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Governing the GM Crop Revolution

Policy Choices for Developing Countries

Robert L. Paarlberg

International Food Policy Research Institute
2033 K Street, N.W.
Washington, D.C. 20006 U.S.A.
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Foreword

Farmers and consumers have benefited from advances in agricultural technology for centuries, but the most recent innovation—transgenic modification of crops—has generated enormous controversy. It is well known that whereas genetically modified (GM) crops have been grown extensively in Argentina, Canada, and the United States since 1996, environmental and consumer groups have largely blocked the GM crop revolution in Europe and Japan. It is less clear, however, what choices developing countries will make concerning the new technology.

In *Governing the GM Crop Revolution: Policy Choices for Developing Countries*, Robert L. Paarlberg devises a system for classifying policy choices toward GM crops in the areas of intellectual property rights, food safety, biosafety, trade, and public research investment. He then presents an up-to-date snapshot and analysis of policies toward GM crops for four countries: Brazil, China, India, and Kenya. Of these four countries, only China has officially approved the commercial planting of GM crops. Although scientists and some policymakers in Brazil, India, and Kenya are pushing for adoption of GM crops, precautionary biosafety policies in these countries are keeping these crops out of the hands of farmers.

Paarlberg seeks to explain the differences among the four countries in these policy areas, and he determines that international pressures—from, for example, international environmental and nongovernmental organizations, international agreements, and donors—are working to discourage GM crop adoption in Brazil, India, and Kenya. China has taken a different path in part because it is relatively insulated from such pressures.

This study should be of great interest to anyone who follows the international debate over GM foods and crops, including policymakers, researchers and students, and those in the international private sector. A larger, more detailed version of this study will be published in 2001 by the Johns Hopkins University Press and IFPRI.

Per Pinstrup-Andersen
Director General

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1. The Challenge of the GM Crop Revolution

The genetic modification (GM) of plants and animals has been the foundation of all modern agriculture. For 10,000 years human societies have modified natural species through crude practices such as seed selection and controlled breeding. The power of these practices was enhanced dramatically in the 20th century by breakthroughs in basic genetic science, leading eventually to modern hybrid seed varieties for important food crops such as maize and, by mid-century, to high-yielding "Green Revolution" seed varieties for wheat and rice.

In 1953 science moved toward a deeper understanding of the molecular foundation of plant and animal genetics with the discovery of the double helical structure of the DNA molecules that are the critical constituents of genes.[1] The modification of species could now be undertaken at the molecular level through engineered gene transfers. In 1973 scientists began engineering recombinations of DNA molecules by moving specific genes carrying desired traits from a source organism into the DNA of a living target organism. That genetic transformation technique—which has been called genetic engineering but is now commonly know simply as GM—seemed to promise not only greater range and speed for genetic modification processes but also greater control over the outcome.

Commercial applications of GM techniques in agriculture were nonetheless expensive to develop and slow to be commercialized. The modern commercial GM crop revolution did not begin until 1995–96. At that point a number of new GM corn, cotton, and soybean varieties, engineered to resist pests and viruses or to tolerate broad-spectrum herbicides, won approval from regulators and were released commercially in a number of countries, led by the United States. In some countries the new crops spread quickly. By 1999 roughly half the U.S. soybean crop and one-third of the U.S. corn crop was grown from GM seed. Farmers were attracted to these new varieties because they required less management or tillage and less pesticide or herbicide spraying.

The planting of GM crops spread rapidly between 1996 and 1999, but only in three countries: Argentina, Canada, and the United States. Together, these three countries accounted for 99 percent of all GM crop acreage in 1999 (James 2000). One reason for this confinement of GM crop acreage was commercial: the private companies that developed GM crops initially designed them for use by wealthier farmers in temperate-zone countries with the purchasing power and commercial seed-buying habits to support the new products. Poor subsistence farmers in tropical countries were less attractive as commercial customers, so developing-country subsistence crops such as cassava, millet, and cowpeas were not among the first crops transformed with GM techniques.

[1]Genes are segments of DNA that contain enough information to produce a polypeptide strand or protein that, in turn, determines the traits expressed in the organism. The four base chemicals making up DNA (adenine, thymine, guanine, and cytosine) are the basis of the chemical mechanism for storing genetic information.

Conscious policy choice has now become a second reason for the restricted spread of GM crops. While some governments have taken a permissive regulatory attitude toward new GM crop technologies, other governments have taken a more cautious view. The U.S. government led the way with a permissive approach, screening GM crop technologies for food safety and biosafety risks using essentially the same methods employed for conventional crops, then allowing private markets for GM crops to operate without any new labeling or segregation restrictions. Argentina and Canada followed a similar policy path. Governments in Europe and Japan initially did the same but then quickly became more cautious as anxieties or opposition grew among domestic consumers, environmental organizations, and antiglobalization advocacy groups. In Europe, where "green" parties are strong and where a "mad cow disease" crisis in 1996 sensitized the media to food safety issues, the GM crop revolution encountered strong social resistance.

Responding to demands from consumers, green party leaders, organic farmers, environmental organizations, and international seed company critics, governments in Europe began imposing separate labeling requirements on GM foods in 1997. In 1998 the European Union (EU) then blocked the registration of any new varieties of GM crops. This had the effect of halting the import into the EU of any bulk commodities from Argentina, Canada, or the United States that might contain GM varieties unregistered in Europe. Private food companies and retailers in Europe, hoping to stay ahead of the backlash against GM foods and crops, began voluntarily removing GM products from the shelf or reducing their use of GM ingredients.

European governments and food companies explained they were taking these measures on a "precautionary" basis. They had no scientific evidence that any GM foods or crops on the market were any less safe for human consumption or for the environment than the corresponding conventional foods and crops. Yet the novelty of the GM process seemed to suggest that conventional food safety and biosafety screening procedures were no longer adequate for judging possible risks. Pending greater certainty, governments in Europe began to block new applications of the technology and to require that consumers be informed when purchasing foods with GM content. Elements of this more cautious European policy approach to GM crops and foods spread to Japan and to the other industrial countries of East Asia and the Pacific in 1999 and 2000.

These divergent policies toward GM technologies in rich countries have now created a complicated problem of policy choice in the developing world (Serageldin and Persley 2000). Should governments in the developing world follow the more permissive U.S. approach toward GM crop technologies or the more precautionary EU approach? Developing-country officials have come under growing pressure from various donor agencies, international organizations, philanthropic foundations, private business firms, and nongovernmental organizations (NGOs) to adopt either one set of polices or the other, to fall in line behind either Europe or the United States. The separate and distinct interests that some developing countries have in GM crop technologies risk being obscured in the process.

For example, poor tropical countries face a stronger agricultural production imperative than either Europe or the United States, suggesting that GM crops could eventually be of higher value to them, compared with some rich countries. Yet at the same time these developing countries tend to have a weaker scientific, technical, and regulatory capacity within their own borders, which could make the safe development and use of GM crops more difficult for their scientists and farmers. The private industry–driven U.S. approach may not be well suited to developing-country circumstances because of natural tensions between the commercial interests and property rights of private international firms on the one hand and the meager financial resources and distinct technological needs of tropical-country farmers on the other. Yet the European approach may be equally inappropriate, given that so many farmers and consumers in poor countries are not yet as wealthy and well fed as Europeans. In addition, farmers in most poor countries face rural environmental protection challenges quite distinct from those caused or faced by agriculture in Europe or other rich countries (Paarlberg 1994).

This 2020 Discussion Paper presents an analytic framework for classifying some of the policy choices developing countries must now make with regard to GM crops and foods. Five policy choice settings are germane: intellectual property rights (IPR), biosafety, food safety and consumer choice, trade, and public research investment. In each of these settings, I describe a range of possible policy choices, from those that might do the most to speed development and planting of GM crops to those that might slow the spread of GM crops. A summary examination of the actual policy choices recently made in four important developing countries—Kenya, Brazil, India, and China—then illustrates the utility of this classification scheme. A concluding section presents some of the lessons we can learn from these choices.

One important finding from this study is that Kenya, Brazil, and India have each recently adopted national policies that are slowing the spread of GM crops within their borders. In some respects these policies are actually more cautious than those adopted in Europe. Farmers in most European countries may legally plant at least some GM crops if they wish to do so, and imports of some GM crops are still permitted. Yet, as of late 2000, authorities in Kenya, Brazil, and India had not yet approved commercial planting of any GM crops or the routine commercial importation of GM commodities. This degree of caution is surprising, given the conspicuous unmet food production needs in some of these countries. The extreme caution is also surprising given the prevalence in some of these countries of precisely the crop-pest and crop-disease problems that GM crops have been designed to address. Also puzzling is the fact that all three of these countries have slowed the planting of GM crops primarily in the name of biological safety, which has not otherwise been a high policy priority.

Of the developing countries examined in this study, only China had approved any kind of commercial GM crop production by 2000. China began commercial production of GM crops in 1997, partly on the strength of a strong national GM crop research program. Yet what sets China apart is not its research program, since Brazil and India have both invested substantial amounts in GM crop research as well. Nor has China granted stronger IPR guarantees to the private companies that are now the leading purveyors of this new technology. To the contrary, China has at times antagonized the international private sector with its failure to control IPR piracy in the area of crop biotechnology. What sets China most clearly apart from Kenya, Brazil, and India so far is its decision to implement a biosafety policy toward GM crops that focuses solely on demonstrated risks, rather than on scientific uncertainties and hypothetical or undemonstrated risks. A major challenge for this study is therefore to explain the emergence of highly precautionary biosafety policies toward GM crops in some developing countries but not in others.

2. Classifying Policies toward GM Crops and Foods

Powerful new technologies require new policy choices. This section suggests one method of classifying the most important choices governments in the developing world must make regarding GM crops and foods. This classification scheme will then make it possible to examine and compare actual choices recently made by government authorities in Kenya, Brazil, India, and China.

Several ways of classifying policy choices regarding GM crops and foods come to mind: which institutions make these choices, what policy processes (democratic or otherwise) are used, and who in society benefits. This paper classifies policy choices according to a more fundamental question: will they tend to promote use of the new technology or prevent its use?

From among the gradients between promotion and prevention, four overall policy postures emerge. Policies that accelerate the spread of GM crop and food technologies within the borders of a nation can be termed "promotional." Policies that are neutral toward the new technology, intending neither to speed nor to slow its spread, will herein be called "permissive." Policies intended to slow the spread of GM crops and foods for various reasons will be called "precautionary."[2] Finally, policies that tend to block or ban entirely the spread of this new technology will be called "preventive."

Governments can choose to be promotional, permissive, precautionary, or preventive toward GM crops in several distinct policy venues. Five important venues dominate:

- intellectual property rights (IPR) policy;
- biosafety policy;
- trade policy;
- food safety and consumer choice policy; and
- public research policy.

In each of these settings, a separate set of choices regarding GM crops and foods will eventually have to be made.

Intellectual Property Rights Policy

During the Green Revolution of the 1960s and 1970s, governments in the developing world did not feel compelled to provide private companies or private plant breeders with exclusive intellectual property rights to the sale or use of new crop technologies. The new high-yielding crop varieties then being offered to developing-country farmers had been developed by breeders working for philanthropic or public research institutions. The new seeds were not developed and sold by private companies; instead they were given away through international assistance programs, distributed by nonprofit NGOs, or sold at subsidized prices by government corporations.

So far in the GM crop revolution, it is private companies that have taken the lead. When public funding for international agricultural research

[2]The term "precautionary" has a wider significance today, since the emergence in international policy circles (particularly since the 1992 Rio Earth Summit Conference) of a so-called Precautionary Principle for managing environmental risks under conditions of scientific uncertainty. Many soft and hard variants of this Precautionary Principle are now variously in use or under discussion (Soule 2000). In this paper I use the term "precautionary" only as a label for a specific range of carefully defined policy choices, not as a larger principle for assessment or management of risk.

faltered in the 1980s, the initiative in developing most new GM crops fell to private seed and biotechnology companies (James 2000; Enriquez and Goldberg 2000). These companies do not normally behave like public sector extension services. To recover their expensive private investments in the development of GM seeds, they seek exclusive rights to sell or to license the sale of those seeds to farmers.

Given the lead role of the private sector, developing countries wishing to promote GM crops might consider, at one extreme, a policy of offering the same generous IPR protections currently provided under U.S. patent and trademark laws. Under the terms of the landmark *Diamond v. Chakrabarty* Supreme Court decision of 1980 and the subsequent evolution of legal precedent in the United States, private firms engaged in developing new and inventive uses of plant or animal genetic materials may seek full patent protection for their inventions, even down to the level of individual genes or gene sequences. Advocates of this kind of patent protection say it is one reason U.S.-based companies have become world leaders in the development of commercially applicable GM crop inventions.

A slightly less promotional option would be to extend to companies and GM crop developers the somewhat weaker IPR protection provided under the International Union for the Protection of New Varieties of Plants (UPOV). This "plant breeders' rights" approach is favored over patent protection by most governments in Europe. UPOV strikes an important balance between the rights of plant breeders to capture commercial benefits from innovation and the rights of those same breeders to use protected genetic resources as an initial source of variation in the breeding process. Early forms of the UPOV convention also sought to protect the traditional privilege of farmers to replicate seeds of protected varieties for replanting on their own farms.

The most recent (1991) version of UPOV is the strongest, and nations following this approach will be considered here to have a permissive IPR policy toward GM crops. UPOV 1991 gives breeders IPR protection for 20–25 years, and prior authorization from the holder of these rights is necessary for any production, commercial marketing, offering in sale, or marketing of propagating material of the protected variety. The breeder earns royalty payments for the protected variety, and anyone infringing on those rights may be prosecuted. At the same time, breeders themselves may use protected varieties as an initial source of variation for the creation of new varieties and then market those *new* varieties without authorization from the original breeder (Dutfield 1999). UPOV 1991 permits member states to protect plant varieties with patents as well as plant breeders' rights (PBR), and the United States follows this "double protection" option, but most European countries expressly forbid patenting of plant varieties and operate under UPOV only.

A weaker but coexisting version of the UPOV Convention dating back to 1978 will be classified here as a precautionary IPR policy toward GM crops. Under UPOV 1978, the balance was tilted less toward incentives to innovate or invest in new technologies and more toward options for poor farmers to use technologies that already existed. UPOV 1978 implicitly protected the privilege of farmers to use protected plant varieties for propagation purposes on their own holdings, the so-called "farmers' privilege." This relatively weak UPOV 1978 standard is nonetheless sufficient to meet the minimum PBRs required under the trade-related intellectual property rights (TRIPS) agreement of the World Trade Organization (WTO), an international agreement that became binding for many developing countries beginning in January 2000.

At a preventive extreme, developing-country governments might decide to offer no IPR guarantees at all to private companies or commercial breeders for newly created varieties of plants or animals. Blocking the spread of GM crop technologies would not have to be the primary motive for taking this preventive IPR policy approach, but the preventive result could be the same.

Table 1 summarizes the four different policy postures toward GM crops within the IPR venue as well as policies in the other areas discussed in this paper.

Table 1—Policy options toward GM crops

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights	Full patent protection, plus plant breeders' rights (PBR) under UPOV 1991	PBRs under UPOV 1991	PBRs under UPOV 1978, which preserves farmers' privilege	No IPRs for plants or animals or IPRs on paper that are not enforced
Biosafety	No careful screening, only token screening, or approval based on approvals in other countries	Case-by-case screening primarily for demonstrated risk, depending on intended use of product	Case-by-case screening also for scientific uncertainties owing to novelty of GM process	No careful case-by-case screening; risk assumed because of GM process
Trade	GM crops promoted to lower commodity production costs and boost exports; no restrictions on imports of GM seeds or plant materials	GM crops neither promoted nor prevented; imports of GM commodities limited in same way as non-GM in accordance with science-based WTO standards	Imports of GM seeds and materials screened or restrained separately and more tightly than non-GM; labeling requirements imposed on import of GM foods or commodities	GM seed and plant imports blocked; GM-free status maintained in hopes of capturing export market premiums
Food safety and consumer choice	No regulatory distinction drawn between GM and non-GM foods when either testing or labeling for food safety	Distinction made between GM and non-GM foods on some existing food labels but not so as to require segregation of market channels	Comprehensive positive labeling of all GM foods required and enforced with segregated market channels	GM food sales banned or warning labels that stigmatize GM foods as unsafe to consumers required
Public research investment	Treasury resources spent on both development and local adaptations of GM crop technologies	Treasury resources spent on local adaptations of GM crop technologies but not on development of new transgenes	No significant treasury resources spent on either GM crop research or adaptation; donors allowed to finance local adaptations of GM crops	Neither treasury nor donor funds spent on any adaptation or development of GM crop technology

Biosafety Policy

As indicated in Table 1, a second policy venue in which developing-country governments must make choices regarding GM crops is the area of biological safety, or biosafety. A number of known hazards to the biological environment must be considered whenever a new plant variety (GM or otherwise) is introduced into a farming ecosystem. These include harmful competition with or direct damage to desirable species, unwanted gene flow (including transgene flow) into close relative species, unwanted resistance to herbicides among weeds or unwanted resistance to insecticides among pests, the creation of new strains of viral pathogens, and undesired losses in biodiversity. Environmental adovcates have worried that the risks of such biosafety hazards from novel GM crops might be greater than from conventional crops.

When choosing a biosafety policy toward GM crops, developing countries can again be promotional, permissive, precautionary, or preventive. Governments wishing to be fully promotional might either impose no biosafety screening at all for new GM crops or give routine approval to any new crop approved elsewhere. Commercial release of new GM seeds into the farming environment could then proceed as soon as the transgenic seeds were bred for the agronomic traits (such as color, yield, or cooking properties) desired by local farmers.

A permissive approach would be to test GM crops on a case-by-case basis for the same known biosafety risks that have long been associated with conventional crops. Under this approach GM crops would not be singled out because of their novel transgenic nature as inherently more dangerous; they would be screened for biosafety risks in the same manner that non-GM crops have long been screened for such risks. This is a permissive approach in the sense that it does not set a higher biosafety standard for GM than for non-GM crops. Yet it may not be a lax or a lenient approach if the biosafety standards being met are set sufficiently high. The U.S. government follows this permissive approach and claims that its standards for screening both GM and non-GM crops have so far been high enough to protect against any documented biodamage (Committee on Science 2000).

Most of the industrial nations beyond the United States, and many developing countries as well, are more inclined to view GM crops as sufficiently novel to require separate and more cautious biosafety consideration. This precautionary approach singles out GM crops for tighter biosafety regulation simply because of their novelty and the scientific uncertainties that are always associated with novelty. Under this approach, governments would slow down or hold back on the field testing or commercial release of GM crops not just to avoid biosafety risks that are known and have been demonstrated, but also to avoid some risks that may not yet be known or are still undemonstrated.

At an even more cautious extreme, a fully preventive approach to the biosafety of GM crops might be adopted. Under this approach, new GM crop varieties would not be screened for risks case by case; instead the presence of risk would be assumed without testing because of the novelty of the GM process alone, and permission to release GM crops into the environment would be denied.

See Table 1 for a summary of these four different policies toward GM crops that developing countries might take within the biosafety venue.

Trade Policy

In the area of trade policy, the gradient from promotion to prevention is more difficult to describe because consumer and importer acceptance of GM crops in international commodity markets is uncertain and evolving. Assuming consumers and importers accept GM crops, a developing country hoping to promote those crops would plant them with confidence, knowing they would cut production costs and increase export competitiveness. However, if consumers and importers increasingly reject GM crops, developing countries seeking export sales might be induced to ban GM crops internally so as to be able to offer bulk commodities to the world market with a "GM-free" label.

Recognizing this ambiguity, I nonetheless define a promotional trade policy toward GM crops as one that (1) promotes planting of GM crops in hopes of reducing farm production costs, thus increasing price competitiveness, and (2) permits GM commodities, seeds, and plant materials to come into the country with little or no restraint. A permissive trade policy would neither promote nor prevent the planting of GM crops internally and might regulate imports, but in a way that draws no invidious distinction between GM and non-GM imports. A permissive policy would follow the WTO's science-based standards for sanitary and phytosanitary (SPS) trade restrictions (Roberts 1998).

A precautionary trade policy toward GM crops would impose a separate and more restrictive set of regulations on transboundary movements of GM plant materials and seeds. Such special regulations might take the form of additional testing or information-sharing requirements and procedures, labeling requirements, or prior notification requirements. One framework for this precautionary approach is the advance informed assent (AIA) agreement incorporated into the Cartagena Protocol on Biosafety, negotiated in January 2000 within the Convention on Biological Diversity (CBD 1992, 2000).

If strict enough, precautionary import regulations might present such an inconvenience to exporters as to block virtually all movements of GM materials, seeds, or commodities into the country. In that case, the policy would have to be classified as preventive rather than precautionary. Imposing an outright ban or an open-ended moratorium on imports of GM crops or material would be a more direct way of embracing a preventive policy approach. One emerging trade policy motive for a preventive approach toward GM crops has been the recent international consumer backlash against GM. If this backlash continues to strengthen, banning GM crops at home could be one way for developing countries to strengthen their attractiveness as a source of bulk commodities in the eyes of industrial-country importers in Europe or Japan.

Table 1 includes a summary of this trade policy gradient from promotional to preventive.

Food Safety and Consumer Choice Policy

Issues of food safety and informed consumer choice tend to dominate the public debate over GM crops in the industrial world while remaining less salient in most developing countries. Food safety is of course a serious problem in poor countries, but the principal dangers come more from already demonstrated hazards—such as unclean water, lack of refrigeration, and unsanitary conditions for food transport, storage, marketing, and preparation—than from speculative hazards associated with the GM content of foods.

Nonetheless, a gradient of developing-country policy choices toward GM foods, from promotional to preventive, can be drawn. At a promotional extreme, these governments might be reassured by the evidence developed so far through testing and actual consumption in the developed world and conclude that the food safety risks posed by the GM crops already on the market in rich countries are no greater than the risks posed by the non-GM equivalents of those crops (Nuffield Council on Bioethics 1999). Their policy response would be to require no new testing or labeling procedures for those already-approved GM crops. Only if a GM food were significantly different from its conventional counterpart—for example, if the nutritional value were different or if it caused allergies—would a label be required to indicate that difference. Such an approach would mimic the promotional approach taken so far by the United States.

Following a slightly more heedful approach, governments might conclude that even if new risks specific to GM foods have not yet been demonstrated by scientists, consumers still have some right to know when they are consuming GM foods. Following this approach (classified here as permissive) governments might require food companies to designate foods as "GM" if more than a specified percentage of the content came from GM crops. To avoid placing an undue burden on companies and producers, fresh foods that do not currently require labeling and processed foods (such as hydrogenated vegetable oil) that cannot be tested physically for GM content[3] might be excluded from such a regulation. Consumer choice policies in some EU countries have at times tried to follow this permissive model (EU 2000).

Under a still more precautionary approach, governments would require labeling for all GM foods, including fresh and processed foods. The only way to enforce such a requirement would be to require totally segregated or "identity-preserved" marketing channels for GM versus

[3]Physical tests of samples of *unprocessed* foods using techniques such as polymerase chain reaction (PCR) can detect the presence or absence of either the transformed DNA or the protein resulting from that DNA. Such tests can cost from $400 to $700 per sample and take 3–10 days. Novel proteins can be detected even more easily in GM crops using immunoassays, which are capable of determining GM concentrations quantitatively. One form of immunoassay (the immunochromatographic strip test) has been developed for testing GM crops in the field. The cost is less than $10 per test, it can be performed truck-side, and it takes only 5–10 minutes (Stave and Durandetta 2000).

non-GM foods, all the way from the farmer's field to the consumer's plate. That would be a costly option for any nation growing, importing, or exporting GM foods, as it would require an expensive duplication of equipment and facilities in the food transport, storage, and processing sectors (USDA 2000). Yet it would be the only way to give all consumers a fully informed choice.

A preventive approach in this area would ban all internal sales of GM foods. This approach might be taken as an ultra-precautionary step to protect domestic consumers against hypothetical or unknown risks. For countries not yet growing GM crops, a total ban might even have the attraction of being cheaper than the precautionary "fully informed choice" approach because it would avoid the need to segregate markets and duplicate food-handling infrastructures. This advantage, however, would be gained at the cost of eliminating all consumer choice. A softer preventive approach might be to require stigmatizing labels on all GM foods, describing them (even without any scientific evidence) as dangerous to consumers.

Table 1 includes a summary of this policy choice gradient in the food safety policy venue.

Public Research Investment Policy

Public investments in agricultural research have helped developing countries generate high rates of economic return from higher farm productivity growth. How to allocate these research investments across different crops or farming systems has always been a difficult policy problem for national agricultural research institutes, given the persistent scarcity of funds available for any kind of research activity in the developing world. With the emergence of transgenic crop technologies, national research institutes now face a new choice. Should they invest scarce treasury funds or scarce donor funding in this new technology? In those developing countries where private corporate involvement or investment in the farm and seed sector has not traditionally been welcomed or, conversely, has been hard to attract, the investment of treasury funds may be the only way to launch a GM crop revolution.

At a promotional extreme, then, governments might invest their own treasury funds in the actual development of their own GM crops. One motive might be to steer GM technology development toward the crops most critical to low-resource farm communities that tend to be "orphaned" by researchers in the profit-making private sector.

A slightly less promotional approach would not invest in the development of new GM crops but only in the transfer ("backcrossing") of already-developed GM crop traits into local crop varieties. That is, rather than trying to compete with the international companies and research centers that have already developed potentially useful GM crop applications, developing-country governments would seek agreements with those companies or institutes to permit the transfer of already-developed GM crop traits into local crop germplasm.

A more precautionary approach toward public sector research would allow backcrossing of GM traits into local cultivars but would not spend any significant national treasury resources for that purpose. If donors or international agricultural research centers wanted to sponsor the introduction of desirable transgenes into local germplasm, and if they wanted to finance the associated upgrade that might be needed in biosafety facilities or personnel training, that would be welcomed. But treasury funds would be reserved for more traditional agricultural research activities, perhaps including non-GM biotechnology research in areas like tissue culture or molecular marker-assisted breeding.

A preventive approach would make no investments at all—of either treasury funds or donor funds—in any transgenic technology development or adaptation work. Table 1 again summarizes these choices.

Summary

This classification scheme is not intended to favor one set of policy choices over another. Its purpose is only to suggest some useful dividing lines between choices, for classification purposes. Nor does this classification scheme imply that the best choice for one developing country will be the best for all others. Different developing-country governments might make different choices depending on their size, ecological endowment, research capacity, trade posture, or the distinctive agricultural and rural development challenges they face. In the IPR venue, for example, countries with large internal commercial seed markets may be able to attract significant private sector investments and technology transfers in the GM crop area even without the lure of a strong IPR policy. In the trade venue, countries that export bulk commodities to Europe or Japan may have reasons to become precautionary or even preventive toward GM crops. In biosafety, countries with rural environments that contain the wild relatives of GM crops may have more cause to worry about unwanted geneflow and may wish to select a more cautious biosafety policy as a result. In food safety, for those countries where most foods are sold in rural markets without any packaging or labeling, some of the consumer choice policy options listed here may be moot. And in public research, countries starting with small internal research capacities will naturally have fewer options to pursue a promotional public investment strategy, compared with countries starting with a strong capacity.

Nor does this scheme assume that a country making a cautious choice in one venue will necessarily make a cautious choice in all others. For example, a country might well make a precautionary or preventive IPR policy choice while at the same time making a promotional public research investment choice. This might be rational if the country wanted the technology to develop in the public rather than the private sector. Also countries making a precautionary or preventive choice toward the planting of GM crops on biosafety or trade grounds might have no need to make a separate or equally precautionary choice in the area of consumer choice because there might be no GM foods on the local market.

How might developing countries be expected to make their choices overall? One might guess that most developing countries, compared with rich countries, would place less emphasis on biosafety and perhaps more emphasis on enhanced farm productivity and commodity export promotion, since in the developing world environmental goals such as biodiversity protection are frequently subordinated to developmental goals such as increased food production and growth in foreign exchange earnings or rural income. Developing countries with significant unsolved agricultural development problems or food security problems might thus be expected to take at least a permissive view of GM crop technologies in most venues, particularly biosafety. For three of the four countries examined here, this expectation is not met. In Kenya, Brazil, and India, biosafety policies toward GM crops have so far emerged as precautionary rather than permissive, and the result has been a visible slowdown in the spread of GM crops.

3. Policies toward GM Crops in Kenya

Despite Africa's apparent need for new food production technologies to solve problems with crop pests and crop disease, the GM crop revolution has yet to spread there in any significant way. In the case of Kenya, this retarded spread of GM crop technologies stems in part from the government's own policies, particularly biosafety policies. As of 2000, Kenya's farmers were not permitted to grow any GM crops commercially, pending more complete screenings for biosafety. As recently as 1999, the Government of Kenya had not permitted entry of any GM plant materials into the country even for research purposes, once again on biosafety grounds.

Leaders in Kenya have endorsed the potential gains their country could make from GM crops. In August 2000, the president of Kenya, Daniel T. arap Moi, wrote in a letter to President Clinton of the United States, "While the Green Revolution was a remarkable success in Asia it largely bypassed Africa. Today the international community is on the verge of the biotechnology revolution which Africa cannot afford to miss" (Moi 2000). But farmers in Kenya are not yet participating in the GM crop revolution, partly because of policy choices Kenya's own officials have made.

Kenya: Intellectual Property Rights

Like much of the rest of Africa, Kenya has no legal tradition of strong IPR guarantees. Before 1989 Kenya had no independent patent system at all. Nor did it have a plant variety protection law. This frustrated many plant breeders in Kenya who feared the country would be cut off from conventional international seed exchange if it did not meet a minimal international standard for guaranteeing plant breeders' rights (Juma 1989). A need to provide minimum IPR guarantees was also suggested by the emergence of the new TRIPS agreement in WTO. Accordingly, Kenya passed a new PBR law in 1991 and in 1993 approached UPOV with a request to accede to the 1978 version of the convention. Kenya preferred UPOV 1978 over the 1991 version because the earlier version preserved the traditional privilege of farmers to replicate, replant, and exchange protected seed varieties for use on their own farms.

By embracing a PBR system conforming to UPOV 1978, Kenya ensured its compliance with the TRIPS agreement in WTO. The relative weakness of the 1978 UPOV standard for attracting GM crop investments was not an issue when Kenya took this step, and even today it is not a salient issue given the early stage of most GM crop developments in Kenya and the many factors other than IPR policy that tend to discourage private international investments there.

Kenya: Biosafety

Kenya's biosafety policies have so far prevented any GM crops from being commercially grown or knowingly imported into the country (other than for emergency food relief or research purposes). For a number of years this caution derived from Kenya's lack of a national biosafety procedure for approving GM crops. Not until 1998 did the National Council for Science and Technology (NCST) finally promulgate a set of "Regulations and Guidelines for Biosafety in Biotechnology for Kenya" (NCST 1998). The language of this document mixes a permissive approach (science-based methods for classifying levels of risk posed by GM crops to human health and the environment) with a distinctly precautionary tone. The guidelines single out GM crops for tighter scrutiny than non-GM crops, and they call for attention to potential as well as scientifically documented biosafety risks. They advise that all permissions for commercial release of GM crops given by the National Biosafety Committee (NBC) should take into account "whether enough is known to evaluate the relative safety or risk of introduction of such organisms" (NCST 1998, pp. 1–2).

This precautionary tone can be traced in part to the influence of European donor countries in the drafting process. Dutch foreign assistance largely financed the drafting, and the standards themselves were borrowed in part from Sweden. NBC's implementation of these guidelines has also been precautionary, even with regard to the importation of GM crop materials for research purposes, as will be illustrated in the case of GM sweet potatoes.

Kenya: Trade

Kenya also follows a precautionary trade policy toward GM crops and plant materials, screening commodity imports separately for GM content and taking a cautious view toward imports of GM crop materials even for research purposes. Some of this trade precaution toward GM commodities reflects Kenya's larger aversion to all commodity imports, both GM and non-GM. But Kenya's precaution on trade is most directly linked to its parallel precaution on biosafety. Under the NCST guidelines, NBC must separately approve all imports of GM crop and plant materials, and to date NBC has been slow to do so, citing biosafety grounds for the delays.

As one example, the Kenya Agricultural Research Institute (KARI) encountered long delays when it asked NBC in 1998 for permission to bring GM sweet potato materials into the country, materials that the Monsanto Company had for years been offering to KARI free of charge. NBC should have found it relatively easy to act on this import request, since it came from another part of the Kenyan government and sought to import GM plant materials at first for controlled research purposes only. Even so, NBC waited almost two years before it finally approved KARI's request in January 2000. The sweet potato materials finally arrived in March 2000, and KARI now expects to begin two years of controlled field trials. After that, KARI will have to make a new application to NBC for actual commercial release of this first GM crop in Kenya.

Kenya's import caution can always be set aside in an emergency. In 2000 Kenya imported maize from Canada and the United States to help feed 5 million of its citizens who were at risk of starvation because of severe drought. Those bulk shipments were known to have some GM content, given the countries of origin, yet one senior government official justified the decision: "[T]he government and Kenyans did not have time and the necessary scientific capacity to undertake risk assessment. Our confidence was established in the fact that if Americans are eating it, it should be safe for our starving people" (Mugabe et al. 2000).

Kenya: Food Safety and Consumer Choice

Because farmers in Kenya are not yet growing any GM foods except for research purposes, and because only a small part of Kenya's food supply comes from imports that might have GM content, the government has not yet felt any pressure to develop a food safety or consumer choice policy specifically addressing GM crops. Kenya's most important GM crop policy document—the 1998 Regulations and Guidelines—makes no separate reference to consumer food safety issues. In Kenya, food safety policy is still governed by Chapter 254 of the 1980 "Food, Drugs and Chemical Substances Act" of the Laws of Kenya and administered by the Ministry of Health. This food safety law predates the development of GM foods, so it is designed to protect against more conventional concerns, such as the sale of unwholesome, poisonous, or adulterated food, or food sold deceptively or prepared under unsanitary conditions (Laws of Kenya 1980).

Kenya's policy in the food safety area is therefore nominally promotional toward GM crops and foods, according to the classification scheme in use here.

Table 2—Policies toward GM crops in Kenya

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights			In March 1999, Kenya acceded to UPOV 1978	
Biosafety			NBC screens GM crops according to a separate and higher biosafety standard, and when in doubt opts for delay	
Trade			NBC is slow to approve imports of GM plant materials, even for research purposes	
Food safety and consumer choice	Food safety laws and labeling laws make no distinction between GM and non-GM foods			
Public research investment			Public sector investments are small; research is largely donor dependent and mostly for local adoption of GM crops developed elsewhere	

Kenya: Public Research Investment

Historically, Kenya had a relatively strong record of public investment in agricultural research (Roseboom and Pardey 1993). More recently, Kenya's public research investment performance has lagged, along with international donor support in this area. Agribiotechnology research (both conventional and transgenic) in Kenya, never a large part of the nation's total investment in farm research, stood at just 3.3 percent of the total in 1989 and fell to 2.8 percent in 1996. In nominal U.S. dollar terms, Kenya's total spending on all forms of agribiotechnology research (GM and non-GM) in 1996 was just $1.18 million. Only a small part of that spending was treasury financed, with the rest provided by donors.

The GM share of this small amount of public research spending in Kenya has been smaller still. In 1996 only 7 of the 28 KARI biotechnology researchers were working in the specific area of genetic engineering of crops or animal vaccines (Wafula and Falconi 1998, 15). To date, Kenya's public investment policies must therefore be rated as precautionary toward GM crops.

These Kenyan policy choices are summarized in Table 2.

4. Policies toward GM Crops in Brazil

In the global policy contest over GM crops, Brazil has emerged as an important battleground. While most industrial countries—including the United States, most countries in Europe, and Japan—had approved several GM crop applications by 1996, Brazil and most other developing countries moved more slowly. This caution seemed at first a commercial disadvantage for Brazil's export-oriented agricultural sector. Soybean farmers in competitor countries such as Argentina and the United States were cutting their production costs by growing GM soybeans, while farmers in Brazil were not. However, when a consumer backlash against GM crops began to gain strength in Europe and Japan in 1998/99, Brazil's status as a country that was still nominally GM-free took on an interesting new significance. Some agricultural interests in Brazil began to see the country's official GM-free status as a possible advantage in export markets vis-à-vis Argentina and the United States. European-based consumer and environmental advocacy NGOs also began fighting to keep Brazil GM-free. They worried that if Brazil joined other major exporters in planting GM crops, the technology might become pervasive in global markets and hence far more costly for European importers to resist. Such international pressures are now pulling Brazil's internal policies toward GM crops in several different directions.

Brazil: Intellectual Property Rights

IPR policies have recently been strengthened in Brazil (as in Kenya) for reasons largely unrelated to GM crops. In 1996 the federal government enacted both a new patent law and a separate cultivar protection law that provided a basis for Brazil's accession to UPOV in May 1999 (Sampaio 2000a, 2000b). Brazil acceded to UPOV 1978, yet its plant variety law ensures breeders protection even for "essentially derived varieties" in conformity with the stronger UPOV 1991 standard. Brazil's laws also protect the traditional farmers' privilege only for small farmers' communities involved in government-supported programs. Because of these features, Brazil's IPR policies may be classified as stronger than precautionary and are herein classified as essentially permissive toward GM crop developments. These policies have helped attract a number of private GM crop investors into Brazil. After 1997 prominent international life science companies then doing work with GM crops (Monsanto, Novartis, AgrEvo, Mycogen, and Dupont) began investing hundreds of millions of dollars in the purchase of local Brazilian plant breeding, seed multiplication, and distribution firms.

Brazil: Biosafety

In the area of biosafety policy, the Government of Brazil originally intended to be permissive toward GM crops. However, since 1998 a federal court judge has forced the government to be highly precautionary. Brazil enacted a new biosafety law in 1995 that empowered a technical commission to provide definitive opinions on the biosafety of new GM crops (Republic of Brazil 1995). The National Technical Commission on Biosafety (CTNBio) began operating in 1996, just as GM crops were being planted for the first time in significant quantity abroad. In February 1997, after operating just six months CTNBio gave Monsanto approval to field-test GM herbicide-resistant soybeans in Brazil. Then in September 1998, only 18 months later, CTNBio issued a technical opinion approving five varieties of GM soybeans for commercial release in Brazil (CTNBio 1998, 1999).

It thus appeared that Brazil would be moving quickly to join Argentina, Canada, and the United States in the wide commercialization of GM crops. However, a lawsuit filed by Brazil's leading consumer protection organization (IDEC) charged that CTNBio had failed to seek a full environmental impact assessment, or EIA, before giving technical approval to GM soybeans. In response, a Brazilian federal court judge issued a restraining order against the commercial release of GM soybeans. IDEC was soon joined in its lawsuit by Greenpeace and by the technical institute inside the Brazilian Environment Ministry, named IBAMA, responsible for carrying out EIAs. This legal case against release of GM crops is still working its way through the Brazilian federal court system, with no consensus yet on what the final outcome is likely to be. In the meantime, despite the intent of the federal government to operate a permissive biosafety policy, farmers in Brazil do not have official permission to plant any GM crops.

Brazil: Trade

In 1996 Brazil's two largest competitors in the soybean export market—Argentina and the United States—began growing GM soybeans, and it seemed at first that Brazil should do the same to remain competitive. Since 1998, however, a growing consumer and environmentalist backlash against GM foods in Europe and Japan has raised doubts regarding consumer acceptance, and some in Brazil have argued that a trade advantage would come from remaining GM-free. This approach has emerged most conspicuously in the southern state of Rio Grande do Sul, a soybean-producing region where in 1998 a newly elected opposition party governor began promoting his state to international customers as a "GM-free zone." His effort was undercut, however, when it became clear that many farmers in Rio Grande do Sul had begun growing GM soybeans illegally, using seeds smuggled in from Argentina.

Policy on GM commodity imports is also contested in Brazil. Federal officials at first tried to treat GM imports (such as maize or soy from Argentina or the United States) the same as conventional imports. Since 1997, however, Greenpeace has challenged this approach on grounds that no adequate labeling law for GM products is yet in place to protect consumers, and the federal government has been obliged to screen out GM imports in most cases. One exception occurred in 2000, when a feed shortage in Brazil and protests from poultry and hog producers led to an eventual import of GM maize from Argentina.

Brazil: Food Safety and Consumer Choice

In the food safety and consumer choice area, Brazil's policies have recently moved from fully promotional back to permissive. In response to complaints from consumer advocates, the federal government took steps in 1999 toward a mandatory GM labeling policy, in the name of informed consumer choice. Yet the labeling standard provided in the new draft policy was permissive rather than precautionary because it was carefully written not to require market segregation. It did not cover unpackaged fresh foods or processed foods, suggesting that it could be adequately enforced with physical testing alone (Ministry of Justice 1999).

Brazil: Public Research Investment

The Government of Brazil had an early history of strong and successful public investment in agricultural research, yet since the economic crisis of the 1980s its national research system, EMBRAPA, has struggled to secure adequate treasury resources. EMBRAPA's expenditures for actual research activities (not including salaries and routine expenses) are small, totaling only R$100 million annually for all purposes (roughly US$55 million at 1999 exchange rates). Only about 5 percent of EMBRAPA's budget goes for any kind of biotechnology through the Center for National Genetic Resources, known as CENARGEN. The GM versus non-GM share of this biotechnology research is not easily estimated, but within EMBRAPA's own budget, GM work has received only about R$1.8 million per year in treasury money, or about US$1 million at 1999 exchange rates.

EMBRAPA's budget is not the same as total treasury spending. For most projects, EMBRAPA's contribution tends to be roughly matched by treasury funds from CNPq, a funding agency in the Ministry of Science and Technology. Still other moneys are available through ad hoc links to private or bilateral international sources and through PADCT, a World Bank lending facility for research administered by the Ministry of Science and Technology. Putting such sources together, Brazil's total public sector spending on GM crop research can be estimated at about US$2.5 million a year at 1999 exchange rates. That figure measures genuine research funding not counting salaries, facilities, overhead, or equipment. The funds are used for separate molecular-level or GM projects on a range of crops including soybeans, cotton, maize, potato, papaya, common black bean, banana, cassava, and rice.[4]

Significant results in the area of GM crop development have been achieved with these public investments. Scientists at EMBRAPA/CENARGEN have developed and patented their own system for crop transformation (applicable to more than one species of crop) and have field-tested their own transformed herbicide-resistant soybeans and virus-resistant potatoes. Further progress toward commercialization of these transgenic varieties may be slow, however, as it must await the negotiation of commercial license agreements with international companies holding the relevant transgene patents, not to mention approval on biosafety grounds by both CTNBio and Brazil's federal court.

Summarizing this discussion, Table 3 maps out Brazil's recent policies toward GM crops.

[4]Interviews at EMBRAPA/CENARGEN, December 1999.

Table 3—Policies toward GM crops in Brazil

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights		Plant variety protection law has elements of UPOV 1991 and restricted farmers' privilege		
Biosafety			In 1998/99, IDEC, Greenpeace, and IBAMA secured federal court rulings requiring highly precautionary biosafety approach	
Trade			GM commodity imports screened and partially blocked; some states (not yet the federal government) attempt to use GM-free status to promote exports	
Food safety and consumer choice		Draft labeling law distinguishes between GM and non-GM on some existing labels but does not require market segregation		
Public research investment	Significant treasury resources are spent on building capacity to develop GM crop varieties independently			

5. Policies toward GM Crops in India

India's people are far better fed on average than in the past, but 2.7 million children still die every year in India, 60 percent of them from diseases linked to malnutrition (Sharma 2000). A leading cause of malnutrition in India is poverty, and in rural areas a leading cause of poverty is low productivity in agriculture. With yields on irrigated land now plateauing, India has little choice but to seek new technical solutions for its low-production farmers in dry rainfed areas. GM crops might seem an unlikely solution, given the difficulty of engineering the multigene traits needed to provide greater resistance to drought or heat. Yet India's producers of dryland crops (such as sorghum, groundnut, or pigeon pea) face severe pest and disease problems as well as abiotic stress problems such as drought or heat, and for these problems some existing GM applications can be highly attractive. Pigeon pea farmers can sometimes lose their entire crop through damage from a single insect. Pod borers attack all pulses, and viral diseases are a widespread blight on dryland crops. Small dryland cotton farmers in India are devastated by bollworm infestations. Together with integrated pest management, and supplemented by conventional breeding, genetic engineering might help provide solutions to these biotic stress problems. Somewhat farther into the scientific future, GM crops might also be able to help address some of India's more severe nutritional problems.[5]

Political leaders as well as scientists and technocrats in India have noticed these opportunities and now routinely endorse the contributions that biotechnology, including transgenic crops, might make to agricultural productivity growth and poverty reduction in the years ahead. Yet most of India's actual policies toward GM crops are far from promotional. Critics of GM crops have been able to work within India's open and democratic political system to secure a far more cautious approach. As a result, no GM crops have yet been released for commercial planting in India.

India: Intellectual Property Rights

India has traditionally relied on its own public sector scientists and government extension agents rather than domestic or international private companies to develop and extend productive new agricultural technologies. While taking this approach India has felt little need to offer IPR guarantees to private companies or plant breeders in the area of crop development. By 1991, however, India's agricultural research establishment concluded it was necessary and prudent to move the nation's IPR policies closer to international standards (Selvarajan, Joshi, and O'Toole 1999). Accordingly, a draft plant variety protection act (PVPA) was submitted to Parliament in 1993. The draft act was modeled largely after UPOV 1978 to protect both plant breeders' rights and farmers' privileges.

This decision to move toward a minimal plant variety protection law triggered a surprisingly emotional debate in India's Parliament. The first draft

[5]Roughly 50,000 children in India go blind every year from vitamin A deficiency, and iron deficiency is a major threat to women's health. The possibility of engineering iron-rich rice or vitamin A–rich rice or rapeseed oil becomes interesting in this context.

of the PVPA was criticized by the private seed industry as too weak, yet at the same time NGOs claiming to represent farmers' groups warned it was too strong and would allow professional plant breeders and private companies to appropriate some of the crop improvements that traditional farmers had been making for thousands of years. A revised draft was produced in 1996/97 to address this "farmers' rights" issue. India's cabinet then approved the revised draft in October 1997, but under intense NGO criticism Parliament continued to stall. A revised December 1999 version of the PVPA is currently working its way slowly through Parliament (Government of India 1999).

GM crops were not originally the trigger for this emotional plant variety IPR debate in India, but efforts by western companies to sell or develop protected GM crop varieties in India eventually moved to the center of the issue. In 1998 the Monsanto Company purchased a 26 percent share of India's premier private hybrid seed company, Mahyco, hoping to introduce GM cotton into India. NGOs responded by organizing attacks on Mahyco's Bt cotton field trials in India, claiming they were a surreptitious effort by Monsanto to test its so-called "terminator gene" in India. Monsanto's GM cotton contained no gene use restriction traits, but because of a media campaign by NGOs it came to be viewed widely as a possible threat to the tradition of seed saving by poor farmers in India. The resulting public sensation created around Monsanto and the terminator technology in 1998/99 did not make it any easier for India's government to secure Parliament's approval of the draft PVPA.

Pending final passage of the PVPA, India's IPR policies toward GM crops must be classified as preventive. Partly because of these weak IPR policies, international life science companies interested in the Indian market for GM products have so far been willing to bring only hybrid GM varieties into the country. IPR protection is less critical for these hybrids because the valuable traits of the seed are mostly lost after the first planting.

India: Biosafety

India's IPR policies toward plant varieties became highly politicized even before the GM crop revolution. In the area of biosafety, however, GM crops themselves were always the issue. The Indian government began issuing biosafety guidelines for handling GM organisms in December 1989 (DBT 1990, 1998). These guidelines were borrowed partly from the United States, and at the research stage they required screening of GM crop technologies only for risks that could be scientifically demonstrated (Ghosh 1997, 1999; Ghosh and Ramanaiah 2000). Beyond the research phase, however, India's biosafety procedures implied more caution. The guidelines created two separate committees with policy authority: a Review Committee on Genetic Manipulation (RCGM) empowered to approve (or not approve) applications for all small-scale research activities on GM crops in India, and a Genetic Engineering Approval Committee (GEAC) empowered to approve (or not) large-scale research activities as well as actual industrial use or environmental release. The RCGM is established within the Department of Biotechnology (DBT) and naturally has a pro-research bias. The GEAC is chaired by the Ministry of Environment and Forests (MoEF), opening the way for a more precautionary approach to biosafety questions.

So far the biosafety approval system has been, on balance, more cautious than permissive, as illustrated by the case of Bt cotton. India's cotton farmers 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 for Bt cotton from RCGM and GEAC have repeatedly been slowed by NGO protests. By filing lawsuits against RCGM for authorizing Bt cotton field trials in 1998, and by sponsoring physical attacks against those field trials, anti-GM activist groups in India have transformed the biosafety approval process into a highly politicized—and at times paralyzed—policy struggle. India's GEAC finally did approve large-scale field trials for Bt cotton (up to 85 total hectares) in July 2000, a move that pleased Monsanto/Mahyco but antagonized GM crop critics, who filed a new petition against the trials. The GEAC decision stopped short of approving Bt cotton for commercial release, so on biosafety grounds it is still not legal for farmers in India to grow any GM crops.

India: Trade

To accompany its policy of not yet growing any GM crops commercially at home, India has also attempted so far to block most imports of GM commodities into the country. Whenever India has considered commercial imports of commodities with some GM content such as soy or maize from the United States, activist groups have raised loud objections and the government has decided to retreat. Some extreme groups in India have even objected to the import of maize from the United States for emergency food aid purposes because of its likely GM content (RFSTE 2000). Imports of GM germplasm for research purposes have been readily permitted, however, partly reflecting the fact that RCGM rather than GEAC has final authority to clear transgenic imports for small-scale research purposes (DBT 1998, 8).

In export markets, India is now using its nominal GM-free status to seek price premiums. India is an exporter of soybean meal (1.5 to 2.2 million tons per year, in recent years) and has recently promoted its soy, sunflower, and rapeseed meal exports as "GM free" when selling to markets in Indonesia, Japan, the Philippines, Thailand, the Gulf countries, and the Middle East (APBN 2000). However, since most of these sales are for animal feed purposes rather than direct human consumption, price premiums have been difficult to secure. Nonetheless, Indian meal exporters have begun hoping that Asian countries, such as Thailand, which export chickens to the GM-conscious European market, will soon see the advantage of buying feed from a GM-free supplier such as India rather than from the United States.

India: Food Safety and Consumer Choice

Because India does not yet officially grow or import any GM foods, it has been able to get along with food safety policies that draw little or no distinction between GM and non-GM food ingredients. India's 1954 Prevention of Food Adulteration Act predates the GM crop revolution and does not mention transgenics. In 1998, however, India revised its GM crop biosafety approval guidelines to require that GM seeds, plants, and plant parts be screened for toxicity and allergenicity (DBT 1998). This new RCGM procedure singling out GM gives India a permissive rather than a fully promotional safety policy toward GM foods.

Labeling policies in India have been moot until now because of the nation's nominal GM-free status and also because most food consumption in India continues to be satisfied through home or street preparations of natural foods that are never packaged, let alone labeled. Foods grown for export must be labeled according to the policies of the importing countries, which may provide India a competitive advantage given its GM-free status. Without any costly market segregation, all of India's soy or castor oilseed cake destined for export can currently be labeled "GM free."

India: Public Research Investment

The Government of India, principally through its Department of Biotechnology (DBT), has for more than a decade directed a small but steady stream of treasury resources toward the development as well as the local adaptation of GM crop varieties. Between 1989 and 1997, DBT spent a total of nearly 270 million rupees from the treasury (roughly US$6 million) on plant and molecular biology research with projects focused primarily on development of transgenic plants (Ghosh 1999). Because these investments have gone for development as well as local adaptation, India's public research investment policies toward GM crops deserve to be classified here as promotional.

DBT must secure its budget every year from the Planning Commission and the Ministry of Finance, and the resources it receives are quite modest, despite the fact that senior political leaders frequently list biotechnology as among the keys to

India's future economic growth and prosperity.[6] In 1998–99, the total DBT research budget across all areas (agriculture and nonagriculture) was 1,040 million rupees (roughly US$26 million). About 15 percent of this total, roughly 153 million rupees (or US$3.8 million), went for plant biotechnology. DBT's investments in *transgenic* plant biotechnology in 1998–99 totaled roughly 51 million rupees, or about US$1.3 million.

Tangible social or commercial payoffs from these investments have been slow to develop. Such delays reflect not only the modest size of the total investment, but also some longstanding limitations of India's public sector research establishment, which can be slow to move useful concepts from the laboratory to the market (Murthyunjaya and Ranjitha 1998). Without greater public spending on research and significant institutional and policy adjustments to promote more effective partnerships with the private sector (both national and international), India's goal of developing its own commercially useful GM crop technologies may be difficult to reach. Even a second-order goal of using national institutes to backcross internationally developed GM crop traits into local germplasm could prove difficult if national policies in other areas, such as biosafety and IPR, do not become more permissive.

Table 4 summarizes current policies in India toward GM crops and foods.

[6]At the 87th Indian Science Congress in Pune in January 2000, Prime Minister Atal Bihari Vajpayee said that Indian science and technology, including "information technology, biotechnology, and other knowledge-based sectors of science and technology," were going to be the propellers for India's next "big leap forward."

Table 4—Policies toward GM crops in India

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights				Until India enacts its draft plant variety protection law and joins UPOV, IPRs not protected
Biosafety			RCGM and GEAC have moved slowly on bio-safety approvals, fearing criticism from anti-GM NGOs	
Trade				GEAC has not formally approved GM commodity imports; efforts have been made to seek premiums for GM-free products in export markets
Food safety and consumer choice		RCGM and GEAC require same testing of GM and non-GM foods; no separate GM food labeling is required since GM foods are not officially on the market		
Public research investment	Modest treasury funds are spent on independent GM crop development			

6. Policies toward GM Crops in China

While Kenya, Brazil, and India have for different reasons held off the commercial release of GM crops, China has moved ahead without hesitation. In the 1990s China developed its own Bt cotton varieties and promptly approved them for planting on a commercial scale along with an imported Monsanto variety. China also approved commercial use of its own GM tomato and green pepper varieties and is pushing ahead with field tests of its own GM rice. China has gone farther with the actual commercialization of GM crops partly because of a promotional national research and investment program (which has helped offset the drag of China's decidedly non-promotional IPR policies). Yet the key difference between China and the other countries examined here can be found in the area of biosafety policy. While Kenya, Brazil, and India have followed a precautionary biosafety policy, China has maintained a permissive policy.

China: Intellectual Property Rights

In the last two decades China has moved a long way on paper toward providing important IPR guarantees, yet in practice these guarantees are not sufficiently well developed or enforced to provide additional incentives for innovation or private investment in GM crops. The incentives that have driven the private sector to invest in GM crop transfers to China have come from the size of the Chinese market rather than from the strength of China's IPR policies.

IPR language has been incorporated into China's basic civil law since 1987, but lax enforcement has persisted. In the specific area of plant variety protection, not until October 1997 did China put into force its current Regulations on the Protection of New Varieties of Plants (Pan 2000). In 1998 China used this regulation as the basis for acceding to UPOV 1978. Yet China's plant variety IPR guarantees are weaker than this in practice. An openly pollinated variety of Bt cotton brought into China by Monsanto for field tests in 1995 and released for commercial use in 1997 was widely pirated by Chinese farmers and seed companies. Monsanto could not object to Chinese farmers' saving and replanting the seed on their own farms or exchanging with other farmers because seed saving and exchange is permitted under the UPOV 1978 standard. But in Hebei Province in 1999, illicit commercial sales of Monsanto's seeds took place as well (Pray et al. 2000). Chinese merchants who had pirated the seed sold it in the market at a discount, in some cases even using copied versions of the seed bags and logos used by Monsanto's joint venture partner in Hebei.

The Chinese seed market is big enough and growing fast enough to tempt some private companies to bring GM technologies into the country (especially hybrid varieties) even without strong IPR guarantees. Yet China's IPR policies by themselves are extremely weak for the purpose of advancing the spread of new GM crop technologies.

China: Biosafety

China's biosafety policies toward GM crops have changed over time. Early in the GM crop revolution China pursued a promotional policy, allowing GM crops to be field tested (cotton) and even grown commercially over wide areas (tobacco) without any systematic case-by-case screening for biohazards. China's first formal biosafety regulation in the area of genetic engineering was produced in December 1993 by the State Science and Technology Commission (SSTC) under the Ministry of Science and Technology (SSTC 1993). The regulation assigned administrative responsibility for safety to the "relevant administrative departments." In the case of farm crops and animals, that meant the Ministry of Agriculture (MOA), which finally issued its own more detailed Implementation Regulation on Agricultural Biological Genetic Engineering (hereafter, the "IR") in July 1996 (MOA 1996). Given its MOA authorship, it is not surprising that the IR created an essentially permissive biosafety policy for regulating GM crops in China. The IR standard is based on demonstrated risks more than on uncertainties and viewing GM crops as inherently no more dangerous than their conventional counterparts. To ensure that these guidelines would be implemented in an equally permissive manner, the IR assigned approval authority directly to a Committee on Safety of Agricultural Biological Genetic Engineering (CS) within MOA.

Clear differences exist between China's technical biosafety committee and the corresponding biosafety review committees in Kenya, Brazil, and India. China's CS is the only one of this group that rests entirely within a ministry of agriculture rather than a ministry of science and technology (as in Kenya and Brazil) or chaired by an environment ministry (as with GEAC in India). The CS has consequently been less prone to paralysis over issues of scientific uncertainty in the biosafety area. Through 1999 the CS gave 26 separate commercial production approvals for GM crops, including multiple varieties of cotton, green pepper, tomato, petunia, and rice.

The State Environmental Protection Administration (SEPA) is the only part of the Chinese government not satisfied with current GM crop biosafety policies. SEPA would prefer a biosafety policy toward GM crops not so heavily dominated by molecular biologists and agricultural production scientists from MOA and the Chinese Academy of Agricultural Sciences. SEPA calls for moving the administration of biosafety regulations for crops out of the MOA and into a "national administrative system" under SEPA chairmanship and supervision (Liu and Xue 1999). On this question, however, SEPA so far remains isolated.

The continued permissive nature of GM crop biosafety policy in China reflects, among other things, the constraints imposed on environmental NGOs in China. Greenpeace is active in Hong Kong but is not permitted to operate in Beijing. Environmental organizations such as World Wildlife Fund are permitted to work with the Chinese government on matters such as trying to save habitat for giant pandas, but NGOs (foreign or domestic) are not allowed to express opposition to government policy on GM crops (or on anything else).

China: Trade

So far China has not drawn any formal regulatory distinction between imports of GM and non-GM commodities. When commodities arrive at ports of entry, they are routinely inspected by commodity inspection quarantine (CIQ) agents from China's Office of Customs Tariffs, but these inspections are only for product quality (for example, moisture or trash content) or for SPS compliance (for example, crop disease). As of 2000, the CIQ agents conducting these inspections had not yet drawn distinctions between GM and non-GM commodities. With regard to trade in GM commodities then, China's import policies can be classified as permissive.

Lack of consumer knowledge and interest partly explains the permissive policy. Chinese consumers are not yet looking for GM-free options, so state sector provincial grain and oil companies in China have consequently shown no great interest in finding GM-free soybeans, for example. However, even if China were someday to embrace a Japanese-style policy of screening or regulating GM soybean imports for food use, its trade would not have to be affected since soybean imports in China are not used for human food; China still makes its tofu entirely from domestic (non-GM) soybeans.

China: Food Safety and Consumer Choice

China's GM rules do not focus on food safety.[7] China's food safety laws similarly do not mention GM. Under China's current basic food law, the Ministry of Health officially approves foods, spices, and food additives for human consumption and (assisted by MOA) sets standards for chemical pesticide residues on foods. China recently promulgated rules for labeling organic or natural foods presumably "unpolluted" by farm chemicals. Yet China's various laws and regulations do not make any separate reference to the safety of GM foods or to the right of consumers to know if the food they are consuming is GM (Zhao 2000).

Food safety issues linked to GM crops have nonetheless been working their way onto the CS agenda informally. Before granting commercial release, the CS now requires that GM food crops be separately screened in one of two laboratories under the Ministry of Health and given 30 days of standard toxicity testing for food safety using rats and mice. This requirement is stated explicitly in the "Explanation of the Regulations" issued by the CS Administrative Office in October 1999 (MOA 1999). The requirement does not, however, imply a significantly higher food safety hurdle for GM crops compared with non-GM crops. And China does not require any labeling of GM foods for consumer information purposes. China's food safety policies toward GM crops can thus be classified as promotional.

China: Public Research Investment

China's policies toward GM crops have been most promotional in the area of public research investment. State-sponsored applied work in plant genetic engineering in China dates to the establishment in 1983 of a Molecular Biotechnology Research Laboratory at the Chinese Academy of Science (CAS). In 1986 China's State Council reacted positively to a direct petition from the nation's top scientists for more support in several high technology fields—biotechnology, in particular—and elevated the laboratory to the status of a Biotechnology Research Centre (BRC). The change came as part of the State Council's decision to create a national program for developing high technologies (known as the 863 program) and six new National Key Laboratories in north, central, and south China, all equipped to do biotechnology and molecular biology research. In addition, existing laboratories under CAS and the Ministries of Education and Agriculture were encouraged through competitive grants to move into biotechnology research. By 1996 Chinese scientists were engaged in research on 47 different kinds of transgenic plants and were using more than 100 different genes to transform those plants (Zhao 2000). By the end of the 1990s more than 80 state-funded institutions were involved in research on agricultural genetic engineering (Li and Liu 1999).

One of China's most visible and successful institutes working in the area of transgenic crops is a renamed successor to the BRC, the Biotechnology Research Institute (BRI) within the Chinese Academy of Agricultural Sciences (CAAS) in Beijing. In 1991 BRI launched a major program to develop Bt cotton, and by 1993 BRI scientists had successfully synthesized (and patented) a new pesticidal Bt gene and had used that synthesized gene to transform cotton plants. Field testing began in 1995, and seeds for the new GM cotton variety were given to farmers on a small scale in 1996. In 1997 the CS approved four different CAAS Bt cotton cultivars for commercial-scale planting in nine provinces (Pray et al. 2000). By 1999 roughly 100,000–200,000 hectares of cotton land were successfully planted to this China-developed Bt variety, roughly the

[7] The 1996 IR covering GM crops stipulates that GM technologies be assessed for their level of risk to "human health" and requires assessments of whether the recipient plant being used in any transformation is "toxic to human beings and other organisms." It does not refer to conventional food safety issues such as allergenicity or digestivity.

same area planted that year to Monsanto's Bt cotton variety, which the CS had limited to just Hebei province.

The capacity of China's scientists to develop and deploy GM varieties on their own is largely attributable to the excellent foreign training of many of its scientists plus strong state financial incentives. It is difficult to estimate the total value of state resources put into promoting GM crop technologies in China because those resources come from so many different ministries and flow through so many different competitive grant programs. The most important single source of support has been the 863 program, launched in 1986. The original program ran for 15 years and dispensed 10 billion renminbi (RMB) for high-technology research in all areas. Roughly 15 percent of that total went to biotechnology. Nationwide 863 program allocations for GM crop research have recently been roughly 100 million RMB annually (about US$12 million).

A 10-year renewal of this program has now been launched, called the Super-863 program (or S-863) because it will allocate three times as much as the original program over a 10-year period. That implies an effective tripling of the most important source of state budget support for leading-edge biotechnology research. These substantial 863 program grants represent only one part of China's total state resource commitment to GM crop research. Researchers can also get non-863 grant support through a so-called key technology program, which focuses more on technology applications, or from various other sources within the Ministry of Science and Technology, the National Planning Commission, or directly from the Ministry of Agriculture itself.

Table 5 summarizes the classification of China's policies toward GM crops, policies that have been on the whole more supportive toward the technology than those of the other countries examined here.

Table 5—Policies toward GM crops in China

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights			Since 1997, China has provided PBR protection and has joined UPOV 1978; regulations are weak, and enforcement is weaker still	
Biosafety		GM crops are screened for demonstrated risks on a case-by-case basis; GM varieties of five plants were released commercially in 1997–99		
Trade		No formal distinction is drawn between GM and non-GM commodity imports		
Food safety and consumer choice	No distinction is drawn between GM and non-GM foods when testing or labeling for food safety			
Public research investment	Significant public resources are spent on independent development as well as adaptation of GM crops			

7. Comparing and Explaining Developing-Country Policy Choices

The four countries covered in this study are individually important, and the policy choices they have made regarding GM crops are individually interesting, yet some value can also be gained from a comparison of their choices. Several of the patterns that emerge deserve comment. Table 6 summarizes the policy classifications (in the period 1999–2000) that have been made here for Kenya, Brazil, India, and China.

In some respects the pattern of policy choices is unsurprising. In the area of food safety, permissive or even promotional policies toward GM foods are found in all four countries. This was to be expected: consumers in developing countries have more serious food safety risks to worry about than the still hypothetical consumer risks associated with GM food. Rich and well-fed countries can afford to invest policy resources to protect against this hypothetical risk; in the developing world priority must go to more clearly demonstrated safety risks such as unsanitary food processing or unrefrigerated storage, and also to more fundamental concerns such as the simple availability or affordability of food.

The IPR policy choices made by the four countries also conform to expectations. None of these developing countries should have been expected to embrace the fully promotional U.S. policy of genetic patenting, since not even the other industrial countries of Europe follow this approach. Each of the countries in this study opted instead for the more widespread plant breeders' rights (PBR) approach under UPOV. Moreover, they all embraced this approach mostly to satisfy their minimum TRIPS obligations within WTO rather than to promote research or investments in GM crops (or any other kinds of crops). Of course some IPR policy variations do exist among the four

Table 6—Policies toward GM crops in Kenya, Brazil, India, and China, 1999–2000

	Promotional	Permissive	Precautionary	Preventive
Intellectual property rights		Brazil	Kenya China	India
Biosafety		China	Kenya Brazil India	
Trade		China	Kenya Brazil	India
Food safety and consumer choice	Kenya China	Brazil India		
Public research investment	Brazil India China		Kenya	

countries, but these were not surprising either. Brazil's policies go somewhat beyond UPOV 1978 as befits Brazil's recent interest in stimulating and attracting private international investment in its agribusiness sector. Meanwhile, India's PBR law at this writing has not yet worked its way through Parliament, partly reflecting traditional political suspicions in India toward the property rights of the international private sector. China's plant variety protection policies are stronger on paper than in practice, yet that is also true with its IPR policies in other areas.

Public investment policies in these countries also largely conform to expectations. Brazil, India, and China have all maintained traditionally strong national agricultural research systems capable of independent farm technology development, not just adaptation. Not surprisingly, these three countries are now all using treasury resources to develop their own GM crops. Nor is it surprising that Kenya is attempting less, given the high costs of independent GM crop development and Kenya's limited budget resources.

Much less expected were the highly precautionary biosafety policies of three of the four countries. In Kenya, Brazil, and India because of highly cautious national biosafety policies, farmers have not yet been given official permission to grow any GM crops. Authorities in Brazil tried to release herbicide-tolerant soybeans for commercial use in 1998 but were blocked when a federal court judge concluded that a full EIA would first be required. Biosafety authorities in India tried to take a permissive approach toward the testing and release of Bt cotton, but the screening process slowed down when field trials were attacked by anti-GM activists in 1998/99, and as of 2000 only large-scale field trials had been approved. In Kenya the National Biosafety Committee waited nearly two years before approving a modest request from the nation's leading agricultural research institute to import transgenic sweet potato materials into the country merely for research purposes.

This sort of caution toward GM crops on biosafety grounds is surprising in the developing world, given that so many other biosafety threats (such as loss of habitat, bioinvasions by exotic species, resistance in pest populations to conventional insecticide sprays) seldom receive priority attention from authorities. Poor countries are of course sensitive to serving as "guinea pigs" for unproven new technologies. Yet that does not explain what is happening here, since the key technologies in question—GM soybeans and GM cotton—have already been tested, proven, and widely adopted in some wealthy industrial countries, specifically the United States. These technologies have actually reduced some demonstrated biohazards by encouraging no-till farming and permitting fewer or less toxic herbicide and insecticide sprays.

Further puzzles arise. Developing countries frequently complain about their inability to get access to the latest or most powerful technologies in use by private industries in rich countries. Yet in Kenya, Brazil, and India so far it is the national government authorities themselves rather than private international companies that have slowed the technology transfer process. In Kenya Monsanto had been offering its GM sweet potato technology to KARI free of charge for nearly a decade before NBC finally allowed the materials into the country in 2000 so field trials could begin. Nor can the slow embrace of GM technology by developing countries be attributed to cultural resistance by farmers. In southern Brazil, farmers are so eager to plant GM soybeans that they have taken to doing so illegally on a widespread basis. It is not yet known what low-resource farmers in Kenya or India will think of GM crops—but this is because their own governments have not yet permitted them to grow any GM crops. Nor are these governments in the developing world keeping a superior technology out in order to protect their own inefficient state sectors from unwanted foreign competition. Kenya is cautious even though it has no independent national GM crop program of its own to protect, and Brazil and India have slowed their own national as well as foreign GM crop development efforts on the same biosafety grounds.

To a lesser extent IPR policies may also be slowing the GM crop revolution in the developing world. In Kenya, China, and India plant variety protection policy falls short of the standard preferred by the private biotechnology companies that are best able to make GM crop technology transfers or investments. Yet weak IPR policy was not the principal reason for the lagging technology development or transfer problems noted in the countries examined here. In Kenya, despite weak IPR policies, Monsanto was willing to share one of its technologies with Kenyan researchers at no charge; the biosafety issue, not IPR, kept Monsanto's GM sweet potato out of the hands of Kenyan researchers for so long. In India, despite an extremely weak IPR environment, private companies found a way into the country mostly by concentrating on hybrids. The size of India's market was by itself a sufficient lure. In China as well, despite blatant IPR piracy, private companies attracted by China's large and rapidly growing seed market looked for ways to bring in GM crops, including openly pollinated varieties.

Conversely, relatively strong IPR policies are not enough by themselves to get a GM crop revolution going. Brazil strengthened its IPR policies toward GM crops in 1996/97, and international biotechnology companies with valuable GM crop varieties did respond by purchasing local seed companies in anticipation of being able to begin local sales. But Brazil's stronger IPR policies have not made the negotiation of commercial agreements between private companies and EMBRAPA much easier. Differences remain here over how far the companies will be permitted to go in collecting fees or restricting on-farm replication of protected varieties. In the meantime, Brazil blocked the commercial release of GM seeds on biosafety policy grounds. It was not Brazil with its relatively strong IPRs that initiated South America's GM crop revolution. Instead it was Argentina, under circumstances of weaker IPR protection.

Adding to the puzzle is the fact that two of these countries—Brazil and India—have recently been operating highly cautious biosafety policies toward GM crops while at the same time supporting ambitious publicly funded national research programs designed explicitly to promote such crops. Perhaps no direct conflict exists between promotional public investment policies and precautionary IPR policies in the GM crop area, since one can help make up for the other. Precautionary biosafety policies in Brazil and India do, however, tend to undercut the promotional intent of some treasury monies spent on GM research. In Brazil, India, and also Kenya, national agricultural research scientists routinely complain about the slowdown on GM crops imposed within their countries on biosafety grounds.

The first step in explaining these anomalies is to recall that neither Brazil nor India originally intended to adopt a highly precautionary biosafety policy toward GM crops. In Brazil, CTNBio was structured and empowered to pursue a permissive biosafety policy. In India, RCGM was also designed to be permissive. In both countries biosafety policy shifted toward a more precautionary posture primarily in response to criticisms and court actions taken by independent environmental NGOs and consumer advocacy groups. This local resistance to GM crops drew some of its support from anti-GM activist groups in the industrial world, particularly Greenpeace based in Europe.

Several other international sources of caution then reinforced the NGO message. International commodity markets transmitted the caution of European and Japanese consumers into the domestic commodity markets of the developing countries. The signal given through these markets was that it might be commercially dangerous to begin planting GM varieties; better to remain GM-free pending greater certainty regarding consumer acceptance of GM products in the major importing countries. The most convenient way to remain at least nominally GM-free was to continue blocking commercial release of GM seeds for planting on biosafety grounds. The limits of this approach are visible in the case of Brazil, however, where farmers have begun growing GM crops without official permission, thereby compromising any hope of winning commercial advantages abroad from being a GM-free country.

Another international source of biosafety caution toward GM crops in developing countries has been the recent negotiation of a new biosafety protocol within the Convention on Biological Diversity (CBD 2000). The new protocol endorses a highly cautious view toward GM crop technologies. It calls for labeling and states that "lack of scientific certainty" should not prevent states worried about biosafety from placing precautionary barriers in the path of GM imports. In addition, it incorporates an advance informed assent (AIA) feature toward some kinds of GM materials, modeled after an international convention governing transboundary movement of hazardous wastes. The process of negotiating this international protocol, where environmental ministries took the lead, also tended to empower environmentalists with cautious preferences within developing countries rather than agriculturalists with more permissive preferences.

A final international source of biosafety policy caution has been the donor community. Especially in low-resource countries such as Kenya, the drafting of biosafety policies and procedures can easily fall under donor influence. Some wealthy donor countries (many from Europe) have naturally wanted to help poor countries such as Kenya develop biosafety policies toward GM crops no less cautious than the European standard. Bilateral donors have been supported in this policy-shaping effort by multilateral agencies including the Global Environment Facility within United Nations Environment Programme and the World Bank. Unfortunately, although donors have provided generous assistance for drafting tight biosafety policies on paper, they have provided much less for building the scientific, technical, and infrastructural capacity needed to implement those policies. Biosafety administrators in these countries know they will be criticized by NGOs or the press if they fail to meet the high standards they have set down on paper. As a result, these administrators are prone to err on the side of moving slowly and making the fewest decisions possible.

Of the four countries examined here only China, so far, has embraced a more permissive biosafety policy toward GM crops. One reason has been its greater insulation from the international influences that seem elsewhere to be promoting caution. In contrast to Kenya, China does not depend so heavily on donor funding and therefore has more freedom to draft and implement biosafety policies that are permissive rather than precautionary. In contrast to Brazil and India, China does not have to respond to European-based environmental NGOs because it does not allow such organizations to challenge policy or even to operate freely in Beijing. In addition, China's political system does not yet provide space for rival political parties, independent journalists, or an independent judiciary to challenge its permissive biosafety policy approach to GM crops.

In developing countries that are more open to these international influences, governments have recently had more difficulty pursuing a permissive policy toward GM crops. This was true despite several variations in institutional design. In Kenya, NBC was nominally neutral among ministries, yet it moved slowly in approving GM crop research because it feared being criticized by NGOs and possibly being overruled by the Environment Ministry (which operated from a legislative foundation whereas NBC did not). In Brazil, GM crop supporters tried to set in place a permissive biosafety review process by creating CTNBio outside of the Environment Ministry and by giving private industry a seat at the table. Yet the permissive nature of this arrangement so offended consumer and environmental activists and so badly excluded IBAMA that CTNBio became vulnerable to a court challenge. GM crop supporters in India took a different approach. They gave the Environment Ministry through GEAC an institutionalized veto power over any final commercial release of GM crops while hoping to build momentum for approval by leaving the review process up to that final point firmly in the grip of the RCGM and other biotechnology advocates in DBT. Anti-GM activists in India did not, however, allow much momentum for final approval to build. They brought a public interest lawsuit against DBT for the manner in which RCGM had approved field trials and then fanned enough flames of public opposition against GM crops to leave the Environment Ministry ample room through GEAC to slow down or block a final commercial release after all.

Based on this brief review, can advice be given to those developing-country officials that might be interested in pursuing a permissive rather than a precautionary or preventive biosafety policy toward

GM crops? One part of the Chinese approach should not be imitated by others: insulating biosafety policy processes from all internal political challenge or from international NGO pressures or media scrutiny. This approach risks technocratic abuse and falls short on grounds of social accountability. Yet some other features of the Chinese approach could be usefully considered.

The China case suggests there is one respect in which institutional jurisdictions do matter. Proponents of GM crops in China gained an advantage by locating the biosafety review process within the Ministry of Agriculture, where the nation's ambitious farm productivity goals could set the larger political context. To a large extent this has also been the approach of the United States, where most biosafety review processes for crops (GM and otherwise) take place within the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture. Only in the case of insecticidal crops such as Bt maize or Bt cotton does APHIS yield jurisdiction to the U.S. Environmental Protection Agency (EPA). Partly as a consequence of such jurisdictional choices, regulatory authorities in both China and the United States have been able to keep the interests of agricultural producers in mind as the controversy over GM crops has evolved. Despite this controversy they have been able to persist in basing GM crop biosafety reviews on scientifically demonstrated risks only, rather than on uncertain risks that have not yet been demonstrated.

A second lesson also grows from the Chinese experience. Governments in the developing world that wish to move ahead with the GM crop revolution and shape its potential to their own needs and purposes must be prepared to invest their own treasury resources in developing an independent national scientific capacity in the GM crop field. China's State Council began making substantial investments in transgenic crop research beginning in 1986, and by 1993 Chinese scientists were successfully synthesizing (and even patenting) their own insecticidal Bt gene for use in transforming cotton plants. So when the time came in 1997 for China's biosafety committee to review Bt cotton for commercial release it was not only looking at a Monsanto variety introduced by a multinational company from abroad; it was also reviewing four different nationally developed CAAS varieties. This eased the decision process considerably.

It is naturally easier for regulatory authorities in the developing world, under pressure from GM crop critics, to defend a GM crop approval decision if the crop in question has been developed by national scientists with public sector resources, rather than by a foreign multinational corporation. There are several other probable advantages from placing heavier emphasis on public sector research. Public sector GM crop development efforts are less likely to neglect the "orphan crops" grown by many poor farmers in the tropics. Private companies do not see poor farmers as good customers, so the profit-making private sector is unlikely to invest in GM varieties of cassava or cowpeas; it is the public sector (working with nonprofit private foundations) that must invest the needed resources here. Developing GM crops through the public sector is also less likely to leave new innovations heavily encumbered with IPR claims.

The private marketplace, by itself, is not likely to work much GM crop magic for the poorest farmers of the developing world. The lead role that so far has been played by private international companies in the GM crop revolution is arguably a leading reason why this revolution has not yet reached the poorest farmers of the developing world, and one reason why GM crops are encountering political and social opposition. During the successful Green Revolution of the 1960s and 1970s, it was not the profit-making private sector that took the lead. Instead, national and international public sector research institutes, philanthropic foundations, agricultural ministries, and extension agencies developed and moved new high-yielding seed varieties to farmers. Too often in the current "gene" revolution the public sector has abdicated this role.

If public sector institutions—especially governments in both the developed and developing world—are willing to invest more financial resources in shaping this new technology, the benefits can more often be targeted toward poor farmers and might also be placed more often in the public domain. Social resistance to the technology will then diminish as well, as publics come to view GM crops more in the context of a national development policy strategy and less as the product of foreign corporate interests.

GM crops have been planted commercially for only half a decade, so many of the developing-country policies described here are of recent origin and still rapidly evolving. The international debate regarding GM crops is likewise recent and still largely unresolved. Estimating the most likely direction of policy change in the years ahead is thus a difficult task. This paper only provides a snapshot of policies toward GM crops in four countries at one moment in time, in the years 1999–2000. As policy toward this new technology evolves in the years ahead, one may hope that the views of the real stakeholders in these developing countries—consumers, farmers, and rural communities—will be heard as loudly as the various and conflicting opinions of GM crop advocates or opponents from the industrial world.

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Robert L. Paarlberg is a professor of political science at Wellesley College, Wellesley, Massachusetts, U.S.A., and an associate at the Weatherhead Center for International Affairs at Harvard University.

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2033 K Street, N.W., Washington, DC 20006-1002 U.S.A.
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