TECHNOPOLICY BRIEF 3

WHAT CAN BIOTECHNOLOGY DO FOR AFRICA?

HOW CAN THE ASSOCIATED RISKS AND UNCERTAINTIES BE MANAGED?

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AFRICAN TECHNOLOGY POLICY STUDIES NETWORK

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Abbreviations and Acronyms

Bt	*Bacillus Thuringiensis*
CBD	Convention for Biological Diversity
CINVESTAV	Centre of Research and Advanced Studies
CNGOs	Consumer Organizations
DNA	Deoxyribonucleic Acid
ENGOs	Environmental Pressure Groups
FOs	Farmers' Organizations
GMOs	Genetically Modified Organisms
IFPRI	International Food Policy Research Institute
IPR	Intellectual Property Rights
LMOs	Living Modified Organisms
MNCs	Multi-National Corporations
NGOs	Non-Governmental Organizations
R&D	Research and Development
SCBA	Social Cost-Benefit Analysis
SMEs	Small and Medium Size Enterprises
S&T	Science and Technology

I

Introduction

This paper is a contribution to the current policy debate on the status of biotechnology for Africa's development. As we move into the 21st century, biotechnology is certain to play a key role in economic and social development throughout the world. Its impact on agriculture, health and the environment has been noted in the relevant literature but this is nothing compared to the widely held expectation that this generic technology will revolutionize these sectors and other sectors in the coming decades. However, biotechnology is also a two-edged sword because its capacity to modify and alter the course of nature raises many questions of risks and ethics. Unless these issues are resolved the economic potential of biotechnology will be compromised. For developing countries, risk perception and management have great significance. This was recognized at an early stage in Article 8 (g) of the Convention for Biological Diversity (CBD), which enjoins all signatories to:

> establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking into account the risks to human health[1].

Essegbey and Stokes (1998) point out two main types of risks: "those associated with the contained use of biotechnological processes and intermediate products in laboratories; and potential risks and uncertainty of the impacts of biotechnological products when released into the wider environment"[2] . However, while the former have been well catered for in most countries in regulatory guidelines, the situation is not clear-cut for the latter category. In the USA and Europe, risk assessment has been done on a step-by-step, case-by-case basis (Commandeur et al., 1996:3) and has

[1] See Glowka et al (1994), p. 45.
[2] Op. cit. p 35.

co-evolved with technology development, governance structures and management expertise. But in many parts of the Third World the, "international diffusion of biotechnologies is progressing at far greater speed than their original development, leading to fears that developing countries are, or soon will be, exposed to biotechnology related risks that they do not yet have the capacity to manage"[3]. The question is how these countries plan to cope with this dilemma in the best interests of development.

This paper addresses the issue in the following ways:

- providing a broad canvas of the potential benefits that Africa can derive from biotechnology
- illustrating the risks associated with biotechnology
- giving distinction of measurable risks and how scientists can account for them
- using agriculture to focus on risks associated with biotechnology
- stating the implications for public policy
- deliberating on the likely impact of sectional interests on policy outcomes
- discussing building appropriate capacity in African citizens and institutions

[3] Essegbey and Stokes, op. cit. p. 6.

II

What Can Biotechnology Do for Africa?

How then has biotechnology impinged on the developing world?

The threats and promises from the invasion of biotechnology on the developed world are considerable. In agriculture, for example, biotechnology promises the capacity to radically improve rates of growth of primary commodities, such as cash crops for export. Tissue culture (tc) is now used to promote the production of high value horticulture crops, such as cut flowers and vegetables for European markets[4]. Other potential export products include fine chemicals and cosmetics based on plant genetic resources that are native to many African countries. In the realm of food security, the potential benefits for many subsistence farmers are likely to be considerable. Wambugu et al. (2000), for example, show how tc has been used to promote the production of disease-free bananas in East Africa, thus solving a major problem of the region. On an industrial scale, new genetically engineered seeds have the potential for increasing yields, substantially, by minimizing the influence of poor soils or reducing the impact of harmful pests, among other benefits. One well-known example is the Bt maize that is being modified with a gene from a bacterium, *Bacillus thuringiensis* (*Bt*) that codes for a toxin against pests, such as the stemborer. This pathogen has had a devastating effect on maize yields in recent years and by incorporating the toxin into the seed, the pathogen is destroyed as it attempts to invade the young crop.

Sometimes such applications involve inputs from international companies, like the Monsanto-CINVESTAV agreement for the transfer of transgenic virus resistant potato technology. The Centre of Research and Advanced Studies (CINVESTAV) is a Mexican public research and development (R&D) institute that has been active

[4] See Clark (2002) for a series of examples of this.

in building plant biotechnology capacity. Under this arrangement, Monsanto transferred a technology that protects the potato from two major viruses; offered training to the scientists and legal rights to exploit that technology in Mexico. For CINVESTAV the arrangement would add to their long-term capacity in this field rather than lead to immediate benefits for the poor farmer.

There are some factors to consider but according to Bustamente (1995) these are mainly concerned with the economics of potato production. For the small farmer, the risks associated with normally highly unstable market prices and the high investments typically necessary in this sector (fertilizers, seed potatoes, insecticides, fungicides and nematocides) make the marginal benefits from this technology small. Large production groups in the north of the country have shown interest because the technology will improve the profitability of the seed potato sub-sector. However, Commandeur (1996) points out that there are longer-term benefits from the technology because of better possibilities to apply the resultant capabilities to areas that address problems of poor farmers.

In health, breakthrough in genomics show that resultant biotechnology applications have the potential, through improved diagnostic and therapeutic tools, to reduce the impact of endemic diseases. Cuba has developed the meningitis B vaccine for which the US has broken its trade embargoes and now permits imports. Similarly, India has identified a candidate vaccine for malaria[5]. A more generic example is vaccine development that DNA technology is expected to revolutionize in the future. DNA vaccines have only recently started the testing process, but are expected to eventually replace other methods of vaccine production. Conventional vaccines are made from live, weakened or killed pathogens. Vaccines produced from live pathogens confer greater and longer-lasting immunity than those from killed pathogens, but they carry some risk of causing the full-blown disease to develop. DNA vaccines contain only genes of the pathogen that produce the antigen and not those used by the pathogen to reproduce itself in host cells. Therefore, DNA

[5] See Singer and Daar (2001)

vaccines are expected to combine the effectiveness of live vaccines with the comparative safety of those based on killed pathogens. Several preventative and therapeutic vaccines for HIV are currently in early trials.

DNA vaccines are more extensively available to developing countries than conventionally produced vaccines for the following reasons:

- the cost of DNA is low compared to producing weakened live organisms
- DNA vaccines are more stable at normal temperatures while refrigeration can cost up to 80 per cent of the budget of a vaccination programme where conventional vaccines are used in tropical countries

A second case is in disease diagnosis where two key and broad areas of modern biotechnology are now used. The first is cell fusion involving the production of self-replicating antibodies (monoclonal antibodies for a specific antigen) or disease agent. Monoclonal antibody diagnostic tests have been in the market for several years and are now one of the most profitable areas of commercial biotechnology. The diagnostic tests are inexpensive to produce presenting opportunities for developing countries to enter the international biotechnology market, and develop diagnostics for diseases that are relevant locally, where these do not yet exist. The second area of biotechnology used for diagnostics is DNA technology. DNA probes that use isolated segments of DNA to 'attract' complementary gene sequences from pathogens are already in the market. They are cheap to produce and are usually more stable in transit and in tropical climates than conventional diagnostics. DNA diagnostics are likely to grow into a major product area in future developments on DNA arrays, also known as DNA chips and micro arrays. Micro arrays allow the detection and analysis of thousands of genes in a single small sample, giving the power of many DNA probes in one small array. Micro array is also expected to greatly increase the efficiency of drug discovery, though no drugs have yet been developed using the technology[6].

[6] See Zweiger (2000) for a detailed discussion of many of these techniques.

III

What are the Risks and Threats?

Biotechnology carries many risks, such as the danger that new synthetic substitutes derived from biotechnology can drive traditional export products out of the market. Companies based in the north can manufacture commodities, like pyrethrum and artificial sweeteners without any recourse to traditional products and chances are that this capacity will grow over the coming decades. In addition, there is concern in the way international seed corporations have started dominating agricultural production in many developing countries by using genetically engineered seeds. A potential problem is that the novel gene might be accidentally transferred by pollination to other plants including weeds and wild relatives of the crop species. Scientific research has shown this to be technically possible, but the potential long-term impacts are still vague. There are fears that such transfers could lead to the development of resistant 'super-weeds', loss of genetic diversity within crop species, and possibly, the destabilisation of entire ecosystems. This last concern also emerges from specific application of *Bt*, where genetic modification results in toxin produced directly by the crop. Environmentalists argue that the toxin might be taken up, unintentionally, by non-targeted organisms that might destroy populations of benign insect species. There are also issues associated with intellectual property rights (IPR) and dangers that alternative "non-genetically modified organisms" (GMO) solutions to food security may become marginalized because the exercise of corporate power closes off such options. Finally, there are concerns that rapid growth of export-based horticulture may damage the environment [7].

[7] For a detailed account of these and many related issues see papers in LEISA (2001)

Additionally, there are three types of “risks” in health applications. The first one refers to unforeseen dangers associated with technology use. In the case of vaccine as outlined above, there are uncertainties on the potential for the vaccine DNA to ‘invade’ the genome of the host and trigger genes for tumour development. There is, therefore, a caution surrounding the development of DNA vaccines.
The second risk is on ethics related to interference with fundamental building blocks of life, and there have been discussions on the subject in Europe and North America though not in Africa. An example is where genetic information on an individual is available to organizations outside the medical profession, including insurance companies and employers causing concerns about loss of privacy and genetic discrimination. The third is the bias of related research and development (R&D) towards the so-called “rich country diseases”, such as Alzheimer’s disease, Huntingdon’s chorea and many types of cancer. Conversely diseases, such as AIDS, malaria and tuberculosis that bedevil African populations receive comparatively little research support. Arguably, this bias is driven primarily by profit for the international pharmaceuticals industry.

IV

How Do Scientists Account for Risks?

To understand problems involved in risk analysis in biotechnology it is necessary to take a step back in time. Science has always understood that technological and economic interventions are subject to risks, but such risks were computable because values could be assigned to them. Decision-makers would then combine standard estimates of contributions to welfare with the risk values before making final policy recommendations. The decision to introduce an innovation in crop production in a region, for example, would depend foremost, on projected net benefits that would be determined through social cost-benefit analysis (SCBA). SCBA often values expected outputs and inputs to projects and computes a resultant "rate of return" to the relevant capital investments. But these estimates would then be adjusted to allow for factors preventing the expected costs and benefits from being realized. The techniques used would vary, but ultimately rest on probability theory, that is, by computing the likelihood of sub-optimal performance based on past events of a similar nature[8]. The adjusted projected net benefits would be computed and the decision to proceed with the intervention taken according to a wider set of decision criteria. An example of whether or not the adjusted rate of return to the investment exceeded some numerical percentage like the current social discount rate used by the national planning agency[9].

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8 Thus formally a distinction is made between "risk" and "uncertainty". In the latter whereas future states of nature are known there is not enough prior knowledge available to determine an exact set of probabilities. In such cases these would be estimated with aid of by "experts", those who were trusted to know the state-of-the-art and could make judgements with authority. This type of technique is sometimes called a Bayesian technique after the scientist who first suggested this statistical approach. See Clark and O'Donnell (1986) for a discussion of the use of Bayesian formulae in relation to Third World science policy decisions.

9 Alternatively where investment funds were limited only the high value projects would be sanctioned

The numerical forecasts, as discussed above, would be imperfect. To take account of this, a "safety" factor is often added to allow for the possibility of "non-computable" risks. For example, in the building of a new bridge, it would be accepted that despite over a century of bridge-building knowledge by civil engineers, things could still go wrong. Therefore, the so-called "fail safe" factors would be included to allow for this. But of importance is that ultimately the system in question was always seen to be computable in principle. It existed as an objective entity in reality however hard it was to formulate it numerically in practice. As Thompson (2000) indicates, the view is based on an acceptance of 18th Century natural law and the utilitarian ethics that followed from the enlightenment. It is useful at this stage to distinguish between two criticisms of this view[10]. The first criticism is on systems and the second one is on ethics.

On the first criticism, we must realize that much of modern experimental science is based on the view that the system under investigation is relatively stable. It can then be subject to experiment and characterization because its parameters are computable. Once we know these, we can predict with some certainty, how it will behave in the future. We can assign probability values to future behaviour based on how the system has behaved in the past. If the system in question is evolving by its underlying structure, then the procedure is flawed because its parameters are no longer stable. Its parametric instability increases in proportion to its rate of evolution. This should not be too much of a problem in bridge building (bridges and their immediate environments are relatively stable systems) but is certain to be serious in biotechnology that is subject to rapid technical change. Assigning probability values to the impact of a GMO, for example, becomes impossible simply because the future "states of nature" are unknown. We live genuinely in ignorance about the future system in question[11].

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10 See Thompson (2000) page 24, for a reference to John Stuart Mill in this context.

11 Again more rigorously, a distinction should be made between "uncertainty" and "ignorance". In the former future states of nature are known. In the latter they are not, in which case the assigning of objective probabilities becomes impossible. In the case of biotechnology change the level of ignorance is certain to be considerable. Clark and Juma (1992) explore these issues in respect of technology more generally. See Chapters 1 and 9.

The second criticism is equally fundamental because even if formal risk analysis show that an intervention is likely to be harmless, there may still be important issues associated with values and ethics. Thompson, for example, shows how in the context of the GM controversy consumers became "deeply resentful of a marketing approach that denied them the opportunity to give or withhold consent. Even consumers who thought of themselves as potentially benefiting from GM foods nevertheless insisted upon the right to decide for themselves whether to eat it or not"[12] Tait (2000) shows how throughout the 1990s there arose increased resistance, among many sections of European public opinion, to the use of biotechnology to modify crop production. Some of these opinions may have been "irrational" in formal science. The impact of "mad cow" disease in the UK did great damage to public trust of government regulation. It also called in question the inability of science to provide coherent and impartial judgement on such issues, and the early attitude of the industry did not help. Tait and Chataway (2000), for example, show how "Monsanto's response to European calls for a more precautionary approach to regulation was to mount a campaign of opposition"[13] , including a refusal to countenance "product labelling" as a mechanism that might allay public concerns. Though much of the agro-biotechnology industry has realized that a more inclusive strategy is necessary to deal with such issues, much damage has been done to their corporate interests.

From the discussions, the application of formal risk analysis to biotechnology issues is twofold. Firstly, it runs foul of the speed at which biotechnology is moving, and so it has difficulty in making judgements that stand up to strict scientific scrutiny. Even the applications of fail-safe devices do not deal with the problem, because scientists have not always been sincere about the validity of their methods. Secondly, however, there are important ethical objections about the nature of biotechnology interventions on the rights of the public to agree or to disagree with the objective risks involved. Many environmental groups have emerged in recent years to argue against the application of the biosciences to many aspects of economic production, and they are doing so to great effect not only in Europe but also in many Third World countries.

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12 See op. cit. p. 25. Thompson also makes reference to Durant, Bauer and Gaskell (1998).
13 See p. 6

V

How Can We Account for Risks in Biotechnology?

To deal with the risks associated with modern biotechnology, new approaches are suggested. Central to these approaches is the notion of the Precautionary Principle that emerged as an important conceptual organizer in the build up to the UNCED Earth Summit in the early 1990s. Hence Common (1995) quotes Principle 15 of the Rio Declaration as follows:

> In order to protect the environment the precautionary principle shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation[14].

The Precautionary Principle is thus a general injunction to decision-makers to postpone action where the environment is at risk but as Common points out, "it does not offer guidance on how the problem should be dealt with. To say that uncertainty should not inhibit measures to protect the environment from serious and irreversible damage does not indicate what should be done and how it should be done, nor does the principle suggest how one might set about answering such questions"[15]. Common then discusses some recent proposed mechanisms designed to effect the Precautionary Principle like the adoption of a Safe Minimum Standard or the posting of Environmental Performance Bonds[16] for project interventions. However, in both cases these measures are controversial and have been criticized even for well-defined projects. In radical biotechnological change it is difficult to see how a specific decision tool of such types could be useful.

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[14] See Common (1995) p. 213
[15] Ibid. p. 214.
[16] See also Perrings (1989)

Nevertheless, it is clear that in many countries the Precautionary Principle is practical. Tait (2001), for example, shows how many European countries now take a more cautious approach to biotechnology policy, especially with the advent of GM crops. Her view is that time has come to take the principle more seriously than before but this cannot be done through the simple application of the old risk-based formulae because we are now dealing with future events and our perceptions of such events and their implications. We are living in a world of great uncertainty and ignorance and economic, social, ethical and ideological interests influence views.

Decision-making, therefore, has to be consensual if it is to be successful. One of the major problems facing industry, science and government is that for many years each of these "estates" has refused to see the issue in this light and has, therefore, lost credibility in the eyes of ordinary people. Tait calls for a constructive dialogue among all interested parties to clarify issues and reach a social consensus on all the underlying problems. This does not mean that science is abandoned. Rather, it implies the need to recognize the limitations of science in a field that is developing fast.

The first step is to recognize the interest groups and factors that influence their views. Tait identifies the following groups:

- environmental pressure groups (ENGOs)
- consumer organizations (CNGOs)
- multinational companies (MNCs)
- small and medium size enterprises (SMEs)
- farmers' organizations (FOs)
- public research systems and scientists working in them
- government ministries and secretariats

Each of these interest groups views issues of biotechnology risk quite differently even where the presenting evidence appears to be very similar. But their views are neither static nor homogeneous, for example, "unlike their American counterparts, several European companies would have been prepared, at an early stage, to accept labelling of food products arising from GM crops, and avoiding one of the stimuli that has had an important impact on European public opinion"[17]. Again Paarlberg (2000)

[17] See Tait, Op. cit. p. 184.

shows how agricultural and scientific ministries usually promote biotechnology than environmental ministries and the views of European CNGOs have changed from a neutral to a more hostile position over the 1990s because trust in regulatory authority has dissipated (Tait 2001).

In a recent International Food Policy Research Institute (IFPRI) publication Paarlberg (2000) analyzed policies towards GM crops in four developing countries: Brazil, China, India and Kenya. Of these countries, only China has been positive about granting permission for planting GM crops to proceed. In the other countries, international pressures from ENGOs, CNGOs and donors are working to discourage such developments despite a more positive attitude from government agencies in all three countries. In China, however, NGO pressure groups are not allowed to function. Interestingly, Paarlberg concludes that IPR regimes are not the main determinants of the behaviour of MNCs in any of the countries. Monsanto, for example, has been offering to share GM sweet potato technology with Kenyan scientists for nearly a decade but has been prohibited on biosafety grounds. In China, MNCs have been happy to enter into collaborative agreements despite widespread and blatant IPR piracy. Conversely, a relatively strong IPR regime in Brazil has not in itself been enough to create a GM revolution in that country (Paarlberg 2000)[18] . Stokes (1998) has come to similar conclusions in her study of the Zimbabwean biotechnology policy.

A related issue concerns international trade. Because trade in GM crops, for example, is also subject to the WTO agreement, signing up to the WTO has constrained the ability of many countries to prevent imports of GM crops on grounds of risk and safety. This issue is important so the WTO has set up a Committee on Trade and Environment to deal with associated disputes. As Tait and Bruce (2001) point out, however, the current position of WTO is that such trade restrictions should be based on current internationally agreed food safety regulations and that if national standards are higher than the current Codex standards, "the additional safeguards must be based on scientific evidence and grounded in risk assessment"[19]. The WTO position, therefore, does not recognize the wider view of risks associated with biotechnology development as outlined above.

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[18] See Paarlberg (2000), Page 30.

[19] See Tait and Bruce (2001) p. 105. These standards refer to the *Codex Alimentarius* established in the 1960s by the FAO and WHO Tait and Bruce show that the Codex contains more than 200 standards for foodstuffs and in 1998 membership of the Codex Commission comprised 163 countries representing 97per cent of the world population. They also refer to the Codex web site— www.fao.org./docrep/w9114e/

VI

How Can Africa Manage Risk and Uncertainty?

How then should African governments proceed with respect to biosafety issues given the promises and threats of modern biotechnology?

They should build capacity to understand all aspects of biotechnology so that the regulatory/promotional regime put in place by countries are as fully informed as possible. Such countries are bound to confront a more basic issue of science and technology (S&T) policy—the inability of traditional governance structures to fully understand the details of possible technology developments and hence construct effective plans and policies to promote them safely. While there are usually well-trained scientists within national laboratory systems who understand the detailed nature of biotechnology they are often not well connected into government decision-making structures. The degree of "connectivity" between relevant S&T organizations is also often not very good. This means that since "innovation systems" are not well developed, mechanisms for relevant governance are hampered by lack of knowledge[20].

I would, therefore, advise that countries take an approach similar to that recommended by Tait (2001). Firstly, national governments should recognize explicitly that they are dealing with an extremely complex issue with no simple solutions. They should not assume that they could issue directives from on high and wait for action. Secondly, governments should encourage dialogue between and among all relevant stakeholders to clarify issues and minimize confusion and misunderstandings. An example of how this could be done is the recent attempt in Ghana to raise awareness in biotechnology through a "stakeholder conference". Representatives of many interest groups came together through a donor-funded project to set priorities

[20] See for example Clark (2002)

for developing biotechnology in Ghana in the medium term[21]. Led by a policy research organ from a key ministry, the project team conducted research, through analysis of secondary literature and interviews with individual stakeholder groups, on how well such priorities are being met in practice. Finally, a feedback workshop comprising a smaller group was arranged to discuss and disseminate results. A newsletter was published and disseminated widely so that all the groups could be part of this dialogue and benefit from the resultant exchange of views. The appropriate use of the Internet could enhance and promote such initiatives.

Thirdly, countries need to do more to build up relevant S&T capacities amongst civil servants. As Paarlberg (2000) points out, biosafety administrators are prone to err about undue caution if they know that they will be subject to criticism by NGOs and the media. This has been the case in Kenya where the drafting of policies has progressed faster than the capacity to administer the resulting decisions. Donors have an important role to play since they are more ready to fund the drafting of biosafety policies than to build the necessary implementation capacity. Out of all the countries in the Paarlberg study, it is arguably the one that has done most to build up an independent (of donors) biotechnology capacity (China) that has done most to promote the sensible use of GM crops for development. Fourthly, developing countries need to invest more at higher education level and assist their scientists to understand the social and economic contexts within which biotechnology is likely to develop. So fundamental is this technology to every avenue in modern life, that training the current generation of students solely in narrow areas of relevant disciplines, like molecular genetics, is certain to produce graduates that have difficulty in offering the necessary advice to policy makers.

However, this does not mean that there has been no progress. The intense dialogue on the drafting of the Biosafety Protocol to the Biodiversity Convention (signed finally in Cartagena in January 2000) shows that countries can get their act together when it comes to international policy. In this case, the big debate was between two major blocs: the so-called Miami group of countries (Argentina, Australia, Canada, Chile, Uruguay and the USA) and the like-minded group of developing countries,

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21 See Essegbey et al. (2000). The donor in this case was the UK bilateral agency DFID.

including Africa and NGOs. The former group felt it had most to lose in trade, than the latter group and was reluctant to accept a restrictive protocol. It was able to "water down labelling requirements and succeed because the protocol applies only to living modified organisms (LMOs) so that no segregation is required for non-living GMOs"[22]. However, that the like-minded group was not successful may well reflect its weaker capacity to argue what must have been a complex case at that event. In other words while sub-Saharan Africa countries have started to be engaged with these issues, their capacity to do this in an informed way is still short of what is desirable.

[22] Tait and Bruce Op. cit. p. 107.

VII

Whose Interests are the Lobby Groups Serving?

Finally, policy makers should be made fully aware of the "interests" of different lobby groups. In the absence of this awareness, the different interest groups try to exploit a confused situation. Paarlberg, for example, shows how the NGO sector in India has agitated feelings against GM technology by playing on fears about the activities of international corporations despite some beneficial cases of GM technology. Cotton farms in India, for example, are plagued by bollworms that have become resistant to chemical sprays. Insecticidal Bt cotton presents an alternative method to control bollworms, yet efforts by Monsanto/Mahyco since 1997 to gain biosafety approval have repeatedly been slowed by protests of NGOs. By filing law suits and sponsoring physical attacks on field trials, anti-GM activist groups in India have transformed biosafety approval into a highly politicized process and at times paralyzed the policy struggle"[23]. Thus an activity with clear development and environmental benefits has been stopped by pressure groups that ostensibly are working in the best interests of the environment and development. The issue here is usually about a perceived conflict between commercial and environmental interests though often the conflict may in reality be less than perceptions would indicate. Policy makers should be aware of these issues and come to sensible judgements on cognate decisions.

The battles are not confined to the NGO sector since there are often similar conflicts at government level. Environmental ministries, for example, often take a fairly negative view about biotechnology whereas ministries of science are usually more sanguine. A good example of this is in Brazil where disagreements between environmental and science ministries have played an important role in slowing down biotechnology development. Another source of conflict may occasionally be the do-

[23] Op. cit. p. 19

nor community whose ideological biases may be negative and may, therefore, try to prevent or hold up biotechnology applications. There is evidence that donors whose views may have been so slanted have thus influenced Kenyan biosafety legislation[24]. The important point is that those people who make national policies in such areas should be aware of these factors and take account of them in policy formulation. Where they feel that the necessary technical competence is lacking, they should make fully informed decisions and also know how to commission advice from disinterested expertise.

[24] Ibid. pp. 15 and 12.

VIII

Conclusion

This paper is a contribution to current debates about biotechnology policy in and for Africa. Inevitably it has set out the issue in simple terms and readers are encouraged to consult the cited texts and other sources for more detailed discussion of the issues. However, not only is biotechnology now evolving very rapidly, it is almost certainly going to play a fundamental role in future development policies in developed and developing countries. It promises immense gains in food security, environmental protection, agriculture, health and industrial production. However, it also interferes with life in ways and degrees that have never occurred before in human history. The impacts, how widely they will spread and with what effects are not known yet. Moreover, the advent of third generation biotechnology has raised ethical issues that are deeply felt by people and organizations at all levels. The more reason, therefore, to approach associated public policy analysis with as much dispassion and objectivity as possible. Decision-making in this sphere should not rest solely upon narrow instruments as conventionally understood. Instead governments must establish new initiatives, capabilities and institutions that can have a profound effect on legitimacy at a more fundamental level. Unfortunately there are no standard models here. Each country must establish its own procedures in the light of its own unique circumstances.

To do this sensibly, there must be radically increased investment in the associated science base and supportive institutions, such as schools, regulatory bodies and government departments. At one level the argument is straightforward: so strategic is biotechnology today that no country can afford to neglect it. However, at a deeper level the issue is not clear-cut since it begs the question, "what is biotechnology capacity?" Essegbey and Stokes (1998) show that capacity goes well beyond "laboratories and scientists." In most African countries shortage of suitably trained scientific manpower in the life sciences may not be the basic issue (though there are constraints, as well as lack of equipment and related laboratory apparatus).

What seems to be mainly missing, however, in many cases are the entrepreneurial capabilities, supportive institutions and associated networks needed to translate raw

scientific knowledge into economic production[25]. It is this systemic competence that determines "biotechnology capacity" and that appears in very short supply[26]. Nevertheless the agenda is clear. While African countries should certainly continue to monitor the use of this powerful new technology, their success in so doing will depend on building up the appropriate capacity. The time to start this process is now.

25 Mugabe (2002) explores this issue in terms of environmental policy more generally.

26 Clark and Juma (1991) explore this point in some detail arguing that strategic links with carefully chosen types of production is probably a necessary ingredient in building such capacity. And there is an important role for government in helping to create and nurture such links. And as noted above Essegbey and Stokes (1998) come to similar conclusions in their assessment of biotechnology in Ghana. On a scale of technological sophistication they examine the different stages involved, concluding in this case that Ghana has probably reached the stage at which the application of tissue culture techniques is feasible. But it is an open question as to whether real biotechnology "capacity" is yet present.

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