Biotechnology in Agriculture in Asia: Social Scientist's Concerns

Sudarshan Iyengar[1]

I am indeed grateful to the Vietnam's Department of International Cooperation, Ministry of Science and Technology, Science Council of Asia (SCA) and the Indian Council of Social Science Research, India to grant me this opportunity to address this august gathering on a fairly important issue that is going to significantly affect the humanity in general and people in Asia in particular, as substantial number of them are poor from the viewpoint of westerners. The subject of biotechnology and its implications on society is indeed very vast and I have limitation in taking on the subject in a comprehensive way. I plan to restrict my observations on the subject from the perspective of a social scientist.

Introduction

A general and dominant impression about science and technology is that it is essentially beneficial to the human society by ay of reducing misery and poverty. The basis for this impression lies in an evolved understanding that science and technology strive only for the good of the society and it is per se neutral. It is the users who misuse and abuse. However, this general understanding ignores a basic question as to how and what type of science progresses and why, and who benefits from it? I do not intend to address the question directly in the present paper, but it would get an indirect attention when I try to put before you some concerns as a social scientists about biotechnology in Agriculture in Asia.

Application of biotechnology in agriculture is favoured largely because of its potential to help reduce the poverty from Asia. Non-availability of adequate food to poor is the critical deprivation among poor. A study report prepared by the Asian Development Bank (ADB) in the year 2001 on agricultural biotechnology records that out of 900 million people in the world who constitute the poor spending less than one US dollar a day for living, 75 per cent lived in Asia. That is, more than 500 million people that include children, lack purchasing power to buy enough food. It is generally agreed that the past success in reducing poverty and improving food security in the ever-growing world could achieve thus far and it can't achieve any further. The achievement is not small by any means. The future scenario with respect to population and food demand as project by the expert groups further confirms that the Green Revolution Technology (GRT) can no longer stretch beyond the present production levels. By 2025 population in Asia is likely to increase from 3.0 billion to 4.5 billion. The demand for food is projected to increase by 40 percent from the present level of 650 million tons. It means that the world will have to produce 260 million tons more food to meet the Asia demand.

Increase in area under cultivation is not possible in any significant way. Increase in output per unit of land is the only option left. By increasing the yield per hectare the

[1] Director, Centre for Social Studies, SURAT, INDIA. Dr. Lalitha and I started work on this subject together, I have learnt a great deal from her and I acknowledge her contribution in this paper as well. I also acknowledge and thank Ms. Seema Shukla, Library in-charge at CSS for helping me find relevant literature.

real supply of land can be augmented. GRT had mostly bypassed the rain fed and marginal land areas. The increase in production will have to come from such hitherto neglected land areas with less labour, water and arable land. It is therefore argued that development of biotechnology in agriculture has immense potential to eliminate the food scarcity from the world map. According to Louise O. Fresco, Assistant-Director General, FAO Agriculture Department "Genetically modified organisms (GMOs) are here to stay. Scientists in both public and private sectors clearly regard genetic modification as a major new set of tools, while industry sees GMOs as an opportunity for increased profits". This position in favour of biotechnology is being strongly contended by many including scholars and activists.

Biotechnology has been variously defined and explained. But the definition adopted by the Office of Technology Assessment (OTA) of US Congress is perhaps widely accepted. OTA has defined biotechnology as "any technique that uses living organisms, to make or modify a product, to improve plants, animals or to develop micro organisms for special uses". A fundamental difference between the green revolution technology and the biotechnology is that the later is gene based and hence has implications on health and environment. It is perceived to be more risky than GRT. Bio safety is a major issue that been raised against the GMOs. Gene transfer, weediness, trait effects, genetic and phenotypic variability, expression of genetic material from pathogens and worker safety are some of the issues that still need to settle satisfactorily among the scientists. Nevertheless, the considerations about bio safety have led to an international understanding called Cartagena Protocol, agreed by 130 countries in January 2000. There are conflicting reports on satisfactory compliance. The issue has been flagged for debate both on legal and on moral grounds. Besides the bio safety issue, another important difference between GRT and biotechnology is that the later has been developed largely in private domain and the trade in it is also controlled by private sector. In the new economic environment at the global level, the technology is traded in international markets and thus has been subjected to intellectual property rights. GRT was introduced via research done in public sector but the outcomes were common property. With private domain and intellectual property rights law and legal system became an important third pillar, the other two being science and business. The debate is around these three pillars on which biotechnology is trying to stand. The users are likely to have their own set of perceptions, practices and problems. They are yet to be part of the debate in a significant way. In fact, they form the fourth pillar on which more research needs to be done to make the debate more informed. Scientists and business people vouch for the welfare component in the biotechnology and governments too are eager to put appropriate legal framework so that poor are helped, but the major stakeholders that is farmers poor or otherwise are yet to be heard fully in the debate.

In this brief paper I plan to review the issues around the three pillars science, business and law and try to argue that without considering adequately feedback and pre use assessment from the current and potential users in the developing countries, the debate remains lopsided.

Issues in Science of Biotechnology

The science of biotechnology has developed in developed countries. The developing countries are following. According to an article cited in Economist.com in May 2005, America has grown some 3.5 trillion genetically modified plants since 1994. The reading of the human genome has been completed. Patents have been granted, linked to individual human genes. In a positivist frame nothing seems to be wrong with the science of biotechnology. If something is indeed wrong and seriously so there is no ‘proof positive’. Risk and uncertainty is accepted in stride. Outside this framework ethical issues galore and bio-politics is on. According to Economist.com article for most non-scientists these things all seem to involve fiddling around with nature to a greater or lesser extent. And, taken together, they prompt a whole series of perplexing ethical questions that will affect politics everywhere. The article quotes Leon Kass, an ethicist at the University of Chicago and presents his narrative. According to Kass, he cannot name any national politician who understands the subject. And, second, experience has taught him that his side (he is one of the leading sceptics) will always lose: it is fighting “against an enormous amount of money, against the general liberal prejudice that it is wrong to stop people doing something and, in many cases, against everybody’s quite rational fear of death” (Economist.com, May 3, 2005).

Before we get into further details on biopolitics and how different stakeholders view it, it would be useful to go through some scientific aspects as they have been brought out. From the discussion and literature review scientific issues relating to biotechnology can be classified under two heads food safety and environmental safety. The ADP report (2001) that I have mentioned in the beginning contains an informative table, which the authors have compiled with help of the work by Skerrit and Wolfenbargen and Phifer done in 2000. The table lists the issues and contains remarks almost as compliance. The table is reproduced in appendix. Going through the list of risks and remarks one gets an impression that most risks are *perceived* and *not genuine*. The tone in the remarks is that yes, the gene technology can get notorious and the persons and brains behind them can play mischief and hence they require monitors and prefects who can and should control. Let us look at various types in this. An example of food safety is about toxin and poison case. In 1998, a scientist in Rowett Institute in U.K. found that GE potatoes spliced with DNA from the snowdrop plant (a viral promoter) are poisonous to mammals. The monitor, in this case, U.K government’s advisory committee for Novel Food and Process examined the data and concluded that the experiment was faulty and conclusions were wrong. So, Mr. Scientist, don’t conduct experiments wrongly. Well, it may be true in the case mentioned. The issue is biotechnology can make GE product splice with DNA of any material that can be poisonous. How does one answer this question? Well, the answer is that there is risk and such risk is there in many other non-gene sciences and humanity is lived with it for such a long time.

Second type of risk listed is increased cancer risk by using biotech material. The worry expressed is over Monsanto’s bovine smatotrophin (a growth hormone). Remark has been fairly straightforward it is not GM food. In any event it is banned in Europe and America. Not widely used in US. It might be true that it is not widely used in America and banned in Europe because they are flushed with milk and do not know what to do with this perishable commodity, but the developing countries have choice between cancer and hunger, so hunger wins, cancer can wait. Would this not be the solution in the name of pragmatism? Obviously, the hormone trace is entering the human body via milk. Milk is genetically engineered food. The hormone per se may not be GM food. If there is increased risk of cancer, it is an issue in biotechnology science that will have to be addressed. Banning at one place does not solve global level human problem related to it.

Third type of risk and an example listed in the ADB report is about Brazil nut gene spliced into Soybean that reportedly induced allergies among people sensitive to Brazil nuts. The Science verified that the protein was allergen and hence further development was abandoned. Standard lab is the answer for identifying possible allergenicity in GE products. Same question becomes relevant; if there is potential risk why get into it? Fourth type of risk is contamination. The Starlink case of GE Maize is a known example. The example given in the table is about US beer makers using the Starlink Maize ingredients. The remarks say that it was an accident and Starlink maize got mixed with other maize for human consumption. The remarks made are incomplete and therefore highly misleading, as the mix was not only accidental, but also farmers were not necessarily aware that they are not supposed to mix. Some farmers who planted a variety of bio engineered corn unapproved for human consumption say they were not adequately warned about restrictions on how it was to be planted, stored and sold, despite suppliers' claims to have done so. Farmers in several midwestern states have said they were not told that the corn, known as StarLink, must be kept separate from other crops until reports emerged last month that it had been detected in a brand of taco shells… "The farmers calling in, to a man, said they had never been told it wasn't fit for human consumption," said Kenneth Root, host of "Agritalk," a program carried on many rural radio stations…"We never found out until two weeks ago," said Fred Rosenberger, who grew 40 acres of StarLink corn in Rineyville, Ky., this year. Mr. Rosenberger said that because he stored the corn before realizing that it should be segregated, some 8,000 bushels of StarLink corn were mixed in with about 42,000 bushels of other varieties…"I'm sick of it," Mr. Smith said, vowing to never plant another Aventis product (quoted in the Friends of Earth Report, 2001). The matter in reality did not end with Starlink getting used in beer production. It came to market for direct sale and shops had to withdraw huge quantities. If the US pushes the stock to hungry Asia and Africa even by accident, what mechanisms these countries have to know that it is Starlink Maize and not the non-GE that is edible? The answer to this should come from science and not from regulation.

Fifth type of risk is more in the area of uncertainty. It is the use of antibiotic marker gene possibility of human body developing resistance to antibiotics. The remark says that there is no evidence as yet and antibiotic maker has been replaced with a safer marker. Who controls the experiments and if cost criterion sits heavy what would private entrepreneurs do?

The second set of risks relate to possible environmental impacts. The ADP report lists seven of them. Increased pesticide residue, genetic pollution carried by rain, wind, birds and bees (pollen carriers), damage to beneficial insects, creation superweeds, superpests, creation of new viruses ad bacteria, and genetic bioinvasion are possible environmental risks. The remarks in most cases says that nothing has been conclusively observed and found so far and monitoring systems have been put in place in some cases such as damage to beneficial insects etc. How does one feel confident that if a particular disaster has not occurred thus far, it is not likely to occur in future? In case environmental risks relating to new viruses and bacteria and superweeds and superpests, an Indian Molecular Biologist G Padmanabhan of the

Indian Institute of Science, Bangalore, India has this to say. “The battle between micro- organisms and human beings is millennium old and the former are much smarter than all the scientists put together. Sooner or later resistance will emerge but our work is to find new ways of handling them” (as quoted in Visvanathan and Parmar 2002, p 2720). The issue is who settles the need to interfere in the gene world and for what usefulness to the humanity. The scientists are not the final risk assessors. Politics overpowers them and they too become opinionated. Scientists have also constructed their narratives and Visvanathan and Parmar (2002) have analysed it well. We have already seen what Padmanabhan’s narrative is. It is an Asian perspective likely to be shared by many other scientists in Asia and those who think and write about Asia. Carrying forward his narrative one understands that according to him at the level of science there is hardly any problem. “The molecular method adopted now, which involves addition of one, two or more genes is a drop in the ocean compared to enormous genetic influx going in nature” (Visvanathan and Parmar 2002 p 2720). The debate according to him has to be different in America and Europe and India and Asia. A well-fed and well-provided Europe opposes GE food dumped by America in Europe stores is a different proposition than the food supply to hungry and undernourished people in developing countries. It is an economic issue between America and Europe; it has hardly anything to do with science.

In another similar construct Balasubramanium of Centre for Cellular and Molecular Biology, Hyderabad, India draws from Bronowaskian approach and says that both food plants and human being need each other for propagation. He looks at agriculture in a broader perspective and differentiates between gene based and non-gene based technologies and emphasises the place for the latter in recent times. According to Visvanathan and Parmar (2002) who quote him, he (Balasubramanium creates not another ‘disciplinary’ narrative, but a domesticating one. He naturally develops human being’s familiarity and ownership in it.

The second set of narratives is about the control of the technology. Dr. Pushpa Bhargava (founder of the Centre for Cellular and Molecular Biology in India), as per the analysis of Visvanathan and Parmar (2002), does not worry about the science of biotechnology. For him it appears to be all right. It is the framework within which it is coming to the developing countries. If it comes to the developing countries from the developed countries it will have maximum exploitation component in it and the developing countries will be destroyed economically. Developing countries should not depend on developed countries for ideas, know-how and products. Visvanathan and Parmar call this political anxiety and according to them Dr. Bhargava is eloquent when he asks, “How do you dominate a country where 700 million people are directly dependent on farming? *You infiltrate its agriculture*” (Visvanathan and Parmar 2002 p 2720). This point would be considered again when I discuss business and biotechnology.

The biopolitics within the developed nations where the advancements in biotechnology has been achieved and in the developing countries are certainly different. Leon Kass, an ethicist at the University of Chicago has as I have narrated earlier has aptly summed the position of ethicists. In fact, Suman Sahai of India has been highly vocal about this. She argues, “Ethical concerns are a luxury if developed countries. Developing countries should not just follow the moral dilemmas of the north but balance the ethics of biotechnology against the ethics of poverty” (as quoted in Visvanathan and Parmar 2002 p 2721). She gives examples of two GE products growth hormone rBST and *Flavar Savar* GE tomato and carried forward the argument that developing countries cannot afford to ignore the advantage and should accept both for improving food and nutrition availability. What she objects vehemently is the western supremacy and control over it. Starting from the ethical considerations she holds a very firm view that it has to be completely indigenous and should be developed to the fullest extent.

Let me end this section by bringing the views of M.S. Swaminathan of the Swaminathan Research Foundation Chennai, India. The ex IRRI Director General needs no more introduction, as he is known among the Asian and the World community of agricultural scientists. Visvanathan and Parmar (2002) have given an extensive account on Swaminathan's position on biotechnology. According to him it is an extension of GRT and in addition it is more inclined towards sustainable agriculture. Swaminathan appears to be politically more correct than any one else in the country. Both Suman Sahai and Swaminathan converge on the point of using local and traditional knowledge. Swaminathan suggests a strategy wherein he says that for village development the integration of the best in traditional wisdom and technologies with the best in modern biological technologies. Visvanathan and Parmar (2002, p 2716) have the following to say on Swaminathan's formulation. "Note how every major concept has been absorbed, every dualism bridged, participation, sustainability, local knowledge, technological blending, every fashionable concept of the development-democratic world has been absorbed. Every scientist is happy, all economists are content, and any activist would be hopeful".

Though differently both Sahai and Swaminathan would tend to harm the long-term interest of the developing countries including the ones in Asia. Sahai offers the biotechnology deal to the companies from developed countries on platter. The defence that she puts up for biotechnology goes only to suggest that future survival is impossible without biotechnology. The companies in business look for such blanket certificates only to push their agenda and sell. As we shall see, it is not only that they sell, but also that they successfully manipulate to see that no one else sells! Sahai makes a serious mistake when she shows total ignorance about the way the in which regulatory systems are set up and run in the developing countries. Swaminathan also by his 'holdall' recipe gives green signal to all and sundry in biotechnology to come into developing world since his concept of development is integrating global developments with local needs (glocal - to borrow form Visvanathan and Parmar). By providing argument in favour of one particular technological option they make the politicians job in developing countries easy. Gupta and Chandak (2005) make a case on this. The poser obviously is in the realm of ethics. The authors argue that when good economic returns follow a bad ethical practice in terms of technological change by not respecting environmental regulation and monitoring, nor intellectual property rights, do end justify means? The authors go on to quote the case of Bt. Cotton in Gujarat, a province in western India and show that despite possibility of other non-Bt. alternatives to losing hybrid cotton, all stakeholders opted for Bt. cotton.

One may conclude on this aspect of science in biotechnology that neither all is with the science in agricultural biotechnology nor is everything is correct with perceptions, construct and narratives of the established scientists. As far as the science is concerned it has been introduced premature and the possible reason is because its development has been mainly in the hands of the private sector that is in a hurry to make up for the losses due to failure of GRT ingredients. There are two basic concerns that a social scientist would have. First, whether there is a standard norm about the assessment of risk and uncertainty of negative impacts of technology before it is recommended for commercial or non-commercial use on a wide scale. Second, how would society at large be informed confidently about the safety in using or warning about potential hazards? In case Starlink Maize farmers were not told that they have to store and stock the GE Maize separately and not with other non-GE Maize. Second is how scientists not only become open but also create scope for examining all possible alternatives in each society at local levels.

Issues in Business of Biotechnology

Discussion in this section is on two aspects. One aspect is the economic benefits of the use biotechnology in agriculture especially to the poor and marginalized sections of population who also suffer from the problem of under nutrition. Second aspect is business of biotechnology experiments and products and international trading in it.

As I had mentioned earlier the major players in the game namely, business people, scientists and governments all vouch for the interest of the poor and small farm holders doing agriculture. At most levels there is also an acceptance that the GRT has failed. The Biotech is the newfound panacea for the food and poverty problems in the developing countries. Before one discusses the potential benefits, let us take a look at some statistics relating to poor and under nourished.

Table 1 Population Scene in the Developing Countries and Countries in Transition

(Population in millions)

Region/ Countries	**Total Population**			**Proportion in Total Population**		
	1979-1981	1990-1992	1999-2001	1979-1981	1990-1992	1999-2001
Developing World	**3240.2**	**4050.0**	**4712.2**	**100.0**	**100.0**	**100.0**
Asia and the Pacific	2303.5	2812.1	3204.8	71.1	69.4	68.0
East Asia	**1060.9**	**1241.1**	**1353.4**	**32.7**	**30.6**	**28.7**
China	998.9	1169.5	1275.0	30.8	28.9	27.0
S.E. Asia	**354.8**	**444.8**	**517.0**	**10.9**	**11.0**	**11.0**
Indonesia	150.3	185.6	212.1	4.6	4.6	4.5
Vietnam	53.0	67.5	78.1	1.6	1.7	1.7
South Asia	**884.9**	**1122.4**	**1329.6**	**27.3**	**27.7**	**28.2**
India	689.0	861.3	1008.9	21.3	21.3	21.4
Latin America & Caribbean	355.9	442.2	512.0	11.0	10.9	10.9
Near East and North Africa	237.0	321.3	392.4	7.3	7.9	8.3
Sub-Saharan Africa	343.8	474.5	603.0	10.6	11.7	12.8
Countries in Transition	N.A.	412.6	411.8	N.A.	10.2	8.7
India + China	**1687.9**	**2102.4**	**2362.3**	**52.1**	**51.9**	**50.1**

Source: 1. The State of Food Security in the World 2002, FAO.
2. The State of Food Security in the World 2003, FAO for the year 1999-2001 data.

World population in 2001 was 6132 million. The proportion of population living in the developing world was about 77 per cent. It can be seen from table 1 that India and china constitute majority of the population in the developing countries. During the last two decades beginning 1980, change in population in countries and regions among the developing countries are worth noting. East Asian countries including China have experienced a relatively fast decline in its populations. South East Asia has registered a small growth and its share has gone up by 0.1 percentage point. Similar increase in share has been registered by India, although South Asia's share has increased by more than half a per cent. It means countries other than India has experienced higher growth in population. Bangladesh has experienced relatively faster growth in population among the South Asian countries.

Near East and whole of Africa has experienced rapid population growth in the last two decades. From Table 1 we can see that share of Sub-Saharan Africa in the total population of the developing countries went up from 10.6 per cent in 1979-81 to 12.8 per cent in 1999-2001. It is known that the population in developed countries have stabilised and in some cases it is decreasing. It is obvious that the developing countries would be home for most population in the world and its share might touch 87 per cent when the World population stabilises at about 10 billion with middle level fertility rates.

It is obvious that poor are also found in more in developing countries. In fact, developed countries do not have poor people who spend less than two US dollars a day on living. Considering the same time period 1999 and 2001, the poverty profile revealed by the World Bank's World Development Report in electronic version that contains regional profiles, one finds that the absolute number of poor living on less than one US dollar a day came down from 1482 million in 1981 to 1089 million in 2001. China experienced drastic reduction from 634 million to 212 million. In 1981 China had nearly 64 per cent population living with less than one US dollar spending. In 2001 such population in China was about 17 per cent. South Asia including India too experienced fall in the percentage of population living below the international poverty line, but the fall has not been as drastic as that observed in China. If China follows the same rate of decrease China will do away with poverty soon. Developing countries as a whole had 40 per cent of population spending less than one US dollar in 1981 and this percentage came down to 21 in 2001. Sub-Saharan Africa shows persistence of poverty. It is around 45 to 46 per cent. When one considers the population below the level of two US dollars a day spending, developing countries are in stark situation. More than 52 per cent were still below poverty line in 2001. Even in China such population was about 46 per cent. In Sub-Saharan Africa more than 75 per cent of population lives below poverty line.

It is worth noting that people living with less than one and two US dollars a day are not necessarily going without food. Data one under nutrition show the divergence between money poverty and ability to get nourishment. Table 2 below contains data on under nourishment in the countries of the developing world. One may note that the number of people spending less than one US dollar a day in almost all developing countries are more than those who suffer from under nourishment. There are some exceptions to this and the picture between 1981 and 2001 is not very happy one. Before we get into the analysis it must be admitted that the data sources are different, i.e. one agency is not responsible for both data sets. Under nourishment data is from

FAO and poverty data are from the World Bank. Both draw from various country surveys that might have been conducted by different agencies. Yet, macro level comparison should be possible to derive some insights.

Let us begin with developing countries as a whole. In 1981, 38 percent of all those who spent less than one US dollar a day could buy their full nourishment, as the number of people reported in under nourishment category were 62 percent of those who spent less than one dollar. In 2001, the situation has worsened. Out of all those who spent less than one US dollar only 27 percent could buy their nourishment, as 73 per cent were under nourished (Table 2). The situation in sub-regions and some specific countries reflect the trends in detail. Let take China first. The drastic change one notices in the poverty figures is somewhat mystical. In 1981, 52 per cent of persons in china who earned less than on US dollar a day did not report under nutrition, but in 2001, only 36 per cent could buy full nourishment. Is it likely that the data collection had some methodological problems? Or those who were relatively better of in the less than one dollar income group crossed over the poverty line and the poorest remained where they were or went further down.

Table 2 Prevalence of Under nourishment in Developing Countries and Countries in Transition

	Number of People Under nourished (Millions)			Proportion of Under nourished in Total Population %		
	1979-1981	**1990-1992**	**1999-2001**	**1979-1981**	**1990-1992**	**1999-2001**
Developing World	920.0 (1482.0)	818.5	798.9 (1089.0)	28	20	17
Asia and the Pacific	727.3 (796.0)	567.3	505.1 (271.0)	32	20	16
East Asia	307.7	198.2	144.5	29	16	11
China	303.8 (634.0)	193.0	135.3 (212.0)	30	16	11
S.E. Asia	88.4	76.5	66.3	25	16	13
Indonesia	36.6	16.7	12.6	24	9	6
Vietnam	16.8	18.0	15.1	32	27	19
South Asia	330.5 (475.0)	291.6	293.1 (431.0)	37	26	22
India	261.5	215.6	213.7	38	25	21
Latin America & Caribbean	45.9 (36.0)	58.8	53.4 (50.0)	13	13	10
Near East and North Africa	21.5 (9.0)	26.0	40.9 (7.0)	9	8	10
Sub-Saharan Africa	125.4 (164.0)	166.4	198.4 (313.0)	36	35	33
Countries in Transition	N.A.	30.2	33.6	36	35	33
India + China	565.3	408.6	349.0	68.0	41.0	32.0

Figures in brackets are numbers in million showing population living with less than one US dollar a day.

Source: 1. The State of Food Security in the World 2002, FAO.
2. The State of Food Security in the World 2003, FAO for the year 1999-2001 data.

Latin American countries give a totally different picture. In 1981, not only all those who spent less than one US dollar a day were under nourished, but also some of those who spent up to two US dollars a day. The positive aspect is that the percentage of persons falling in this category of spending less than two dollars a day and yet remaining under nourished declined substantially. Sub-Saharan Africa also improved its position with respect to proportion of persons being able to buy full nourishment. In 1981, only 23.5 per cent of all those who spent less than a dollar a day could buy full nourishment whereas, in 201 the share increased to 37 per cent.

Before we analyse the under nourishment and food security issue, let us take a look at Table 3 that contains information on distribution of undernourished within the developing countries.

Table 3 Distribution of under nourishment People in Developing Countries and Countries in Transition

Region/Country	1979-1981	1990-1992	1999-2001
Developing World	100.0	100.0	100.0
Asia and the Pacific	79.1	69.3	63.3
East Asia	33.4	24.2	18.1
China	33.0	23.6	18.1
S.E. Asia	9.6	9.3	8.3
South Asia	35.9	35.6	36.8
India	28.4	26.3	26.8
Latin America & Caribbean	5.0	7.2	6.7
Near East and North Africa	2.3	3.2	5.1
Sub-Saharan Africa	13.6	20.3	24.8
Countries in Transition	--	3.7	4.2

Under nourishment and poverty has shifted from China to Sub-Saharan Africa.
Source: Computed from Table-2

It is clear from the table above that under nourishment profile has changed between 1981 and 2001. From Asia and Pacific, under nourishment has moved to Africa. This has been made possible because China has been able to affect a drastic reduction in the proportion of under nourished population. In South Asia the proportion has increased marginally.

The food problem is to be viewed in the above context. In recent times, Bjorn Lomborg (2005) has made a very scintillating contribution to the debate on environmental crisis and sustainability. He has presented a database according to which developing countries have done well with respect to average food availability in terms of calories. Obviously, one of the limitations of this type of macro exercise is that it conceals distribution. But one has to admit that even the data on under nourishment records relative decline. An interesting aspect of Lomborg's analysis on food situation is that agricultural biotechnology is conspicuous by its absence. The only reference he makes about it indirectly is referring to it as "designer" varieties of crops that offer greater resistance to diseases, thereby reducing pesticide consumption (Lomborg p 64). He attributes the increase in agricultural productivity and total production to Green Revolution Technologies. High yielding crops, irrigation and controlled water supply, fertilisers and pesticides and farmers' management skills are identified as specific factor that have contributed to the phenomenal rise in agricultural productivity. He records that in the 1960s Sub-Saharan Africa and Asia almost started at same levels and Asia progressed fast because of irrigation which now stands at 37 per cent, and per hectare chemical fertiliser consumption that has averaged 129 kg. Sub-Saharan Africa still is with 5 per cent irrigation and 11 kg of chemical fertilise use per hectare. Lomborg does not show any dislike for biotechnology, but clearly thinks that the next phase of growth that has to be there is Africa will come form GRT approach. He argues, "One sometimes hears that the use of pesticides and intensive farming methods are harmful to environment. But what alternative do we have, with ore than 6 billion people on earth? If we abandon intensive cultivation and the use of pesticides, farmers would either need *far more space* to grow the same quantities or end up producing *far less food*" (p 64).

Lomborg in another chapter in part III of the books further breaks the myth about declining per capita grain availability, declining productivity, limits to yield, biomass debate, ordinary peasant (read small land holders) etc. He shows that per capita availability has increased and there is no "wall" or maximum yields in sight. He suggests that most farmers should be able to achieve maximum yield that only 20 per cent of farmers in the world achieve in case of wheat, rice and corn, the basic cereals. He quotes FAO projections that production of foodgrains will still increase at 1.6 per cent annually in the developing countries over next 15 years. Grain stocks are enough and with smooth international trade facility any disaster or catastrophic harvest failure anywhere in the world can be met. Africa remains a problem. It will grow but slowly. To sum up lomborg on this issue of food availability practically everything is fine. Some monitoring and smooth international trade (implying that developing country imports food) will help the GRT achieve spectacular results up to 2050 and after that world population stabilises.

Now let us ask a simple question. If what Lomborg says is true why is biotechnology debate? Second, the food problem is and in future likely to occur in Africa and some other developing countries. How has the biotechnology based agriculture growing? Let us take the second question first.

Crop biotechnology in the field is relatively recent phenomenon. It can be seen from table 4 that even in 2001 there were only 13 countries that had begun with GM crops. The area under GM crops has jumped impressively from about 2 million hectare in 1996 to about 53 million in 2001.

Table 4 Area under GM crops, globally, from 1996 to 2001

Year	Number of countries	Million ha	Change in area over previous year	Million ha
1996	6	1.7	-	N.A.
1997	N.A.	11.0	550	9.3
1998	9	27.8	153	16.8
1999	12	39.9	44	12.1
2000	13	44.2	11	4.3
2001	13	52.6	19	8.4

Source: ISAAA (2001).

The relevant question in the context of the debate is which countries have taken lead? Table 5 below contains data by country.

Table 5 Area under GM crops by country, 1999 and 2001

Countries	1999		2001		1999-2001	
	Area	Share in global area	Area	Share in global area	Change in area	
	Million ha	Percentage	Million ha	Percentage	Million ha	Percentage
Developed countries	32.8	82	39.1	75	6.3	19.2
United States	28.7	72	35.7	68	7	24.4
Canada	4	10	3.2	7	-0.8	-20.0
Australia	0.1	<1	0.2	<1	0.1	100.0
Others	<0.1	<1	<0.1	<1	n.a.	n.a.
Developing countries	7.1	18	13.5	24	3.6	90.1
Argentina	6.7	17	11.8	23	3.3	76.1
China	0.3	1	1.5	1	0.2	400.0
South Africa	0.1	<1	0.2	<1	0.1	100.0
Others	<0.1	<1	<0.1	<1	n.a.	n.a.
Total	39.9	100	52.6	100	12.7	31.8

Source: ISAAA (2001) and calculations

With 10 years of track record in the world United States and Canada together contribute for more than 80 per cent area in 1999 and 75 per cent in 2001. India is not on the map at all. China has just about 1.5 million hectares in 2001. South Africa is just 0.2 million hectares in 2001. Most hungry countries are yet to start GM crop cultivation in any meaningful way.

The next important inquiry is what GM crops are being cultivated. In 2000 the picture was the following.

Table 6 Major GM Crops grown in the World

Crop	1998	%	1999	%	2000	%
Soybean	14.5	52	21.6	54	25.8	58
Maize	8.34	30	11.1	28	10.3	23
Cotton	2.5	9	3.7	9	5.3	12
Canola	2.5	9	3.4	9	2.58	7
Potato	-	< 1	<0.1	>1	<0.1	<1
Squash	0.0	0	<0.1	<1	<0.1	<1
Papaya	0.0	0	<0.1	<1	<0.1	<1
Total	27.8	100	39.9	100	44.2	100

Source: *Agricultural Biotechnology, Poverty Reduction, and Food Security,* Asian Development Bank. Manila 2001.

If we read all the tables on GM crops together we may say that America is happy growing Soybean and exporting to other countries of the world. I am not so sure that the poor and hungry in Asia and Africa consume Soybean in large quantities. Maize also is grown in large quantities in United States. Rejected from the American super markets has Starlink found way to poor countries as human food?

At this stage it is useful to go back to some basic statistics generated by the FAO. In a report published in 2003 as a contribution to the World Water Development Report it is estimated that all countries taken together about 1438 million hectares in 1998. Area irrigated at the global level in 1998 was about 271 million hectares, which is about 19 per cent of the cultivated area. If we focus on major Asian countries the following picture emerges.

Table 7 Values of Key Indicators on agriculture, food and water for selected Asian Countries

Country Developing Group	Population 1999-2001 in millions	% Poor less than 1 US $ 1998	% under nourished 1999-2001	Cultivated land in 000 ha.	Irrigated area as 5 of cultivated area	Agricultural water withdrawn as % of total renewable water
China	1275.0	18.8	11	135365 (0.12)	39	14
Indonesia	212.1	12.9	6	30987 (0.15)	16	3
Philippines	75.7	36.8*	22	10000 (0.13)	16	4
Vietnam	78.1	50.9*	19	7250 (0.09)	41	5
India	1008.9	44.2	21	169650 (0.17)	34	31
Bangladesh	137.5	29.1	32	8332 (0.06)	46	6
Pakistan	141.3	31.0	19	21970 (0.16)	82	39

Figures in brackets show cultivated area per person.
* National Poverty figures are given, as international poverty figures are reported
Source: FAO, 2003. *The State of Food Insecurity in the World*, FAO, Rome.
FAO 2003. *Agriculture, Food and Water*. FAO., Rome
World Development Report, 2003. The World Bank, Washington D.C.

The availability of cultivated land per capita is low as may be observed from Table 7. In 1998 the average cultivated land per person at the global level was 0.26 ha and we can see in the table the selected Asian countries with high population base have almost half of the world average. Irrigation and use of renewable water figures vary significantly across the countries. South Asian countries India, Pakistan and Bangladesh are very high in irrigation percentage and Pakistan and India also use more than 30 per cent of annual renewable water stock. Pakistan is second only to Egypt in using water, as Egypt uses 100 per cent of its renewable water for agriculture. China and Vietnam are two other countries that have near or above 40 per cent area under irrigation.

It can be once again seen that poverty and food availability do not completely overlap. People are poor but not necessarily undernourished. According to the FAO report on food and water (2003), “It is expected that in future 80 per cent of increased crop production in developing countries will come from intensification through higher yields, increased multiple cropping and shorter fallow periods. The remaining 20 percent would come from expansion of agricultural land in those developing countries and regions where the potential for expansion exists and where the prevailing farming systems and general demographic and socio-economic conditions favour it” (p13).

It is interesting that FAO does not mention in any significant way even in its 2003 report the possibility of increase in agricultural yield via GM crops root. The future increases in yield and output that are predicted for coming 15 to 30 years are to largely come from non-GM crop combinations. If there is an agreement on the stability of population at global level, then it appears that the non-GM sources of growth in agricultural output should tide over the food requirement of the world. If one believes in the FAO statistics, with increased population the cereal availability per capita per year has gone up from 141 kg to 173 kg during last 30 years. The cereal production has grown faster than the population.

While the macro picture is not so very disheartening and pessimistic, micro situations are likely to differ. Both small and big countries that have utilised soil and water in an unsustainable fashion and are stuck with problems of acute water scarcity and soil degradation might not be able to increase productivity so impressively and if population segments in such areas continue to grow steadily, the poverty and food insecurity will increase. The argument in favour of GM crops is that it would help poor farmers to grow with assured yields. Assured yields will generate income through which they will be able to buy food.

Suppose for a moment let us accept that GM crops have minimal and tolerable food safety and environmental risks, how is planned to be reached to small landholders and poor farmers. The existing scheme and the scheme that is being pushed forward is that of leaving it to the private sector. This brings us to the second part of the discussion on issues in biotechnology as a business.

The business of Biotechnology

The evolution of Biotechnology in agriculture is interesting and yet quite complicated. The research in biotechnologies began in private sector when the GRT technologies and especially the use of pesticides failed to produce expected results. Cost of cultivation increased and profits came down. The pesticide companies wanted to examine some other alternatives. It supported the gene-based research. It was high tech and therefore expensive and high-risk venture too. Damodaran (1999) has attempted a comprehensive analysis of the growth of high tech business at global level. Damodaran has traced the growth of Monsanto and shown that the merger and acquisitions among the pesticides and agricultural inputs companies has been phenomenal. Monsanto from almost a non-entity emerged as the biggest player in agricultural inputs and at present it is the single largest company controlling GM seed market. Damodaran’s argument appears convincing when he says that the evolutionary processes suggest that ultimately there would be very few companies who would control the seed market at the global level. He clearly establishes that oligopolistic tendencies have taken hold of the biotech industry in the world and things are not likely to change.

Capturing market share at the global level will become very important and the powerful companies will further become powerful. It is no surprise that two things are being emphasised and lobbied constantly by these companies. First, there is pressure for free trade so that international markets are assured. Even if whole of United States and Canada use Monsanto GM seeds, the operations might not become profitable for the company and hence the future market and profit prospects are to be found in the developing countries. Profit being a dirty word, the multinational companies want to display ‘corporate social responsibility’. They thus announce their commitment to remove hunger from the planet earth. Discussing one of the environmental risks earlier ‘terminator gene’ was not discussed in full. Monsanto had made all moves to get the terminator gene approved. It is argued that wiser counsel prevailed and there was tremendous pressure on the governments and the regulating authorities not to grant permission for marketing the terminator gene. The danger is not over. If the biotech world is the ultimate reality if the protests group loses as Kass feels that it would, the danger of gaining complete control over the supply of seeds will become a potent threat like the danger of nuclear weapons. The second weapon, which will be made more powerful because of the failure to get the terminator gene approved, is the intellectual property right. Since there has been an agreement on IPRs, it will be made more stringent in way that in which the companies will gain.

Nearer home, in one of the Asia’s vibrant cities Bangalore in India, which commands the global respect for IT growth, biotech business has displays more hype than real. In an interestingly analysis, Scoons (2002) examines whether there is any growth of agricultural biotechnology in a developing country that is likely to help the poor. His findings suggest that the answer is in negative. He concludes, “Somewhat ironically, the local emergent companies riding on the back of the Indian biotech revolution will service US/European companies for US/European products and markets (designer medicines and crops), while (at least in the near term) it will be only foreign concerns (multinationals, and probably increasingly the Chinese) that will provide products in to the local market, and these only as spin-offs from product development for elsewhere”(p 2732). Scoons thinks that urban up starts with capital, real estate owners, companies with approved propriety to sell and well-to-do farmers are likely to benefit. He refers to findings of the Nuffield Report in which the worst-case scenario for India is depicted as favouring only some in a selective manner.

It is fairly clear from the above discussions that biotechnology in agriculture appears to be a quintessentially a business proposition that is trying to introduce a novel item in agriculture with the backing of modern and cutting edge science and immense political support from the powerful developed nations. The use for the novelty is purportedly for the poor and hungry of the world. This is a case where the demand does not exist in reality, but is created. The positivist frame of mind in solving developing world’s problem is once again very clear. Technological fix is still the *mantra* for solving poverty and underdevelopment problems. The struggle is to provide ‘proof positive’ by experimentations manipulated or otherwise. Swaminathan with his holdall (combining traditional wisdom and local knowledge with modern technology) will sound good, but the Glocal village is hardly going to be a common sight.

There is a set of people, and perhaps in fairly large number, who agree that more than profit greed will be the motive for capturing the markets in the developing countries. Many among them also agree that biotechnology per se is neutral and hence in order to reach it to the needy and poor it should be regulated. Damodaran (1999) has shown that despite the oligopolistic tendencies among the producers, the consumers are a careful lot. His survey of farmers in Karnataka has shown that farmers are not blindly accepting the GM variety of seeds. And he predicts that farmers are going to be like that everywhere and therefore argues that the demand for the product that the oligopolistic is producing is not going to be inelastic. However, to safeguard the farmers and their interest governments should intervene and regulate the dealings. The third pillar on which the biotechnology is likely to stand is Law.

Biotechnology and Law

Glover (2002) gives an interesting account of the requirement of the legal pillar in the development of biotechnology. According to him the Business-science hybrid requires a third pillar, a legal one, and which is critically important. Biosafety and intellectual property rights are very important to get established in regulatory framework because they help in determining the chances of successes in commercialisation. Industry’s engagement with the policy makers and World Trade Organisation has been significant in arriving at the TRIPS agreement. Developing countries were under pressure to provide either patents or an effective sui generis protection for the ownership of plant varieties. All the countries have not been able to accomplish this within the time period. Chaturvedi (2002) argues that while the pressure on the developing countries was on, developed countries were already attempting varietal protection through much more stronger patent regime, which did not allow any exemption and were much narrower in scope than the plant patent and plant variety protection. Utility patents and research patent tools have further made things difficult for the developing countries.

It is important to understand the background a little in the above context to appreciate the unfolding of the IPRs scenario with regard to biological research in agriculture. Traditionally most biological research in the field of agriculture were kept outside intellectual protection because, these biological entities have ability to reproduce themselves, which made it difficult to enforce property protection. In recent past, private sector has invested heavily in agricultural crops in developed countries. According to an estimate biotechnology research has attracted huge investment of about US $ 5 billion in intensive research in agricultural crops by the private sector of the developed countries (Iyengar and Lalitha, 2004). In developing countries there is hardly any private investment and public investment is in the range of US $ 125 million. Various researchers have recorded that US leads in this regard and is followed by European countries and Japan. As we noted the point made Chaturvedi and Glover, there has been intense lobbying to get the patents for the biotechnological innovations in agriculture.

Plant breeder’ right, patents, trademarks, geographical indications and trade secretes can protect innovations in agriculture. Union Internationale pour la protection Obtentions Vegetables (UPOV) is a multilateral treaty. It is administered in cooperation with the World Intellectual Property Organisation. Several countries have also adopted it. Iyengar and Lalitha have discussed the Indian case and it is illustrative. India has developed a sui generis system which is weaker than the patent system. The draft bill on Indian Plant Varieties and Farmers Rights Bill in 2001 is relatively stronger than the UPOV. According to the Indian Act the distinctiveness criterion requires that the variety seeking protection is to be distinguishable from other variety by at least one essential characteristic. Secondly, the extent of protection provided to the breeder stops at the right to produce, sell, market, distribute, import or export the variety and does not extend to harvested material and other products obtained from material of the variety. Thus, Monsanto cannot claim right over the harvest from the protected seed and the farmers are allowed to reuse the seeds. Most non-European legislations including that of US allow the farmers to reuse the seeds. European legislation is more stringent. Farmers, if they reuse the seeds, they have to pay royalty to the breeder. In short, the private sector participation in seed technology has led to evolving of complicated legal structure.

The second part of the legality is related to ensuring biosafety. It must be noted that hitherto in other GRT the safety issue was there in the case of pesticides and other chemical input in agriculture but they did not require any strict protocols before they were introduced. Exposure to pesticide spray could be lethal and yet it did not mean that one had to take permission to introduce in any country. For introducing biotechnology based agricultural product there has to be a national governmental level committee and there have to be extensive system of experimentations to ensure that the product is safe for use. The political environment finally determines the rigor of the protocol system.

There are three types of models one observes. First type is where laissez faire principle is in operation and democracies offer maximum opportunity and freedom to individuals and their initiatives. Western countries fall in this category. As we have noted, the business interests in these countries have immense capacity to lobby for their space and expansion in business. Strong business interests at times bypass the real hazards, danger, risks and negative externalities. The second type is democracies in developing countries. The greed is crass and manipulation levels are high. Iyengar and Lalitha (2002 and 2004) have elaborately discussed the process in which Bt. Cotton has got approval of the Government. The third type of government are totalitarian and incidentally, these types of governments are also in strong positivist frame and once convinced that what they are deciding was scientifically correct, they coerce the subject to follow the regulation. The governments can also fudge figures and features and manipulate results and problems. Facts could be twisted. There would be both under and over reporting depending upon the requirement. Admittedly, the laissez faire societies have better chance of setting up best protocols and be constantly monitoring, but these societies are also economically powerful and strong and the business houses there want to gain control over the other weaker economies. The biotechnology thus, is not necessarily ‘safe’ even with legal support.

Biotechnology as if People Matter

Persley (2001) calls agricultural biotechnology a Promethean science. This frank admission brings to the fore the risks involved in it. Introducing biotechnology widely in agriculture appears like playing with fire. But with great ease Persley quotes M.S. Swaminathan’s holdall approach! Persley describes poverty and the problem of food security. He again takes recourse to Swaminathan. Most researchers who are taking macro view of the problem of poverty and under nutrition argue that increase in population in poor countries reduces land per capita and irrigation water. Poor in desperation move to urban areas and urban poor have severe food security problem. Agricultural biotechnology is a saviour; it will produce food in farms and incomes in urban areas. There is clearly a paradox in this. One has to agree that application of biotechnology in agriculture is in its infancy in the developing countries, but it has been receiving overwhelming response. The ADB report (2001) that I have referred earlier describes the process how biotechnology will contribute toward poverty reduction and food security. "Agricultural biotechnology is expected to contribute significantly toward poverty reduction and food security in Asia through increased productivity, lower production costs and food prices, and improved nutrition." (p xix). It is recorded in the report that the focus of the biotechnology in Asian countries has been on 'orphan crops' implying thereby that rich countries and private sector has not been paying attention to it. It is doubtful whether this is happening on large scale. Scoon's (2002) analysis suggests that the biotechnology development in Bangalore in India is to support the western countries requirements and he argues that the multinationals from west would come forward with biotechnology in some of the orphan crops.

To put the situation in perspective for Asia, agricultural biotechnology is yet to prove its usefulness for poor and hungry. Let us go back to table 2 and recapitulate that all those who earned less than one dollar did not suffer from under nourishment or nutrition. Food availability is not completely linked with income poverty. Control over production resource is important and it includes well-defined property rights. If the poorest of the lot do not own piece of land they will have more food insecurity than those who own some land. Further when we look at the cultivated land and water situation, we find that climate and rainfall still play a dominant role. In China Bt cotton yields came down substantially in 2000 to 2237 kg per hectare from 3371 kg/ha in 1999. The reason recorded for the drop in the yield was bad weather. (Huang et.al 2002). The drop was one third. For a poor farmer it is substantial. In most developing countries small and poor farmers with land undertake agriculture that has family and neighbourhood nature's inputs. Irrigation with GRT did bring the agriculture into market vortex, but farmers had choice to use their own seeds. However, in case of hybrid cotton, they had to buy. Marketisation of agriculture increases the risks to the small farmers. Lack of irrigation facilities compounds the risk many more times. A bad weather can cause devastation. Farmers' suicides in Andhra Pradesh in India are now well-known. The main reason is that small farmers when get into market vortex have to borrow heavily to buy inputs. If the output is not commensurate the economy is shattered. Biotechnology offers reducing yield risk by an improved or resistant trait, but at a cost that is not low. Problem of controlling weather factor still remains. If pushed too hard small farmers would sell land in distress and join the ranks of landless labourers army and move to urban areas to create pressure over there. Damodaran (1999) has already recorded that farmers in Karnataka are not blindly after Bt varieties. Similarly, Iyengar and Lalitha (2004) have also found significant variations in inter farm, inter village and inter region variations in Bt cotton in Gujarat.

Finally, there is a sense of déjà vu here. The GRT also promised great improvement in the lives of small farmers and poor in the world. Its impact has been there, but again it has not been the only saviour of the poor. Biotechnology has yet another dimension of risk and safety which has potential to cause serious reversals and generate high negative externality. Even if American farmers are not told that Starlink maize has to be stored separately because it is not fit for human consumption, what is the guaranty that poor farmers in poor countries are going to be made aware about the dos and don’ts of Bt crops. In developing country such as India one of the well-know constraints in the way of achieving better agricultural productivity is credit to buy inputs. Even in the conventional agriculture if the societies are unable to set up and run institutions facilitating small marginal farmers, in a totally market driven cultivation of Bt crops how could one expect poor farmers to operate? If FAO’s own predictions are right then with possible expansion in the area under agriculture and with better water application to crops and some GRT, food production can be increased, why engage the poor in more risk and uncertainty?

Appendix

Table 1

Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops

Nature of Risk	Type of Risk	Remarks
Food Safety	1. Toxins and poison. In 1998, a scientist in the Rowett Institute found that GE potatoes spliced with DNA from the snowdrop plant (a viral promoter) are poisonous to mammals.	The UK Government's Advisory Committee for Novel Food and Process examined the data and concluded that the experiment was faulty and the conclusions were wrong.
	2. Increased cancer risks. Monsanto's bovine somatotrophin (growth hormone) injected into dairy cows to produce more milk has been reported to cause cancer in human breast, prostate, and colon.	This is not a GM food. In any event, Canada and the European Union have banned its use. A United Nations Food Standard body has not certified its safe use. The hormone is no longer widely used in US.
	3. Food allergies. In 1996, a Brazil nut gene spliced into soybean was reported to induce potentially fatal allergies in people sensitive to Brazil nuts.	The safety assessment confirmed that the protein was an allergen and the development was abandoned. A standard laboratory test has been available to test possible allergenicity in GE products.
	4. Contamination. StarLink, a GE maize variety approved for animal feed but not for human consumption, was found in an ingredient used by some US beer makers and in taco shells in the US in 2000.	The incident was caused by an accidental mix of StarLink with vast amounts of other maize during harvest, storage and distribution. The contaminated food was recalled and destroyed. A number of quick and cheap tests are available to determine the presence of GM products in food.
	5. Antibiotic Resistance. Use of an antibiotic marker gene in the development of GE crops may contribute to the growing public health danger of antibiotic resistance.	There is little or no evidence about this risk yet. But this is an emotive topic, and developers have now replaced the antibiotic marker with a safer marker.

Nature of Risk	Type of Risk	Remarks
Environmental Risks	1. Increased pesticide residues. Farmers growing GE crops will use as many toxic insecticides and herbicides and conventional farmers, thus increasing pesticide residues in soils and on crops.	This risk is not yet proven statistically. There are reports that farmers growing GE crops resistant to pests and herbicides are able to reduce production cost significantly through the reduced use of pesticides. That was a major reason why farmers adopted GE crops widely in the PRC and the US.
	2. Genetic pollution. Wind, rain, birds, and bees have carried genetically altered pollen into adjoining fields, contaminating the DNA of organic, non-GE crops.	This genetic pollution is not an environmental issue unless the transfer of pollens causes some kind of environmental damage. Pollen contamination has taken place for centuries with or without genetic engineering.
	3. Damage to beneficial insects. Scientists from Cornell University found that pollen from Bt maize was poisonous to Monarch butterflies and may be to other beneficial insects as well.	Monitoring systems have been devised in the PRC and the US to evaluate the long-term effect of GE crops on beneficial insects.
	4. Creation of superweeds. GE crops (soybean and canola) resistant to herbicides may transfer their resistance to weeds, turning them into superweeds, which cannot be controlled by herbicides.	This fear has yet to be proven. Scientists are closely monitoring the use of GE crops resistant to herbicides.
	5. Creation of superpests. GE crops (maize and cotton) resistant to pests may transfer their resistance to pests, turning them into superpests which cannot be controlled by pesticides.	As above, this fear has yet to be proven in practice. There is no known mechanism by which pest resistance from a plant may be transferred to an insect pest.
	6. Creation of new viruses and bacteria. Biotechnology could help terrorists to create killer viruses or bacteria, which could be used in biological weapons.	This could happen, even without biotechnology. Terrorists historically have managed to acquire and subvert beneficial technologies to antisocial purposes.

Nature of Risk	Type of Risk	Remarks
	7. Genetic bioinvasion. By virtue of their superior genes, some GE plants and animals will inevitably run amok, overpowering wild species in the same way that introduced exotic species do.	There is as yet no scientific evidence that such plants and animals can be created through biotechnology.
Socioeconomic Risks	1. Terminator technology will render seeds infertile and force hundreds of millions of farmers to purchase more expensive GE seeds and chemical inputs from a handful of global biotechnology and seed companies.	The Monsanto Company has withdrawn the terminator gene from its GE crops following many complaints from farmers.
	2. High concentration of biotechnology research and development in developed countries will widen the income disparity between developed and developing countries, and between large and small farmers.	The public sector is Asia should accord high priority to biotechnology development that addresses the problems of small farmers.
Ethical Concerns	1. Biotechnology reduces all life to bits of information (genetic code) that can be rearranged at whim by scientists. The creation of the first genetically modified monkey in 2000 brings the possibility to genetic manipulation closer to human. There is fear that the technique will be used to create "designer babies."	Although most of these ethical concerns relate to non-agricultural biotechnology, they point to the need for the private sector to incorporate work ethics in biotechnology research and development.
	2. There seems to be little ethical concern by the private companies over the use of GE animals to produce therapeutic drugs.	

Bt = *bacillus thuringiensis*, DNA = deoxyribonucleic acid, GE = genetically engineered, GM = genetically modified, PRC = People's Republic of China, US = United States.

Source: Skerritt (2000) and Wolfenbargen and Phifer (2000) as quoted in Asian Development Bank 2001. *Agricultural Biotechnology, Poverty Reduction, and Food Security.* A Working paper, Asian Development Bank, Manila.

References

Asian Development Bank 2001. *Agricultural Biotechnology, Poverty Reduction, and Food Security*. A Working paper, Asian Development Bank, Manila.

Chaturvedi Sachin,2002. "Agricultural Biotechnology and New Trends in IPR Regime: Challenges before Developing Countries", in *Economic and Political Weekly*, Vol. XXXVII No. 13

Damodaran A. 1999. "Regulating Transgenic Plants in India: Bio Safety, Plant Variety Protection and Beyond", in *Economic and Political Weekly*, Vol. XXXIV No. 13.

Economist.com May 3, 2005

FAO 2003. *Agriculture, Food and Water*. FAO., Rome

Friends of the Earth, 2001, Chronology of the Exposé of Genetically Engineered Corn Not Approved for Human Consumption. www.foe.org.

Glover Dominic, 2002. "Transnational Corporate Science and Regulation of Agricultural Biotechnology", in *Economic and Political Weekly* Vol. XXXVII No. 27.

Gupta Anil K and Chandak Vikas, 2005. "Agricultural Biotechnology in India: Ethics, Business and Politics", in *International Journal of Biotechnology* Vol.7 No. 1/2/3 pp 212-225.

Huang Jikun et al., 2002. "Agricultural Biotechnology Development Policy and Impact in China", in *Economic and Political Weekly* Vol. XXXVII No. 27

Iyengar Sudarshan and Lalitha N, 2002. "Bt. Cotton in India: Controversy Visited", in *Indian Journal of Agricultural Economics* Vol. 57 No.3

Iyengar Sudarshan and Lalitha N, 2004. "GM Cotton in Gujarat: General Madness or, Genuine Miracle?" Paper presented in *National Conference on Biotechnology* held at Institute for Social and Economic Change, Bangalore, November 2004.

Lomborg Bjorn, 2005. *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge University Press, U.K.

Office of Technology Assessment of the US Congress (OTA) 1986. *Technology, Public Policy and Structure of the American Agriculture*. U.S. Government Printer, Washington D.C.

Persley G.J, 2001. *Agricultural Biotechnology and the Poor: Promethean Science*. http:/www.cgiar.org/bioech/repo1oo/persley.pdf

Scoons Ian, 2002. "Biotech Science, Biotech Business: Current Challenges and Future Prospects", in *Economic and Political Weekly* Vol. XXXVII No. 27.

Visvanathan Shiva and Parmar Chandrika, 2002. "A Biotechnology Story: Notes from India", in *Economic and Political Weekly* Vol. XXXVII No. 27.