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# Biotechnology and Biodiversity Debates and Policies in Africa*

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## Abstract

After a decade of global diffusion, and the realisation of some economic benefits, the environmental impact of genetically modified (GM) crop technologies remains inconclusive and a source of considerable threat to biodiversity-rich Africa. Drawing on evidence from Ethiopia and South Africa, this paper characterises debates, considers policy, and discusses the rationale for proactive GM policy (as in South Africa) and precautionary ones (such as in Ethiopia). It shows that GM crop adoption, or rejection, crucially depends on the scientific, technological and institutional capabilities for the development and use of the technology, and perceptions about risk and socio-economic impacts. Overly protective policies (inadvertently) suppress the development of biotechnological capacities that have the potential to add more value to biodiversity-derived products, and reduce loss of biodiversity. It argues that Africa's progress in science and biotechnological innovation is central to conservation and sustainable use of its biodiversity for the improvement of the livelihoods of its people.

## Introduction

Crop genetic modification (GM) techniques have been hailed as revolutionising the conservation and use of biodiversity by enhancing the process of genetic identification and selection, transforming specific genetic traits to increase productivity; protecting plants from diseases, pests and weeds; and enhancing the nutritional value of products (FAO, 2004). Indeed research has provided some positive evidence confirming these claims, such as increased availability of food and reduced use of agricultural chemicals (FAO, 2004; James, 2006; Brookes and Barfoot, 2006). However, there remains, particularly in Africa, a critical knowledge gap over GM effects on biodiversity (FAO, 2004). Hence many in Africa remain concerned that these crops might deplete biodiversity and increase the vulnerability of smallholder farmers (see, for example, Egziabher, 2003).

Social science research on the African biotechnology sector characterises countries as polarised between those embracing GM technology and those with a 'precautionary' policy, slowing applications and the spread of GM products. It analyses countries - often meaning South Africa, or at best a very few others such as Egypt, Kenya and Zimbabwe - undertaking genetic modification or building capacities into national systems (see for example, Cohen, 2005; Ayele and Wield, 2005). Recent research also discusses how differences in national biotechnology policies and biosafety systems have been hampering pan-African biosafety systems harmonisation initiatives (Ayele, 2007). However, detailing the underlying *reasons* for the differences has not been a strength of past research.

This paper aims to contribute to filling this gap. It uses empirical evidence from Ethiopia and South Africa, countries that offer contrasting policy choices. Both are rich in biodiversity and accord high priority to its conservation and sustainable use (FDRE, 2005; GSA, 2005). For both countries GM crop policies involving agriculture and food production are inseparable from the protection and use of biodiversity (FDRE, *ibid*; GSA, *ibid*). But, as the paper will show, South Africa pursues a proactive approach that is willing to balance risks and benefits associated with the GM crops while Ethiopia follows a precautionary approach. It presents and discusses debates underlying national policies for GM technologies as these relate to biodiversity. Empirical evidence is used to build a better understanding of the issues involved, and it is hoped that the paper will stimulate scientific research on GM effects on African biodiversity. Issues of GM crops are, unsurprisingly, extremely important as many Africans depend on biodiversity for food, shelter, medicines, employment and foreign exchange earnings (Millennium Ecosystem Assessment, 2005).

Evidence is drawn from legal and technical documents related to crop genetic modification organisms (GMOs) and biodiversity, and some 26 detailed interviews conducted over 2005-06 with senior representatives of organisations involved in the regulation, development and politics of GM plants in both countries. Interviewees were drawn from government research organisations and science and technology policy-making bodies, researchers at universities, the for-profit private sector, non-profit organisations and pressure groups. Balanced views were captured by involving interviewees from organisations with different positions over GM plants. While the analysis is based on 'national' positions, the evidence and discussion also encompasses contestations within the two countries to capture more grounded issues linking plant genetic modification and biodiversity, often masked under 'national' policies.

Setting the context, the next section defines key terms used in the paper, and surveys and discusses the literature on modern biotechnology directly relating to the conservation and use of biodiversity. Sections three and four present and discuss the empirical evidence on the application of modern biotechnology in relation to biodiversity in Ethiopia and South Africa, respectively. Section five discuss findings and draws some conclusions.

## Agricultural biotechnology, conservation and the use of biodiversity

The Convention on Biological Diversity (CBD) and the Cartagena Protocol on Biosafety give authoritative definitions of the terms *biodiversity* and *biotechnology.* These definitions are adopted here, hence *biodiversity* means '…the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (CBD, 1992: article 2). While this broad definition suggests the many complex dimensions of diversity and its uses (Millennium Ecosystem Assessment, 2005); our particular focus is on the diversity of plants and associated species used for food and cash crop production. Similarly, acknowledging the broad meaning of *biotechnology* as 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use' (CBD, 1992: article 2), the focus here is on genetic modification or transformation of plants, in other words, applications '…that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection' (CBD, 2000: article 3: i). Finally the term *biosafety* is understood to refer to a range of measures, policies and procedures for minimising the potential risks that modern biotechnology, particularly genetic modification, may pose to the environment and human health (Zedan, 2005: 499).

As noted earlier, biodiversity matters for many Africans as it is source of their livelihoods. Modern biotechnologies matter for the conservation and use of such an important resource. The growing literature shows applications of modern biotechnology for conservational purposes in the acquisition of samples, locating and describing diversity, effective procedures for conservation, and evaluation (Ferreira, 2006; de Vincente *et al*., 2006). Unlike traditional methods of characterization, such as descriptors of physical features and agronomic traits, genetic characterization offers an 'enhanced power for detecting diversity' – revealing differences at 'the ultimate level of variation embodied by the DNA sequences of individual and uninfluenced environment'. Genetic characterization offers speed and quality of large-scale plant germplasm characterization (de Vincente *et al*., 2006: 130; Ferreira, 2006). Similarly, genetic modification techniques have been used in plant breeding to raise yields, to improve resistance to diseases, pest and drought, etc. Other agricultural biotechnologies too have been used to produce, for example, low cost disease-free planting materials for plants such as banana and potatoes, and for the measurement and conservation of genetic resources. Marker-assisted breeding is also used for locating and selecting genes affecting traits of economic value in plants (and animals). The distinctive advantage of these modern agricultural biotechnologies is to make breeding more effective. These tools work by increasing the speed or efficiency of introducing genes from one population into another (see review in FAO, 2004). The key point here is that agricultural biotechnologies play a significant role in understanding and using knowledge about genetic resources.

New knowledge about genetic resources and technologies has already been put to use. For example, since commercialisation a little over ten years ago, the global spread of GM crops has been phenomenal. In 2006 the global land area growing GM crops reached 102 million hectares. Some 10.3 million farmers in 22 countries, eleven of them developing countries, grew these crops (James, 2006). Research has also increasingly shown that these varieties have generated some economic benefits, such as increased availability and variety of food, reduction in labour time, and a reduction in environmental damage caused by toxic agricultural chemicals (see for example, FAO, 2004; Brookes and Barfoot, 2006). Moreover, the FAO report (*ibid*) concludes that foods derived from GM crops are 'safe to eat'. In South Africa (the only African country to commercialise GM crops) GM crops, including insect resistant Bt cotton, provided smallholder farmers some 'significant' benefits from increased yield and lower insecticide spraying costs, less negative impact on the environment; and fall in pesticide poisoning in areas where the technology has been adopted (Bennett *et al.*, 2006; Morse *et al.*, 2006). However, apart from these limited cases, the economic benefits of modern biotechnology have not reached poor farmers in a large part of the developing world, for a number of reasons. One of these relates to the fact that the global industry focuses on small range of profitable crops (maize, soybean, rapeseed and cotton) at the expense of many other crops, particularly so-called 'orphan crops' that are important to the poor such as *teff* in Ethiopia. The other reason has been weak public agricultural research capacity and inadequate regulatory procedures in many developing countries for the application of biotechnologies to crops that directly combat poverty (FAO, 2004).

Given the useful roles modern agricultural biotechnologies play in the conservation and use of biodiversity, the key question is then: what threats does genetic modification of crops pose to biodiversity? Before attempting to answer the question, however, it is important to set the discussion in context, and point out that biodiversity has been lost irrespective of modern agricultural biotechnology. The many and complex causes of plant genetic diversity loss include habitat destruction due to such factors as expanding cities; new and uniform crop varieties increasingly replacing traditional varieties; in some poor countries in particular, the expansion of farming often accompanied by burning forests; invasion of exotic plants which threaten native ones by becoming strongly competitive due to lack of local predators such as insects; the increase in demand for fuel wood; and desertification (Millennium Ecosystem Assessment, 2005; Zedan, 2005).

Despite the positive claims, there remain a number of environmental threats associated with crop genetic modification (as, for example, highlighted by FAO report, 2004). These threats include gene transfer to wild relatives or conventional crops. GM plants may acquire some ‘fitness advantage’ to become established as ‘weeds’ in other fields or become ‘invasive species’ in other habitats; there may be trait effects on non-target species, and increased loss to the abundance and biodiversity of plants and other species. Based on the synthesis of globally available evidence, the FAO report (*ibid:* viii) highlights the ‘little evidence’ that these scenarios have occurred but it nonetheless concedes that there is ‘less scientific agreement on the environmental impacts of the transgenic crops’ and little is known about long term effects.

Strikingly there have been only a limited number of scientific studies looking at GM plant impacts on the environment, specifically biodiversity, and these studies barely relate to the African context. Two of the few studies were UK-based. The first, the Bright Link project (Sweet *et. al*., 2004), studied GM sugar beet and winter oil seed rapes tolerant to specific herbicides grown in rotation with cereals and other crops for four years, starting in 1999, and compared results with conventional counterparts. The conclusion of the study was that ‘[n]o significant decrease in botanical (species) diversity were observed’ due to growing the specific GM plants (*ibid*, p. 5). The second study, described as ‘the largest and most thorough of its kind in the world’, was the Farm Scale Evaluations (FSE) study (Defra, 2005: 2) that were conducted over 2000-2002. The study looked at the effects of growing GM herbicide tolerant (GMHT) sugar beet, winter rape, spring rape and maize on the abundance and diversity of farmland wildlife (weeds, insects and other creatures) compared to conventional varieties of the same crops, and it found:

- GMHT winter rape: same number of weeds overall, more grass weeds but fewer broad-leaved weed seeds, fewer butterflies and bees and more springtails.
- GMHT spring rape and beet: fewer weeds, fewer seeds, fewer bees and butterflies, and more springtails.
- GMHT maize: more weeds, more seeds, more bees and butterflies, and more springtails (Defra, 2005:p. 3).

The FSE study clearly shows that while growing GM maize was better than its conventional counterpart for much wildlife, GM winter rape varieties produced mixed results, and spring rape and beet resulted in reductions in weeds, seeds and invertebrates.

To our knowledge, then, the understanding of links between GM crops and biodiversity in Africa is largely based on evidence from industrial agriculture in developed countries. Such an understanding, and particularly in the light of the inconclusive results above, I argue, is of limited value to Africa which is diversity rich and has different agro-ecological conditions that potentially make GM crop impacts more complex and less predictable. Implications for African livelihoods could also be different, as many Africans who depend on agriculture and biodiversity also have limited capacity to bear risk, and restricted access to technologies and markets. The potential introduction of GM plants into African agriculture – often small scale and multi-cropped - is likely to cause problems for managing biodiversity. Some (for example, Ponti (2005)) also suggest that modern agricultural biotechnology speeds up genetic uniformity, and hence loss of plant diversity. Ponti (*ibid*) notes that there was more uniformity over the ten years since GM crops were introduced than over fifty years of the green revolution. If such articulations hold and the spread of GM plants is to cause increased loss of biodiversity, then this also means increased plant vulnerability to epidemics, pest and diseases.

Finally, I highlight two key developments relevant to our later discussion, related to scientific and technological developments and to institutional issues. On the scientific and technical side, besides offering agronomic values such as increases in yields, plants also offer environmental and health related benefits. With the application of modern biotechnology, plants are now being modified to produce pharmaceutical proteins and chemicals they do not produce naturally. Vaccine-producing plants offer the potential to treat chronic diseases such as HIV/AIDS and TB (Ma *et al*., 2005). Similarly, environmental biotechnologies are offering remedies to a damaged environment by absorbing or processing pollutants. In this regard, for example, the weed plant *vernonia* that grows in Ethiopia is proven to be a rich source of epoxy compounds that is believed to overcome problems of polluting organic compounds in petrochemicals (FT, 2006). Second, besides advances in GM technologies, institutions for accessing and using biodiversity and biotechnologies have also been fundamentally changing in recent years. In this regard, following the coming into effect of the Convention on Biological Diversity, biodiversity has ceased to be a freely accessible resource or 'common heritage of humans'. Industrially advanced economies have also strengthened the roles of the private sector in knowledge production and holding of biotechnological proprietary rights. Thus, limited access to biodiversity, on the one hand, and increased demand for germplasm spurred by the private sector, on the other, has been pushing up the value of biodiversity (see, for example, Zerbe, 2002).

The literature discussed above clearly shows that crop genetic modification techniques play important roles in the conservation and use of biodiversity. It also indicates that the link between GM crops and biodiversity has not been established particularly in the African context, posing some concerns about GM crops. Against this background, the next sections present and discuss the case study evidence from Ethiopia and South Africa.

## Biodiversity, agriculture and biotechnology in Ethiopia

Ethiopia's geographical position, range of altitude, rainfall pattern and soil variability are believed to have been factors that generated its wealth of biodiversity. It has at least 6603 known species of higher order plants (WRI, 2006). Crop plants such as coffee and *teff* are known to have originated in Ethiopia (FDRE, 2005). Germplasms of such native plants are likely to offer Ethiopia significant economic benefit from their global exploitation, for example, *vernonia* for environmental remedies from polluting petrochemicals.

Biodiversity provides for food, fuel, medicines, and industrial materials in Ethiopia. For example, some 80 per cent of the rural communities are believed to depend on herbal medicine for primary health care provision (Seyoum *et al.*, 2006). However, these vital resources have been under threat - estimates indicate that in Ethiopia some 22 species of higher plants are endangered (WRI, 2006). Rural resettlement programmes (notably in the 1980s), the spread of extensive cultivation, and land tenure insecurity have been key determinants of the erosion of plant diversity (Seyoum *et a*l., 2006).

Successive governments in Ethiopia have recognised the importance of genetic resources, as manifested in steps taken in establishing institutions, policies and strategies for its conservation and sustainable use. The establishment of the Plants Genetic Resource Centre in 1976 was one such major step (Table 1). The Centre, now the Institute of Biodiversity Conservation and Research (IBCR), has been collecting and conserving diversity in crop plants. In 2005 its germplasm collection bank held, according to the interviewees, over 60 000 accessions of some 104 food crop and medicinal plants. Similarly the National Herbarium at Addis Ababa University holds over 72 000 specimen collections, covering 80 per cent of the flora of higher plants. Although government has provided some institutions and financial means for training personnel and infrastructure development, reports show that efforts made are inadequate considering the magnitude of the need for conservation (FDRE, 2005).

| **Table 1** | **Some biodiversity and biotechnology policies and institutions in Ethiopia** |
|---|---|
| 1976 | Establishment of the Plant Genetic Resource Centre (in 1998 became the Institute of Biodiversity Conservation and Research). |
| 1992 | Signing of the Convention on Biological Diversity (ratified in 1994). |
| 1997 | Environmental Policy published. |
| 2003 | Ratified Cartagena Protocol on Biosafety; became party to the Protocol in 2004. |
| 2004-present | National Biosafety Policy and Strategy drafted. |
| 2005 | Biodiversity Conservation and Development Strategy and Action Plan published. |

Ethiopia’s biodiversity and agriculture are intertwined. Agriculture contributes 85, 46 and 92 per cent of total employment, gross domestic product and export earnings, respectively (Beintema and Solomon, 2003). Agriculture is predominantly smallholder farming dependent on family labour for land preparation and planting, weeding and harvesting. However, despite the wide variety of its genetic resources and diverse agro-ecological zones, the country is prone to periodic food shortages, often attributed to recurrent droughts, water shortages, and environmental degradation, pest and plant diseases. Modern biotechnology has played hardly any part in supporting the country’s food security.

Government policy in the early nineties acknowledged the role of biotechnology and promised support but progress has been limited to pockets of research infrastructure and institution building activities, such as in the Ethiopian Institute of Agricultural Research (EIAR), IBCR and Addis Ababa University. In 2005-6 EIAR had about 32 staff, mainly working on tissue culture projects. Although some investment in research infrastructure has been undertaken to progress biotechnology generation to a higher level, at the time of writing Ethiopia did not have any GM-based research programme. Nor does IBCR have a fully functioning modern biotechnology lab to support its core activities of molecular characterization of genetic resources for conservation and use. Addis Ababa University has begun training some PhD candidates, researching the distribution of molecular genetic diversity of forest coffee. But biotechnology development in Ethiopia has faced constraints including limited R&D capacity, training, difficulties with recruitment and retention of graduates, and government and donor funding.

## The genetic engineering debate and biosafety system development

In order to clearly show the emerging biotechnology policy and biosafety system in Ethiopia, I begin by laying out the context in which the debate over crop genetic modification is conducted and policy evolves. Following the adoption of the Cartagena Protocol on Biosafety (the Protocol) in 2004, Ethiopia embarked on the implementation of the Protocol's biosafety framework. To give legitimacy and direction to the emerging institution, implementation started with the establishment of a National Steering Committee, largely drawn from government organisations and academia. Representation to the Committee outside of government organisations and academia was limited, and there was hardly any debate on biotechnology issues involving the private sector and non-governmental organisations. Nor was there substantial media coverage (Ayele, 2007). So it can be said that debating, decision-making and implementation of biotechnology polices were matters for governmental organisations. Second, shortly after the launch of the programme for implementing the biosafety framework, major differences emerged between key members of the Steering Committee, over the process of developing the draft bill, its content, and the proposed location of GMOs administration – that is the Ethiopian Environmental Protection Authority (EPA). Although views over genetic modification varied within and between the organisations, in this instance it was clear that the split was largely between EPA authorities on the one hand, and on the other, the major representatives to the Committee, namely those drawn from EIAR, IBCR and Addis Ababa University. What was the controversy about?

For EPA authorities, the central objective is *conserving biodiversity*. The interviewees were keen to establish the country's position as a centre and origin of some plant diversity. They explained how gene flow from GM crops could affect the natural plant communities, and how GM plants could produce resistance to pesticides and affect non-target species. A summary of some of their concerns was:

- genetic engineering could cause irreversible damage to our biodiversity;
- the conduct of private sector-led genetic engineering is mistrusted;
- genetic engineering is incompatible with the farming practices of Ethiopia;

- genetic engineering carries high risk to the livelihoods of many vulnerable poor and small-holder farmers from loss of biodiversity, jobs, etc.; and
- genetic engineering is a threat to our exports.

Because of such concerns, EPA authorities recommended that Ethiopia's GM policy and biosafety bill should be based on precaution, as articulated by the head of EPA, Dr Tewolde Berhan Gebre Egziabher: 'we have under our responsibility some of the genetic resources that the world needs for food...we should be more frightened and we should adhere more to the precautionary principle, than the industrialised countries do'. He also added that protecting diversity is a matter of responsibility not just for Ethiopia but for the world.

EPA authorities perceive that genetic modification not only carries a high risk to biodiversity but also adversely affects the livelihoods of smallholder farmers. The livelihood impacts follow from their assumption that GM crops and smallholder farming practices are incompatible – in other words they think that GM crops are better suited to large scale monocultures where GM and non-GM planting is better managed, overcoming potential problem of gene flow. Echoing the literature, they note that, regardless of plants being GM or not, monoculture farming contributes to loss of biodiversity. Should there be any potential 'GM contamination', they pointed out their fear that anti-GMO consumers would reject Ethiopian exports, particularly the major export earner, coffee. Their concern is also based on their assumption that large scale farming is 'bad' for smallholder farmers anyway as some could be led to landlessness and unemployment. They emphasise that, as a labour surplus country, some labour-saving devices such as herbicide-tolerant Bt technologies, are technically inappropriate for Ethiopia. Finally, despite widely reported evidence in the literature, for the EPA authorities GM crops do not necessarily provide 'substantially higher yields' or higher economic values. Even when these crops were to result in 'better' yield, according to head of EPA's Impact Assessment Division, Ethiopian poor farmers will be less likely to benefit from it for lack of domestic (as well as export) market for their surplus produce. The head noted the core problem as being that only 15 per cent of Ethiopians, who themselves are low income urban dwellers, are target consumers.

An important point, also shared by some non-EPA interviewees, was the discomfort they had with private sector-led biotechnological developments, often entailing private patent-holding rights of plant germplasm. The concerns here were wide-ranging, from farmers' dependence on multinational companies for patented seeds to possibilities that science undertaken by agribusiness would become less objective:

> …I think the private sector develops a given technology with financial gain being its motivating force. … With the growing tendency of privatising research and development, and protecting confidential information, it is conceivable that science and technology will lose its credibility (Egziabher, head of EPA).

Finally, for EPA authorities, as things stand, the application of genetic modification in Ethiopia is constrained by 'limited investment resources' and 'little capacity in genetic engineering'. Given their doubt over the suitability of GM technology to Ethiopia, however, they call for regulatory capacity building, but not for national capacities in production and use of biotechnologies.

Almost all the non-EPA interviewee scientists support the selective application of crop genetic modification in Ethiopia, and the health of biodiversity is as important to them as it is to the EPA authorities. They see biodiversity as a reservoir to growth and development. They emphasise the potential that the technology offers in generating knowledge about plant genes. Many see modern biotechnology, including genetic modification, as beneficial to biodiversity as ‘it can be used for inventory and characterisation of genetic resources’ and ‘some Bt technologies can reduce chemical spraying that is damaging to biodiversity’, etc. They note that, with the country’s high level of food deficit and population growth rate, bridging the gap between the demand for and supply of food has become increasingly difficult. They thus see modern biotechnologies having clear complementary roles to conventional technologies in alleviating food insecurity and malnutrition in the country. However, they think EAP uses ‘uncertainties’ about GM technology as a device to further delay the application of biotechnologies in Ethiopia. They noted that EPA’s ‘success’ in promoting its position has been aided by its direct access to the Office of the Prime Minister, while the national research organisations are accountable to ministers. Furthermore, interviewees noted, the fact that EPA’s figurehead has international reputation for his sceptical position on GMOs, also helped to propose a precautionary policy on GMOs.

Supporters of selective application of GM crops also see some limitations to the use of these crops under present Ethiopia’s conditions but, unlike EPA authorities, they see some scope for GM crops:

> Current developments on GMOs focus on pest control and weed control. For the poor farmer with very little land holding but a lot of time to work on [their] farm, or in a situation where hand-weeding is possible, the GMOs out there are not very useful to them. However, GM crops can be useful where the land holding system is larger and where commercial spraying is now destroying biodiversity (Addis Ababa University Professor).

However, the EPA-led Steering Committee proposed, in the draft biosafety bill, what the supporters of the technology regard as ‘protective’ principles and criteria of risk assessment[1]. According to some pro-GM crop interviewees, the emerging national position is already resulting in adverse and far reaching consequences at individual, institutional and country levels as the following voices tell:

> … I sometimes regret studying biotechnology as I don’t apply it. …some specialists in the field have already left the country (Senior Scientist, IBCR).

Yet another senior scientist, depicting what he sees as the vicious circle scenario that the country is in, noted:

> If we are to continue with [the current] policy, we will not be able to build capacity to identify and access biotechnologies. …unless we develop capacity at home I don’t think others will be willing to invest [in the field] in Ethiopia. …and unless we are able to apply biotechnologies in the country, I don’t think we will be able to produce a sufficient number of trainees (Senior Scientist, EIAR).

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1 It is not permitted to refer to articles from draft proclamations.

Supporters of the technology acknowledge that, owing to expensive infrastructure and skilled personnel requirements, financing biotechnology through conventional government budgets would be difficult to do and sustain. But, they underlined, the emerging policy itself has not been encouraging donors to come forward, engage in partnerships, and support capacity building efforts. Clearly the emerging GM policy and institutions are fiercely contested at this institutionalisation stage, and will likely remain so at implementation stage unless the Government finds a way through the competing positions over GMOs.

## Biodiversity and biotechnology in South Africa

South Africa is one of the most biologically diverse countries in the world. It covers 2 per cent of the world's surface area but is home to about 24 000 plant species (including some endemic ones) – about 10 per cent of the world's plant species (GSA, 2005; WRI, 2006). As well as subsistence use for food, shelter, traditional medicine and employment, South Africa's biodiversity is used for commercial and semi-commercial applications such as ecotourism. This suggests that, unlike in Ethiopia, South Africa has better information on biodiversity, and it can be better managed and protected through instruments such as licensing and taxation (GSA, 2005).

However, all is not well with South Africa's biodiversity. World Resource Institute (WRI) data show South Africa has no less than 45 threatened higher plant species (WRI, 2006), one of the highest concentration of threatened plants in the world. The country is home to three global biodiversity hotspots – areas with high concentrations of biodiversity but which are under serious threat (Cape Flora Kingdom, Succulent Karoo and Maputaland-Pondoland-Albany Centre) (GSA, 2005). Building on its long history of conservation, the Government is committed to the conservation of biodiversity as, for example, it has signed and ratified international conventions and protocols, and taken some steps pertinent to biodiversity and biotechnology (see examples in Table 2).

**Table 2 Biodiversity and biotechnology policies and institutions in South Africa**

| | |
|---|---|
| 1995 | Ratification of the Convention on Biological Diversity (signed 1993) |
| 1997 | Passed the GMO Act |
| 2001 | National Biotechnology Strategy for South Africa |
| 2003 | Accessed Cartagena Protocol on Biosafety |
| 2004 | The National Environmental Management: Biodiversity Bill |
| 2005 | National Biodiversity and Strategy Action Plan. |

In particular South Africa's 2005 National Biodiversity and Strategy Action Plan (NBSAP) recognizes biodiversity as an asset of international, national and local significance. NBSAP articulated the application of biotechnological advances to biodiversity, on condition that agencies take measures appropriate to ensure the conservation of biodiversity. This central position largely rested on South Africa's accumulated science and technology (S&T) capacity in general and its biotechnological capabilities in particular (GSA, 2005). Strength in capacity, in turn, was the result of South Africa's progressive support to S&T through attraction of foreign direct investment, as well as government investment. As the biggest economy in Africa, it spends relatively highly on R&D, for example, in 2000 it spent two-thirds of sub-Saharan Africa's total expenditure on R&D (Pardey, *et al*., 2006). Its sustained investment has created university research centres and research organisations, such as the Council for Scientific and Industrial Research, that are of regional and international standing and both compete with and work collaboratively with other organisations internationally. Thus based on its strong S&T base, and also taking into account the decline in its traditional industries (primary agriculture, manufacturing and mining) South Africa has adopted a knowledge-based economy strategy, the key component of which involves the application of modern biotechnologies (GSA, 2001)[2].

## The genetic modification vs. biodiversity debate

Historically experimentation in, and recognition of, the potential uses of modern biotechnologies in South Africa date back to the 1970s, but there were no statutory rules and standards to regulate activities until 1990. According to the interviewees, South African scientists, organised under the South African Committee on Genetic Experimentation (SAGEN) and along with the private sector, initiated the drafting of the national biosafety bill in 1994. Approved by Parliament in 1997, the Act (GSA, 1997) provided policy and regulations for GMO activities. While the Act was implemented in 1999, South Africa has been approving GM R&D and field trials since 1990. Approval over 1990-99 followed biosafety guidelines developed by SAGEN and in accordance with existing legislation, notably the Agricultural Pests Act (Act No. 15 of 1983). To date South Africa remains the only country on the continent to have commercialised insect resistant maize and cotton, and herbicide tolerant cotton, maize and soybeans (Ayele, 2007).

In South Africa, unlike in Ethiopia, controversy over genetic modification issues among government departments appears to be mild. Arguably this is a result of the Government's strong leadership over modern biotechnologies, as manifested in, for example, the passing of the GMO Act and national biotechnology strategy (GSA, 1997; GSA, 2001). The GMO Act not only provided policy and regulations for GMO activities, it also instituted the Office of the Registrar for GMOs in one location, at the Department of Agriculture (DoA). It is true to say that this institutionalisation process was built on existing capacity for biotechnology production and regulation as, at the time of writing the Act, most of the GM activities were agriculture and DoA based, DoA had 'a fair number of experts' in biotechnology, inspectorates, and an inspection infrastructure that stretched down to province level. The institutionalisation provision, as some interviewees pointed out, helped to avoid potential inter-departmental conflicts over GMO decision-making, the saving and releasing of resources for developing biotechnological capacities.

In contrast to Ethiopia, however, in South Africa genetic modification has been widely debated and contested, outside of government circles, by a range of participants, including non-governmental

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[2] Unlike in Ethiopia, South Africa's economic structure appears to favour using modern biotechnologies. Its economy is diversified and the service sector dominates. While tourism accounts for about 10 per cent, agriculture contributes even less to GDP. Relative to Ethiopia, South Africa's agriculture also employs a smaller proportion of the labour force (GSA, 2005).

organisations, and the media. For those sceptical or opposed to GMOs (these include some non-governmental and faith-based organisations and pressure groups such as South African Freeze Alliance on Genetic Engineering (SAFeAGE) and BioWatch South Africa), biodiversity and livelihoods are major areas of contestation. But unlike in Ethiopia, the opposition's concerns are more sophisticated and wide-ranging, including issues of access to information and accountability of the governance system. For example, a particular case that received wide publicity was the case of access to some GM related information guarded as 'confidential'. On this matter BioWatch South Africa, after unsuccessfully requesting access to information on the impact assessment of field trials, took the DoA to court to make them release the information and ended up winning the case.

The GMO governing body has received a series of criticisms mainly from those sceptical or opposed to GMOs and who see GMO activities as supply-driven, and the regulatory system as 'elitist and non-participatory'. Some noted that communication of the science of genetic modification was 'not good', particularly in the early days – although later the establishment of agencies like AfricaBio (a pro-GMOs stakeholders association), SAFeAGE and Biowatch South Africa ,and the government-funded Public Understanding of Biotechnology unit have contributed to the debate over GMOs, awareness building, and innovative changes in the system. Drawing on interview responses, below is a summary of the opposition's concerns about GMOs:

- we are concerned that genetic engineering could cause damage to our environment, and biodiversity.
- we are concerned that small scale farmers are becoming or will become dependent on big companies for seeds, including for staple food crops.
- industry is neglecting more relevant but commercially less viable technologies, for example, it is not giving enough attention to 'drought resistant crops',
- 'the public has the right to know' about genetic engineering, and
- a series of critiques of the GMOs regulatory body.

More specifically, referring to the practice in South Africa, BioWatch South Africa's Outreach Coordinator for Gauteng, Limpopo & North West alleged that releasing GM crops into the environment 'does not adequately address potential impacts on biodiversity'. In this regard, he said, the authorities 'rely on environmental impact assessment done elsewhere', raising concerns that those experiences from different agro-ecological settings might be wrongly applied. However, the executive director of AfricaBio saw the current environmental impact assessment as 'adequate', and was opposed to the idea of conducting rigorous socio-economic impact assessments, on the grounds that such assessments should only be conducted in post commercialisation conditions.

For the Government (and pro-GMO groups) the competence of the GMO governing body has never been in doubt, as for example, the National Biodiversity and Strategy Action Plan allowed the commercial exploitation, including using modern science and technology, of the country's biodiversity. The Government is confident that the country has 'well-developed research and institutional capacity' to make sustainable use of biodiversity (GSA, 2005: 20). The GMO Registrar also noted that the 1997 GMO Act provides measures to ensure that GMOs do not present hazards to the environment, and for the safety of food and feed, and human and animal health. The Act obliges the GMO Registrar to 'ensure that appropriate measures are undertaken by all users at all times with a view to the protection of the environment from hazards' (Article, 9 (f)). Overall Government authorities emphasise that they are responding to the criticisms levelled against the GMOs governance system. They argue that, as per the provisions of the GMO Act, the public are invited to participate and comment on 'every environmental release' programme.

Some pro-GM interviewees were quick to highlight the potentials of genetic modification to biodiversity, investment, management and appropriation of benefits from biodiversity. For example a retired senior public servant/consultant noted:

> We are sitting…on a goldmine of indigenous floral diversity and medicinal plant diversity. [But] we're investing very little in that and what we do, we don't protect under intellectual property, so it's open for the rest of the world to grab (Dr Wynard J. van ver Walt, FoodNCropBio).

While views on genetic modification remain diverse and often polarised, the Government firmly recognizes the benefits and risks of the technology. Its policies are based on the view that safely applied biotechnologies are compatible with the conservation and use of biodiversity. Central to South Africa's proactive approach to GM crops is also its strength in science and technology and relative independence in agriculture and biodiversity.

## Discussion and Conclusion

It emerges, from the analysis above, that potentially 'irreversible' GM crop related risks, such as loss to biodiversity and gene flow to conventional or wild varieties are key concerns for Ethiopia and South Africa (as well as the rest of the world), home to rich and complex biodiversity. The analysis also showed that besides the central concern for loss of biodiversity due to the potential introduction of GM plants, complex internal and external socio-economic, technological and institutional conditions lead to different national policy positions. South Africa pursues a proactive policy that is willing to balance risks and benefits associated with GM technologies. The policy rests strongly on the country's strength in scientific and technological capabilities to optimise the benefits, while containing potential risks. The fact that the economy is largely service sector-based also means that potential adverse socio-economic impacts on agriculture and people drawing their living in agriculture are thought to be minimal.

Ethiopia's strongly cautious stance towards GM technologies appears to rest mainly on its inability to ensure the safe development and use of the technology. However, while S&T capacity is genuinely a problem, precaution has become synonymous with Ethiopia's position on GMOs because of the political strength of its Environment Authority and the scientists leading it. Moreover, unlike for the regulators, it appears that the scientists favouring selective use of GM crops are less embedded in the national research organisations as there have not been programmes to actively work on. There also exists, among the dominant policy-makers, a perception that the risk burden falls disproportionately on the millions of poor and small-scale farmers who derive their livelihoods from agriculture and biodiversity. Low S&T capacity and vulnerability to potential risks are manifestations of Ethiopia's economy and society. The economy is heavily dependent on agriculture and biodiversity. As this agriculture is largely subsistence-based, its ability to generate investment is limited. Alternative investments, particularly in what is regarded as more investment intensive modern biotechnology, therefore have high opportunity costs and are regarded as expensive and of low priority. Some GM technologies, such as herbicide-tolerant Bt technologies, are regarded as inappropriate as they are labour-saving devices.

While biotechnological and institutional capacities are key factors for GM adoption, Ethiopia's overly restrictive biosafety system has been suppressing capacity for the conservation and use of biodiversity, for example, by limiting budgetary allocations for building institutions and undertaking R&D and training activities. Ethiopia's emerging biotechnology policy and biosafety system, therefore, amounts to an endorsement of subsistence-based use of biodiversity for food, shelter and less value-added export products[3].

Adverse risk perception in Ethiopia has possibly been overemphasised, because of lack of knowledge about and understanding of the technology, as manifested, for example, in insufficient training and lab-based experimentation in GM crops and inadequate debates over the benefits and risks of the technology. Whilst the notion that the country is the 'centre' or 'origin' of biodiversity applies to only a small range of plants, the safety argument against GM crops was often extrapolated to 'biodiversity' in general. Some of the highly contested concerns over employment or the economy were misplaced. If/when an herbicide-tolerant Bt technology proves to be inappropriate then this should not be a reason to prevent the use of other GM biotechnologies. Furthermore, as experience shows (see, for example, Knight *et al*., 2005), the presence of GM crops in Ethiopia would hardly be a reason for creating a negative perception of its non-GM coffee or other food exports. The key determinants of such external perceptions however would be the abilities to undertake R&D and commercial production in a safe environment.

It therefore follows that Ethiopia perhaps needs to reassess its emerging GM policy and biosafety system to be able to make best use of modern biotechnologies. Crucially the Government needs to take a clear position on whether it allows the conservation and sustainable use of the country's biodiversity using modern biotechnologies. It also needs to ensure that its emerging policy takes into account the diverse views on GMOs by curbing the excessive power and influence of the sceptics on its GMO policy and

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[3] The *vernonia* plant, mentioned earlier, is a good example here. According to the FT (2006), in 2006 Ethiopia and Vernique Biotech made a deal, in which the Ethiopian government provides access to the genetic resources from *vernonia* in return for Vernique Biotech paying licence fees, royalties, and share of profits over ten years. Farmers in Ethiopia will grow the plant with a view to selling the yields to Vernique Biotech. However, while Vernique Biotech's business proposition promises the creation of a multi-billion dollar global value chain from *vernonia*, due to its limited S&T capacity, Ethiopia's participation in the value chain is only as a supplier of (less value added) raw material.

biosafety system. The South African experience too provides some lessons to Ethiopia, and perhaps the rest of Africa. South Africa has been very clear, from the start, about the advantages and risks of the new technology. It put in place regulatory structures and guidelines to ensure that biotechnology is safely applied to biodiversity but without posing constraints to innovation in GM crops.

South Africa's biotechnology and innovation policies are also broadly in line with the widely acknowledged view that scientific and technological progress is the basis for success in economic growth and development (Juma, 2007). As Juma (*ibid*) argued, and where opportunities exist, African countries should access global knowledge and technologies through efforts of technology prospecting and partnerships. Alston and Pardey (2006) rightly note too that African countries, poor or rich, must find ways of meeting their demand for new technologies, crucially by investing in technological capacities. Accessing a global 'public pool of new technologies' is no longer an option for poor countries (or not without cost) for at least two major reasons. First, increased involvement of the private sector in knowledge and technology production has been limiting 'free' access to new innovations. And, second, in recent years the Consultative Group on International Agricultural Research has been scaling back its effort in producing global public goods (*ibid*). What this means is that external knowledge and technologies are not readily available or accessible. The key barrier to access could be the patenting of lucrative technologies by big private sector companies, but also, accessing technologies requires national capacity in people, organisations and firms that must require public policy on investment. Central to my argument for developing national biotechnological capacity is that such capacity can be directly linked to local resources and needs, for example, to work on crops such as *teff* and *vernonia*. Such an approach would have the capacity to address local level diversity threats too.

As this paper demonstrates, differences in S&T capacities, particularly in biotechnologies, between African countries are one set of key factors for the different policies on the adoption of GM crops. The development, spread and deepening of such biotechnological capacities across Africa is one necessary step in reducing national biotechnology policy and biosafety system differences and thereby supporting the pan-African system harmonisation imperative. African governments would do well to have clear biotechnology policies supportive of the efforts of biotechnological and institutional capacity building and innovation. Africa faces huge challenges of meeting demands of food production, and combating diseases and environmental malfunctions. Its ability to combat poverty, diseases and hunger hang on its ability to harness S&T for development.

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