth* and finally, while recognising that agricultural biotechnology has potential to alleviate food insecurity in rural Kenya, its programmes must be strongly linked to the interests of smallholder farmers and institutions that support local participation. This paper has argued that if these five issues are addressed, modern biotechnology can potentially contribute to food security and rural development in Kenya.

References

Aluoka, O. Where Kenya's Voice in Intellectual Property Rights Will Find Consonance. http://www.econewsafrica.org/shrinkaugust01.html. EcoNews Africa

Anyango, B and P. Shiundu. (1999). Institutional Arrangements Towards Biotechnology Policy Making in Kenya. Paper prepared for Biotechnology and Public Policy Training Course. ACTS, Nairobi, Kenya

Bates, R. H. 1989. Beyond the Miracle of the Market: The Political Economy of Agrarian Development in Kenya, Canada, Cambridge University Press.

BIO-EARN (2001a). Development of Institutional Intellectual Property Rights Management System. Proceedings of A Regional Workshop Under BIO-EARN Programme on Biotechnology and Intellectual Property Rights. NSCT/KIPO, Nairobi, Kenya.

BIO-EARN (2001b). Safety in Biotechnology of Foods and Feeds. Proceedings of A Kenyan Workshop Under the BIO-ERAN Programme. NCST, No.43/2002, Nairobi, Kenya.

Bunders, J. F. G. and J. E. W. Broerse, eds. 1991. Appropriate Biotechnology in Small Scale agriculture: How to re-orient research and development. Wellingford, Oxford UK: CAB International.

CIDSE (2000). Biopatenting and the Threat to Food Security. Part 2 Beyond Trade and Patents to Food Security. International Co-operation for Development and Solidarity

P. Cullet, Plant Variety Protection in Africa: Towards Compliance with the TRIPs Agreement, *Biopolicy No. 23,* ACTS Press, 2001.

Daily Nation Newspaper (2000-2001). ttp://www.nationaudio.com/News/DailyNation

De Groote, H. (2000). Using Biotechnology to Develop New Insect Resistant Maize Varieties for Kenyan Farmers. An Overview of the KARI/CIMMYT Insect Resistant Maize for Africa (IRMA) Project.

Gibbons, S. (2000). Linkages Newsletter Fourth Quarter Feature Article. Transgenic sweet potato research collaboration: A case study of ABSP involvement in Kenya

GOK (2002). National Development Plan for the Period 2002 to 2008. Government Press.

GOK (1997). National Development Plan for the Period 1997 to 2001. Government Press.

Hinche, M. (1998). 'Development of Virus-Resistant Sweet Potato' in Clives and B M Bedford (eds) 1998, Agricultural Biotechnology in International Development, CABI Publishing, New York, US.

IRMA (2001). Insect Resistant Maize for Africa Updates. Insect Resistant Maize for Africa Vol. 2, Issue 4

IRMA Updates. (2000). Insect Resistant Maize for Africa.

ISNAR. (2000). Biotechnology in African Agricultural Research: Opportunities for Donor Organizations. ISNAR Briefing Paper no. 43

Institute of Economic Affairs and Society for International Development (2001). Kenya at the Crossroads: Scenarios For Our Future, Nairobi, Kenya and Rome, Italy.

KARI. (2000). KARI/Monsanto Virus Resistant Sweet potato Project. " For Alleviation of Hunger and Poverty"

Patricia Kameri-Mbote & Philippe Cullet, Agrobiodiversity and International Law, *Biopolicy No. 22,* ACTS Press, 1999.

KARI (1997). Training Mater Plan 1997/98 –2001/02; ISNAR, The Hague.

Ministry of Agriculture. (1993-2000). Annual Reports of Food Production. MOA&RD, Nairobi, Kenya MOA&RD, Nairobi, Kenya

Mwangi, J. G. 1998. The role of extension in the transfer and adoption of agricultural technologies. *Journal of International Agricultural and Extension Education* (Spring), 3-68.

Mungai, N. (2000). Transgenic Sweet Potato Could End Famine. Environment News Service

National Council for Science and Technology (NCST) (1998). Biosafety Framework for Kenya. Prepared under the UNEP/GEF Pilot Biosafety Enabling Activity Project.

Nyangito, H. and J. Okello. (1998). Kenya's Agricultural Policy and Sector Performance 1964 to 1996. IPAR Occasional Paper.

Nyariki D M, Thirtle C.G (2000). Technical innovation and farm productivity growth in dryland Africa: The effects of structural adjustment on smallholders in Kenya. Agrekon, 39(4)/Dec, pp 597-606

Nyoro, J.K. and W. Nguyo. N.d. Market Liberalisation and House Hold Nutrition in Kenya

Odame, H. and P. Mbote. (2000). Agricultural Biotechnology Assessment in Sub-Saharan Africa: A Case Study of Kenya. Paper prepared for the Regional Workshop on Building National Biotechnology Innovation Systems: New Forms of Institutional Arrangements and Financial Mechanisms; organised by ACTS on December 6-8, 2000, Nairobi, Kenya.

Odhiambo, B. (2000). Institutional Experiences in Implementation of the National Biosafety Regulations and Guidelines in Kenya. Paper presented at a National Workshop on Experiences with and the Future of Kenya's Biosafety System.

Omamo, Steven Were. 1998. Transport Costs and Smallholder Cropping Choices: An Application to Siaya District, Kenya, American Journal of Agricultural Economics.

Persley, G. and M.M.Lantin. (eds.) (2000). Agricultural Biotechnology and the Poor: Proceedings of an International Conference on Biotechnology, Washington DC, 21-22 October 1999. Washington DC: Consultative Group on International Agricultural Research. http://www.cgiar.org/biotech/rep0100/persley.pdf

Pearson, S., Monke E., et.al (1995). Agricultural Policy in Kenya. Applications of the Policy Analysis Matrix. Cornell University Press, USA.pp. 43-54.

Poats, S.V., M. Schminck and A. Spring, eds. 1988. Gender Issues in Farming Systems Research and Extension. Boulder: Westview Press.

Qaim, M. (1999). The Economic Effects of Genetically Modified Orphan Commodities: Projections for Sweet Potato in Kenya. ISAAA Briefs No.13. ISAAA: Ithaca, NY and ZEF: Bonn

Republic of Kenya (2000) Rural Poverty Eradication Strategy Paper

Republic of Kenya (2001) Industrial Property Bill, 2000.

Songa, J.M. (2002). Towards Development of Environmentally Safe, Insect Resistant Maize Varieties for Food Security in Kenya. Paper presented to the Sygenta Symposium, Washington D.C, U.S.A, June 25 2002, the Syngenta staff in Greensboro, NC, USA, June 26 2002, and to the Syngenta staff in Basel, Switzeland, June 27 2002

Wafula J. and C. Falconi (1998). Agricultural Biotechnology Research Indicators: Kenya. Discussion Paper; No. 98-9 September 1998, ISNAR, The Hague.

Wekundah, J. (2000). Document on National Capacity Building in Biotechnology. Kenya Agricultural Biotechnology Platform (KABP), Nairobi, Kenya.

Endnotes

[1] One metric tonne (or 1MT) is equivalent to 1000 kilograms (or 1000kg). The calculation is based on a 90-kg bag).

[2] For instance, such as cutworm, potato tuber moth, woolly aphids, diamond back moth.

[3] Agricultural Biotechnology Support Project (ABSP) is USAID-funded project to assist developing countries in the development and management of the tools and products of agricultural biotechnology. The International Service for Acquisition of Agri-biotech Applications (ISAAA) is an international organisation created to facilitate and assist developing countries acquire modern biotechnology applications.

[4] Note that KIPO was created in 1990 with the enactment of the Industrial Property Act. Cap. 509 in while the Industrial Property Bill passed in 2001 amended Cap. 509 and transformed KIPO to KIPI.

[5] See Article 8(j) of the Convention on Biological Diversity

[6] *StarLink* is a type of corn produced by Aventis Corporation and was approved by federal authorities in 1998 as an animal feed. But because the corn has been genetically modified in a way that makes it more difficult to breakdown in the human gut, the agencies have refused to approve it for human use.

www.ielrc.org