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Policy Challenges for Agricultural Biotechnology in the Asia Pacific: Developing a Framework for Analysis†

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Policy Challenges for Agricultural Biotechnology in the Asia Pacific: Developing a Framework for Analysis

Introduction

Developments in modern biotechnology and genetic engineering have introduced new options in agriculture. Many of these have controversial effects, and are being opposed by environmental and social activists around the world. However while opposition to these new technologies in agriculture has come from activists, scholarly studies charting the actual impacts for peoples' livelihoods have been few partly because of the recent nature, or low levels of adoption of these technologies. This is particularly true of developing countries, where despite high levels of research investments in biotechnology and increasing demand for agri-biotech products, there are few studies on these technologies[1].

The paper then seeks to go beyond rhetoric and emotive debates and develop a framework for facilitating effective technology development and transfer in different countries in the Asia-Pacific region. By focusing on issues related to agrarian structure, agricultural systems, and the nature of global and regional integration, a heterodox and heterogeneous approach to the analysis of technology uptake and impact assessment will be developed. It is argued that such an approach is essential for formulating effective policies for agricultural biotechnology.

A preliminary analysis of studies of agricultural technologies based on modern biotechnology and genetic engineering reveals several strands in the way in which these are critiqued by scholars and activists in the developed and developing countries. Ethical – as differentiated from moral – reasons and environmental and health effects are most often cited by opponents of these technologies for imposing restrictions on them. On the other hand, activists particularly in developing countries have cited direct effects on poverty, and indirect effects, in terms of the impacts of environmental degradation on livelihoods, as reasons for opposing these technologies. In particular, effects for specific groups such as women, agricultural labour, and those who are more dependent on natural resources, common property, and diversified farming and livelihood systems are projected as being acute.[2] However while activists have quoted selected studies and anecdotal evidence in support of their positions, rigorous studies similar to those in the west are absent for most developing countries. This is partly due to the methodological complexity of assessing actual and potential long-term environmental impacts on people's livelihoods.

Conversely, supporters of modern agricultural biotechnology have quoted environmental sustainability and poverty reduction as key reasons for encouraging adoption of these technologies. There has been general acceptance of such arguments by governments in developing countries such as India and China, despite misgivings by environmental activists. Actual strategies for introduction of agricultural technologies based on biotechnology and genetic engineering, as well as safety regulations have differed from country to country, with implications for actual uptake and dissemination of these technologies. However while environmental sustainability and economic profitability have been key arguments for investing in research and development by authorities in developing countries, rarely have other socio-economic concerns been taken into consideration as will be shown in this paper.

Particularly, the impacts (actual and potential) in terms of the consequences of biotechnology adoption for peoples' sources of livelihoods, and the mechanisms by which rural people are able to meet their subsistence needs, have not been adequately analyzed. What are the capabilities and

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[1] An exception is China where a number of studies have been carried out on the adoption and impact of Bt cotton varieties.

[2] For a detailed discussion of the above arguments and issues, see Parthasarathy, 2002.

entitlements that people gain or lose as a result of a particular configuration of natural resource management strategies, access to resources and technology use?[3] What are the implications of new regulatory systems introduced, on farmer's abilities to manage resources, and cope with vulnerability contexts?

This paper logically develops some of the consequences of modern biotechnology and genetic engineering for peoples' capabilities and entitlements, in different countries, keeping in mind the differences in demography and political economy - especially the agrarian structure and the levels of development and global economic integration – that prevail in the countries of the Asia-Pacific. Secondly, the paper attempts to assess both the probabilities for increasing adoption of agri-biotech products and negative externalities in terms of environmental sustainability, economic independence, and farmer's capabilities to adapt and innovate. This assessment will involve an evaluation of the impacts of increasing interdependence of countries in the Asia-Pacific, and global interdependence in general, with respect to increasing trade, technology, political, and environmental linkages. Intellectual Property Rights (IPR) regimes enhance interdependence among countries and may affect people's abilities to cope, adjust and innovate in order to adapt to changes. Environmental consequences of these new options such as loss of biodiversity also can significantly impair community resilience in the face of stresses and shocks, and environmental, demographic and economic changes. Thus it becomes important to assess whether these technologies, despite their benefits, have the capability as critics allege of perpetuating inequalities among groups within a nation and between nations and economies. This can occur through excluding people from access to forms of knowledge, skills, techniques, and markets, all of which are important for subsistence, survival and for competing in a globalized economy.

Shifts in technology and IPR regimes resulting from the process of globalization transform the social organization of knowledge systems and their application - with a concomitant decay in indigenous knowledge systems. More importantly these have significant impacts on particular social groups such as women, small and marginal farmers, pastoral communities, agricultural labour, groups more dependent on commons etc. A significant aspect of the new changes is that they are brought about by a specific combination of international legal mechanisms and technological / scientific techniques that recast social and economic relations between social groups, communities and nation-states.

Apart from the scientific / technical differences between modern biotechnology and conventional agricultural technologies, all of which have consequences for the environment, plant behaviour and human metabolism, other differences emerge when the principles of modern biotechnology are put into practice. The implications for developing countries include those for biodiversity, problems related to technology transfer, knowledge and skills retention for women, and the role of privatization in influencing the choice of research area in terms of commercial versus social considerations. Arguments for 'substantial equivalence' (of new technologies with older ones) then, are derived from a narrow, laboratory based view of the science of genetic engineering. As we shall show laws and regulations relating to the testing, use, production and patents of these technologies then do not even consider the social and economic consequences of these technologies, and seem to be concerned only with certain kinds of private property rights and prevention of environmental damage. Assessments of costs and benefits of these technologies do not touch upon many social, economic, and cultural issues of communities who are affected by the new technologies.

Thus while some scholars (Janvry et al, 1999) gloss over capabilities effects by stating that GMO (Genetically Modified Organisms) technology "substitutes for human capital at the farm level", the actual effect *can* be one of throwing existing skills into disuse, *or* reducing the capabilities to adapt,

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[3] The terms 'capabilities' and 'entitlements' here are used in the sense made popular by Amartya Sen.

innovate and experiment. In conditions of high variability and risk, this loss cannot simply be substituted by technologies.

On the other hand some activists and scholars, particularly in India have argued that global economic linkages and new technologies create the capacity among marginalized groups in developing countries to overcome barriers to poverty reduction arising from feudal social and economic structures, and government inefficiencies[4]. However it is well recognized in the literature that enabling factors such as asset ownership, access to resources (irrigation), access to credit, information flows etc. are crucial for determining and facilitating adoption of new agricultural technologies. The need for enabling factors though is determined by the actual and specific traits of the technology - hybrids for instance, are more input intensive compared to open pollinated varieties (OPVs), and seeds need to be purchased every year, whereas OPV seeds can be saved for sowing the next season. As a study by Vasavi (1999) reveals, there is a crucial link between technology change, government policy and the working of market forces that affect sustainability of cropping systems and adaptation to changes in important ways[5]. A proper understanding of this linkage is therefore essential to understand the impact of technology led agrarian change on marginalized and vulnerable groups.

However, contrary to this individualization and community breakdown paradigm, some studies (Parthasarathy and Chopde 2000) indicate that commercialization of agriculture and/or the introduction of technological innovations need not necessarily result in the 'separation of the economic dimension of local agriculture from its established cultural bases', nor result in social implications in terms of 'disjunctions' and 'dissonances' within society, as Vasavi (1999) argues. If, in 'privileging the economic impetus of taking to commercial agriculture, many had overlooked the importance of retaining social ties' in parts of the country, this could be because of the traits or characteristics of the technology[6], the mode of transfer and diffusion of technology, and the strength of social ties and social relations in the community under study. In societies that had been studied by us 'collective social reproduction of the society has not been made subordinate to individual economic reproduction', and therein perhaps lies hope for technology and R & D led poverty reduction strategies. The discussion of policy challenges regarding uptake and impact of modern biotechnology will therefore be guided by these considerations.

In this paper three countries – China, India, and Thailand - are taken up for detailed study and analysis. The choice of these countries was partly determined by the fact that these countries possess strong research capacity in molecular biology and biotechnology, including what is termed as "upstream" capacity located in universities and national research institutions, to develop new tools to address specific in-country needs.In the rest of the paper, I analyze the policy frameworks for managing research capacities, channeling research investments, and regulating the use of products and tools of modern biotechnology. These are then assessed and evaluated in terms of the agrarian structures and agricultural systems, and integration of these countries into global trade regimes. A theoretical framework is then developed which identifies sound criteria for identifying techniques and tools which promote economic development and reduce poverty in rural areas of these countries, and which can serve as a starting point for research priority setting and drive policy

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[4] Gail Omvedt in India has made such arguments which have been quite influential in countering the arguments of opponents of modern biotechnology such as Vandana Shiva. For a discussion of their debate, see Viswanathan and Parmar, 2002.

[5] These linkages are stronger as globalization and regional integration strategies proceed apace.

[6] Hybrid seeds need to be purchased. They also require purchase of more inputs and therefore make the farmers more dependent on external agents. On the contrary cultivars require less inputs, and seeds can be saved from the previous year's harvest.

making. On the basis of this, the range of techniques that have become available as a result of research and technology development suited to these agrarian structures are identified.

The Need For Sound Policy Frameworks

Preliminary reviews of policies in many Asian countries reveal confusion in the policy frameworks affection agricultural biotechnology and genetic engineering, as evidenced in the statement of the Thai Prime Minister Thaksin Shinawatra in response to a question about Thailand's position on Genetically Modified Organisms - "We should not say that we want or do not want GM". Trade issues, pressures from groups opposed to the new technologies, and the pressing need to address issues of agricultural productivity and sustainability all influence policy making. The objective in this paper is not simply to review the contentious debates, nor just to develop an argument for or against the introduction of these new technologies. Much of the debate rests on offering new or old 'scientific' evidence, as proponents and critics base themselves on ethical, moral, and socio-economic considerations to make their point. The position adopted here is that such arguments should be tested out in concrete situations and that micro-level field studies are necessary to make headway in the debate. However the few existing studies seem to use conventional cost-benefit analytical techniques, which ignore both the unique characteristics of the technology and also leave out a range of issues that are not captured by such techniques[7]. In order to avoid the problems of doing "empirical research without theoretical imagination[8]", this paper adopts the 'progressive politics' approach outlined by Foucault, which requires going beyond recognizing "ideal necessities, univocal determinations, or the free play of individual initiatives". Progressive politics requires an approach which seeks "to understand the manner in which diverse scientific discourses ….. (as practices linked to certain conditions, obedient to certain rules, susceptible to certain transformations) are part of a system of correlations with other practices." In analyzing the scientific discourse on biotechnology then, we need to go beyond just adducing 'scientific' evidence to support or oppose its use for developing agricultural economies. The technologies available have to be linked to other systems and practices under very specific socio-economic contexts themselves undergoing change. The progressive politics approach is apt, particularly because choice of techniques are simultaneously political choices.

Scholars from a liberal perspective as well as those from radical or Marxist traditions have tended to believe that there is "nothing inherently harmful in this new set of tools"[9], or that problems emerge because they are "tied to private profit". These and others from an anti-globalization position have also written about the effects of corporatization (MNC Control) and proletarianization on farmers in developed and developing countries. Such a position however takes an undifferentiated approach to the tools and techniques of modern biotechnology and genetic engineering and furthermore seems to focus more on the products that have emerged out of R & D rather than the techniques themselves. Suggestions by those working in the International Agricultural Research Centres[10] for greater public sector involvement for instance assumes the unproblematic nature of the technologies that have become available, similar to the position of some Marxists that with the abolition of capitalism, the technologies will be used beneficially under socialism or state control. But what of economic or health concerns or concerns regarding our inability to roll back or recall certain technologies which may have adverse consequences? What of societies and communities where the state or the public sector may emerge as a more powerful entity dominating over peasants and farmers and reducing their freedom to follow chosen livelihood paths? What are the

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[7]Studies carried out by Carl Pray and his colleagues in China constitute an example of this.

[8] A statement made by Bourdieu.

[9] Meddeindorf et al, 2000.

[10] See article by Sharma et al, 2002.The writings of Per Pinstrup Andersen of IFPRI are typical of this view.

possible impacts of environmental change resulting from new technologies on livelihoods for specific groups such as women, agricultural labourers, and those more dependent on natural resources, common property, and diversified farming and livelihood systems?

Such questions lead us to the conclusion that consensus statements that are coming out with increasing frequency are of little use. In trying to overcome some of the problems outlined above, these statements advocate public-private partnerships, participatory approaches, or the marriage of 'biotech' with organic or traditional systems of agriculture. An ADB study for instance states that after "weighing risks and benefits" comes to the conclusion that developing countries in Asia should promote new technologies since the benefits are more[11]. Not only does such an approach overlook long-term consequences, but it is also an inappropriate strategy for policy making. Such approaches and consensus statements ignore the question of choice, that technological choices are also political choices, in that power relations are involved in making technological choices. They tend to overlook the problem of understanding the needs of farmers, and how these needs are to be assessed.

Technological policies generally have several objectives. Depending on the usefulness and threat / risk perceptions, policies are usually a combination of enabling or facilitative features and regulatory or restrictive aspects. Developing unambiguous and specific policy guidelines requires a clear understanding of the implications of a technology gained from an evaluation of the range of possibilities inherent in the technology and their impacts on poverty, income, equity, sustainability, risks etc. Where policies are shaped more by threat perceptions and only a vague understanding of benefits, they are unlikely to fulfil their objectives.

Assessment of impacts requires knowledge of real and potential adoption which in turn are dependent on the appropriateness of the technology. Vague understandings or estimates of adoption from developed country contexts are unlikely to be of much use in assessing technology uptake in developing countries. Technologies are likely to be adopted only if they are suitable in terms of agro-ecological context, agricultural systems, agrarian structures, and presence of appropriate institutions. Differential adoption in a stratified society may lead to gender, ethnic or class based equity problems. A sound policy on agricultural technology whether from a developmental or regulatory perspective therefore requires an analysis of these issues in order to determine the 'fitness' of these technologies.

Policies on Agricultural Biotechnology and Genetic Engineering: India, China, and Thailand

China, India and Thailand, among the developing countries of Asia, are arguably ahead of other countries in developing capacity and acquiring advance research capabilities in agri-biotech research. However, China is the only country where commercial cultivation is taking place of genetically engineered crops. The others are yet to permit commercial cultivation though field trials and testing are at an advanced stage. Techniques other than genetic engineering however have contributed to developing new products and practices which are being used by farmers in all countries. An analysis of policy statements, guidelines, and other declarations by government and research bodies in China, India and Thailand on agricultural biotechnology leads to the identification of several determinants of policy. Pre-existing discourses on agricultural development seem to have a strong influence on the decision by the governments in these countries to invest heavily and promote private sector participation in biotechnology R & D. It is possible to agree only partially with the view that "the technological trajectory of the Green Revolution was shaped by the exigencies of modernization in post-colonial societies, while the technological trajectory of the Gene Revolution is being shaped by the imperatives of neo-liberal economic globalization" (Parayil, 2003). Statements made by authorities in China and India especially reflect the feeling that their countries

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[11] See ADB, 2001. In responding to critics, the argument is made that biotechnology is useful provided there is a focus on the needs of the poor, provided public sector is involved etc.

'should not be left behind' in the race to develop biotechnology innovations. Both India and China have a history of investing in big science, in areas which require huge investments, and which carry prestige internationally but which haven't yielded benefits consistent with the level of investments. This perhaps explains why China and India have been among the early starters in agri-biotech research among developing countries, and why they are now regarded as having a strong research and development capacity in molecular biology, including "upstream" capacity to develop new technologies and products for their own specific needs. Hence the modernization discourse still seems to steer research policy and priorities in India and China.

Regional networks and trade agreements also appear to have had impacts on the decision to invest in and develop research capacities for biotechnology R & D. The Asian Rice (and Maize) Biotechnology Network, the Asia Pacific International Molecular Biology Network, the Sub-Group on Research, Development and Extension of Agricultural Biotechnology of the Agricultural Technical Cooperation Experts Group (ATCEG) of APEC, and the Sub-Committee on Biotechnology (SCB) of the ASEAN Committee on Science and Technology (COST), all have contributed immensely to promote interest and research in agricultural biotechnology and genetic engineering in the Asia Pacific region. The UNDP in association with the International Centre for Genetic Engineering and Bio-technology (ICGEB) at Trieste has set up a sister centre at New Delhi for promoting biotechnology in the Asian region.

'Real life' problems have been an important influence too. The imperative to ensure food security, declining or stagnating crop yields, droughts, degradation of natural resources and resource scarcities, increasing pest and disease incidence – all figure in official discourse. However evidence of actual investment and research do not seem to match these concerns. In Thailand biotechnology research has yielded important benefits to tackle disease in shrimp – an important export commodity. Rice biotechnology continues to be an important area of research in all three countries. However research largely seems to be focused on those areas in which substantial progress has been made by the private sector (eg. Bt Cotton), or in areas which are not very important in economic terms for the country in question – vanilla, cotton and mustard in India for example. In general very little research is being done or results have been obtained in subsistence crop, or other crops that can enhance food security and productivity of major food crops.

International funding for agricultural research from corporate sources and donor agencies are more for modern biotechnology, while funding for conventional breeding seems to be on the decline, especially in the IARCs. The CGIAR centers in Asia in recent years have seen substantial reductions in funding situations but are going ahead with more expensive molecular biology and genetic engineering research[12]. Due to their still preeminent role in influencing research priorities and objectives, these centers have without doubt exercised an influence on policy making in Asian countries.

Finally movements of opposition to the new technologies have influenced regulatory aspects of biotechnology policies based on substantiated and unsubstantiated evidence of the risks involved. Policies are influenced both by the perceived risks for producers (farmers), as well as risks deriving from consumer demand and trade – a major agricultural commodity exporter like Thailand has been wary of losing European markets by opting for GM technology, and so has precluded commercialization for the present.

Policies on agricultural biotechnology are linked to larger policies on agriculture, and in theory the technology aspect constitutes one of a possible range of solutions to agrarian and agricultural problems. Problems of productivity are as much related to institutions, tenurial arrangements, asset ownership, and access to resources as adoption of new technology. While it is clear that the emphasis on biotechnology is partly a response to new situations arising out of national and international changes (de-collectivization in China, economic liberalization in India), it is by no

[12] This is the case for instance of ICRISAT and IRRI, both located in Asia.

means clear that the policies have considered other technological and non-technological measures to problems, and even whether the new technologies are likely to yield results given the current agrarian situation. In the other words, while the 'fitness' to global market conditions, and to markets as such seem to be a consideration, the fitness to agrarian structure which will determine both adoption and nature of impact do not seem to be part of the policy making process.

China

China claims to be the first country to introduce a GM crop commercially (an insect resistant tobacco variety), and currently has the fourth largest GM crop area sown in the world, and the highest area among Asian countries (Zhang, 2002). The official policy of the Chinese government is to promote biotechnology as a national priority. The government views agricultural biotechnology as a tool to improve food security, raise agricultural productivity, increase farmer's income, foster sustainable development, and improve its competitive position in international agricultural markets. An additional objective of China's technology policy is to pursue a leadership position in biotechnology development. To achieve these objectives the Chinese government has given priority to agricultural biotechnology investment in their policies and programmes including the National Program on High Technology Development (popularly known as the 863 Program), and the National Program on the Development of Basic Research (referred to as the 973 Program)[13].

Research to develop transgenic crops is being carried out for rice, wheat, corn, cotton, tomato, pepper, potato, cucumber, papaya, and tobacco. The major traits targeted for improvement include disease resistance, pest resistance, herbicide resistance, and quality improvement, drought tolerance – all important issues in China (and India, and in the semi arid and arid tropics in general). Government reports indicate that transgenic research has been carried out on 47 plant species using 103 genes. Over 100 crops have been field-tested and over 50 given permission for commercial production. The major GM crop in China cultivated commercially is Bt Cotton and most of the Bt cotton varieties that are being cultivated have been developed by scientists working in public research institutes in China.

In keeping with the need to avoid patented technologies, China has given a major role for molecular marker-assisted selection for genetic improvement of crops – a technology which is claimed to be cheaper, involves less R & D gestation time, has less adverse effects and the progeny are more predictable compared to genetically engineered crops. Growing concern among policy makers regarding the ongoing global debate over biotechnology and its potential effects on China's agricultural international trade have in recent years led to caution in approving commercialization and promoting expansion of area under GM crops. In such a situation marker assisted breeding is a safer approach and allows farmers (and the national economy) to benefit from new knowledge and yet not be subservient to multinational interests. A developmentalist rather than a market-oriented approach therefore marks the Chinese policy process.

Several 'supra-ministries' and agencies have been involved in the design of research strategies, priorities, and the approval and allocation of budgets for biotechnology research. These include the Ministry of Sciences and Technology, State Development Planning Commission, and the Ministry of Agriculture. Like in many other countries this has translated into multiple jurisdiction and overlapping legislation and guidelines. The regulatory framework itself has been adopted more or less unchanged from OECD regulations, though specific guidelines have been introduced in recent years for complying with the regulations. A national committee for the regulation of biosafety of Genetically Modified Organisms was established in 1996.

India

India is one of the first Asian countries to officially support biotechnology research and set up bodies to oversee, supervise and promote R & D in this area. The National Biotechnology Board

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[13] Much of the information on Chinese policies are obtained from official Chinese websites.

was established in1982, which became the Department of Biotechnology (DBT) under the Ministry of Science and Technology in 1986. Its early and continuing priorities included human resource development, creation of infrastructure facilities, and supporting research and development (R&D) in identified areas. A National Plant Genome Research Centre was set up at the prestigious Jawaharlal Nehru University, and the UNDP supported an International Centre for Genetic Engineering and Bio-technology (ICGEB) at New Delhi. These are in addition to biotechnology research capabilities located in a number of research laboratories, research institutes and universities.

Though official policy pronouncements by the Government on biotechnology as such have been few, the National Agricultural Policy 2000 contains a blue-print for agricultural sector for the next two decades and explores "options to ensure that growth is sustainable technologically, environmentally and economically" (Sharma, 2001). Biotechnology is specified as one of the alternatives for achieving this objective. As in the case of China, research priorities and objectives for agricultural biotechnology reflect national needs and socio-economic contexts. These include "exploitation of heterosis and development of new hybrids (including apomixis), genes for resistance to or tolerance for biotic or abiotic stress, developing plant material with desirable traits, and genetic enhancement of all-important crops." (Sharma op. cit.) Development of new biofertilizers and biopesticides are also given importance. Stress biology and marker-assisted breeding programs are viewed as being important to avoid IPR problems and develop technologies suited to local conditions and enable farmers to retain their autonomy. Use of biotechnologies for evolving plants that are drought resistant, pest resistant, consume less water, contain more nutrition, give higher yields and are environmentally safe are part of the objectives. Attempts are also on to identify appropriate determinants of male sterility so as to extend the benefit of hybrid seeds to more crops than was done during the green revolution. The government claims significant leads in areas of basic plant biotechnology & plant genome research, development of markers of high quality protein content, and development of molecular methods for hybrid mustard and production of transgenic plants of tobacco with viral resistance[14]. Despite the clear identification of priorities however, research efforts and testing and approval seem to be focused on the needs of commercial interests of a minority as reflected in research on vanilla, tobacco, cotton, and mustard which are not the major crops in India, nor are they food crops cultivated by a majority of farmers. There is not much evidence for use of biotechnologies for evolving plants that are drought resistant, pest resistant, consume less water, contain more nutrition, give higher yields and are environmentally safe, though conventional breeding programmes have very much concentrated on achieving solutions in these areas.

Regulatory processes in India are stricter but miss out on crucial aspects and decisions are often taken on an ad hoc basis. Moreover the multi-tier mechanism of assuring biosafety consisting of Institutional Biosafety Committees, Review Committee on Genetic Manipulation, the Genetic Engineering Approval Committee, and the state level coordination committees not only lead to bureaucratic delays, but the inability of many states to set up state and district level committees have made the whole process defunct. Guidelines and laws to ensure biosafety and regulation of new technologies include the Revised Guidelines for Research in Transgenic Plants, Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts- 1998, The Environment (Protection) Act, 1986 and the Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms, Genetically Engineered Organisms or Cells Rules, 1989. As in the case of China there is overlapping legislation and multiple regulation and supervision which often leads to delays and confusion.

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[14] The above paragraph is based on statements made by Manju Sharma, Secretary Department of Biotechnology, Government of India.

Thailand

The Thai government and industry has focused on applications of biotechnology to traditional foods, fruits, and export commodities such as shrimp, and R&D priorities have been on increasing production and reducing production cost on important crops such as rice, cassava, sugarcane, rubber, durian, and orchids. An early success in Thailand was the development of new molecular diagnostics for the diagnosis and control of virus diseases in shrimp which affected production and export earnings. The National Centre for Genetic Engineering and Biotechnology (BIOTEC) was established in 1983 under the Ministry for Science, Technology and Energy and then moved under the National Science and Technology Development Agency as an autonomous centre. A master plan for Thailand's agricultural development was presented by the government in 1998 as part of which BIOTEC seeks to provide "resources for the country to develop critical mass of researchers necessary to achieve Thailand's national R&D requirements in biotechnology" (Tanticharoen, 2001). This was to be achieved through support for R&D projects, "facilitation of transfer of advanced technologies from overseas, human resource development, institution building, information services, and the development of public understanding of the benefits of biotechnology".

Thailand allows field-testing of genetically modified crops but continues to ban genetically engineered products from being imported and sold. Experimental field trials of Monsanto's GM cotton, and BIOTEC's GM papaya, tomato and cucumber are on. Animal feed imports from GM countries (used for Thai tuna packed in soya oil from US which had GM) have been banned in response to concerns of importing countries in Europe. Thailand claims to be the first country in Asia to call itself GMO free – a statement of reassurance to European concerns and threats and for preserving their share in the export markets.

Among the three countries, on issues relating to biosafety guidelines for genetic engineering and biotechnology, Thailand does not have in place comprehensive laws to address biosafety concerns. A set of guidelines is the primary instrument, while other laws apply in part. The Guidelines in Genetic Engineering and Biotechnology for Laboratory Work specifies procedures for research on "viroids, viruses, cells or organisms, carrying novel genetic material which are either improbable to arise naturally or are potentially detrimental towards public safety and environmental health". There is also a set of Guidelines in Genetic Engineering and Biotechnology for Field Work and Planned Release for plants & microorganisms. These guidelines are considered "soft law based on voluntary action". They identify three categories of risk : (1) work bearing no risk; (2) work bearing low risk; and (3) work with high risk. Thus risk management and control appears to be relative to the organism/risk category at issue. Institutional arrangements for monitoring and control are also similar to India, for example, three groups of personnel and organizations are involved: (1) principal investigators and researchers; (2) institutional biosafety committees (IBC) and (3) the National Biosafety Committee (NBC). The NBC has a general responsibility to (1) ensure that genetic manipulation work adheres to the Guidelines; (2) review and direct research methodologies; (3) recommend appropriate experimental conditions; and co-ordinate public information and education on biosafety issues and on proposed national policies. For field research, the NBC also (1) provides advice to Institutional Biosafety Committees, (2) suggests alternatives to high risk field procedures; and (3) protects and restricts access to commercially significant information. The task of keeping Thailand GM free rests on the Plant Quarantine Act, which prohibits GMO imports without a permit from the Department of Agriculture and allows imports only for experimental purposes. The Plant Variety Protection Act disallows new plant varieties from being registered if they have severe adverse impacts, directly or indirectly, "on the environment, health or public welfare". Registration of new plant varieties derived from genetic modification can be registered only upon "a successful result of a safety appraisal" on environment, health or public welfare conducted by the Department of Agriculture or another agency designated by the Plant Variety Protection Commission in accordance with a ministerial regulation".

Common elements in the design of formal regulations of all three countries pertain to structure of committees, data requirements, categorization of risk types, limited scope for enforcement and monitoring, overlapping legislation and multiple authorities. Problems with enforcement of regulations are already emerging in India where states have handed over the responsibility to the very companies who produce and sell new seeds. There are few studies on how regulations and procedures are followed and monitored in China despite large-scale adoption of GM crops. Inability to monitor and enforce regulations has led to surreptitious adoption whose environmental consequences are unknown. Subsequent evidence of such adoption has led to destroying of crops on farmers' fields with resultant economic losses.

The official policies give the image of a strong focus on national priorities, but available evidence reflect that this is largely partial, and in reality investment and research in these areas take place only where market concerns coincide as in the case of shrimp biotechnology in Thailand, and to a certain extent cotton in India which though not a major crop has been in the public image due to continuing suicides by cotton farmers, and there is large private investment in Bt cotton research. Also often rhetoric is not matched by funding, especially in the case of crops and crop traits which are relevant for subsistence farmers in environmentally marginal areas. Moreover there is no evidence that the policy process has ever considered the agrarian structures of their societies, and the actual needs of the majority of farmers. Official statements reveal no awareness of the likely impacts of the different and unevenly developed enabling and regulatory features of policies and guidelines on biotechnology. This awareness can be gained only if they start looking at the agrarian structure, agricultural systems, agro-ecological contexts, and economic trends affecting their respective countries. Good policies require the ability to predict the impact of agricultural biotechnology and genetic engineering. We need to understand whether they are beneficial, risky, impoverishing, disempowering and so on. In what contexts or under what conditions do differential impacts occur? What opportunities existing for coping and adapting to threats and changes arising from economic liberalization, globalization, or climate change? In the next section, it is attempted to develop an approach to address these questions.

Agrarian Structures and Agricultural Systems in Developing Asia Pacific

A range of literature and information pertaining to land ownership patterns, tenurial arrangements, cropping patterns, employment, agricultural growth and production problems and prospects, environmental changes, and economic changes and integration were reviewed to attain a broad and general understanding of trends and patterns affecting farming communities and influencing their decision to adopt and benefit from new technologies[15].

Three main types of regions can be identified in developing Asia Pacific. These include areas,

- where collectivization of agriculture has been practiced, with fairly equitable distribution of resources, and which are now gradually being opened to market forces (China)
- which have undergone agricultural modernization and some level of land reforms (India, China, Thailand)
- where traditional social patterns exist with a feudal or semi-feudal character and are increasingly exposed to market forces & modernization (Parts of India and Thailand)

In all three countries agriculture has a high share of total employment (61%, 65% and 59% respectively in India, China and Thailand). Despite this however, agricultural production accounts for only a small percentage of GDP, even in Thailand where export orientation is higher. Poverty is largely rural in all three countries, with household food security being a major problem, even though national food security has been assured for the (very) near future. Education and literacy levels are higher in Thailand and China, but doubts persist as to the level of education required for adopting, managing and benefiting from new technologies.

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[15] Some of these are Guangzhou, 1998 Brandt et al, 2002, Lastarria-Cornhiel, 2001, and Dennis Tao Yang, 1997

The countries are characterized by a low ratio of land per farm worker. Attaining food self sufficiency and ability to produce and feed ones population is therefore an imperative affecting policy making. It is suggested that development of the agricultural sector is restricted in these societies because of individual farm size. Other than the scale neutrality of technology which affects adoption, some scholars have also warned about 'resource neutrality" – the differences in resource endowment affecting adoption decisions and the ability to adopt (Swaminathan, 1991). GM crops typically require a refuge area to prevent gene flow and outcrossing, and small and marginal farmers simply cannot afford to set land aside or in other ways follow this safety regulation. In China under the 'responsibility land' system following de-collectivization, the average size of the plot is quite small preventing use of mechanized tools and other modern technologies[16].

Problems with land tenancy may also affect adoption of the existing range of biotechnology products. Land tenancy is estimated between 15-40% in different regions of Asia. Traditional land and crop sharing and land tenancy agreements under subsistence agriculture have often been blamed for the lack of adoption of modern technologies. However there is a very real possibility of "reverse leasing" with further agricultural modernization, as small farmers may lease out land to large landholders due to an inability to invest in or manage new technologies. This has implications for biotechnology product design.

Cropping patterns in the three countries are dominated by food grain and cereals. However recent reports in all three countries, including from regions which benefited from the green revolution, indicate stagnation and / or decline in yield levels of major grain crops. These are partly due to technological limits, and partly due to environmental and resource degradation. Environmental pressures have been particularly severe in Thailand where intensive agriculture and natural resource use has been an important contributor to its impressive economic growth in the last few decades. But other countries are also characterized by accelerated deforestation, soil degradation (salinity and acidification), water scarcity, increased pest and disease incidence, shrinking cropland base, and increased frequency of droughts all of which have affected productivity and income resulting in some areas in conflicts over resources.

Resource and land related conflicts have also been accelerated by agricultural involution resulting from insufficient expansion of non-farm employment, and cycles of economic crisis. Economic crisis in the late 1990s in Thailand led to migration of urban population into rural areas and greater dependence and exploitation of both farm and non-farm (forest) resources (Nathan and Kelkar, 1999). Estimates of labour surplus in China go up to 150 million, leading to quite low marginal productivity of the agricultural workforce. The situation is similar in India where as Bina Agarwal (1998) mentions there has been a near stagnation of farm employment over the last decade, with growth declines particularly greater for women, who also encounter barriers in entering this sector. Can modern biotechnology offer a solution to this problem?

Notwithstanding the level of integration of the agricultural sector these countries into global markets, economic liberalization, deregulation and global flows of capital are having an impact on the ability of farmers to cope with changes in a positive or negative direction. Contrary to popular view Thailand's exposure to European markets has actually constrained adoption of new technologies due to fears of losing the markets for Thai agricultural commodities. There have also been fears of product substitution effects emerging from "In vitro biotechnologies" which are cell culture techniques, wherein processed products such as flavouring agents can be produced in laboratories instead of being processed from plant products, and so permit the global displacement of markets. However it is possible biotechnology may provide alternate options to farmers so affected. Similarly technology adoption deriving from the increasing spread of contract farming may have both positive and negative consequences for the farmers involved. While stability and amount

[16] Often less than an acre. Average landholding is less than a hectare. See Guangzhou and Davis, 1998, and Brandt et al, 2002.

of income may be enhanced, inattention to long-term environmental consequences, may decrease productivity or affect quality of products, at which point contracts may be terminated. On the other hand, where new technologies incorporate and deal with such problems, biotechnology may have greater promise.In general typical features of Asian agriculture may be identified which have provided the contexts especially for small farmers to cope with and develop livelihood strategies. These include:

- vulnerability to climatic change and variability, and extreme weather conditions
- landscape and wildlife (flora and fauna) are inextricably mixed with farming
- livelihoods in marginal areas are more diversified, and
- low productivity of cultivated land

These vulnerability contexts have generated over a long time methods of coping and livelihood strategies which are quite unique and diverse. For instance, mixed crop livestock systems have evolved which reject crop genetic enhancement strategies in which there is a tradeoff between grain yield and fodder. This has been a traditional problem with hybrids resulting in severe fodder shortages in many areas. Not only will genetically engineered crops have to optimize the plant for several traits including food, fodder, and fuel wood, the quality of by-products will also have to be considered. In India commercial approval for Bt cotton was withheld since allerginicity tests for cottonseed going into cattle feed had not been done. Small farm size also militates against solutions similar to developed countries where separate crops can be grown for humans and livestock. In fact in countries like China, cropland sown to animal feed has diverted land away from food production. While environmental changes resulting from gene flow or biodiversity decline may not lower profits for cultivators of land, those dependent on commons, pasture, forest resources etc. may be directly affected in terms of loss of livelihood source. It is important to remember that farmers in developing countries evaluate a technology in terms of its contribution to the farming system as a whole, not to a single component of that system. Thus economic profitability alone is no guarantee of adoption, which means that cost benefit analysis[17] is not a proper indicator of the suitability of a technology.

Strategies of technological modernization focusing on one component alone can exacerbate and lead to 'chain' conflicts - from land to resource conflicts (conflicts over water rights; access to pastures, fishing grounds & forestlands). This has to be studied in the context of conflicting policies and priorities on land, but also the complex and overlapping legal systems that exist in many societies, and conflicts between state and customary laws, which large numbers of indigenous populations follow. Again such laws have been developed historically as strategies of coping with problems of resource scarcity, instability and risk. New sources of instability and risk leading to vulnerability arise from globalization, market integration, or climate variability. They may also arise from a specific pattern of modernization of agriculture which narrows the base of food security including the number of species constituting the food basket and the number of genetic strains cultivated. What this means is that learning and innovation are of crucial importance for farmers in developing countries. Agriculture is not just about crop production. It is a question of survival and a way of life. Farmers produce food and other commodities, but also develop knowledge and technology with reference to improving, storing and exchanging seed, and conserving and managing natural resources. In the process technologies are accumulated as local, traditional or indigenous knowledge, and farmers also adopt new technologies from outside. Such behaviour constitutes manifestations of coping mechanisms to environmental and economic challenges.

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[17] The reference here is to analysis which looks at the component of a system where the technology is adopted to the exclusion of another components.

Biotechnology, in order to play a positive role in this system, has to enhance skills to help people cope better, especially under emerging contexts of living and contact with the outside world, with external markets, environmental change, and pest and disease epidemics. Indigenous knowledge may not be adequate to tackle new problems. It is in such situations that some activists and scholars working on gender issues in agriculture argue that biotechnology has the promise and potential for rural women. Omvedt, Kelkar and Mitter (Omvedt and Kelkar, 1995; Mitter, 1995) among others argue that biotech contributes to low external input sustainable agriculture and help women contest male domination of technology, as well as support the entry of women into high-tech fields. Women traditionally have contributed to seed selection, preservation, and saving, and so new options are seen as building on existing knowledge base and enhancing technical skills and knowledge, in the process empowering them. This perspective has to be understood in the light of arguments against the green revolution where with seed production and distribution having taken place with total exclusion of farmers, farmers 'forgot' how to experiment, innovate and develop new varieties or improve upon existing ones. Farmers were seen to have become disempowered and became passive recipients of technology, with little or no access and control over production resources such as seeds, technology, and landFeminist scholars have argued that a focus on indigenous or traditional knowledge "give women the task of preserving the traditions that oppress them" (Omvedt and Kelkar, 1995) whereas new technologies have the capacity to give them rights and capabilities to overcome their situation. However a more traditional view has been that with new technologies, instead of recognizing women's central positions in the household, in community rituals and their knowledge and skills, women learn to see themselves as oppressed, ignorant, useless etc. So technologies can be empowering only when women are able to or allowed to use them. Will the advent of modern biotechnology tools and techniques automatically ensure their entry into women's hands? While social institutions play a role in this, technology design is also of importance. What is also important is to focus on those crops that are of importance to women in managing their households, rather than develop crops which simply yield more cash income from market sales which may be taken away by male household members. Technology development and knowledge acquisition result from long processes of experimentation and innovation through which people build up their skills, knowledge and self-confidence necessary to shape their livelihoods. Before technology can be empowering whether for men or women we need to understand how new knowledge forms and techniques diffuse, by whom and to whom. This indicates that new technologies as a means of development, growth, poverty reduction or equity is not a simple question of technology transfer as many scholars seem to believe[18]. Rosenberg (1982) draws attention to a significant insight of Marx to the effect that not all technologies permit application of scientific knowledge to the productive sphere in equal degrees. We need to "unravel and examine the inner logic of individual technologies" as well as the mediating role of social institutions and social structure. Marx is also credited with stating that no single technological innovation can make a difference to economic development and that it is society's capacity for generating technical progress and ability to generate substitute technologies that determines the trajectory of economic growth. Many developing countries are in the process (albeit on a small scale) of reforming their technology development and transfer systems to refocus on developing cultures and institutions, which promote innovation and learning[19]. In the next section some important and relevant social science theories pertaining to technology, innovation, and technology impacts are reviewed with a view to identifying the directions in which agricultural biotechnology should move so that they are empowering for those who adopt these technologies.

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[18] This applies especially to those who are supportive of large scale deployment of biotechnology and GM products in developing countries.

[19] The work being done at the National Foundation for Innovation in India is one such example.

Innovation, Learning and Autonomy: Implications for Agricultural Biotechnology Research and Policy

Supporters of biotechnology as a tool for poverty reduction and improving food security often accuse critics of being *luddites*. To the extent that critics reject modern biotechnology absolutely, and see no scope in improving productivity and farmer well being, the argument is valid. But critics base their argument on the issue of control over development, replication and use of technology. Sophistication is seen to lead to control; complexity is viewed as reducing the ability to use and replicate, and yielding control to 'experts'. However there are alternate criteria for judging the usefulness of a technology Ivan Illich in proposing the concept of "tools of conviviality" uses increase in autonomy of users as a criteria to judge if a technology is good or not. Autonomy refers to ability to use and control of technology that produces a product. Since the ability to develop, improve and modify technology is an integral component of farmers' empowerment, such an approach ought to be appropriate in judging the various tools and techniques that have become available through developments in biotechnology and genetic engineering. In all societies competition and constraints force organizations or individuals to continually invest in skills and knowledge to survive. The kinds of skills and knowledge individuals and their organizations acquire shapes evolving perceptions about opportunities and threats, or even to convert threats into opportunities. These then affect the choices that people make and how they make them.

As the economist Douglass North puts it what we need to look at then in relation to how people manage their resources is not "allocative efficiency", but "adaptive efficiency". Given the state of pervasive uncertainty that individuals live in especially in developing countries, "decision making in the face of risk cannot be done on the basis of probability distribution of possible outcomes"; therefore an emphasis on flexibility, adaptive capacity and choice. Hence also an emphasis on education and learning, on developing new technologies and practices, on adapting social relations and institutions, on changing consumption and investment practices, and on evolving appropriate policy mechanisms. Transgenic varieties and products of biotechnology imply differences in management and cultivation that require increased knowledge, and therefore their benefits can be derived only in contexts of learning and skill development; but learning and skill development can occur only when technology design is such as to promote them, not when technologies development costs are extremely high or so complex that they can be carried out only in sophisticated laboratories.

Hence consensus statements on agricultural biotechnology which simply attempt to change policies to involve the public sector, or provide institutional support (credit) for new technologies, will not necessarily enhance the ability to cope under conditions of uncertainty; ability to innovate is more important, forms of capital other than finance, and policy support other than institutional reform are required. Merely training extension agents may not be adequate. To repeat an earlier point, the issue is not one of technology transfer and training, if we seek to provide farmers with long term ability to cope with uncertainties and risk using technology as a mechanism. Bourdieu's concept of "cultural capital" may be appropriate here. Knowledge and skills relating to natural resource management and agriculture have historically been a part of the repertoire of symbolic and cultural capital. In Bourdieu's (1985) view cultural capital includes the full range of a society's symbolic resources comprising norms and values, and religious, philosophical, artistic and scientific understandings that frame and interpret reality and enable individuals to act upon it. These understandings become a part of an individual's personality and go to constitute the habitus defined as "socially acquired, embodied systems of dispositions and/or predispositions", which bestow ""deep structural" classificatory and assessment propensities" to individuals. Perceiving subjects, through these principles "have a world of common sense", which means that technology and skills are akin to second nature for farmers eking out livelihoods from natural resources. There is a world of difference between an approach which works on the basis of transfer of technology from experts via extension agents to end users, and an approach that allows end users to participate in and develop technological solutions to problems themselves. For biotechnology to provide appropriate solutions we need to promote those tools which will eventually be a part of the individual or society's cultural and symbolic capital as well as an aspect of individual or class habitus. This approach has the advantage of effecting effective technology dissemination in that habits actually spread faster than knowledge.

However an argument may be made that in most other economic sectors workers on technology do not necessarily have complete knowledge of production and reproduction, and these have not necessarily had negative social and economic consequences for the individuals concerned. Lack of control or autonomy is not a very important issue for industrial workers[20]. An answer to this question requires an understanding of the peculiar nature of agriculture and the possibilities of change in the future. In the case of agriculture despite the corporatization of input and output markets, and the emergence of contract farming, the means of production – land and labour – continue to be held by the primary producer. For political and other reasons, in developing countries, it looks unlikely that this will change in the foreseeable future. Nor is a rapid transition of labour from rural to non-farm, urban sectors likely to occur in any large number given the current state of the economies. In such a situation, autonomy and technical knowledge and innovation capacity is important to deal with uncertainties and capitalize on new opportunities. Also, as mentioned earlier, corporate control and contract farming tend to look at the short term, whereas under conditions of environmental degradation, and other biotic and abiotic stresses, strategies of adaptation require long term focus which can only be implemented by direct producers owning the means of production. Even under extremely favourable contracts, the maintenance of flexibility and maintenance of productivity levels are crucial to benefit from contract farming. Hence the need for appropriate choice of technique and technology design. An additional point of significance is that in developing countries in particular, unfavourable or adverse consequences of technologies cannot simply be managed or avoided through regulations, as the consensus statements propose. For one regulation increases control and decreases flexibility. A body of literature is emerging which applies Foucault's concept of governmentality (Darier, 1999) to environmental issues. Governmentality itself is defined as the "ensemble of institutions and procedures exercising a specific relation of power on the population". In the name of welfare, sustainability, pollution control and so on concern over the environment has simultaneously increased control over human beings and their activities. Regulatory technologies such as genetically engineered crops require both technological regulation (cultivation practices) and legal regulation. In countries like India or China with high levels of corruption, regulatory instruments do not provide adequate criteria to guide decision makers, or by their mere existence may give decision makers too much discretion to decide or to withhold approvals, leading to poor or arbitrary decision making and increasing corruption. From the perspective of this paper environmental risks of technologies otherwise having benefits cannot be suitable for many Asian and developing countries because as *regulatory technologies* they also place restrictions on 'capabilities' and 'entitlements', reduce choice, or prevent innovation and learning, since the current range of technologies available, despite their benefits do not meet the criteria of "tools of conviviality".

Amartya Sen's theory of entitlements is based on a set of rights of 'ownership, transfer and rectification' (Sen, 1984: 311). In this framework, 'endowment vectors' are related to sets of alternative commodity entitlements through what is called an 'entitlement exchange mapping'. The entitlement approach centres on an individual's entitlements to commodity bundles that may also include food. Exchange can be of two types: trade - which involves exchange with others, and production - which involves exchange with nature. Entitlement then depends not only on the endowment vector that an individual starts with, but is also related to exchange relations. These relations in the form of entitlement exchange mapping (or 'E-mapping' as Sen refers to them) depend on the *legal*, political, economic, and social characteristics of the society in question. Entitlements therefore refer to "the set of all the alternative bundles of commodities that he can acquire in exchange for what he owns" which is the "'exchange entitlement' of what he owns" (1999: 3). Sen further states that '"production opportunities, trade possibilities, legal rights to the produce, and social conventions" all affect the e-mapping. While endowments can decline (eg.

[20] Unless of course one is talking of the Marxist concept of alienation.

through land alienation), entitlements can also fail if for instance food entitlement declines because one has produced less food (direct entitlement failure), or one cannot obtain adequate food through trade (trade entitlement failure). Poverty and starvation therefore result from both a "fall in the endowment bundle and unfavourable shifts in exchange mapping". Analysis of technological shifts with reference to natural resources ownership and control precisely enable us to understand how for instance, the decline in access to, or the degradation of common property and biological resources can result in change in ownership bundles, and consequent entitlement failures

An understanding of entitlements would not be complete without the complementary concept of capabilities. For Sen, a capability is a feature of a person in relation to goods. In that sense it is much more than simply 'endowments'. Capability is the ability to function and "reflects what a person can do" In Sen's words, "capabilities are … directly valuable in a way that the possession of primary goods[21] cannot be, since they evidently are means to some more human ends" (1984:323). A capability set refers to the alternatives sets of functioning that an individual has access to based on endowments but also on political, legal, social, and economic structures, and includes such features as freedom, health and education, or technological skills.

To go back to the argument, by focusing on the shifts in entitlements and capabilities arising from technological changes, this paper attempts to explain how people's abilities to cope, experiment, innovate, adapt, and manage natural resources as part of survival strategies are affected. An outline of these shifts and their consequences arising from probable consequences of adoption of modern biotechnology is presented in Figures 1 and 2.

Sen in his work on Hunger and Entitlements: (p13): specifically draws attention to "diversification of production and of sources of income…., rather than concentrating exclusively on the expansion of food output", as a means of enhancing entitlements. Monoculture either by directly substituting variety in germplasm, or decline in biodiversity through intercrossing between species triggered by transgenic crops are likely to result in reduction of diversified production systems in such a way to as to reduce entitlements for individuals and families deriving their livelihoods from the presence of diversity (ecological and economic).

Taking the example of the impact of introduction of new crop varieties on biodiversity loss and common property resources, scholars have pointed out that" events or conditions occurring at a particular position in environmental space lead to consequences elsewhere in environmental space" (Reiners and Dreise, 2001) Economic science provides only a very incomplete perspective on the unknown value of biodiversity changes. Changes in biodiversity affecting resources used commonly have not been well documented but are not unknown. Studies have shown that genetic diversity of crops plays a very important role in increasing yield stability (Bantilan et al, 2000). Consequences of adoption of new technologies for both ecological and economic systems have not been well investigated. Environmental impacts as well as negative impacts on societies and economies do not enter the calculus of assessments of these technologies. In fact most studies focus only on economic costs and benefits at the individual farm level, for those who are able to pay for the use of these technologies. (eg. Pardey et al, 2002, Pray et al, 2001)

There are several ways in which the introduction of products derived from biotechnology and genetic engineering, and the imposition of international conventions on IPRs may impact on the livelihoods of poor and marginal farmers and workers in the rural areas of developing countries. First the crop varieties may be such as to take away the capacity to adapt and innovate, owing to the irreproducibility of the seeds, (the terminator technology). This outcome is also possible through a loss of biodiversity and dilution of the genetic material within a species. Secondly since most of these technologies focus on a single trait or characteristic (yield, pest resistance etc.); other traits of the crops may not be given importance, forcing farmers to further degrade the environment by over-utilizing the commons. Third, through a decline in biodiversity, there may be a direct impact

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[21] In the Rawlsian sense

on loss of several species in common lands and common resources. This can happen through inter-crossing between species, by creating tolerance among pests to certain toxic material, by wiping out certain species of plants and animals, insects etc., or by creating some very strong species such as superweeds which suppress other plants from obtaining the necessary nutrition for growth. Finally, the poor are disabled from exchanging their labour for entitlements through either the decline in commons, where they can work or use their labour (collection of forest products, grazing, fishing), or by eliminating certain tasks involved in cultivation (pest management, weeding etc.)

However such changes are not necessarily an unavoidable consequence of all products developed using modern biotechnology or genetic engineering tools. There are some of the consequences that emerge from existing range of products mostly developed by the large multinational corporations. If technology assessments can map out the actual implications of technology for the mechanisms that poor people use in adapting to their environments, manage risks, and eke out sustainable livelihoods in extreme social, economic and ecological conditions, then technologies can be designed which rather than lead to entitlement failures or reductions in capabilities can enhance them. Based on a review of the range of technologies that have been developed as part of R & D efforts in agricultural biotechnology, in the final section, examples of techniques and tools are presented which enhance autonomy, capabilities and entitlements, and promote innovation and learning, and thereby adaptive capacities under conditions of vulnerability and risk.

Accessing Modern Science: Research Priorities for Agricultural Biotechnology in the Asia Pacific

The following are identified as the kinds of technologies in which developing countries specially in the Asia Pacific region are to invest, research and promote.

1. Genomics (the molecular characterization of all the genes in a species) has dramatically increased knowledge of plant genes and their functions. Advances in this field will enable increased efficiency of selection for useful genes, based on knowledge of the biology of the organism and the role of specific genes in regulating particular traits. New plant varieties with preferred traits can then be developed with conventional techniques which aside from issued of environmental risk, can be reproduced and changed by end users.

2. Research is being carried out which propose hybridization as a solution to concerns regarding gene flow or genetic contamination. Similarly work is also being carried out on molecular containment strategies which will minimize risks of accidental gene flow into the environment and reduce risk of spread of GM traits into native species. Such strategies attempt to prevent outcrossing by engineering pollen incompatibility and other mechanisms into crops.

3. An important recent development involves moving beyond the "pesticide paradigm," Research agendas and regulatory regimes need to promote technologies designed to induce pest *damage tolerance*, rather than resistance to pests[22]. Focusing on tolerance rather than resistance is more environmentally sustainable.

4. Many popular biotechnology applications are not seen to present any new threats to the environment. These include tissue culture, diagnostics, and market-assisted plant breeding, and ought to be promoted. Advances in mapping of QTL (quantitative trait loci) underlying agronomic traits in less studied crops promises rapid and efficient utilization of novel traits from closely related wild species. When linked with marker-assisted selection, plant and animal breeders obtain new tools to identify and transfer genes through more

[22] Tolerance does not rely on toxicity to kill pests and therefore does not negatively affect non-target organisms or promote resistance development. This characteristic has been used with conventional breeding with high degree of success and genetic modification could be used to amplify these types of properties in crops where it was not possible to do so earlier.

conventional breeding approaches with less risks and opposition from critics of genetic engineering. For example, manipulation of complex traits such as drought or heat tolerance, is often difficult to identify and use in a conventional breeding program, but can be done with greater effectiveness using biotechnology tools. Similar is the case with understanding the molecular mechanisms governing the uptake of nutrients by plants.[23] Knowledge of molecular mechanisms, which enable naturally occurring species to grow in particularly adverse soils, are also usefully incorporated into conventional breeding programmes.

5. The use of biotechnology in crops where genetic diversity is narrow is of particular importance, since breeding for specific traits is very difficult under such conditions.

6. Biotechnology research, concerning techniques to assist in soil and water management, have not been given as much importance as insect resistance or other crop related trait. Securing fungal resistance in adult plants by “switching on” resistance genes that are active in the seed, but not in adult plants constitutes “a *safe* use of biotechnology” and is also likely to be sustainable due to reductions in fungicide use.

7. Traditional plant science gave much importance given to form and structure. Insect resistance was achieved by altering physical characteristics of plants - increasing hairiness or thickening the plant cuticle; such strategies reduce insecticide use, without using in-plant toxin as in the case of modern biotechnology’ first generation insect resistant crops. It is possible to emphasize plant morphology and architecture: stem stiffness, number of tillers, grains per panicle, reduced height, erect leaves, wide adaptation etc. using the tools of biotechnology to acquire knowledge of traits and transfer them to the desired variety. Similarly crops can be developed which can tolerate high levels of natural herbivory, yet remain viable, eliminating or reducing the need for herbicides.

8. Genetic Engineering provides the possibility of introducing desirable characters from closely-related plants without associated deleterious genes or from related species which do not readily cross with the crop of interest. Genetic engineering need not necessarily be used only to transfer genes from one species to another.

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[23]Molecular techniques can be applied to overcome problems in traditional bean breeding, without introduction of transgenic DNA.

Figure 1. Generalized entitlement exchange mapping for an agricultural community

Ownership and Capabilities Set

Land	**Labour (knowledge & skills)**	**Common Property Resources**	**Biodiversity**	**Diversified Cropping Pattern/Farming System**
1. Production for self-consumption 2. Production for exchange (trade)	1. Labour for wages 2. Labour on own farm 3. Labour on commons for self-consumption and/or trade	1. Extraction of commodities for trade 2. Extraction of products for self-consumption (food, fodder, water) 3. Optimize conditions of various kinds of resource scarcity (all the above is done through use of labour)	1. Maintain health of commons 2. Reduces risk and increases system stability 3. Capacity to experiment and innovate 4. Enables use of other endowments (labour, land, livestock)	1. Enables risk management through diversified production system 2. Enables use of products and by-products for a variety of purposes (food, trade, livestock, building material)

Entitlement Commodity Bundles
Food, fodder, fuelwood, housing material, cash, commodities and goods for meeting other basic needs

Maintenance of capability levels and availability of entitlement opportunities can increase security of livelihood, risk minimization, expansion of knowledge, increased system stability, and insures against future distress and scarcity

Figure 2. Possible range of impacts due to expanded use of biotechnology and genetic engineering in agriculture

Impacts on Common Property Resources	**Impacts on Biodiversity**	**Impacts on Cropping Pattern**
1. Quality and quantity commons: deterioration, decline or improvement 2. Encroachment of products not available from farming system (from humans and livestock)	1. Changes in the flora and fauna in the commonly owned land 2. In privately owned land, species and varietal diversity	1. Quantum and number of by-products from farming system 2. Changes in mixed cropping (decline or increase in certain products such as vegetable; problems with crop/pest management)

Outcomes

Cash requirement for purchase of products obtained from farming system and commons

Change in diversity of sources of livelihood, affects risk

Increase or decline in certain forms of skills and knowledge

Ability to use labour on farm and in the commons

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