Chapter 4

Questions relating to the use of GM crops in developing countries
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In view of the amount of food available worldwide, are GM crops really necessary?

4.1 Some argue that GM food crops are unnecessary because enough food is already produced globally. Instead, they recommend that greater effort should be given to achieving a more equitable distribution of food. It is true that the world’s current population could obtain more than enough calories and most other essential nutrients from the global production of staple crops. 3,600 calories per person per day are available. However there are two critical objections to this argument.

- Most cattle and poultry consume maize or soybean. The conversion of fodder into meat and milk requires three to six times the amount of these crops than would be needed if people ate them directly. Therefore, the provision of 3,600 calories (or even only the recommended 2,000-2,500 calories), daily for each person from existing production of staple crops would require the consumption of meat, dairy products, eggs and poultry to be abandoned.

- The land on which to grow staple crops, and cash to buy them, would need to be distributed equally to all in the world, entailing considerable logistical and political challenges.

4.2 Progress towards such ends has been, and will probably remain, slow, as we pointed out in our 1999 Report (paragraph 4.8 of that Report). Moreover, the growing demand for meat, milk and eggs has meant that a rapidly rising proportion of the world’s staple crops are used for their production. This rise is set to continue. As for redistribution, political difficulties within, let alone between, countries would be considerable. In addition, there are onerous logistical problems to be taken into account. Costs for local and international distribution of food are high, and it may not always be possible to consider cultural preferences for certain types of food. All in all, while striving for a fairer distribution of land, food and purchasing power, we take the view that it would be unethical to rely entirely on these means to address food security. Given the limits of redistribution, we consider that there is a duty to explore the possible contributions which GM crops can make in relation to reducing world hunger, malnutrition, unemployment and poverty. We consider it unacceptable to reject such exploration on the basis that there are theoretical possibilities of achieving the intended ends by other means.

4.3 Providing farmers with, for example, pest-resistant crops is a more appropriate solution than the alternative of leaving them to rely on food donations supplied by the World Food Programme (WFP) or other organisations, if their harvest is destroyed by pests or viruses. The production of food is not just a necessity of life, but an integral part of social and cultural practice. A substantial part of people’s livelihood in developing countries depends on agriculture. We conclude that the potential of GM crops to benefit small-scale farmers whose

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3 Delgado C et al. (1999) 2020 Vision for Food, Agriculture and the Environment Discussion Paper 28 Livestock to 2020: The Next Food Revolution (Washington, DC: IFPRI). A further increase in the use of staple crops for animal feed can be expected because animal feed derived from meat has been abandoned due to risks associated with BSE.
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crops are seriously affected by droughts, pests or viruses should be explored as far as possible. We have noted promising approaches in the case of rice (see case study 2), GM sweet potato (see case study 5) and banana (see case study 6). If such crops can be made freely available in developing countries, they could contribute to preserving the independence and livelihood of farmers, and avoid reliance on redistribution or food aid.

Are alternative forms of agriculture, such as organic farming, better suited to improve agricultural practice in developing countries?

4.4 Farmers in many developing countries currently practise a form of organic farming. They are unable to afford artificial fertilisers, insecticides and pesticides. Some people in developed countries view this situation with approval and think that it is a particularly ‘natural’ and desirable form of agriculture. Often, they are unaware of the intensive inputs which are supplied by organic farmers in developed countries. But organic farmers in developing countries are usually not able to provide the continuous enrichment of the soil with fertiliser. On closer inspection ‘organic farming’ in developing countries takes on a different meaning. Most crop yields are too low to provide leftover material to replenish the land. Livestock produce poor quality manure which is mostly burned as fuel. Moreover, cattle are absent from large parts of Africa. Organic manures are little used as fertilisers, and exhaustion of soil nutrients is therefore widespread, leading to rapid soil degradation. Infestations of pests can seldom be countered effectively.4

4.5 As a consequence of these difficult conditions, crop yields are low. For example, yields of maize, rice and sweet potato are on average approximately half of those in developed countries.5 In most of Africa, yields of staple crops are lower still. In addition, we have noted the devastating effect of fungal pathogens, viruses and weevils (see case studies 5 and 6). It is unlikely that organic farming alone can cope with these challenges and provide the basis for sustainable agriculture.

4.6 This view does not imply that other important strategies in agricultural research and practice should be neglected. For example, integrated pest management can be a useful way to combat Striga, a weed that attacks maize. Research has shown that planting maize together with the legume Desmodium uncinatum can help to control Striga. Biological control has also been an effective means of combating the cassava mealy bug. The introduction of a South American wasp, a natural enemy, has helped to reduce the impact of the pest.6 Thus, many factors can contribute to improving agriculture. The development of better adapted crops is as important as the development of alternatives to inorganic fertilisers and pesticides, or the improvement of soil and water management.

4.7 As Gordon Conway, President of the Rockefeller Foundation, has recently observed, the question of whether agriculture should be improved by biotechnological approaches, rather than by more effective use of resources and alternative methods, is hardly ever a question of ‘either/or’. It is mostly a situation of ‘both/and’: ‘the best technology is the one that will safely get the job


6 Herren HR (1995) Cassava and Cowpea in Africa, in Biotechnology and Integrated Pest Management, Persley GJ, Editor (Wallington, UK: CAB International); Khan ZR et al. (2002) Control of witchweed Striga hermonthica by intercropping with Desmodium spp., and the mechanism defined as allelopathic, J Chem Ecol 28: 1871–85. However, we note that, just as with the introduction of any new crop variety, whether GM or non-GM, all such measures have to be carefully considered with regard to their impact on biodiversity (see paragraphs 4.28-4.34). In all cases, a reasonable application of the precautionary approach needs to take place.
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done in the simplest and least expensive way possible.’ Thus, while in some cases, organic farming has the potential to improve agricultural practices of small-scale, resource-poor farmers, it seems highly unlikely that it can address all of the serious problems which they face. For example, growing rice in semi-arid areas (see case study 2), protecting crops from viral or fungal diseases (see case studies 5 and 6) or producing crops with higher levels of micronutrients (case study 4) may require other solutions. In these cases, the use of GM crops may be the more promising approach. We therefore take the view that sustainable agriculture can be achieved most effectively when the relevant approaches and practices are combined, as appropriate.

Will GM crops be of benefit only to large-scale farmers? Is the use of GM crops of advantage in the context of international trade?

4.8 We concluded in our 1999 Report that agriculture has a crucial role in reducing poverty and enhancing local food supply in developing countries. We noted that GM crops could have substantial potential to contribute to improving agriculture (see paragraphs 4.4-4.12 of the 1999 Report). In re-examining the arguments, we find our views confirmed in light of subsequent developments (see paragraphs 2.1-2.13).^7

4.9 Poverty has many causes (see paragraphs 1.12-1.16). Poor efficiency of agriculture is one of them. It is also clear that the efficiency of agriculture has considerable impact on the standard of living of people involved in work on small-scale farms in developing countries. This is most notable in Africa, where the majority of the population live and work on small farms in rural areas (see paragraphs 2.10-2.11). Moreover, it is particularly true with respect to improving the situation of women, who make up the majority of the world’s resource-poor farmers. While it is estimated that worldwide, women produce more than 50% of all the food crops, this percentage is considerably higher in many developing countries. For example, it has been estimated that 80% of the food grown in sub-Saharan Africa, and 50-60% in Asia, is grown by women. In many instances, the improvements which can be achieved through GM crops may reduce much of the effort required in subsistence agriculture.

4.10 With respect to crops grown primarily for commercial reasons, as in the case of Bt cotton in China and South Africa (see case study 1), we conclude that the case for the use of GM crops remains compelling. Beneficiaries of the crop have been predominantly small-scale farmers who manage farms of between one and two hectares. We have noted the significant financial gains (see Table 3.1) and benefits for the health of farm workers, and for the environment, resulting from considerable reductions in the amount of pesticides applied to GM varieties (paragraphs 3.30-3.31, see also case study 6 on GM bananas, and case study 7 on GM soybean).

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8 With regard to alternative ways of improving agricultural practice, Pretty et al. found one or more of the following four mechanisms to show significant effect: intensification of a single component of a farm system, addition of a new productive element to a farm system, better use of water and land, improvements in per hectare yields of staples through introduction of new regenerative elements into farm systems, and new locally appropriate crop varieties and animal breeds. See Pretty JN, Morison JIL and Hine RE (2003) Reducing food poverty by increasing agricultural sustainability in developing countries, Agr Ecosyst Environ 95: 217–34.

9 Similarly, a recent report by DFID points out that agriculture is critical for the reduction of poverty in developing countries as it contributes to economic growth, provides a crucial basis for livelihood strategies of poor people and locally available staple foods for the poor, and enables a sustainable management of resources. DFID (2002) Better Livelihoods for Poor People: The Role of Agriculture (London: DFID).


4.11 We also observed in our 1999 Report that it was important to consider the implications of GM crops for international trade (paragraphs 1.21, 4.31-4.32 of that Report). The main agricultural exports from developing countries are tea, coffee, cocoa, cotton and sugar. In the cases of cotton and sugar, products from developing countries will have to compete with those produced in developed countries. The use of Bt cotton and other GM crops is likely to become more widespread in developed countries. Any lowering of production costs for GM cotton growers is likely to lead to an increase in the global supply of cotton and probably, in the short term, to lower cotton prices. Those farmers who use non-GM varieties would face sharply reduced net income per unit of output. There is also the possibility of losing markets. It is therefore of crucial importance that developing countries have the opportunity to use high-yielding crops to allow their exports to compete on the world markets. Failure to develop the capacity to use GM crops safely may result in increasing the gap between the wealthy and the poor even further.12

4.12 However, some respondents to our Consultation have also suggested that it may be in the interest of developing countries to deliberately opt for a GM-free agriculture. Focusing on food crops, one respondent from the UK observed:

‘There is little doubt that the European position – not only of government regulators, but perhaps more significantly of consumers too – will have an impact on the global trade in agricultural products. This creates a significant market for non-GM products (not necessarily organic). This market for key products with high export value – supermarket-supplied vegetables, soya beans, maize etc. may be highly advantageous for developing countries to capitalise upon.’

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4.13 The implications of decisions made by European policy makers and consumers are complex and are considered in more detail below (see paragraphs 5.16-5.21 and 5.37-5.50). In principle, it may be possible for developing countries to derive benefits from specialisation in non-GM agricultural exports. However, the conditions which have to be met for this to be feasible are manifold and demanding. The non-GM crops involved will need to command durable premium prices sufficient to cover the higher production costs, on their local, regional or global markets. ‘Contamination’ of non-GM material with GM material would have to be excluded. This would require strict monitoring of sowing, growing and transportation of harvested crops. Separation would need to be ensured in facilities for processing and storing produce. Potential spread of genetic material from GM crops grown in neighbouring countries would also have to be considered. Finally, there would be need to ensure that the probable steady rise in the excess production costs of non-GM varieties will not place those countries growing them at a competitive disadvantage. Possible health effects, for example arising from higher pesticide use on non-Bt crops would also have to be take into account (see case studies 1, 6 and 7).

4.14 Where countries decide to grow both GM and non-GM crops, the possibility of benefiting from exports of the latter will depend to a significant degree on the costs for the segregation during cultivation, harvesting and processing. Furthermore, the interplay between policy makers and farmers needs to be considered. While governments of developing countries may decide to adopt a non-GM policy, farmers may wish nevertheless to grow GM crops, if they promise higher yields or lower costs per unit. Hence, and this observation is particularly true for the scenario of a GM-free national agriculture, thought would need to be given to the ethical case, as well as the practical feasibility, of controlling and preventing illegal planting and selling of GM crops by impoverished smallholders.

12 However, the uptake of GM crops in developing countries is, for a variety of reasons, not likely to be straightforward. In particular, the lack of appropriate systems for the administration and monitoring of the use of GM crops, and the restrictive policy currently adopted by the EU are likely constraints. These and other issues relating to international trade and policy will be considered in more detail in Chapter 5.
4.15 Lastly, GM crops may offer solutions to very specific climatic conditions prevalent in developing countries and allow for more effective control of pests and fungal infections (see case studies 1, 2, 5 and 6). Policy makers who favour the scenario of a GM-free national agriculture would need to consider whether the possible benefits offered by exporting non-GM crops are sufficient to justify forgoing the potential advantages of some GM crops, particularly for small-scale farmers who do not benefit from exports to developed countries.

Can GM crops be introduced in such a way that local customs and practices are respected?

4.16 It is sometimes argued that the introduction of GM crops into developing countries will transform agricultural practices without respecting local traditions. It is alleged that so-called ‘informal seed systems’ may break down, which could make it impossible for farmers to keep, or exchange harvested grain as seed for the next season. In the 1990s, more than 80% of crops sown in developing countries were sown from farm-saved seeds.

4.17 While it is clearly important to respect such traditions, we question whether, in contemporary agricultural practice, informal seed systems are significantly challenged. Neither GM crops nor conventional plant breeding more generally prevent farmers from retaining and re-sowing their own seed varieties or landraces if they prefer to do so. If new GM or conventionally bred seeds are preferred by farmers, that is entirely their own concern, provided the crops are safe for human consumption and the environment. Moreover, the retention of seed by farmers is more important for some crops and some countries, than others. Farmers are often aware that, for open-pollinated crops such as maize, saved seed produces lower yields than F1 hybrids (see paragraph 3.3). Many farmers in Zambia, Kenya and South Africa have therefore been buying hybrid seed from local or multinational companies for some years. For self-pollinated crops such as rice and wheat, hybrids are unavailable. However, there is nothing to prevent farmers from retaining seed from the harvest for several years with only minor reductions in yield, as they have been doing for decades with leading varieties developed during the Green Revolution.

4.18 Seed re-use can be prevented by technologies such as GURT which effectively sterilises saved seed. Such technologies continue to be patented and may be problematic, as we observed in our 1999 Report (see paragraphs 2.26 and 4.75 of that Report). Nonetheless,


16 Although there is some loss of yield if farmers apply this practice to the still infrequent F1 hybrids of such crops; we note however, that farmers are not compelled to adopt these varieties.

17 It has been reported that, despite its pledge in 1999 not to commercialise GURT, Monsanto has recently reconsidered its position. See Collins HB and Krueger RW (2003) Potential Impact of GURTs on Smallholder Farmers, Indigenous & Local Communities and Farmers Rights: The Benefits of GURTs Paper made available to the CBD’s Ad Hoc Technical Expert Group on the Impact of GURTs on Smallholder Farmers, Indigenous People and Local Communities, 19 – 21 Feb 2003. The paper is presented as the official position paper of the International Seed Federation.
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this development need not prevent farmers from continuing to save seed from non-terminated varieties.\(^{18}\)

4.19 However, where farmers choose to buy seed, problems of affordability might arise if new varieties of crops, whether GM or not, are more costly than previously used seed. The prevalence of single monopolistic seed suppliers can further complicate access to inexpensive seed. It is therefore desirable that, as far as possible, farmers have a genuine choice. To provide a genuine choice it is important that funding for research in the public sector be sustained, so that suitable seeds (whether GM or non-GM), which can be retained by farmers with minimal yield losses, are available. Policies also need to be in place to keep the private supply of seeds reasonably competitive.

4.20 Some applications of GM crops might have detrimental effects on traditional farming practices, as has been suggested in the case of coffee.\(^ {19} \) However, we are not persuaded by the argument that the use of GM crops, as such, tends to disseminate Western farm practices which will displace the use of locally-adapted crops. As we have noted, researchers are using genetic modification to improve traditional crops such as rice (see case studies 2, 3 and 4) sweet potatoes (see case study 5) and bananas (see case study 6). These crops are frequently grown by small-scale farmers. They are important for subsistence farming and also for local trade. Much of this research is, moreover, being undertaken by researchers from developing countries.

Can GM crops make a relevant contribution to solving health problems in developing countries?

4.21 The development of Golden Rice (see case study 4) has been a focus of much public discussion. Strong claims have been made by both proponents as well as opponents, in some cases in the absence of validated empirical evidence. Some see Golden Rice as a prime example of an ineffective ‘technological fix’ and a waste of public and private funds. They argue that access to food should be achieved through reforms in political, economic and social policies rather than through the introduction of biotechnology-based solutions. Others claim that provision of a greater variety of food is the best solution to improving health.\(^{20} \)

4.22 Most of the proponents of Golden Rice do not see the crop as a long-term substitute for a properly balanced diet. However green leafy vegetables, which are often cited as an appropriate alternative for the provision of vitamin A, are seldom inexpensive nor available year-round to people in developing countries. In addition, if and when they are available and affordable, several servings are required to provide a desirable level of vitamin A.\(^{21} \) Therefore proponents argue that there is every reason to examine the potential of Golden Rice, and that even small increases in the level of vitamin A could be beneficial.

4.23 An important question is whether the increased levels of micronutrients available from Golden Rice are sufficient to achieve the benefits that are claimed. Assessments depend on a number of factors, including: (a) the estimated ideal amount of vitamin A to be ingested, usually expressed as recommended daily allowance (RDA); (b) the levels of \( \beta \)-carotene produced by Golden Rice; and (c) the ratio at which \( \beta \)-carotene is converted into vitamin A.

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\(^{18}\) We also note that in developed countries, the use of GURT has been suggested as an effective way of preventing the spread of pollen from GM crops to neighbouring organic or conventional crops, a cause of great concern to many farmers.


when digested. Regarding RDAs, the environmental group Greenpeace assumes that 400 micrograms of vitamin A per day are adequate for a child of between one and three years. Professor Potrykus and Dr Beyer report that provision of 300 micrograms of vitamin A is an acceptable level. RDAs for adults are estimated to be 50-100% higher.22

4.24 How much Golden Rice would a child have to eat so that VAD related diseases such as blindness and increased risk of mortality would be prevented? Assuming that the sole source of vitamin A would be Golden Rice, Greenpeace estimates an amount of approximately three kilograms of uncooked rice, equalling 7 kilograms of cooked rice.23 The developers of Golden Rice take the view that approximately 200 grams of uncooked rice, or even less, could be sufficient. For the most part this difference can be explained as follows:

- Greenpeace bases its calculation on the assumption that 100 grams of Golden Rice yield 160 micrograms of β-carotene. This level has been confirmed as robust in the first successful strains of Golden Rice. Greenpeace further estimates that β-carotene from Golden Rice is converted into vitamin A in the same way as from leafy greens. Accordingly, a conversion rate of 12:1 is assumed. One hundred grams of rice would therefore provide 13 micrograms of vitamin A. To meet the daily requirement of 400 micrograms of vitamin A, approximately three kilograms (13 micrograms x 30) need to be consumed.24

- The developers of Golden Rice consider that the provision of 30-40% of the RDA is sufficient to prevent increased mortality and blindness in children. With regard to conversion rates they draw on data from the Indian Council of Medical Research and assume a rate of 4:1. One hundred grams of Golden Rice would therefore produce 40 micrograms of vitamin A. To attain the minimum daily requirement of 90-120 micrograms of vitamin A, 225-300 grams would have to be eaten. However, these estimates are based on the first generation of Golden Rice. Research is continuing and the production of significantly increased levels of β-carotene in comparison to the first generation now seems feasible. For example, a threefold increase yielding 480 micrograms of β-carotene would be equivalent to 120 micrograms of vitamin A per 100 grams of Golden Rice. This would already be sufficient to cover the daily requirement to prevent VAD-related ill health.25

4.25 Questions about the efficacy and efficiency of Golden Rice clearly depend upon further scientific research. It is particularly important to identify standard conversion rates for the production of vitamin A from β-carotene in man. We understand that experiments to assess the levels of vitamin A uptake more precisely are being planned, to be led by the United States Department of Agriculture (USDA) Laboratory for Human Nutrition, Boston. These are expected to be completed by the end of 2005. We conclude that it is premature to proclaim that the approach will fail. The need being addressed is an urgent one. It is therefore essential that reliable empirical data from nutritional and bioavailability studies be obtained as a priority. At the same time, in endorsing continuing research on crops such as Golden Rice, we

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emphasise that evaluation of its cost-effectiveness, risk and practicality in comparison to other means of addressing micronutrient deficiency is vital.\footnote{Such comparisons would need to consider, for example, estimations of the cost of averting death by means of vitamin A supplements. One study considered data from the WHO and the United Nations Population Division and estimated the average cost per death averted at US$64 in 1999. Supplementation was carried out as an addition to vaccination programmes. However such approaches are hampered by logistical problems. For example, supplements distributed with a vaccine programme only help those who are able to reach the facility where the vaccination is carried out. See Ching P, Birmingham M, Goodman T, Sutter R and Loevinsohn B (2000) Childhood mortality impact and costs of integrating vitamin A supplementation into immunization campaigns, \textit{Am J Public Health} \textbf{90}: 1526–9.}

4.26 The example of Golden Rice raises the question of the appropriateness of regulatory requirements. Regulatory provisions should always be proportionate to the risks implied. Unnecessarily stringent regulations that hinder the development of crops which can substantially improve malnutrition should be avoided (see paragraph 4.41). Costs for regulatory approval are considerable and there is a risk that only large multinational agrochemical companies will be able to cover them. These companies have so far tailored their research programmes predominantly to the needs of farmers in developed countries. Research on crops and traits relevant to the needs of small-scale farmers in developing countries has been mainly undertaken in the public sector. However, the high costs of gaining regulatory approval may deter publicly funded institutions from pursuing such research.

### Is the introduction of GM crops in developing countries consistent with a precautionary approach to biodiversity and human health?

#### Gene flow and biodiversity

4.28 The possibility that genes from GM crops may be transferred by pollen to other cultivars or wild relatives of the same kind of crop has caused concern. This phenomenon, termed gene flow, occurs frequently in nature where many plant species cross with related species to produce new kinds of plants.\footnote{Ellstrand NC, Prentice HC and Hancock J (1999) Gene flow and introgression from domesticated plants into their wild relatives, \textit{Annu Rev Ecol Syst} \textbf{30}: 539–63.} Gene flow is in part responsible for the wide variety of plants which have evolved over many thousands of years. It may, however, be undesirable where it leads to the transfer of specific unwanted traits, or to the permanent and irreversible transformation of a species or variety. While the possibility for gene flow exists for both non-GM and GM crops, some fear that gene flow from GM crops could endanger biodiversity in a new way. In particular, this could occur where a GM crop has been modified to include a gene from another type of organism (see case study 1 on \textit{Bt} cotton, and case study 8 on the production of biopharmaceuticals).
4.29 In the UK there are no indigenous close relatives of crops such as maize or wheat, reducing the chances of negative consequences of gene flow. However, the situation is different in other countries. For example, in Mexico, gene flow between modern cultivated maize varieties and ancient landraces or wild relatives is likely to occur. Mexico is home to many different kinds of maize, and is a centre of diversity for the crop. The different varieties are used as raw material to improve the quality of maize varieties by farmers and plant breeders around the world. It is feared that the introduction of genetic material from GM maize varieties may have a negative impact.

4.30 Considerable interest was therefore aroused when researchers at the University of California at Berkeley published findings in 2001 which claimed that genes from GM maize had crossed into native Mexican maize landraces and become permanently established in their genetic material (an event known as ‘introgression’). The researchers further claimed that the transgenes were unstable and ‘seemed to have become re-assorted and introduced into different genomic backgrounds’.28 There are fears that these events could lead to unpredictable alterations in native maize. For example, a truncated promoter sequence might activate other genes. Some groups engaged in the monitoring of GM crops interpreted this as an instance of ‘genetic pollution’29 claiming that the ‘well had been poisoned’.30

4.31 While it was unclear how the GM maize might have been introduced in Mexico, where a ban on GM crops has been in place since 1999, subsequent debate about the scientific validity of the research led the journal Nature to disavow the published paper.31 The question of whether or not gene flow from GM maize had actually occurred was not disputed by any of the critics of the original paper and was subsequently supported by independent research.32 Debate centred around methodological issues concerning the study design and data analysis, which were used to support the claim that the alleged introgression was a significant threat to biodiversity.33

4.32 The possibility of gene flow from GM crops may indeed require special attention. However, we need to be clear about the precise characteristics of gene flow. First, the fact that a crop has been genetically modified to express a particular trait does not automatically mean that this trait confers a selective advantage in the wild. A specific trait may be present for a

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29 ETC Group (2002) Genetic Pollution in Mexico’s Center of Maize Diversity, in Backgrounder (Food First Institute for Food and Development Policy) Spring 2002.
32 In 2001, scientists of the Mexican National Institute of Ecology (INE) and the National Biodiversity Council (CONABIO) took randomised samples from 22 locations in Oaxaca and Puebla. The samples were split into two groups and analysed at the National Autonomous University of Mexico and the Centre for Investigation and Advanced Studies (CINVESTAV). Findings suggested that approximately 12% of the analysed plants contained transgenic promoters. In some areas, it was reported that up to 35% of the grain contained foreign sequences, see Mann CC (2002) Has GM corn poisoned Mexico?, Nature 414: 897; the same volume (pages 897–900) also includes a response by the accused researchers, addressing the allegation.
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generation or two in wild plants, and then disappear, because other plants are more suited to the specific environment. Nonetheless, in some instances, selective advantage has been reported, for example, in GM insect-resistant rape seed. Possible risks would therefore depend largely on the particular crop and trait.

4.33 Secondly, research is being undertaken to prevent pollen-mediated transmission of transgenes by ensuring that transgenic DNA is not incorporated in the pollen. Such research would be crucial in the case of GM crops used for the production of biopharmaceuticals (see case study 8). Thirdly, although pollen can travel over considerable distances, pollination, and therefore the successful transfer of genetic material, does not always occur. Fourthly, appropriate separation distances can be established between fields containing GM and non-GM crops. Research to examine these and other issues is underway in the UK and other countries. Where results of such research are not transferable to developing countries, additional research should be undertaken as necessary, to assess the impact of gene flow, particularly in centres of diversity. Finally, we note that many GM crops are male sterile varieties, which means that pollination cannot occur, although pollen may spread widely. While these points make it clear that the risks of gene flow need to be assessed on a case by case basis, we recall that gene flow occurs widely throughout nature. Whether or not it is acceptable depends primarily on its consequences. Research to assess such risks is essential.

4.34 The question to be asked must therefore be: what kinds of risks are posed by the transfer of specific genetic material? Are these risks substantial? A necessary condition for answering these questions depends upon whether gene flow has occurred at a measurable level. We note that these two sets of issues are often confused. We accept that the introduction of GM crops in developing countries which are centres of diversity of specific crops may in some cases be problematic. We recommend that in the case of sensitive areas such as centres of diversity, introgression of genetic material from GM crops in related species should be monitored. However, we are not persuaded that the possibility of gene flow should be sufficient to rule out the planting of GM crops in such areas, provided that regulatory requirements are met. Specific risks need to be assessed in particular contexts, and possibilities of safeguarding biodiversity must be considered carefully. The establishment and maintenance of comprehensive seed banks to conserve genetic resources of crop plants and their relatives is of crucial importance.


Box 4.1: The precautionary approach

The precautionary approach is invoked in order to address the absence of reliable scientific data, as stated in Principle 15 of the Rio Declaration on Environment and Development:

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

The non-binding Declaration was agreed by 178 governments in Rio de Janeiro in 1992.

Similarly, Annex III of the Cartagena Protocol on Biosafety (see paragraphs 5.7-5.10) states that:

‘lack of scientific knowledge or scientific consensus should not necessarily be interpreted as indicating a particular level of risk, an absence of risk, or an acceptable risk’.

The precautionary approach

4.35 Most people agree that an assessment of the environmental safety of GM crops should focus primarily on the severity of the consequences of gene flow. However, some also take the view that GM crops should not be developed at all because there may be a very low probability that some unpredictable and serious adverse consequences may ensue. This case is frequently argued in terms of the so called precautionary approach (see Box 4.1). The argument is that, irrespective of possible benefits, a new technology should never be introduced unless there is a guarantee that no risk will arise.

4.36 An alternative interpretation of the approach with regard to the use of GM crops is that it enjoins us to ‘proceed with care’, when we have no well-grounded reason to think that a hazard will arise and when there is a valuable goal to be achieved. By this interpretation, each new release of a GM crop into the environment needs to be considered on a case by case basis. Each application would require an iterative approach, beginning with the contained use of GM crops, followed by several smaller field trials, and then possibly by larger trials and a provisional and time limited commercial release.

4.37 How might we decide between alternative interpretations of the precautionary approach? We offer the following observations. First, an excessively conservative interpretation, demanding evidence of the absence of all risk before allowing the pursuit of a new technology is fundamentally at odds with any practical strategy of investigating new technologies. Pursued to its logical outcome, a conservative interpretation would require a delay (i.e. a moratorium) in the use of a new technology until a complete assurance of absence of risk is available. However, no one can ever guarantee an absolute absence of risk arising from the use of any new technology. In our view, such an approach would lead to an inappropriate embargo on the introduction of all new technology. There are countless recent cases which indicate that it would make impossible technologies which are now accepted by most people in developed countries, such as the wide deployment of vaccination programmes or the use of mobile phones or aeroplanes. We have come firmly to the view that the only sensible interpretation of the precautionary approach is comparative, i.e. to select the course of action (or of inaction) with least overall risk.
4.38 Secondly, it is easier to forgo possible benefits in the light of assumed hazards, if the existing status quo is already largely satisfactory. Thus, for developed countries, the benefits offered by GM crops may, so far, be relatively modest. However, in developing countries the degree of poverty and the often unsatisfactory state of health and agricultural sustainability is the baseline and the feasibility of alternative ways to improve their situation must be the comparator.

4.39 The precautionary approach is thus relevant to the effectiveness of conventional and ‘organic’ agriculture in developing countries. As we have noted (paragraphs 2.13-2.14), expansion into marginal lands is usually a source of increased average cost, reduced returns, and increased environmental hazards. Nonetheless, for want of other options, the expansion into marginal lands is widely practised throughout much of Africa. This leaves an unmistakable and undesirable farming footprint characterised by exhausted or overgrazed soils, and degraded forests and other areas of wildlife. Much of the current agricultural practice in the farming of cotton, bananas and soybeans requires the application of large amounts of pesticides and fungicides, with adverse consequences for the environment, and the health of farm workers (case studies 1, 6 and 7). Thus, questions about the use of GM crops need to be posed in the light of a realistic comparator system:

- How does the use of a GM crop compare to other alternatives?
- What are the risks of the non-GM approach, that would constitute the option of ‘doing nothing’?
- In what respect are the risks posed by the introduction of a GM crop greater or less than those of the alternative system?
- Does the comparator system involve a higher level of benefits than the alternative system?

It seems likely that GM crops could have an active role to play in the safeguarding of the environment, if they can grow under more demanding conditions imposed by water shortages, or poor soils. The precautionary approach should also be invoked in cases of biological control, where, for example, wasps, are deliberately imported from another continent to act as the natural enemy of a domestic pest (see paragraph 4.6). While these solutions can make valuable contributions to improving agriculture in developing countries, the alleged naturalness of the approach should not distract from careful analysis of possible impacts on the environment. Here, too, the potential for the irreversible alteration of ecosystems needs to be considered.

4.40 Thirdly, to hold to the most conservative interpretation of the precautionary approach invokes the fallacy of thinking that the option of doing nothing is itself without risk. Yet, as we said in our 1999 Report (Chapter 4, see also paragraphs 2.9-2.13 above), food security and environmental conditions are actually deteriorating in many developing countries. This is not to say that we should be imprudent in the assessment of risks. It is to say, however, that restrictive interpretations of the precautionary approach, that imply a general prohibition on the use of GM technology, require very strong justification.

4.41 We therefore conclude that an adequate interpretation of the precautionary approach would require comparison of the risks of the status quo with those posed by possible paths of action. We use the term precautionary approach to indicate that it is

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40 We have also pointed out that, in specific instances, GM crops can have the potential for improving biodiversity (paragraph 3.38) as increased numbers and varieties of spiders, beetles and other insects that are important food for a number of birds have been reported for Bt crops.

41 See also Chapter 3, footnote 14.
not a single inflexible rule, as often implied when commentators refer to the ‘precautionary principle’, but a way of applying a set of interacting criteria to a given situation. Such assessments must be based on sound scientific data. This is consistent with a cautious attitude in the sense that rules and procedures need to be put in place to safeguard against any untoward effects and to mitigate their incidence should they occur. However, it recognises that there can be dangers in inaction, or alternative courses of action, as well as in the adoption of a particular innovation, dangers that are of particular importance when people are vulnerable and hungry. Thus, provided that technological expectations are met, it could well be argued that the use of Golden Rice can be justified by a reasonable application of the precautionary approach, if alternative approaches are less cost-effective and unable to achieve the aim of preventing VAD (see paragraphs 4.21-4.26).

4.42 It is also worth noting that the precautionary approach needs to be applied in ways that ensure broader policy aims are met. A useful contribution in this respect is the Communication from the European Commission on the Precautionary Principle, which recommends that measures based on the precautionary approach should be, among other things:

- proportional to the chosen level of protection;
- non-discriminatory in their application;
- consistent with similar measures already taken;
- based on an examination of the potential benefits and costs of action or lack of action (including, where appropriate and feasible, an economic cost/benefit analysis);
- subject to review, in the light of new scientific data; and
- capable of assigning responsibility for producing the scientific evidence necessary for a more comprehensive risk assessment.

Food safety

4.43 Given the previous arguments, a reasonable interpretation of the precautionary approach should also be applied when assessing the safety of GM crops that are intended for human consumption. In this context, we welcome the use of the concept of ‘substantial equivalence’ as an essential part of safety assessments of GM crops. This concept, which has been endorsed by the World Health Organization (WHO) and the FAO/WHO Codex Alimentarius Commission, involves comparing the GM crop in question to its closest conventional counterpart. The purpose of the procedure is to identify similarities and differences between a GM crop and a comparator which has a history of safe use. Although previous interpretations of the concept viewed ‘substantial equivalence’ as an endpoint in safety assessment, the current interpretation favours the concept as a framework for a comparative approach. The comparison does not aim to establish absolute safety, which is impossible to attain for any type of food. Rather, it should be seen as the first step in

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identifying whether it is safe for human consumption. Although the approach is not infallible, it is useful for identifying intended or unintended differences which might require further safety assessments (see Box 4.2).46

4.44 The concept of substantial equivalence has been applied successfully to crops produced by other forms of contemporary plant breeding, such as mutation breeding (see paragraph 3.8). With regard to assessing risks that are specific to GM crops, we have already seen that the technique often involves the introduction of genetic material from other species. Risks may also arise from the use of gene sequences from some plant viruses to facilitate the expression of an inserted gene (see paragraph 3.10).

4.45 Fears have been expressed that viral promoters could produce new viruses that would affect humans. However, only a small part of a plant virus is used (usually the 35S promoter from the cauliflower mosaic virus). Additionally, viruses usually infect only a very narrowly defined range of species. It is therefore unlikely that viruses that are adapted to infect Brassicas would infect humans.47 Another concern is that plant viruses may produce new viruses in humans by recombination with remnants of viral DNA sequences which exist in human DNA. However, research has shown that there are significant natural barriers to such a process.48 Indeed humans have eaten virally infected plants for millennia and there is no evidence that new viruses have been created as a consequence.49

4.46 There are also questions about whether foreign genetic material that has been introduced into a GM crop will be absorbed by the body. When humans eat plants or animals, they also eat DNA. This also applies to GM crops. However, the fact that such crops have been

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46 The European Network on Safety Assessment of Genetically Modified Food Crops (ENTRANSFOOD) incorporates a major cluster of EC-sponsored research projects and is set to publish a forthcoming report. The coordinator, H Kuiper concluded in a recent paper, “When evaluating a new or GM crops variety, comparison with available data on the nearest comparator, as well as with similar varieties on the market, should form the initial part of the assessment procedure”. See Kok EJ and Kuiper HA (2003) Comparative safety assessment for biotech crops, Trends Biotechnol 21: 439.


49 Royal Society (2002) Genetically Modified Plants for Food Use and Human Health - an update (London: Royal Society), p9. This Report also discusses other implications of the use of viral DNA in plants, relating to the use of the CaMV 35S promoter, which functions in a wide variety of species, and the possibility that viral DNA may activate so called transposable elements which are already present in the human genome. However, the Report concludes that risks to human health associated with the use of specific viral DNA sequences in GM crops are negligible.
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genetically altered does not necessarily equate with the creation of new health risks. According to a recent FAO/WHO document, the amount of DNA which is ingested varies widely, but it is estimated to be in the region of 0.1 to 1.0 grams per day. Novel DNA from a GM crop would represent less than 1/250,000 of the total amount consumed. The probability of gene transfer is extremely low. In fact, it would require that all of the following events occur:

- the relevant gene(s) in the plant DNA would have to be released, probably as linear fragments;
- the gene(s) would have to survive harvesting, preparation and cooking, and also nucleases in the plant;
- the gene(s) would have to compete for uptake with other dietary DNA;
- the recipient bacteria or mammalian cells would have to be able to take up the DNA and the gene(s) would have to survive enzymatic digestion;
- the gene(s) would have to be inserted into the person’s DNA by very rare recombination events.

Thus, the DNA of the modified crop will normally be processed and broken down by the digestive system in exactly the same way as that of conventionally bred, or otherwise modified crops.

4.47 Finally, a number of recent authoritative reviews have concluded that there are no proven health damages arising from the consumption of GM crop products on the market as yet. However, long-term risks for most conventional foods have never been analysed. This is not because all naturally occurring, or conventionally bred foods are safe; indeed, the use of some conventional varieties of crops can have grave health consequences. For example, most varieties of *Lathyrus sativus*, a lentil formerly grown widely in North India and now spreading in Ethiopia, are known to cause the crippling disease of lathyrism. Traditional varieties of cassava in Nigeria also have dangerously high levels of hydrocyanic acid. Research on GM crops could create safer varieties of these and other crops which could replace harmful traditional varieties by reducing the levels of undesirable substances including mycotoxins, alkaloids and glucosinolates. In our judgement, there is no empirical or theoretical evidence that GM crops pose greater hazards to health than plants resulting from conventional plant breeding. However, we welcome the fact that concerns about GM have focused attention on issues of safety with regard to new crops and varieties.

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54 Mycotoxins, for example, are toxic chemical products formed by certain fungal species that readily colonise crops in the field or after harvest; they pose a potential threat to human and animal health through the ingestion of food products prepared from these commodities. Chronic levels are considered to be a major cause of infant mortality, inefficient nutrient uptake in humans and farm animals, liver and other cancers in adults, and may strongly contribute to the lower life expectancy in tropical and sub-tropical developing countries. See Biosafety Information Network and Advisory Service (BINAS) http://binas.unido.org/binas/. Accessed on: 10 Nov 2003.
Summary of Chapters 2-4

4.48 In the short time between the publication of our 1999 Report and 2003, there has been a substantial increase in evidence, relating to the use of GM crops in developing countries (see also Appendix 3). However, the debate about the safety of GM crops remains characterised by highly polarised views. Proponents often claim that all forms of GM crops will benefit developing countries, while opponents frequently argue that any applications of GM crops are unsuitable for use to farmers in developing countries. The examples in Chapter 3 amply demonstrate the potential advantages offered by some GM crops. The discussion in Chapter 4 shows that possible costs, benefits and risks resulting from the introduction of a specific GM crop in a particular developing country depend on a variety of factors and can only be assessed on a case by case basis (see also paragraph 4.36).\textsuperscript{55} We conclude that the potential benefits of contemporary plant breeding, including those arising from the use of genetic modification of crops, have been empirically demonstrated in some instances, and have considerable potential in others, to improve agricultural practice and the livelihood of poor people in developing countries while reducing environmental degradation. There is an ethical obligation to explore these benefits responsibly, in order to improve food security, profitable agriculture and the protection of the environment in developing countries (see also paragraphs 1.20-1.31 of the 1999 Report).

4.49 In assessing whether GM crops should be used or not, it is essential to focus on the specific situation in the particular countries, asking the question: ‘How does the use of a GM crop compare to other alternatives?’ All possible paths of action must be compared, including inaction, in respect of improving, in a cost-effective and environmentally sustainable way, human health, nutrition, and the ability to afford an adequate diet.

4.50 We do not take the view that there is currently enough evidence of actual or potential harm to justify a blanket moratorium on either research, field trials, or the controlled release of GM crops into the environment. We recommend that research on the use of GM crops in developing countries be sustained, governed by a reasonable application of the precautionary approach. Risks arising from the adoption of GM crops need to be compared with risks of other possible courses of action, and of the status quo. Accumulating evidence from new scientific developments must be used to inform discussions about the current or future use of GM crops. The views of farmers and other relevant stakeholders must also be taken into account (see also paragraphs 5.33-5.34). Research and use of GM crops needs to be governed by appropriate regulation. We consider the current regulatory context, relevant recent developments in the area, and ethical issues arising from these, in the next chapter.

\textsuperscript{55} This approach may provoke the objection that most of the GM food crops which are promising for developing countries have not yet been planted in field trials, and that a robust assessment of their usefulness and the associated risks is therefore currently unavailable. However, this objection also applies to promising new developments in conventional plant breeding. With regard to both cases we take the view that it is too early to dismiss ongoing research in its entirety.