



AGRICULTURAL BIOTECHNOLOGY

INTRODUCTION

This second issue of the UNU/INTECH Technology Policy Brief series focuses on agricultural biotechnology, looking particularly at some of the major challenges national governments in developing countries have to face in order to make sure that their population can reap the benefits derived from new technologies.

The underlying assumption in the articles is that national governments should recognise that they are dealing with extremely complex issues. Thus, it is necessary to build local capacity to understand agricultural biotechnology in all its aspects – scientific, technological, economic, socio-political, ethical and cultural. It is also essential to have flexible institutions, stakeholder involvement and democratic decision-making.

The first two articles present the strategic moves of the main players in the agricultural biotechnology world industry. Working with different sets of data for the US and EU, they give evidence of the high concentration of agricultural biotechnology research among a small number of multinational companies (MNCs). According to *J. Chataway, J. Tait and D. Wield* (page 2), the current strategy of MNCs relying on the synergy between chemicals and biotechnology is leading to new patterns of alliance and an increasing concentration of technological power and innovation. *A. Arundel* (page 4) bases his analysis on genetically modified (GM) plant varieties field trials which reveal the concentration of agricultural biotechnology research not only among a few companies but also on a small number of crops and genetic traits.

Considering the strategic moves and research focus of MNCs, *R. Raina* (page 5) points out that public sector research in developing countries will need to shift from conventional 'maintenance' research to sustainable agriculture. The former meaning research which exploits one gene or expression, and the latter, research on a relevant range of agricultural and ecological issues. For doing so, governments will find it necessary to establish new initiatives, capabilities and institutions.

According to *N. Clark* (page 7) governments must also promote the education system to build a multidisciplinary understanding of biotechnology and do more to build-up science and technology (S&T) assessment capacities among civil servants and civil society in general, to enable better risk assessment and prevent undue anti-science rhetoric. In such processes a pro-active social science role is needed to inform the scientific and technological decision-making process, and for more democratic control over technology choices. The latter could be achieved through dialogue among stakeholders, which is the focus of the last two articles.

G. Essegbey (page 9) gives an account of a recent attempt in Ghana to raise biotechnology awareness through a stakeholder conference and the lessons that can be learned from such an experience. *V. Pelaez* (page 10), in turn, reports on the Brazilian negotiations over GM crops discussed at the recent World Social Forum. His piece illustrates the vociferous debate, sometimes degenerating into acrimony, which may arise with the lack of a truly democratic dialogue among stakeholders.

FROM LIFE SCIENCES TO A NEW AGRO-INDUSTRY

The life science concept that emerged in the mid-1980s, and the new emphasis on biotechnology, provided a rationale for the new technological trajectory with strengthened links between the agrochemical and pharmaceutical divisions of multinational chemical companies. At this time references to life science synergies were often made in the context of mergers and demergers. For example, Zeneca was formed in 1993 as part of a demerger by ICI. This pattern of mergers and demergers linked pharmaceutical and agrochemical research and development (R&D), dependent on the intimate intermingling of biology and organic chemistry to avert an external threat (of take-over) and also proactively to launch the new life science-based strategy.

Early interpretations of the term “life science” assumed that, by using biotechnology to gain a better understanding of the functioning of cells across a wide spectrum of species, there would be useful cross-fertilisation of ideas between the development of new drugs and new crop protection products.

The vision here was of synergy at “discovery” level, where a better understanding of genomics and cell processes, made possible by fundamental knowledge gained in life sciences, would lead to new drugs, new pesticides, GM crops and genetic treatments for disease. At this stage, the research itself often does not have any particular application in view and a close association between the agrochemical/seeds and pharmaceutical divisions can allow a company to extract more value from the original research than would otherwise be the case. Also at this level, given the increasing tendency to contract out the synthesis of new chemicals to companies specialising in combinatorial chemistry or to buy-in the services of bioinformatics small and medium-sized enterprises (SMEs), the same contracts can be of value to both divisions. Such assumptions were accepted until recently without much questioning, partly to justify the continued retention within the same company of two sectors with markedly different profit potentials, pharmaceuticals and agrochemicals.

However, the original conception of a life science-based industry structure is now being

reinterpreted. The discovery level synergy works well where both partners are interested in sources of *chemical* novelty, but not in the *gene* area. Functional genomics, as a platform technology, can help both sides to invent novel and profitable chemicals but the major commercial opportunities in the creation of GM crops have no parallel in pharmaceuticals. Although experience in the US and other countries has indicated that GM crop development can be very profitable, the negative public reaction in Europe has created conflicts of interest between agricultural and health-based sectors.

The result of this reinterpretation of the relationships between agro-biotechnology and pharmaceutical sectors of companies can be seen in the changed pattern of mergers and demergers among life science companies. In 2000, the splitting off of the agrochemical and seeds divisions from the pharmaceutical divisions of Novartis and Zeneca to form Syngenta was “the first ever pure play in ag-biotech”. In the merger of Zeneca with Astra in 1999, Zeneca had originally argued for a life sciences model which included agrochemicals but there was no apparent design for the agrochemicals unit in the merged company. Novartis described 1999 as the year in which it took further steps to focus its business portfolio, “moving from a Life Sciences company to a pure Healthcare company”. This pattern has since been repeated in many of the leading agro-biotechnology MNCs.

Thus, beyond the fundamental discovery stage, there is apparently little synergy between the downstream product development processes of the agrochemical and pharmaceutical sectors. When it comes to near-market development, business partners now tend to be in the food processing and retailing sectors rather than in pharmaceuticals.

The demise of pharmaceutical/agrochemical links and the focusing of attention on the synergy between chemicals and biotechnology is leading to new patterns of alliance among life science companies. Most companies can gain leverage from having both a significant crop protection share and a viable seed base. The number of companies that are either pure players in crop protection or in the seeds sector is rapidly diminishing. For example, Novartis integrated agrochemicals with biotechnology because they were not gaining the synergies from being strong in both agrochemicals and seeds, whereas Monsanto was doing that very effectively.

Purely agrochemical companies such as BASF and Bayer have been aiming to expand their coverage into the seeds/biotechnology sector to give them equivalent leverage to competitors such as Syngenta. The few remaining companies that operate only in the seeds sector are unlikely to have the financial resources to do the reverse and, if the life science trajectory continues on its present course, will be vulnerable to take-over.

Multinational companies increasingly depend on a series of alliances with other companies to develop routes to create and capture value. For example, most companies now deal with specialist, unique technology providers to an increasing extent, mainly niche players in gene effects and enabling technology such as combinatorial chemistry, bio-informatics, genomics and proteomics.

Capturing value requires companies to engage in new patterns of alliance with seed companies and others that form the "channel to market". For example, Monsanto has created multiple agreements and partnerships, acquired seed companies and pursued a strong strategy of licensing its technology to farmers. DuPont had a similar approach. The strategies of these two companies are described by others as "buying the channel to market".

Other companies invested in some acquisitions but of a different order of magnitude. Zeneca's investments in seeds took place mainly in the late 1980s when companies could be bought for very different multiples. Novartis, AgrEvo, Zeneca, Rhone Poulenc, and Dow all had a reasonable "route to market" base, but not as far downstream as Monsanto and DuPont.

Bayer, BASF and American Home Products were seen as late starters with a different strategy for patents, technology and time to market, looking for benefits from their agrochemical businesses to help them to move into biotechnology.

These three different approaches to the life science trajectory cover all the candidates with the potential to get into leading market positions. Of the top ten agro-biotechnology companies in 1999, it is expected that only four to six will remain as future leading biotechnology companies, and indeed the subsequent pattern of mergers and demergers has taken the sector close to this prediction.

The development of stronger linkages between the agro-biotechnology divisions of different companies and weakening of links with pharmaceutical counterparts was generally seen as a positive development, offering opportunities to cultivate more useful channels to market for new products.

The maturing market for pesticides and consumer acceptance problems for biotechnology-based products are usual reasons given for the reorientation of the agro-biotechnology industry sector, away from its close association with the pharmaceutical sector. However, the increased complexity of product development pathways and the resulting need for radically new systems within companies, and new structures of relationships among companies, provide equally potent arguments for these changes.

■ Implications for Developing Countries

New opportunities for combined agro-chemical and biotechnology trajectories are leading to stronger pressures to link agro-chemicals and biotechnology/seeds competencies within dedicated agro-industry MNCs. Companies are at different stages of articulating this synergy between biology and chemistry and future product and market directions are being moulded. Leading companies have a global vision that goes beyond simply selling products designed mainly for US and EU markets in developing countries. Developing countries with limited technological capacity face real challenges in this environment. Technological power and innovation are becoming more concentrated in the hands of a few MNCs. It is of vital importance that new linkages and networks between these new technological powerhouses and public and private institutions are encouraged, researched and monitored. Broader national and international institutional environments impacting on partnerships, trade, intellectual property rights and innovation will be crucial in shaping the future.

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GM FIELD TRIALS: RELEVANCE TO DEVELOPING COUNTRIES

The development of GM plants usually runs through three stages: laboratory work, small-scale greenhouse experiments and outdoor field trials under realistic conditions. The US and the EU require firms and public researchers that plan to conduct outdoor field trials to describe the purpose of the trial as part of a field trial application or notification. The EU Joint Research Centre maintains a public database* of all European GM field trials while the Animal and Plant Health Inspection Service (APHIS) of the US Department of Agriculture provides similar data** for the US.

Monitoring and analysing the field trial data for the EU and the US is of strategic value for developing countries. For example, the field trial data can be used to identify genes for stress or pest resistance that are of value for regions outside the EU or the US. Also, researchers in developing countries can use the data to identify private firms or public research institutes that have expertise in a specific crop or genetic trait of interest to them. This information can be used to recognise potential research partnerships or to negotiate licensing agreements. Furthermore, research performed by the public sector in the EU or the US could be of greater interest than private sector research, since the public sector may be more likely to provide promising plant varieties or genetic material at low or no cost.

An analysis of the field test data up until April 2001 for the EU (the most recent date available) and until January 2002 for the US shows that GM research is concentrated among a small number of firms, a small number of crops, and a small number of genetic traits. Three firms account for 48 per cent of all US trials (Monsanto, Pioneer and AgrEvo) and for 26 per cent of all EU trials. Three crops (maize, potatoes and soybeans) account for 64 per cent of all US trials while maize, sugar beet, and rapeseed account for 67 per cent of all EU trials. Finally, 69 per cent of US and 71 per cent of EU trials are for two trait categories: herbicide tolerance and pest resistance. In the US, 63 per cent of the latter are for insect resistance (mostly using Bt), 21 per cent are for viruses, 12.7 per cent for fungi, and 3.3 per cent for other pests including bacteria and nematodes.

Table 1 shows the number of EU and US field trials that include a gene for one of five major trait categories. Table 1 also gives the percentage of trials in each trait category that were performed by the public sector. The US public sector accounts for almost half of the technical trials, which are often part of basic research, while the EU public sector focuses on applied research to develop agronomic (61.6 per cent of the 86 trials) and product quality traits.

Table 1: Distribution of EU and US Field Tests by Trait

Trait category	US			EU		
	N	Share	Public sector trials	N	Share	Public sector trials
Herbicide tolerance	2,509	(27.5%)	4.9%	980	(48.0%)	9.5%
Pest resistance	3,800	(41.7%)	16.3%	477	(23.4%)	18.7%
Other agronomic	394	(4.3%)	25.3%	86	(4.2%)	61.6%
Technical	669	(7.3%)	47.3%	238	(11.7%)	14.7%
Product quality	1,750	(19.2%)	15.6%	259	(12.7%)	29.0%
<i>Total</i>	<i>9,122</i>	<i>(100%)</i>	<i>15.0%</i>	<i>2,040</i>	<i>(100%)</i>	<i>16.9%</i>

Table 2 provides a closer look at the small percentage of trials for agronomic traits. Although seed firms have frequently stressed the value of GM technology for "feeding the world", only 27.8 per cent of US and 12.5 per cent of EU agronomic trials concern yield (in total, these account for only 1.1 per cent of all EU and US field trials combined). Of course, improved pest resistance could also indirectly improve yields.

Table 2: Distribution of EU and US Trials of Agronomic Traits

Trait category	US			EU		
	N	Share	Public sector trials	N	Share	Public sector trials
Stress resistance	153	(38.6%)	52.3%	25	(29.1%)	36.0%
Plant growth/development	114	(28.8%)	27.2%	45	(52.3%)	93.3%
Yield	110	(27.8%)	5.5%	16	(18.6%)	12.5%
Unknown	19	(4.8%)	42.1%	-	-	-
<i>Total</i>	<i>396</i>	<i>(100%)</i>	<i>24.7%</i>	<i>86</i>	<i>(100%)</i>	<i>61.6%</i>

Perhaps of greater interest to developing countries is research on stress resistance to drought, temperature, poor soils, and other conditions. Compared to yield, a much higher percentage of these trials are conducted by the public sector in both the US and the EU. In many cases research on stress resistance is also combined with general resistance to pathogens, although the latter traits are counted under pest resistance.

Almost all of the GM crop varieties that have been tested in EU and US field trials can be grown in at least some developing countries. Of further interest are trials of plant varieties that are commonly grown in sub-tropical and tropical climates. Other than maize, only 876 trials (less than 1 per cent of the total) are for such varieties and 609 of these are for cotton. The remaining plant varieties and the number of trials are as follows: rice (157), sugarcane (45 trials), peanuts (22), papaya (15), sweet potatoes (8), persimmons (8), pineapples (4), citrus (3), coffee (3), and cassava (2). Excluding cotton, about 50 per cent of these field trials were conducted by the public sector.

In conclusion, most of the field trials in the EU and the US are conducted by private firms and are limited to a small number of major crops. These firms may use their expertise to develop GM varieties of value for developing countries, as with Monsanto's research on maize and cotton varieties in China. In addition, the public sector in the EU and the US has several areas of strength that could be relevant to developing countries and they might provide access to these traits at little or no cost. These include traits for stress resistance and for tropical crops. However, only a small number of trials have been conducted in these two areas, which suggests that considerably more research is needed before viable plant varieties are obtained. The field trial evidence indicates that comparatively large numbers of field trials are required before most GM plant varieties are ready for commercialisation.

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R&D CAPABILITY NEEDS FOR AG-BIOTECH IN DEVELOPING COUNTRIES

The green revolution technologies came into being in times when they were put to multi-location trials and released for adoption after scientific and economic assessments. For agro-biotechnology, however, the decisions for research directions, allocations or release of research products now depend not only on scientific judgements but also on a judicious mix of informed public opinion, regulatory and political safeguards and social contracts. While a policy blue-print to address the R&D capability in agro-biotechnology would be misleading, a few general guidelines could help policy-makers find the tools to address institutional reform and enhanced assessment capacity within agricultural research systems. Three of such guidelines are briefly discussed below.

■ From Maintenance Research to Sustainable Agriculture

An important lesson from the green revolution is that a technology in itself can contribute little to agricultural development unless several complementing technologies, institutions and policies are in place.

In the 1960s, the new disciplinary convergence and the first-generation technologies enhanced production/productivity. The ecology responded with more focused and more virulent strains of pests, pathogens and weeds, specific forms of soil and water degradation, and losses in the diversity of crops and other flora and fauna. Research to maintain yields in the face of these second and third generation problems came to be known as "maintenance research". It became the rule in national agricultural research systems (NARS) that an increase in scientific knowledge and crop productivity would necessitate a rise in research resources allocated to maintenance research. This increase in applied and adaptive research became essential to "maintain" the unrelenting pressure of knowledge and technology on the ecosystem.

Biotechnology, despite its immense potential to respond to specific crop-ecosystem requirements, has so far been cudgelled into the

confines of these marginal or incremental changes in agricultural technology, to uphold existing yield levels in the face of second and third-generation problems such as weeds, pests or diseases. Current content in and outputs of biotechnology research are part of this research paradigm to “maintain” pressure on the ecosystem. Modern biotechnology focuses on the identification and expression of one gene or sequence to enhance yield/quality of produce, push resistance to one pest or disease or weed that is manifest now in the ecological response to this unrelenting pressure of knowledge and technology. Biotech research on bollworm-resistant Bt cotton, sheath blight-resistant rice or vitamin A-enriched golden rice fit into this paradigm of “incremental response”.

Biotechnology can study the genetic expression of organisms and interactions in complex ecological systems, generate solutions (in multidisciplinary analyses) for degraded ecosystems, help identify ecological safety limits for flora and fauna in different soil and water systems and help gain a systemic understanding of the diversity of gene pools and ecosystems. This long-term, ecological knowledge base of agricultural production is the niche where agro-biotechnology can and must focus to enable the transition from the green revolution agricultural research paradigm of maintaining pressure on the ecosystem to one of systemic sustainable development with the least ecological disruption. Biotechnology within a policy framework of sustainable agriculture has a much wider and varied role to play than mere incremental technology for yield enhancement. For biotechnology the real scientific challenge is to maintain and improve the sustainability of production and of the ecosystem.

■ **From Institutional Stereotypes to Hybrid Organisations**

Institutional changes fostering increased collaboration and partnerships between private and public sector R&D are more crucial in the era of ag-biotech than in the green revolution. The responsibility for generation of basic/frontier knowledge in biotechnology, in addition to accountability to society and to science is no longer the exclusive prerogative of the state and its public sector R&D. The emergence of the “hybrid firm” in science-based industries, embedded in public sector institutions (legal, scientific and administrative ones) is a pointer to the future of ag-biotech R&D.

Today, the policy vacuum in these institutional aspects of ag-biotech makes progressive institutional reform slow and difficult. Policy-makers must be wary of organisational blue-prints and encourage the organisational hybridity that is essential to exploit biotechnology and enable effective response to specific technological, ecological and market issues. Centralised funding and administration of research may not help excellence and relevant results in ag-biotech research where monitoring and assessment of agro-ecological changes and biodiversity, local stakeholder participation and specific R&D coalitions (public-private, intra-public sector) are important elements in the safe and sustainable use of technology for agricultural development.

The history of the green revolution also tells us that simple and compartmentalised policy-making and S&T initiatives will lead to further institutional and organisational confusion and waste precious public resources. More critical would be the damage done to science, in terms of loss of credibility and public faith. Public participation is a necessity.

■ **A New Role for the Social Sciences and Policy Research**

Ag-biotech poses major challenges for the social sciences in designing appropriate institutional and organisational changes for participatory research and technology development in:

- unravelling the “market incoherence” that is characteristic of seed markets in most developing countries;
- examining the historical, political and philosophical basis of regulatory policies or of criteria used for risk assessment;
- helping research decision-makers see the pros and cons of different decision trajectories; or
- exploring the cognitive empathy between molecular biologists and plant breeders.

In the hierarchy of the sciences in agricultural research systems, the social sciences must not be relegated to the “less prestigious” ranks, and “used” to provide a viability certificate for technologies, technology transfer or developing farmer recommendations, conditional priority setting or for estimating economic benefits from successful research. The social sciences are necessary for policy research, to help us learn from the changes in science-based industries. Biotechnology is an area

that has reversed the knowledge-practice hierarchy, demanding a competence-based evolutionary theory of the firm in place of the classical theory of production.

The social sciences have a major role to play in understanding and reaping the benefits from new technologies. A crucial area is in technology assessment. The environment-agriculture-biotechnology interface, and the problems of evaluation within it, will raise new questions and bring new theoretical positions to bear upon issue-based research. An important agenda for policy-makers and research decision-makers is to encourage the emergence of, and challenges posed by, these questions and assessment problems. The only effective answer to the anti-science rhetoric that threatens ag-biotechnology research and its potential to contribute to agricultural development is this range of open and ethically contestable questions from within science.

Given the environmental risks and uncertainties associated with biotechnology, it is imperative that the responsible nation state and science keep the evidence, decisions, doubts or probabilities of main effects and a series of collective "side effects" open and transparent over time and across space. R&D capability then demands new disciplines such as geography, social anthropology, history, and truly multidisciplinary analysis with people's participation in recording and analysing local observations. Research policy and capacity building in ag-biotech has to be informed by the cultural differences that are basic to a society's conception of risk and what threatens the society. The stakes in science and in policy, for deliberative and discursive processes that lead to democratic decision-making have never been higher and more fervent.

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HANDLING THE RISKS OF BIOTECHNOLOGY IN THE THIRD WORLD

The capacity of biotechnology to modify and alter the course of nature raises many questions of ethics and risk, particularly those related to the release of biotechnological products into the wider environment. In the US and Europe risk assessment has co-evolved with technology development, governance structures and management expertise. However, the speed of diffusion of biotechnologies in developing countries is leading to fears that they soon will be exposed to biotechnology-related risks which they do not yet have the capacity to manage.

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

I suggest that an important and necessary condition is the building up capacity to understand biotechnology in all its aspects so that whatever regulatory/promotional regimes countries put in place are as fully informed as possible. And it is here that such countries are bound to confront a much more basic issue of S&T policy – the inability of traditional governance structures to fully understand the details of possible technology developments and hence to 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 insufficiently connected into decision-making structures at government level. At the same time the degree of "connectivity" between relevant S&T organisations is often not very good either. What this means in practice is that since "innovation systems" are not well developed, mechanisms for relevant governance are hampered by lack of knowledge.

This, in turn, allows different interest groups to exploit a confused situation to try to achieve advantage for this or that position, regardless of the objective situation. Paarlberg, for example, shows how the non-governmental organisation (NGO) sector in India has been able to stir popular feeling against GM technology by playing on fears about the activities of international corporations. And this is despite the fact that in some cases the adoption of GM technology could have beneficial consequences.

Thus an activity with clear development and environmental benefits has been stopped by pressure groups that believe they are working in the best interests of the environment and development. Nor are the battles confined to the NGO sector, for in Brazil disagreements between environmental and science ministries have clearly played an important role in slowing down the commercial use of biotechnology, while in Kenya biosafety legislation has been influenced by donors.

I would therefore recommend that, as a *first step*, national governments recognise explicitly that they are dealing with extremely complex matters for which there are no simple solutions. Certainly they should not assume that they can issue directives from on high and wait for these issues to be obeyed uncritically. *Secondly*, they should begin to encourage dialogue between and among all relevant stakeholders with the aim of clarifying the true nature of the issues and minimising degrees of misunderstanding and confusion. One good example of how this might be done is a recent attempt in Ghana to raise biotechnology awareness through the use of a stakeholder conference (described on page 9).

Thirdly, countries need to do more to increase relevant S&T capacities amongst civil servants. As recent analysis has shown, biosafety administrators are prone to err on the side of undue caution if they know that they will be subject to NGO and media criticism. This has certainly been the case in Kenya where the drafting of policies has proceeded much faster than the capacity to administer the resulting decisions. Indeed donors have an important role to play since they are apparently much readier to fund the drafting of biosafety policies than the building up of necessary implementation capacity. Indeed it is interesting to note that China, which has gone a long way to build-up its own biotechnology capacity (independent of donors), has also done better than most developing countries to promote the sensible use of GM crops for development.

Fourthly, developing countries need to do more at the higher education level to provide their scientists with an understanding of the social and economic contexts within which biotechnology is likely to develop. So fundamental is this technology to practically every avenue in modern life that training the current generation of students solely in narrow areas of relevant disciplines (like molecular genetics, for example), is certain to produce graduates that have great difficulty in providing the necessary advice to policy-makers.

This is not to say that progress is not being made. The intense dialogue surrounding the drafting of the Biosafety Protocol to the Biodiversity Convention (finally signed in Cartagena in January 2000) shows that countries can certainly get their act together when it comes to international policy. In this case the big debate took place 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 and NGOs. The Miami group felt it had the most to lose in terms of trade and was less willing to agree to a restrictive protocol than the latter group. It finally succeeded in restricting the application of the protocol only to living modified organisms (LMOs) so that no segregation is required for non-living GM organisms. However, the very fact that the like-minded group was unsuccessful here may reflect its weaker capacity to argue what must have been a complex case at that event.

In conclusion, biotechnology is not only evolving very rapidly, it is almost certainly going to play a fundamental role in future development policies in both developed and developing countries. It promises immense gains in food security, environmental protection, agriculture, health and industrial production. But it also interferes with living processes in ways, and to degrees, that have never occurred before in human history. We simply do not know what the impacts will be and how widely they will be spread. Also, the advent of third-generation biotechnology – products which provide value to consumers e.g. foods with low fat or sugar content, edible vaccines, etc. – has raised ethical issues that are deeply felt by people and organisations at all levels. All the more reason, therefore, to approach associated public policy analysis with as much dispassion and objectivity as possible. My suggestion is that decision-making in this sphere should not rest solely upon narrow instruments of decision-making 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. Only when this is done will biotechnology generate benefits in the third world.

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A STAKEHOLDER-DRIVEN APPROACH IN GHANA

The major challenge in the development, application and management of biotechnology is how to integrate the perspectives and initiatives of the stakeholders for synergic impact. In Ghana, the Biotechnology Development Programme (BDP), undertaken jointly by the Council for Scientific and Industrial Research of Ghana (CSIR) and the University of Strathclyde from June 1999 to December 2000, was conceived to meet such a challenge. The BDP had three main objectives:

1) Policy Research

This was aimed at providing inputs for policy formulation to direct and catalyse the development of biotechnology in the country. The first step to achieve this was to identify all stakeholders, categorise them and determine how best to maintain contacts with them. The main categories of stakeholders considered critical in the process were represented at a National Stakeholders' Conference.

2) Institutional Capacity Building

The focus was to expand the institutional capacity for biotechnology development, utilisation and management through linkages and networking of stakeholders, facilitation of work in ongoing biotechnology initiatives and creation of public awareness and education. The climax of the efforts to establish linkages was the National Stakeholders' Conference. It was ostensibly organised under the theme "Priority-Setting for Sustainable Biotechnology in Agriculture and Health". The goal was to use it to determine priorities for the development, utilisation and management of biotechnology in Ghana and to feed this into policy.

3) Technology Assessment

This broad aim was to determine the state of biotechnology in the country. A survey was conducted in purposively sampled institutions and enterprises cutting across the stakeholder categories. Results showed the relatively low level of biotechnology in the country. However, there were positive indications of potentials for biotechnology development. For example, the use of modern biotechnology techniques became routine and they were being integrated into the prevailing culture of science in biotechnology-related research. There was also the diversity of high-level human resource in the country which though inadequate could serve as a core for creating a base for biotechnology applications.

There were a number of lessons gathered from the BDP. These would be discussed looking at the broad categories of activities that were carried out within the framework of the programme. The salient achievements and the shortfalls are summarised in Table 1 below.

Table 1: Summary of BDP Activities, Achievements and Shortfalls

Objectives	Activities	Achievements	Shortfalls
Policy research/ advocacy	Stakeholder workshops, meetings with policy-makers, reports	Sensitisation of policy-makers; constitution of National Biosafety Committee	No biotechnology policy; need for sustainability of some of the advocacy activities
Institutional capacity building	Create linkages and networks among stakeholders; linkage with international institutions, publication of <i>Biotech.Ghana</i> .	Linkages for use of laboratories and equipment, dialogue with end-users, priority setting for biotech in agriculture and health	Need to further develop linkages and concrete networks
Technology assessment	Identification of stakeholders, inventories of biotech physical facilities, survey of biotechnology institutions and human resources	Report of assessment; TA methodology	Gaps in data and need for more comprehensive analysis

In the first place the methodology facilitated obtaining the kinds of achievements enumerated below. It was flexible and suited to addressing the key objectives.

In considering the positive gains for policy, the BDP had a significant impact. The sensitisation of policy-makers led to some important initiatives. The Deputy Ministers and the Chief Directors of the Ministry Environment, Science and Technology and the Ministry of Agriculture participated in the four-day National Stakeholders' Conference. Their commitment to the outputs led to the establishment of a National Biosafety Committee for Ghana. At present the Committee is working on the draft biosafety policy for Ghana. The Conference was held in December 1999 and the following year was declared the Biotechnology Year. The important gain however was the imprinting of biotechnology at the top of technology policy formulation in the country. There came a new appreciation of biotechnology issues, which was not there previously.

In institutional capacity building, some budgetary allocations were made to specific institutions in the Biotechnology Year to improve facilities and enable them to perform specific biotechnology activities. These were insufficient for most of the institutions, however, given the limits of government resources. Yet, it was a good indication of the positive sensitisation that had occurred at the top.

The *Biotech.Ghana* publication supplied a forum for stakeholders to inform and discuss their activities and issues relating to biotechnology development in the country. It also provided a channel for reaching the various categories of stakeholders with information. The use of the mass media, for example reporting of BDP activities on radio, television and in print, and the researchers' participation in radio discussions, contributed in creating awareness and educating the public.

Despite the gains, there were shortfalls. In the area of policy, the ultimate biotechnology policy is not yet in place. Although this was not one of the objectives of the BDP, the stakeholders called for a national policy to guide biotechnology development.

The sustainability of the programme activities has also not come out as envisaged. The Science and Technology Policy Research Institute (STEPRI), the institute expected to continue some of the activities, is faced with budgetary constraints. The new government predictably launched an austere economic policy as part of the Highly Indebted Poor Country (HIPC) initiative. As one would expect, budget cuts of government-funded institutions began with R&D institutes such as STEPRI. It meant that while attempting to integrate some programme activities into the institutional budget, efforts should be directed to initiate other funded projects.

However, sustainability goes beyond budgetary issues. For example the concretisation of networks would imply institutionalising mechanisms and establishing relationships between the point of co-ordination and the stakeholders. The commitment of the stakeholders themselves is as important as the co-ordinators.

In conclusion, the BDP has been a rewarding programme and has demonstrated the usefulness in stimulating a holistic technology development using stakeholders. Through that, one can better define stakeholders' interests and concerns and find out how best to address them. More importantly, one can streamline the diverse initiatives for synergic impact. However, sustainability is critical to the whole process and it is one which the initiators of the programme may have to revisit.

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BRAZILIAN GMOS AT THE WORLD SOCIAL FORUM

A seminar at the World Social Forum, held in Porto Alegre, Brazil on 31 January to 5 February 2002, discussed a current Brazilian dispute on genetically modified organisms (GMOs). First the main elements of this discussion are introduced and then the issues raised at the seminar are summarised.

Transgenic crops in Brazil were banned in June 1998 when the Federal Court decided in favour of a civil action presented by Greenpeace and the Institute for Consumer Defense (IDEC). The Court decision took into account the precautionary principle of the Federal Constitution, which requires environmental impact studies for situations judged as risky for the environment and human health. Ignoring that decision, the National Technical Biosecurity Commission (Comissão Técnica Nacional de Biossegurança – CTNBio) – the regulatory agency in charge of the National Biosecurity Policy and the technical assessment of transgenics products – approved Monsanto's request for the commercialisation of its *Roundup Ready* soybean in Brazil in September 1998. According to the CTNBio report, the specialists understood that GM foods do not pose risks to the environment or human health.

Since then there has been a struggle among the three branches of the government (executive, legislative, judicial) as well as a heated public debate involving judges, prosecutors, members of Congress, state ministers, representatives of public institutions and NGOs and biotechnology experts. On one side some NGOs have insisted on a ban of GMOs until the completion of further environmental impact studies, on the other side Monsanto and the federal government have been pushing for a fast approval of GMOs. The latter has made clear its unconditional support from the beginning. A remarkable fact is that the 18 members of CTNBio are directly appointed by the Minister of Science and Technology. It is also worth pointing out that the content of the research agreement between the Brazilian Enterprise of Agricultural Research (Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA) and Monsanto, concerning the development of GMOs, is not public. Also, EMBRAPA's researchers are not allowed to express their views on GMOs.

In December 2000, a period of recess of the Congress and Justice, the President of Brazil issued a provisional legislative remedy (MP 2137) to alter the Brazilian policy on biosafety. This legal device allows the President to issue a law valid for 30 days. The main element of the MP 2137 was the reinstatement of the CTNBio in order to change its attributions. The main purpose is to give a right to CTNBio to decide about the need for environmental impact studies. In other words, the Commission could decide not to request such studies, making the approval procedure for GMOs faster. In the meantime, a Bill on selling GMO-based food in Brazil was approved by a key commission of the Brazilian Congress on 12 March 2002. Some judges consider this Bill unconstitutional because it does not take into account the precautionary principle of the Brazilian Constitution.

A seminar entitled "*Action Against Transgenics – Building Alliances, Mobilising Society*", held on 3-4 February 2002 at the World Social Forum, highlighted the international implications of this dispute. It was initiated by a group of NGOs (AS-PTA, ACTIONAID, ESPLAR, CECIP, INESC, FASE, CE-IPE) working on the development and diffusion of technologies for small farmers, environmentalist organisations (Greenpeace), and consumer organisations (IDEC). The main issues raised in the seminar are summarised below.

Precautionary Principle

This is the base of the criticism of the movement against the approval of GMOs in Brazil. Through this principle a civil action has succeeded in delaying the cultivation of GMOs in Brazil for four successive crops. A related problem is that despite the existence of a strong biodiversity law in Brazil, it has not been enforced accordingly. The government has regularly bypassed the law in order to attend the lobby of biotech firms.

Subordinated regulatory agency

One of the greatest difficulties in initiating a wide debate concerning the introduction of GMOs in Brazil is the fact that the regulatory agency of biosecurity (CTNBio) is entirely subordinated to the government. CTNBio should be the main agent responsible for insisting on an open and intense discussion about the subject, encouraging a critical and impartial analysis about the real benefits of GMOs. However, CTNBio pushes for a fast approval of GMOs, dismissing further studies of their impacts on nature and health

Monopoly power of transnational seeds firms

The risk of monopolistic control of genetic material, through patents or technologies like "Terminator", is emphasized as a social risk which may intensify the exclusion process of small agricultural properties. The high costs associated to the introduction of the new "technology package" would restrict the feasibility of small-scale agricultural production even more. The power of firms extends also to the practice of lobbying towards public agents involved in the regulation of the technology; to the market control for seeds and chemical inputs for agriculture; and to the control of distribution network and diffusion of the new technology in rural areas.

Economic sovereignty

Besides the social risk of small farmers' exclusion, the economic risk of losing international market share is also at stake. For instance, in the European market the Brazilian non-transgenic corn exports have increased last year at the expense of US transgenic corn exports. The same could happen in the international soybean market where Brazil has great potential for extending its sales to the biggest consumers (EU and China), being the only producer of non-transgenic soybean.

Risk-benefit analysis for whom?

The risk-benefit analysis of GMOs, when discussed by experts, tends to simplify the problem of transmission and reproduction of genetic material, restricting it at the cellular level. The complex interactions between the organism and the environmental diversity are usually neglected. Such a simplistic procedure facilitates a superficial diagnosis by the experts. Based upon this diagnosis the political decisions concerning the regulation of the technology are taken, which guarantee the legitimacy of the public power vis-à-vis the population. The experts appointed by the government thus acquire recognition and power at the technocratic structure of decision. They also have easier access to research funds and publishing opportunities.

Technological alternatives

The current discussion on risk-benefit analysis of GMOs is reductionist. It does not take into account an essential issue concerning the adoption of a new technology, namely the comparison with alternative technologies. That comparison would make clear the availability of other technological options. The proclaimed irreversibility of the biotech

trajectory is essentially a profit-driven argument: biotechnology firms have already invested billions of dollars in this technology and in the means to control the seed market. A wider analysis of the impacts of biotechnology should take into account the conditions of socially, economically and environmentally sustainable agriculture.

The ban of GMOs in Brazil in the last four years, in spite of the strong lobby by Monsanto and the intense support of the federal government, is an unexpected feat in a country like Brazil whose democratic institutions are still fragile. The explanation lies upon the mobilisation capability of NGOs as well as the independence of judicial power to support public actions, established in 1988 by the Brazilian Constitution.

The fragility of democratic institutions has hindered a wider social dialogue about GMOs. The initial polarisation (NGOs vs. Monsanto and Federal Government) has remained, avoiding the democratisation of the biotechnology regulation in Brazil. This polarisation reflects two antagonistic political positions: one has insisted on the "neutrality" of decisions sustained by technical experts; the other on the democratisation of decisions based on the participation and the values of those who are supposed to be directly interested in the social assimilation of the new technology: the citizens.

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FUTURE TECHNOLOGY POLICY BRIEFS

Future Technology Policy Briefs will address issues in health and biopharma; energy and environment; information and communication technologies; and transnational corporations and innovation.

The next Brief will focus on health and biopharma. Topics to be covered will include compulsory licensing, with case studies based on recent developments in South Africa and Brazil; the drug pricing debate and the need for a balancing of health care and discovery needs; and genomics and health security.

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