BIISS JOURNAL, VOL. 24, NO. 2, APRIL 2003: 226-261

Jeevan Kumar

GENETIC ENGINEERING AND FOOD SECURITY : RELATED ISSUES

Abstract

The article is an attempt to deal with issues related to the efforts of contemporary scientists to reorganize life of plants and animals at the genetic level. While the number of genetically engineered products like pharmaceuticals, gene therapy, transgenic plants and animals is increasing rapidly and finding their place in the market, the controversy with respect to their seemingly adverse social, economic, hygienic and environmental consequences is also rising at the same time. In particular, in the agricultural sector, biotechnology is moving fast to produce genetically engineered transgenic crops in order to meet food deficiency and sustain world agriculture. But concern seems to echo in various parts of the world with respect to ultimate hazards likely to be posed by the transgenic crops to health, environment and bio-diversity. As a result, citizen groups, consumers, NGOs, environment activists, scientists, etc. now advocate for more regulatory measures at the global level for monitoring the production and controlling the quality of various transgenic crops. Locked between the need to guarantee 'food security' on the one hand, and the constraints likely to be imposed by several restrictive and regulatory measures at the global level, on the other, the new genetic revolution in the field of agriculture is now confronted with a major dilemma.

Jeevan Kumar, Ph.D. is Professor of Political Science, Bangalore University, India. An earlier version of the paper under the title "Globalization and Food Security in South Asia: An Analysis of the Issues in Genetic Engineering" was presented at an international seminar on *Globalization and Security of South Asia* organized by BIISS on May 25-27, 1999.

1. Understanding Biotechnology

It is time we wake up to the reality that scientists have begun to reorganise life at the genetic level. The new tools of biology are opening up opportunities for refashioning life on Earth, while foreclosing options that have existed over the millennia of evolutionary history. Before our eyes lies an uncharted new landscape whose contours are being shaped in thousands of biotechnology laboratories in universities, government agencies and corporations around the world. Even if the claims already being made for the new science are only partially true, the consequences for society and future generations are likely to be enormous.

Great economic changes in history occur when a number of technological and social forces come together to create a new "operating matrix". According to Jeremy Rifkin, there are seven strands that make up the operational matrix of the Biotech Century:[1] Firstly, the ability to isolate, identify and recombine genes is making the gene pool available, for the first time, as the primary raw resource for future economic activity. Recombinant DNA techniques and other bio-technologies allow scientists and biotech companies to locate, manipulate and exploit genetic resources for specific economic ends. Secondly, the awarding of patents on genes, cell lines, genetically engineered tissue, organs and organisms, as well as the processes used to alter them, is giving the marketplace the commercial incentive to exploit the new resources.

Thirdly, the globalisation of commerce and trade make possible the wholesale reseeding of the Earth's biosphere with a laboratory-conceived Second Genesis, an artificially produced bio-industrial Nature, designed to replace Nature's own evolutionary scheme. A global life-science industry is already beginning to wield unprecedented power over the vast biological resources of the planet.

---

1. Jeremy Rifkin, *The Biotech Century*, (Tarcher/Putnam, New York, 1998), p.1.

Life-science fields ranging from agriculture to medicine are being consolidated under the umbrella of giant "life" companies in the emerging biotech marketplace.

Fourthly, the mapping of the approximately 100,000 genes that comprise the human genome, new breakthroughs in genetic screening, including DNA chips, somatic gene therapy, and the imminent prospect of genetic engineering of human egg, sperm and embryonic cells, is paving the way for the wholesale alteration of the human species and the birth of a commercially driven eugenics civilisation.

Fifthly, a spate of new scientific studies on the genetic basis of human behaviour and the new socio-biology that favours Nature over nurture are providing a cultural context for the widespread acceptance of the new bio-technologies.

Sixthly, the computer is providing the communication and organisational medium to manage the genetic information that makes up the biotech economy. All over the world, researchers are using computers to decipher, download, catalogue and organise genetic information, creating a new store of genetic capital for use in the bio-industrial age. Computational technologies and genetic technologies are fusing together into a powerful new technological reality.

Seventhly, a new cosmological narrative about evolution is beginning to challenge the neo-Darwinian citadel with a view of Nature that is compatible with the operating assumptions of the new technologies and the new global economy. The new ideas about Nature provide the legitimising framework for the Biotech Century by suggesting that the new way we are reorganising our economy and society is amplification of Nature's own principles and practices and, therefore, justifiable.

The Biotech Century brings with it a new resource base, a new set of transforming technologies, new forms of commercial protection to spur commerce, a global trading market to re-seed the Earth with an artificial Second Genesis, an emerging eugenics science, a new supporting sociology, a new communication tool to organise and manage economic activity at the genetic level, and a new cosmological narrative to accompany the journey. Together, genes, bio-technologies, life patents, the global life-science industry, human gene-screening and surgery, the new cultural currents, computers and the revised theories of evolution are beginning to remake the world.

Some might argue that human beings have been interested in increasing the quality and speed of production of biological resources since we first embarked on our agricultural way of life in the early neolithic era. That being the case, it might well be asked if genetic engineering is not simply a change in degree, rather than in kind, in the way we go about conceptualising and organising our relationship with the biological world. While the motivation behind genetic engineering is age-old, the technology itself represents something qualitatively new. To understand why this is the case, we must appreciate the distinction between traditional tinkering with biological organisms and genetic engineering, argues Rifkin.[2]

We have been domesticating, breeding, and hybridising animals and plants for more than ten millennia. But in the long history of such practices, we have been restrained in what we could accomplish because of the natural constraints imposed by species borders. Although Nature has, on occasion, allowed us to cross species boundaries, the incursions have always been very narrowly prescribed. Animal hybrids (mules, for example) are usually sterile, and plant hybrids do not breed true. There are built-in limits as to

2. *Ibid.*, p.13.

how much can be manipulated when working at the organism or species level.

Genetic engineering bypasses species restraints altogether. With this new technology, manipulation occurs not at the species level but at the genetic level. The working unit is no longer the organism, but rather the gene. The implications are enormous and far-reaching. To begin with, the entire notion as a species as a separate recognisable entity with a unique nature becomes an anachronism once we begin recombining genetic traits across natural mating boundaries. Three examples illustrate the dramatic change that genetic engineering makes in our relationship to Nature:[3] (a) In 1983, Ralph Brinster of the University of Pennsylvania Veterinary School inserted human growth hormone genes into mouse embryos. The mice expressed the human genes and grew twice as fast and nearly twice as big as any other mice. These "super mice", as they were dubbed by the press, then passed the human growth hormone onto their offspring. A strain of mice now exists that continues to express human growth genes, generation after generation. The human genes have been permanently incorporated into the genetic makeup of these animals. (b)Early in 1984, a comparable feat was accomplished in England. Scientists fused together embryo cells from a goat and from a sheep, and placed the fused embryo into a surrogate animal who gave birth to a sheep-goat chimera, the first example of the "blending" of two completely unrelated animal species in human history. (c) In 1986, scientists took the gene whose product emits light in a firefly and inserted it into the genetic code of a tobacco plant. The tobacco leaves glow.

These results could never have been achieved even with the most sophisticated conventional breeding techniques. In the biotech laboratories, however, the recombinant possibilities are near

3. *Ibid.*, p.14.

limitless. The new genetic technologies allow us to combine genetic material across natural boundaries, reducing all of life to manipulatable chemical materials. This radical new form of biological manipulation changes both our concept of Nature and our relationship to it. We begin to view life from the perspective of a chemist. The organism and the species no longer commands our attention or respect. Our interest now focuses increasingly on the thousands of chemical strands of genetic information that comprise the blueprints of living things.

With the new-found ability to identify, store and manipulate the very chemical blueprints of living organisms, we assume a new role in the natural scheme of things. For the first time in history, we become the engineers of life itself. We begin to re-programme the genetic codes of living things to suit our own cultural and economic needs and desires. We take on the task of creating a Second Genesis, this time a synthetic one geared to the requisites of efficiency and productivity.

2. Bio-technology in Agriculture

In agricultural biotechnology, the industry is moving quickly to make genetically engineered food crops a commercial reality. Chemical and agro-business companies are introducing a new generation of transgenic crops into agriculture with hopes of making a wholesale shift into the new genetics revolution. The biotech crops contain novel genetic traits from other plants, viruses, bacteria and animals, and are designed to perform in ways that could never have been achieved by scientists working with classical breeding techniques. Many of the gene-spliced crops emanating from the scientific laboratories seem more like creations from the world of science fiction. Scientists have inserted "antifreeze" protein from flounders into the genetic code of tomatoes to protect the fruit from frost damage. Chicken genes have been inserted into potatoes to

increase disease resistance. Firefly genes have been injected into the biological code of corn plants to serve as genetic markers. Chinese hamster genes have been inserted into the genome of tobacco plants to increase sterol production.[4]

The assumption is that biotechnology is benign and its applications should not be hindered by a lack of imagination, a fear of the unknown, or concern for the environment. In fact, the report of the World Bank panel on transgenic crops, authored by eight internationally renowned scientists, including M.S. Swaminathan from India, states: "Transgenic crops are not, in principle, more injurious to the environment than traditionally bred crops. Transgenic crops that are developed and used widely can be very helpful, and may prove essential, to world food production and agricultural sustainability. Biotechnology can certainly be an ally to those developing integrated pest management and crop management systems."[5]

Ecologists are unsure of the consequences of bypassing natural species boundaries by introducing genes into crops from wholly unrelated plant and animal species. The fact is, there is no precedent in history for this kind of "shotgun" experimentation, insists Rifkin.[6] For more than ten thousand years classical breeding techniques have been limited to the transference of genes between closely related plants or animals that can sexually interbreed, limiting the number of possible genetic combinations. Natural evolution appears to be similarly circumscribed. As a result, there is little or no precedent for what might occur in the wake of a global experiment to redefine the fundamental rules of biological development to suit the needs of

4. Jane Rissler and Margaret Mellon, *The Ecological Risks of Engineered Crops*, (MIT Press, Cambridge, 1996), pp. 10-11.
5. Quoted by Shivanand Kanavi, "To Terminate or Not to ..." in *Business India*, Bombay, December 14-27, 1998, p.71.
6. Rifkin, n.1, pp.81-82.

market-driven forces. Might the introduction of novel genes into the genomes of traditional food crops create new characteristics that are unpredictable and uncontrollable? The long and short of the matter is, we simply do not know. That is what makes this intervention into the world of agriculture so problematic. It is a high-risk venture with few ground rules and benchmarks to guide the journey. We are flying blindly into a new era of agricultural biotechnology with high hopes, few constraints and little thought of consequences.

Consider, for example, the ambitious plans to engineer transgenic plants to serve as pharmaceutical factories for the production of chemicals and drugs. Foraging animals, seed-eating birds, and insects who live in the soil will be exposed to a range of genetically engineered drugs, vaccines, industrial enzymes, and hundreds of other foreign substances for the first time, with dangerous consequences. The notion of large numbers of animal species consuming plants and plant debris containing a wide assortment of chemicals that they would normally never be exposed to, is an unsettling prospect.[7]

Much of the current effort in agricultural biotechnology is centred on the creation of herbicide-tolerant, pest-resistant, and virus-resistant transgenic plants. Herbicide-tolerant crops are a favourite of companies like Monsanto and Novartis that are anxious to corner the lucrative world-wide market for their herbicide products. To increase their share of the growing global market for herbicides, chemical companies have created transgenic crops that tolerate their own herbicides. The idea is to sell farmers patented seeds that are resistant to each particular brand of pesticide in the hope of increasing the companies' share of both the seed and herbicide markets. A profile of Monsanto and its strategies reveal a diabolic game-plan to stay in business :

---

7. Rissler and Mellon, n.4, pp.6, 42-43.

- Monsanto (of St. Louis, Missouri) is a major life industry corporation, and the world's second-ranking agro-chemical corporation. Monsanto's investments and acquisitions in seeds and agro-chemicals in the recent past exceeded US$2 billion. Monsanto's total 1996 revenues were US$9.26 billion.[8.]

- Monsanto is a hero on Wall Street. In the three years since Bob Shapiro took over as Chief Executive and started launching its products on a US agriculture market estimated to be worth $100 billions a year, its share price has soared from $11.50 to over $45. The company's business genius lies not just in acquisition but in ensuring that its most lucrative chemical products reap rewards far into the future.[9.]

- The key to Monsanto's operation has been its most successful herbicide, glyphosphate, sold under the name, *Roundup*. Its patent was supposed to run out in 2000, however, allowing competitors to market similar products. So for more than ten years, it has been developing a range of new crops genetically engineered to resist glyphosphate. One legal condition in the purchase of Monsanto's genetically modified seeds is that the crops are treated only with Monsanto's *Roundup* herbicide. Spraying them with *Roundup* does them no harm but destroys weeds around them. New patent legislation in Europe and the US, pushed by Monsanto and other bio-tech firms with backing from the US and British governments, allows Monsanto to secure exclusive rights to their production and collect 'technology fees'.[10.]

---

8. Rural Advancement Foundation International (RAFI), Manitoba, Canada, Communique, *Image*, "The Terminator Technology", March/April 1998.
9. George Monbiot, *et. al.*, "Monsanto" in *The Guardian*, 15 December 1997. See, *Third World Resurgence*, No.97, September 1998, pp.12-13.
10. *Ibid.*

- Monsanto has pioneered enforcement strategies for the protection of its plant patents. Much of this pioneering has been centred on its genetically altered soybeans which have the ability to withstand spraying with the company's *Roundup*. In 1996, the company set a new precedent requiring farmers buying its genetically engineered *Roundup Ready Soybeans* to sign and adhere to the terms of its '1996 Roundup Ready Gene Agreement' Terms. The farmer must pay $5-per-bag 'Technology Fee'; the farmer must give Monsanto the right to inspect, monitor and test his/her fields for up to three years; the farmer must use only Monsanto's brand of the glyphosphate herbicide *Roundup*; the farmer must give up his/her right to save and replant the patented seed; and the farmer must agree not to sell or otherwise supply the seed to any other person or entity. The farmer must also agree, in writing, to pay Monsanto 100 times the then applicable fee for the *Roundup Ready* gene, plus reasonable attorney's fees and expenses should he/she violate any portion of the agreement. Farmers' outcry against the stringent inspection and monitoring of their private property caused Monsanto to modify that part of the agreement in 1997.[11.]

The likelihood of increased use of herbicides raises the possibility of weeds developing resistance, forcing an even greater use of herbicides to control the more resistant strains. In one recent study, researchers at the Charles Stuart University in New South Wales found that ryegrass, a common weed in Australia, was becoming increasingly resistant to Monsanto's *Roundup* and can tolerate nearly five times the recommended dosage before it is killed.[12.] Aware of the growing problem of weed tolerance,

---

11. Geri Guidetti, "Seed Terminator and Mega-Merger Threaten Food and Freedom," *Third World Resurgence, ibid.*, p.19.
12. Ricarda A. Steinbrecher, "From Green to Gene Revolution : The Environmental Risks of Genetically Engineered Crops," *Ecologist*, November/December 1996, p. 273.

Monsanto has applied to the regulatory authorities in a number of countries, requesting an increase in the residue limit for its *Roundup* chemical on crops from six milligrams per kilogram dry weight to twenty milligrams. The potential deleterious impact on soil fertility, water quality and beneficial insects that result from the increased use of poisonous herbicides, like Monsanto's *Roundup*, are a disquieting reminder of the escalating environmental bill that is likely to accompany the introduction of herbicide-tolerant crops.[13]

The new pest-resistant transgenic crops pose similar environmental problems. Chemical companies are readying transgenic crops that produce insecticide in every cell of each plant. A growing body of scientific evidence points to the likelihood of creating 'super bugs' resistant to the effects of the new pesticide-producing genetic crops. Several crops, including Novartis's pest-resistant "maximizer corn" and Rohm and Haas's pest-resistant tobacco, are already available on the commercial market.

Virtually all of the pest-resistant crops contain a gene from a naturally occurring soil bacterium, *Bacillus thuringiensis.* The bacterium produces a crystal protein, known as Bt prototoxin. When the toxin is consumed by larvae and insects, it is activated by the insects' stomach acid and destroys their digestive tract. The naturally occurring Bt toxin is used as a bio-pesticide spray by organic farmers around the world. They rely on it as their chief line of defence against an array of insects including the corn borer and bull worm.

Unlike the naturally occurring bacterial prototoxin, the transgenic toxin has been altered so that it becomes active immediately upon production by the plant. As it does not have to be activated by stomach acids, it can harm a wider range of insects and soil organisms. The transgene also remains toxic up to three times

13. *Ibid.*

longer in the soil, making it far more lethal than its naturally occurring counterpart.[14.]

The unique qualities of pest-resistant transgenic plants make them especially troubling to entomologists and organic farmers, who worry that the widespread use of Bt crops will build resistance among affected insect species, rendering Bt useless as a pesticide. They have good reason to be concerned. Resistance to *Bacillus thuringiensis* bio-pesticides first showed up more than a decade ago. Since that time, eight major species of destructive insects have developed resistance to Bt toxin in either laboratory situations or in the environment, including the Colorado potato beetle, the diamondback moth and the tobacco budworm.[15.]

There is also growing concern that a number of the transgenic commercial introductions will themselves become weeds. The likelihood of a transgenic plant becoming a weed is thought, by some ecologists, to be roughly equivalent to the probability of a non-indigenous species becoming a successful weed. Both are novel organisms being introduced, for the first time, into an ecosystem. Neither newcomer nor the habitat has any prior experience accommodating the other. In these situations, scientists generally hold to what they call the ten-ten rule to compute the likelihood of a newcomer becoming a successful invader. That is, it is generally believed that ten per cent of newcomers are likely to successfully establish themselves in their new surroundings and, of those survivors, it is thought that ten per cent of them are likely to ever become significant pests.

Transgenic plants might enjoy slightly better odds than traditional non-indigenous introductions for the reason that many of the transgenic genes inserted into their genomes confer distinct

14. *Ibid.*, pp. 275-76.
15. Rissler and Mellon, n. 4, p.43.

advantages. Herbicide tolerance, pest resistance, and viral resistance are among the transgenic traits that are likely to confer competitive advantage, making transgenic crops potentially formidable invaders in various environments.

A growing number of ecologists warn that an even bigger danger might lie in what is called 'gene flow' - the transfer of transgenic genes from crops to weedy relatives by way of cross-pollination. Gene flows between crops and weedy relatives are naturally occurring and have been observed for more than a century by biologists. In California in the nineteenth century, a wild radish emerged as a result of hybridisation between an "escaped" cultivated radish and an introduced weed known as jointed charlock. In Africa, a harmful weed, pearl millet, originated from the hybridisation of millet and a wild relative. In France, a new weed evolved over the past several decades by the contamination of sugar beet with pollen from a wild Mediterranean sub-species. Wild rice has been hybridised with cultivated rice, giving rise to wild, weedy rice that often intermingles with the cultivated rice, creating untold problems for farmers. Researchers are concerned that transgenic genes for herbicide tolerance, and pest and viral resistance, might also escape and, through cross-pollination, insert themselves into the genomes of weedy relatives thereby creating weeds that are resistant to herbicides, pests and viruses. Ironically, all of the many efforts to create a bio-industrial future may eventually come to naught because of a massive *Catch 22* situation that lies at the heart of the new technology revolution[16]:

On the one hand, the success of the biotech revolution is wholly dependent on access to a rich reservoir of genes to create new characteristics and properties in crops and animals grown for food, fiber and energy, and products used for pharmaceutical and medical

16. Rifkin, n.1, pp.107-110.

purposes. Genes containing novel and useful traits that can be manipulated, transformed and inserted into organisms destined for the commercial market come either from the wild, from landraces (traditional crops) and domesticated animal breeds, and from human beings. Notwithstanding its awesome potential to transform nature into commercially marketable commodities, the biotech industry still remains utterly dependent upon nature's seed stock - germplasm - for its raw resources. At present, it is impossible to create a 'useful' new gene in the laboratory. In this sense, biotechnology remains an extractive industry. It can "mine" genetic material, but cannot create it *de novo*. On the other hand, the very practice of biotechnology - gene splicing, tissue culture, clonal propagation, and monoculturing - is likely to result in increased genetic uniformity, a narrowing of the gene pool, and loss of the very genetic diversity that is so essential to guaranteeing the success of the biotech industry in the future.

The loss of genetic diversity is compounded by modern farming practices that continue to emphasise monoculturing over mixed cropping methods. Agribusiness and chemical companies are always on the lookout for the "perfect" product, a plant strain that will grow quickly, be resistant to disease, and be easy to pick and transport to the market. Market forces in both the developed and developing world have conspired to force farmers to switch from the growing of landraces to the growing of high-performance monocultures. The abandonment of the enormous number of traditional varieties in favour of the new strains has seriously undermined genetic diversity, creating over-reliance on a dwindling number of plant genomes.

Agricultural biotechnology will only intensify the practice of monoculturing, as did the Green Revolution when it was introduced. Like its predecessor, the goal of the biotech revolution is to create superior varieties that can be planted as mono-cultures in agricultural regions al over the world. A handful of agribusiness and chemical companies are staking out the new biotech surf, each aggressively

marketing their own patented brands of "super seeds" - and soon, transgenic farm animals as well. The new transgenic crops and animals are designed to grow faster, produce greater yield, and withstand more varied environmental and weather-related stresses. Their cost effectiveness, in the short run, is likely to guarantee them a robust market. However, the switch to a handful of "the best" patented transgenic seeds and animals is likely to further erode the genetic pool as farmers abandon the growing of traditional varieties and breeds in favour of the commercially more competitive transgenic products.

Transgenic crops pose an even more direct threat to the world's remaining centres of crop diversity. These centres are the regions that contain both wild relatives and landraces and are the reservoirs for providing new genetic material for purposes of breeding. There is growing concern that the large-scale introduction of transgenic crops could contaminate the world's remaining centres of crop diversity. Gene flow from transgenic plants to landraces is inevitable in the wake of ambitious plans by the biotech industry to aggressively market their new "super seeds" in every agricultural region of the world. It will probably be impossible to shield the few remaining centres of crop diversity from the increasing encroachment of transgenic crops.

The commercial enclosure of the world's seeds - once the common inheritance of all humankind - in little less than one century, while hardly given more than a passing notice in the media, is, nonetheless, one of the more important developments of modern times, writes Rifkin.[17] Just a century ago, hundreds of millions of farmers, scattered across the planet, controlled their own seed stocks, trading them freely among neighbours and friends. Today, much of the seed stock has been bought up, engineered, and patented

17. *Ibid.*, p.114.

by global companies and kept in the form of intellectual property. Farmers wishing to plant for future harvests are increasingly reliant on access to these same companies, to whom they have to pay a fee for use of what was a commonly held good a short time ago. For their part, the chemical and pharmaceutical companies have little desire to champion the interests of small peasants and independent farmers around the world who still grow traditional crops passing on their heirloom crops from one generation to another. The independent farmer, growing traditional varieties, is seen less as a curator of potentially valuable resources and more as a potential market for the new patented seeds. The biotech corporations seek business and make every effort to sell him their brand of seeds. By focusing on short-term, market priorities, the biotech industry threatens to destroy the very genetic heirlooms that might one day be worth their weight in gold as a new line of defence against a new resistant disease or super bug.

The reseeding of the planet with a laboratory-conceived 'Second Genesis' is likely to enjoy some enviable short-term market successes, only to ultimately fail at the hands of an unpredictable and non-compliant Nature, concludes Rifkin.[18] While the genetic technologies we have invented to recolonize the biology of the planet are formidable, our utter lack of knowledge of the intricate workings of the biosphere we are experimenting on poses an even more formidable constraint. The introduction of new genetic-engineering tools and the opening up of global commerce allows an emerging "life industry" to "reinvent" Nature and manage it on a world-wide scale. The new colonization, however, is without a compass. There is no predictive ecology to help guide this journey and likely never will, as Nature is far too alive, complex and variable to ever be predictably modelled by scientists. We may, in the end, find

18. *Ibid.*, p.115.

ourselves lost and cast adrift in this artificial new world we are creating for ourselves in the Biotech Century.

3. United Nations and NGO Response to the Biotechnology Challenge

Is the future really as bleak as that painted here? In attempting to find an answer to this question, this section looks at the response of the United Nations and non-governmental organisations to the challenge posed by biotechnology.

Increasing concerns over the hazards posed by genetic engineering to health and to the environment, and in particular, the adverse effects on the conservation and sustainable use of biological diversity led representatives from an overwhelming number of countries as well as citizen groups and scientists to call for a legally binding international protocol on bio-safety.

In recognition of the threats to biological diversity and human health as research and commercial application of gene biotechnology grows, governments from more than 150 countries agreed that the need for and modalities of such a protocol would be considered under the Convention on Biological Diversity. Soon after the Convention was opened for signing in 1992, the United Nations Environment Programme (UNEP) established four expert panels to assist Contracting Parties in identifying priority areas for the implementation of the Convention. The UNEP Experts Panel IV considered a bio-safety protocol to be a matter of critical importance. An overwhelming majority of its members called for immediate work to begin on a bio-safety protocol, given the fact that bio-safety regulations and procedures were already far behind the technological developments, with industry pressuring for commercialisation of a range of genetically engineered products on the one hand, and growing scientific knowledge of ecological and health hazards of genetic engineering on the other. Of particular concern was the lack

of regulation of trans-boundary transfers in experimentation or field tests, especially from industrialised countries to developing ones. The United States, while not a Party to the Convention, rejected the need for a protocol, with the OECD representative advocating a step-by-step approach of establishing national capacities before considering an international instrument.

In the two Preparatory meetings of the Inter-governmental Committee on the Convention in 1993-94, the issue of a bio-safety protocol was of key concern to the delegates. An overwhelming number of countries agreed on the need for a bio-safety protocol and recommended that the Conference of the Parties (COP), at its first meeting, consider immediate work on a bio-safety protocol. When the COP met for its first meeting in Nassau, the Bahamas, (28 November - 9 December 1994), its first substantive decision was to establish an open-ended *ad hoc* working group of experts nominated by governments. The Secretariat of the Convention was requested by the COP to establish a panel of 15 government-nominated experts, assisted by UNIDO, UNEP, FAO and WHO, to prepare a background document to be submitted to the open-ended ad hoc working group of experts nominated by governments at its meeting in Madrid (24 - 28 July 1995). This background document (known in short as the Cairo Expert Panel Report) was prepared when the panel met in Cairo in May 1995. It was then presented to and discussed by the Madrid working group.

Meanwhile, an independent group of experts was set up by a number of environmental and development organisations involved in bio-safety issues, to produce a separate report. This need was urgently re-affirmed when a draft report of the Cairo Expert Panel revealed fundamental flaws in the scientific underpinnings of genetic engineering, and shockingly omitted the wealth of evidence and data in recent years on the health and ecological hazards of genetically engineered products and organisms.

The report of the Independent Group of Experts represents the joint work and contribution of scientists from Ethiopia, Germany, India, the United Kingdom and the United States as well as the work of legal experts. The report contributed significantly to the work of the open-ended *ad hoc* working group of experts and the COP at the critical stage in 1995 when both the need for and modalities of a legally binding bio-safety protocol were being considered under the Convention. After intense and long-drawn negotiations, the COP decided at its second meeting in November 1995 in Jakarta that a legally binding international bio-safety protocol would be negotiated.

3.1 Existing International Soft-law Instruments

There are no binding international protocols or instruments regulating genetically modified organisms (GMOs). But there exist voluntary guidelines specifically covering the issue of genetic engineering. These are described briefly as follows[19]:

(a) *UNIDO Secretariat Voluntary Code of Conduct for the Release of Organisms into the Environment*: The UNIDO Secretariat proposed a Voluntary Code of Conduct for the Release of Organisms into the Environment. The Code which was finalised in July 1991 fails to address, *inter alia*, the issue of international transfers of GMOs. Only the first version of the Code, titled "Draft for a Voluntary International Code of Conduct for Bio-safety", included a short provision stating that there should be no attempt to introduce into another country products that have been refused licence in their country of origin for clearly stated reasons. However, this provision was not included in the final version. The UNIDO Secretariat Code was watered down considerably during its development due to enormous industry pressure.

19. Third World Network Internet Website.

(b) *FAO Preliminary Draft International Code of Conduct on Plant Biotechnology as it affects the conservation and utilization of plant genetic resources*: In November 1991, the FAO Council endorsed the request of the Commission on Plant Genetic Resources (CPGR) that a draft Code of Conduct on biotechnology as it affects plant genetic resources be prepared for the Fifth Session of the Commission. At the Fourth Session of the Commission it was generally agreed that the Code of Conduct should address, *inter alia*, the promotion of biosafety to minimize environmental risks throughout the world.

A preliminary draft Code was presented to CPGR in the beginning of 1993 (CPGR/93/9). An earlier draft had been prepared by experts in a workshop organised by the FAO Regional Office for Latin America and the Caribbean in Santiago, Chile, in December 1991 (CPGR/91/12).

The preliminary draft Code falls into four chapters: Chapter I includes provisions concerning objectives, scope, definition and nature of the Code and its relationship with other legal provisions. Chapter II focuses on the promotion of biotechnology for the conservation and sustainable use of plant genetic resources (including monitoring and assessment of the socio-economic impacts of biotechnology, in particular on developing countries and local communities). Chapter III addresses the issue of bio-safety and other environmental concerns. Chapter IV defines the duty of governments to report to CPGR on actions taken with regard to the Code.

This FAO preliminary draft Code includes safety regulations including those on transfer. Its Article 15 (2) states that, no transgenic plants or other organisms that could adversely affect plant genetic resources intended for release should be imported into a country without that country's Advance Informed Agreement. The Advance Informed Agreement procedure should apply to all

transgenic plants and other organisms that could affect plants independently of the risk assessment and authorization for release in the exporting country."

However, the Commission on Plant Genetic Resources acknowledges that the issue of bio-safety might be better regulated under the CBD. At its meeting in June 1993 the Commission recommended that, in order to avoid duplication and inconsistencies, bio-safety and other environmental concerns which are a component of the preliminary draft Code should constitute an input to the work of the IGC/CBD on this matter (FAO CL 103/16 June 1993). FAO clearly regards the Convention as the proper forum for a bio-safety protocol.

(c) *UK/Netherlands "Draft International Technical Guidelines for Safety in Biotechnology":* These Guidelines were prepared by the Departments of the Environment in the Netherlands and the United Kingdom. A result of two meetings of "a number of international experts", the final draft is dated January 1995. These Technical Guidelines are being circulated and promoted by UNEP as a basis for developing their own Guidelines.

(d) *Agenda 21*: Agenda 21 also makes several recommendations relating to biotechnology and bio-safety. Its Chapter 16 is entitled "Environmentally Sound Management of Biotechnology". Its para 16.32 states the need for further development of internationally agreed principles on risk assessment and management of all aspects of biotechnology to be developed at the national level. It emphasizes the importance of putting in place adequate and transparent safety and border-control procedures. It states:

> Several fundamental principles could underlie many of these safety procedures, including: primary consideration of the organism, building on the principle of familiarity, applied in a flexible framework, taking into account national requirements and recognizing that the logical

progression is to start with a step-by-step and case-by-case approach but also recognizing that experience has shown that in many instances a more comprehensive approach should be used, based on the experiences of the first period, leading, *inter alia*, to streamlining and categorizing; complementary consideration of risk assessment and risk management, and classification into contained use or release to the environment.

More specifically, Chapter 16.35 (c) recommends the compilation, updating and development of compatible safety procedures into a framework of internationally agreed principles as a basis for guidelines to be applied on safety in biotechnology, including consideration of the need for and feasibility of an international agreement, and the promotion of information exchange as a basis for further development, drawing on the work already undertaken by international or other expert bodies.

3.2. The Lack of Binding International Instruments

The Convention on Biological Diversity (CBD), adopted at Rio in 1992, authorised Parties to consider the development of a Protocol "in the field of safe transfer, use and handling of living modified organisms (LMOs) that may have an adverse effect on bio-diversity". With the exception of Article 19(4) of the CBD, there are no binding self-executing international instruments regulating genetic engineering. However, there are some international treaties which may be applicable to some product categories of genetic engineering. These instruments deal only with some of the genetically engineered products. None of them address those aspects which are specific to genetic engineering.[20] Outlines of the instruments are presented below.

---

20. *Ibid.*

(a) *The International Plant Protection Convention (IPPC):* The IPPC, which entered into force in 1952 and has been revised in 1979 and 1983, aims at securing common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote measures for their control. Pursuant to Article VI of the IPPC, the Contracting Parties have full authority to regulate the entry of plants. For this purpose they may, *inter alia:*

(i) prescribe restrictions or requirements concerning the importation of plants or plant products;

(ii) prohibit the importation of particular plants or plant products, or of particular consignments of plants or plant products; and

(iii) list pests whose introduction is prohibited or restricted because they might adversely affect plants or plant products which are of potential economic importance to the country concerned.

However, the phytosanitary certificates give no information about the overall characteristics of the plants, the possible weediness of the plants or predictable interactions between the plants and the surrounding environment.

Although the IPPC is applicable to genetically modified plants and also to genetically modified seeds, it does not cover those safety considerations specific to genetic engineering. The aim of the IPPC simply is to prevent the spread of plant diseases and plant pests. However, if genetic modifications caused by genetic engineering techniques are not considered as creating a plant pest or disease, the protective safety aspects are not applicable. Its focus on plant pests makes the IPPC an unsuitable instrument for regulating those aspects of safety related to genetic engineering. Further, the IPPC covers only plants and plant materials. Other organisms are not covered by the IPPC. As the IPPC focuses on plant pests and diseases it cannot

be recommended to include by revision aspects related to genetic engineering into the IPPC.

(b) *The Convention on Biological Diversity (CBD):* Whereas Article 19(3) of the CBD only requires Contracting Parties to consider the need for and modalities of a bio-safety protocol, Contracting Parties shall according to Article 19(4)

> directly or by requiring any natural or legal person under its jurisdiction providing the organisms referred to in paragraph 3 above, provide any available information about the use and safety regulations required by that Contracting Party in handling such organisms, as well as any information on the potential adverse impact of the specific organisms concerned to the Contracting Party into which those organisms are to be introduced.

Article 19(4), arguably, appears to create a bilateral obligation to provide information on GMOs which a contracting party considers as potentially dangerous to "the conservation and sustainable use of biological diversity".

Thus, Article 19(4) constitutes an obligation for Contracting Parties to establish an information procedure on transfers of those organisms resulting from biotechnology which may have potential adverse effects on the conservation and sustainable use of biological diversity. Wherever such organisms are transferred the exporting state is under an obligation to provide directly or indirectly any available information to the importing state on

(i) the use and safety regulations required by the exporting state in handling such organisms; and

(ii) the potential adverse impact of the specific organism.

This obligation exists, in one view, even if the Contracting Parties do not adopt a protocol under Article 19(3) of the Convention. However, this obligation does not make a protocol unnecessary,

because, firstly, Article 19(4) needs to be implemented, and, secondly, because the scope of Article 19(4) is too narrow as it covers only aspects of transfer.

3.3. A General Comment on the Underlying Assumptions of these Instruments

The main instruments used as a basis for the ensuing discussion are UNIDO's Voluntary Code of Conduct and UNEP Technical Guidelines. These appear to be widely canvassed for adoption as a basis for a national regulatory system on bio-safety.

3.3.1. Voluntary versus binding protocol

Both these instruments - the Code and the Guidelines - are voluntary. They are predicated on the assumptions that

(a) there is no need to subject this new technology to compulsory and binding international rules;

(b) the prime actors in this technology, the Multinational Corporations, will be responsible enough to voluntarily subsume their corporate interests for the common good.

These assumptions are not well founded. First, it is clear that there is a need for a binding protocol. The safety, health, environmental, socio-economic risks as well as the ethical concerns have been well documented, as set out earlier. Although dangers of different technologies are difficult to compare, those posed by genetic engineering of organisms may be even more threatening than the dangers of nuclear and chemical technologies. Organisms that are genetically engineered, once released into the environment, cannot be recalled if discovered to have dangerous effects. Such organisms can migrate and mutate with unpredictable results. Even the manipulation of harmless viruses can turn them virulent. As two researchers in this field, Wheale and McNally note, there is no real

predictive ecology because the way in which genetically modified life forms interact with other organisms, and in different environments, is uncharted territory.[21]

As has been discussed earlier, genetic engineering could affect agricultural diversity irreparably and commercialising transgenic crops could threaten global centres of crop diversity, located primarily in the South.

In the course of the deliberations at the open-ended experts group meeting on biosafety under the CBD in Madrid in July 1995, several arguments were advanced to suggest that voluntary guidelines were preferable to a binding protocol. It is important to examine some of these reasons. These were:

- That the guidelines are flexible;
- That national capacity building should precede the adoption of a legally binding protocol;
- That any exporting country or company will voluntarily abide by the strict regulatory procedures to which they are subject in their own country;
- That the voluntary guidelines are adequate for ensuring bio-safety in relation to GMOs; and
- That we can adapt existing legislation to provide for bio-safety of GMOs.

However, the Instruments may be flawed on many counts. The following is a critique of the above reasons :

- **Flexible Instruments :** Flexibility is indeed often required especially with regard to evolving technologies. But

21. See, *Report of the Independent Group of Scientific and Legal Experts on Bio-safety*, Third World Network, Penang, July 1996.

legislation, both domestic and international, can and does provide for changing standards or requirements as and when necessary. For example, with regard to the accepted doses of exposure to radioactivity, changes to national regulatory systems have been made from time to time as and when new evidence or analysis made this necessary. The International Atomic Energy Agency (IAEA) revised the acceptable threshold level of exposure to radioactivity as a result of a reinterpretation of the data in relation to the Hiroshima and Nagasaki fallout. Many countries, including the UK, revised their domestic standards as well. (The changes were to allow for a lower level of exposure.)

The well-tried mechanism usually employed to achieve flexibility is to incorporate standards not in the main legislation but in subsidiary legislation. The appropriate authority is empowered to and can easily then, change these regulations without recourse to the cumbersome parliamentary machinery.

- **National capacity:** This capacity is for assessing risks posed by GMOs and not for handling biotechnology, as is often vaguely stated. This capacity can, and should, be built co-terminously with a regulatory mechanism. Indeed, if there is lack of capacity, then an internationally binding protocol with prescribed safety standards, will ensure that no country or company takes advantage of the lack of capacity of another country (especially in the Third World), to release or export their GMO product or industry.

- **Status of a voluntary instrument:** A voluntary document can be ignored or violated with impunity. A binding document has to be obeyed by the parties to it. Such a document may also impose a requirement that parties who do not subscribe to this protocol be excluded from (say)

international trade in that particular activity. This is the position under the Montreal Protocol (Article 4).

- **Differential Domestic Laws:** A question may be raised: will countries/companies with strict regulatory laws will voluntarily abide by these standards and laws when operating in other countries? This has been shown to be largely untrue by past experiences. It was precisely in response to strict regulation that many companies relocated and shifted their operations to the Third World. So as regulations tightened, asbestos factories were relocated from Canada, Europe and Japan, to Mexico, Brazil and Taiwan. So too with manufacturing plants of benzidine dyes (known to cause cancer of the bladder to workers). Many other examples may be cited.

- **Adapting existing legislation:** It may indeed be possible to adapt other existing legislation to deal with GMOs. For example, if the GMO is in some instances classified as waste, then some aspects of the Basel Convention may apply. But this is not an efficient and comprehensive way of dealing with all the problems posed by this new technology. Secondly, it is tedious and would involve an arduous and lengthy process to make amendments of all laws which could deal with this subject. On one assessment, for example, Germany would have to amend 96 of its existing laws to deal comprehensively with GMOs and the products incorporating them. For this reason, Germany has specific legislation dealing with safety with regard to products and activities related to GMOs.

Past experience demonstrates clearly that Northern corporations are bound to transfer GMOs, their products and experiments, and projects and industries in respect of them to the countries of the

South. Without standardised and binding international regulations, the dumping of dangerous procedures and products to developing countries could result. Again, as the experience in respect of hazardous products and industries shows, the corporations of the North practise double standards of safety, research and marketing to the serious detriment of the countries and populace of the South.

As regulations become tougher and public concern grows in the North, the temptation becomes greater for industry to relocate in Third World countries with weak regulations and technical know-how. Dr. Alan Goldhammer of the Industrial Biotechnology Association of the US states that "the pathway may be clearer in foreign nations to getting approval." The Royal Commission on Environmental Pollution of the UK, on The Release of Genetically Engineered Organisms to the Environment, expressed concern in its Report [13th, Cmnd. 720 July 1989] that restrictive regulation in some countries, notably of the industrialised West, would encourage companies and research institutes to take advantage of less strict frameworks of control elsewhere. This, it noted, will result in "..a consequent risk to the environment and to the health in that country and more widely".[22.]

Indeed, there is evidence that this has already been happening. Unregulated releases in countries where there is no scrutinization process to ensure safety have been taking place for some time now. In 1989, for example, Monsanto had tested transgenic Roundup-tolerant soybean in the fields of Puerto Rico (Roundup is a herbicide manufactured by Monsanto). Since 1991, it has been doing the testing in Argentina, Costa Rica and the Dominican Republic. Since 1992, Monsanto has been field-testing transgenic cotton in Belize and Costa Rica. The testing is in respect of tolerance to Roundup or to plants becoming insect resistant using the Bt toxin. Field-testing

22. *Ibid.*

of transgenic cotton varieties has also been planned for in Brazil, India and Zimbabwe.

Calgene released insect-resistant cotton and herbicide- tolerant cotton in Argentina and Bolivia in 1991. It plans to sell its transgenic cotton seed, tested as well in South Africa, in Australia, Spain and Greece. It also tested its delayed ripening genetically engineered tomato, the "Flavr Savr", in the fields of Mexico and Chile in 1990 and 1991 respectively.

Ciba-Geigy conducted their field trials of transgenic insect-resistant corn in 1991 in Argentina. Greenpeace International has also documented illegal releases of genetically engineered micro-organisms (GEMs) in Argentina (a vaccina-rabies virus in 1986); Kenya (3 illegal cases since 1989, one involving ornamental plants from Argentina); India (80 different genetically engineered species of microbes imported from Japan and released into field crops); and Ireland (trials with a genetically engineered vaccine for use in fish were undertaken without the European Commission being notified - a clear violation of the EU directive on deliberate releases of GMOs).

3.4 Recent Developments on an International Bio-safety Protocol

Representatives from some 170 countries convened in the historic city of Cartagena in Colombia in February 1999 to finalise the terms of an international Bio-safety Protocol. The United Nations Convention on Biological Diversity paved the way for such a protocol since Article 19 of the Convention provides for a protocol to regulate the use, handling and cross-border transfers of genetically engineered orgasnisms. The South has been particularly conscious of the need for regulation of such cross-border transfers of GMOs because they are the countries of the original genetic material used in the development of such GMOs. Any ill-advised release of such

organisms in their environment could destroy their bio-diversity and sources of food and threaten food security.

But, from the beginning, the bio-technology industry has been bitterly opposed to such a protocol, claiming that self-regulation is a sufficient safeguard. And since the majority of these powerful biotech corporations are based in the US, it is the latter which has become the leading opponent of all attempts to regulate the technology. The US has tried to either scuttle such an agreement, or where this has not been possible, render such an agreement ineffective.

The US, however, refused to sign the UN Convention on Biological Diversity at the Rio Earth Summit, and although it subsequently added its signature to the document, Congress is yet to ratify it. As a consequence, while it can fully participate in the negotiations for a bio-safety protocol, the US has no voting rights. But this handicap has not proved to be an impediment to its drive to obstruct such a protocol. It has always found it possible to achieve its aims through its allies.

It took three years of work to finally produce the draft of the world's first international law on genetically modified organisms. At a series of negotiation meetings between 1995 and February 1999, the resistance of the US and its allies to such a protocol had to be beaten back. During these intervening years, more scientific evidence of the hazards of genetic engineering emerged and strengthened the hands of activists demanding a protocol.

Such a protocol was to have been finalised and adopted at Cartagena, Colombia by representatives of some 170 countries during 14-23 February 1999. Despite the emergence at the conference of a formidable coalition supported by more than 100 like-minded developing countries committed to the objective of an effective bio-safety protocol, the US managed to thwart this goal.

While this coalition sought the establishment of a system which would oblige exporters of products to furnish all available and accurate information about the genetically engineered product and obtain advance written approval from the importing country, the US organised five other countries (Canada, Australia, Argentina, Chile and Uruguay) to form the 'Miami Group' to resist this move. They fought to exclude genetically engineered agricultural commodities destined for food, feed and processing from such a system of advance consent.

To have acceded to the demands of the 'Miami Group' would have been to accept a weak and wholly ineffective protocol. The coalition thus refused to agree to the US demand. With the US proving intransigent on this score and refusing to accept a compromise, the fate of the conference was sealed. Although there are bound to be moves to reconvene another meeting to try to find a way out, the prospects of securing an effective protocol seem dim. In these circumstances, the only course open to developing countries to protect their agriculture, farmers, citizens' health and bio-diversity would be the enactment of comprehensive domestic bio-safety laws, *as well as regional agreements to that effect.*

4. SAARC and Food Security

South Asia is at a critical juncture in its history. The regional as a whole, as well as individual countries, are facing a deep multi-faceted crisis, which is undermining its potential and its resource base. The absolute number of poor in the region has increased in the recent past. According to the Poverty Commission Report, poverty in the region in 1991, based on the conventional 'Poverty Line'

estimates, was between 330 and 440 million.[23] The figures would most certainly have gone up since then.

The problems of poverty are further aggravated by various other social deprivations and discriminations from which the poor suffer. The structural adjustment programmes which accompany the open economy industrialisation strategy currently being adopted by most South Asian nations are having adverse social consequences and putting further strains on the poor, particularly in the short and medium term. And, in the long run, developments in the field of bio-technology in the international arena, and the entry of agro-chemical multinational companies into the region, are bound to have an even more deleterious effect on the small and marginal farmer first, and later, on the economy and society.

It has become increasingly evident that endemic poverty and the other elements in the multifaceted crises have added strains to the political and social situation in South Asia. The capacity to manage these changes is being eroded. What South Asia faces today is not merely a crisis of development, but a threat to its real resource base, to its fragile eco-system, to its democratic structures and to life itself in the region. There is a systemic crisis. No individual South Asian country can solve these problems by itself. A major effort at regional co-operation would be required to complement national development strategies and nation-building efforts.

Globalisation and liberalisation of trade will only enhance social tensions in the region and increase the numbers of food-insecure people. Domestic food security is not simply a residue of trade and global markets, but the result of local resources, capacities and skills. It is essentially a strategy to escape the risks of global frameworks,

---

23. See, Ponna Wignaraja and Susil Sirivardana (ed), *Readings on Pro-poor Planning Through Social Mobilisation in South Asia - The Strategic Option for Poverty Eradication*, Vol. 1 (Vikas Publishing House, New Delhi).

and is based on people's abilities, strength and commitment to master their own development.

The SAARC Agenda for Poverty Alleviation needs to incorporate the following Common Principles of Food Security :

i. Resisting globalisation of food and nutrition.

ii. Emphasizing local rather than global power structures.

iii. Choice of technologies which are mastered by the people, without dependence on outside experts.

iv. Preserving cultural identity, instead of absorbing Western cultures.

v. Regional solidarity.

The SAARC concept of Food Security, if it is based on the above principles, will be able to challenge the dominant political and economic power structures in the North.

5. Conclusion

The paper made as effort at understanding the challenges posed by genetic engineering. While genetic engineering has opened up enormous opportunities for food security in the contexts of poverty-stricken regions like South Asia, the distortionary and disruptive potentials of GMOs are enormous as well. Human efforts at addressing challenges are not that effective yet. The reasons advanced against the need for a binding protocol are, with respect, specious. The binding Directives of the European Community in respect of contained use and application, as well as releases of GMOs are a clear precedent that binding documents on bio-safety, are both possible and desirable.

Moreover, the UNEP Expert Panel 4, set up under the CBD to consider the need for and modalities of a protocol, concluded on the need for a **binding** protocol, stating as its reasons, the following :

(1) Developing countries could be protected from being experimental grounds for the constantly occurring new developments in the field of biotechnology.

(2) Existing legislation in industrialised countries underscored the need for similar legislation in developing countries. International co-operation could be governed by a protocol. This would facilitate co-operation and avoid unilateral decisions.

(3) A protocol would have the advantage of harmonizing existing legislation in the area of bio-safety as well as facilitate the adoption of unified legislation for those countries without legislation. A protocol would also provide for legal redress in appropriate cases.

(4) A codification of a binding instrument would emphasize the importance of bio-safety.

(5) Having national legislation in developing countries without capacity for oversight would merely encourage experimentation in these countries.

(6) A legally binding instrument would compel importers and exporters to recognize their responsibilities in relation to protecting the earth's bio-diversity.

(7) Ethical reasons require parties to take responsibility for their actions.

(8) A protocol could encourage co-ordinated international research on certain neglected areas, such as the transfer of genetically modified organisms, field-tested in temperate zones, to tropical

ecosystems. This is particularly important because of the inadequacy of existing scientific knowledge.

(9) A harmonized system in all countries would help the industry by clarifying and standardizing requirements.

(10) A protocol is essential to protect the environment and address environmental concerns. Countries arguing that there is no risk in transfers have themselves had legally binding rules on bio-safety for a long time.

(11) A protocol could pave the way for safe technology transfers especially since the public is wary of the risks associated with this technology.

(12) Because of the known ability of organisms to cross national boundaries, harmonization of national regulations through a protocol would protect against such trans-boundary damage.

(13) Implementation of the precautionary principle could best be done through a binding protocol. This would assist in preventing damage to bio-diversity.