ESAP CHAPTER 5

DEVELOPMENT AND SUSTAINABILITY GOALS: AKST OPTIONS

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Key Messages

Technologies and Practices. The post-Green Revolution challenge for agriculture in the ESAP region has been to contribute to the continuous improvement in human livelihoods and welfare in ways that meet the challenge of increasing urbanization and a changing demographic structure while avoiding the problematic social consequences that characterized the Green Revolution. This contribution is framed by the goal of meeting the growing demand for food and industrial raw materials efficiently and without adversely affecting a societies' health and environment (natural resources and climate), particularly of rural dwellers. .

The application of information technology to integrated agriculture is an important part of a strategy to meet AKST goals in the ESAP region. Information technology tools such as cell phones and computer kiosks can facilitate the rapid dissemination of knowledge and the exchange of ideas and information associated with decision-making required of knowledge societies. These tools are already being used to the advantage of rural economies, particularly in China, South India and Bangladesh. In combination with improvements in agricultural systems, information technology can contribute significantly to the realization of AKST goals throughout the ESAP region.

The promotion of organic practices in appropriate locations that can capitalizing on the expanding global demand for organic agricultural products can help realize AKST goals. The strength of organic agriculture is that it can contribute safe and environmentally friendly food production. Organic practices improve soil structure and fertility and minimize fossil fuel dependency. They have positive impacts on human health and welfare and system biodiversity through relatively low seed and input expenses, reduced chemical inputs, and integrated pest management (IPM). Since, they are labor-intensive and require high rates of organic inputs, most typically of manure, their optimal location would be in areas associated with livestock systems. Projected changes in demography, coupled with environmental concerns and forest conservation goals in the ESAP will make the adoption of low-impact technologies increasingly attractive over time. At the same time, the efficient pursuit of sectoral goals would require a combination of indigenous, organic, and integrated practices. The growing demand for organic food in urban centers of many ESAP and other countries is fuelling an expansion of organic production niches, particularly in Australia, New Zealand, and, more recently, India.

Support for traditional and local knowledge systems can help to improve rural livelihoods, particularly in low productivity areas. In reality many of the agricultural systems found in the ESAP region are complex. Indigenous knowledge systems are now being recognized as especially well adapted to ecologies and circumstances where there are multiple goals and interrelated constraints. Their strengths are in maximizing organic inputs and minimizing chemical inputs, including pesticides, with attendant positive ramifications for biodiversity and soil and water resources. Indigenous cropping systems based on traditional varieties conserve landraces and tend to be diverse, employ intercropping and agro forestry to insure against total crop failure, and enhance nutritional value. Further, there can be direct benefits for human welfare, particularly rural livelihoods, through the mining of traditional knowledges associated with plant-based medicines. Where infrastructural support (credit and extension) are a major constraint such low-input systems are particularly advantageous for rural women.

'Resource conserving technologies' will be increasingly attractive to the ESAP region given the need for more efficient input use and concerns about environmentally sustainable practices. Under these circumstances, with careful context specific adaptation, new and emerging technologies (transgenic technologies, nanotechnology, precision agriculture) can contribute to the achievement of AKST productivity goals. These technologies can improve agricultural productivity using existing land and water resources by protecting crops against biotic and abiotic stresses. They also have positive ramifications for natural resource and human welfare through reduced pesticide use, inexpensive vaccine delivery, and increased profits. Nothing about these technologies precludes the integration of low-impact practices. However, they are often expensive and complicated to implement successfully, requiring reliable access to credit and to knowledge in ways that limit their utility in the ESAP region. These social dimensions, coupled with gene flow and insect resistance concerns, make it imperative that their dissemination is undertaken within a stringent biosafety framework and enforcement, in conjunction with scientific and social monitoring. Successful application therefore would require both their adaptation to farmer needs and conditions, and rigorous site-specific scientific and social monitoring.

Capacity Building - Strengthening AKST infrastructure, and facilitating collaboration between the public and private sector can contribute to achieving AKST goals within ESAP. There is wide variation in the technological capacities of ESAP states as exhibited in different levels of basic education, science and technology infrastructure, regulatory capability, bio-safety facilities, and research and extension capacity. Regional variation is a consequence of differences in the adequacy of funding and the extent and integration of public, private, and civil society participation. For example, while Australia, New Zealand, Japan, South Korea, China, and India already provide a basis for infrastructural improvement, the smaller countries of Bhutan and Nepal and the island states of the Pacific still requires improved infrastructure that can benefit from greater collaboration among various national actors. Nongovernment organizations, regional fora, and donors can contribute to these efforts through funding, training, scientist exchange, and policy and institutional reform.

Building producer capacity to integrate different sources of knowledge is important for realizing AKST goals in the ESAP region. Farmers' understanding of and ability to develop and implement integrated agricultural practices and production technologies can be strengthened through training, vocational education, and excellent extension support. This may be accomplished by training personnel to understand how different agricultural practices contribute to achieving productivity and sustainability goals.

To achieve AKST goals, the sector's capacity to be flexible and to react to rapid market changes needs to be greatly enhanced. Increasing globalization and the extension of the communications revolution to trade, on the one hand, and the emergence of new technologies and new rules, on the other hand, mean that success in international and regional markets depend on an informed and responsive producers and agents in the agricultural sector. Consequently, communication, management, and marketing skills will need to be enhanced.

Effective mechanisms to support for particular needs of women farmers are required in response to the feminization of agriculture in the ESAP region. The capacity of women agricultural producers, including those women left behind to manage the productive resources (land, knowledge, and technologies) in the face of male migration, abandonment, and divorce, needs to be strengthened if family welfare is to be improved. Special programs should encompass both increased recruitment of women to positions of power and decision-making and greater recognition of women's participation in agricultural production. This can be accomplished through accelerated vocational and technical training to facilitate appointing women to positions previously denied them, the systematic training of men and women already in posts, including greater recognition of women's contribution to agricultural production.

In the face of the growing trend to a knowledge society, social groups, such as ethnic and caste minorities who are currently excluded from governance, public services and markets, should be brought into and acknowledged as participants in the process. Socio-cultural rigidities and discriminatory barriers that limit the participation of significant populations constrain the performance of AKST across the ESAP region. These barriers and restrictions to equitable participation need to be acknowledged, analyzed, and addressed, and anti-discrimination legislation needs to be instituted, enforced and monitored.

Policies and Institutions - The integrated development and management of knowledge lies at the heart of the knowledge and information society and should be reflected in national and regional agricultural policies. The single most important characteristic of the society that lies on our horizon is a growing dependence on dramatically changing knowledges whose importance cannot be overestimated. Without enhanced capacity, states will not be able to adequately keep up with the growing competition and complexities already evident in products and markets. In order to do so, we must explore patterns of interaction that facilitate the roles of different actors to respond to innovation and manage interventions. Such frameworks need to be flexible, adaptable, inter-related (networked) and science and technology intensive with a capacity to incorporate as well as develop new knowledge streams. Policy formation and implementation therefore have to be consistent with such requirements that are commonly referred to as “innovation systems”. At present, public sector research and extension alone cannot effectively respond to either the increasing complexities of agricultural technologies and markets or the new challenges posed by an increasingly fragile environment. To meet these challenges requires integrating the public sector, private sector and civil society in ways that synergize their complementary knowledges and expertise. However, a number of institutional barriers including institutional hierarchies that reflect high levels of mistrust, a linear approach to technology development and promotion, and centralized funding, implementation and evaluation prevent knowledge flows and joint working relations among AKST actors. .

Where appropriate, fiscal policy and funding arrangements should be employed to facilitate collaboration and partnerships among AKST actors. Stakeholder meetings and ‘handholding’ for the development of collaborative activities can bring about appropriate institutional changes (rules, norms, habits and practices) required to nurture partnership skills and promote a culture of learning within organizational settings.

Recognition the need for greater networking, extension systems must expand their traditional client base and restricted mandate of technology dissemination to help producers cope with new challenges. In order for the agricultural sector to be competitive and enhance livelihoods a broad actor-networks need to relate to each other and improve their efficiency in line with other rural actors. To achieve these goals, producers as well as other NGOs, producer associations, rural entrepreneurs, and agricultural labor and women’s self-help groups would benefit from organizational, marketing and entrepreneurial support that ought to include information on value added, markets, prices, standards, and quality. This support should be provided by the extension system to farmers as well as to agro-industrial producers, cooperatives, and farmer and processor associations. Implementing these institutional changes is among the most important challenges for reforming public sector extension in the ESA{ region.

Policies to improve the ESAP region's natural resource base (especially soil, water and forests), conserve genetic resources, and maintain biodiversity are critical for attaining the sustainability and development goals of AKST. Policies to achieve these goals need to be developed and implemented by national governments and inter-governmental organizations and could be iteratively improved through ongoing monitoring and evaluation.

Trade and Markets - The growing importance of ESAP agricultural producers is making the ESAP region a magnet of transnational production. However, the growth of GDP and per capita consumption also are making the region a site of rivalry among transnational producers even as a comprehensive regime of rules to govern international trade are being forged. The rules and their management are to the ESAP region because they can affect access to other markets, the sharing of the gains from expanded trade, and opportunities for producers to become domestically more competitive. The latter is especially important as the inability to compete has serious implications for the viability of domestic producers, the structure of national industry, and employment.

The development of regional groups represented by ASEAN, SAARC and the proposed Pacific Islands FTA, will place a premium on competitiveness, especially in the case of small-scale farmers. Whether consumer welfare gains in terms of lower prices will be sufficient to offset employment and capacity losses from competition will depend on whether and how governments address the skewed allocations of support and investment in agriculture, the demand for local consumption crops, and the threats to low income/small-scale producers posed by grain and plantation crops.

National trade policies will need to be fashioned with an eye to the new global trade architecture recognizing that the region will need to become more involved in international trade negotiations. Importantly, such negotiations would need to account for the specific domestic social and industrial objectives of states within the region in ways that are consistent with other domestic and regional policies. The international drive to impose WTO discipline in relation to tariffs, protection, and market access have implications for agricultural policies that differently affect large and small farmers, market organization, and the region's ability to take advantage of the demand for new products and services. The CAP reforms, the EU GSPs and US reforms in relation to cotton and textiles, for example, carry risks for China. Other international negotiations of likely importance to the region's capacity for export include geographical indicators (GIs) and TRIPs. These specific concerns are in addition to the routine challenges that arise from technological advances, where, for example, ESAP textile and rubber producers will face increased price competition from a growing dependence on nanotechnologies unless they are early adopters or establish a market niche.

Intellectual Property Rights (IPR) have the potential to create barriers to the transformation of ESAP states and their capacity to start higher up on the science and technology ladder. The equitable resolution of conflicting international interests will largely depend on the extent to which the region is able to draw negotiators' attention to intra-regional differences in capacity and needs since. IPRs will have consequences for a range of activities, from the development of indigenous knowledge to the exploitation of processes developed in low-income states. These effects are likely to attract increasing attention as negotiating IPR agreements, and their final form will have different implications for states within the ESAP region.

With increasing concern about the environmental impact of economic activities, the international community continues to address international agreements that will likely have a direct impact on trade issues. These include the growing dependence on fossil fuels and the relationship between the growing demand for traditional medicines and species endangerment. At the same time, there is a growing use of market mechanisms to ameliorate the extent of carbon emissions and to employ regulation to attenuate the endangerment of Central Pacific tuna stocks. The market approach to these types of problems are aniticpated to have implications for the region, particularly for the countries of Japan, India and China.

Investment - In the ESAP region, increases in the composition and level investment are required in order to increase growth rates in agriculture. In the recent past, investment allocations in agriculture have been skewed in favor of a few selected crops and commodities (cereals and plantation crops) at the expense of rain-fed crops and those grown predominantly by the poor. To realize changes in investment criteria and priorities investment in all but the most advanced economies is needed in basic socio-economic rural infrastructure -- education, health care, farm-to-market roads, energy (e.g.; electricity and clean cooking fuels), post-harvest technologies (storage facilities), agro-industries, and markets. Equally urgent is the need for investment in science and technology infrastructure in order to deepen the innovative capacities of the region's human resources and institutions. As well, support for research and extension to address the loss of biodiversity, the degradation of natural resources, and the consequences of climate change (drought and floods), and to assess the potential of bio-fuel production, particularly on marginal lands, represent issues and needs that must be addressed in the current context.

An important challenge facing public sector managers in ESAP is to judiciously foster the involvement of the private and non-state sectors in research activities and investment in ways that bolster and support growth and equitable distribution. Such involvement could include the increased role of the latter in research where they may have special strengths as well as promoting collaboration among the sectors. State institutions also will need to reevaluate their current funding portfolios and institutions capacities so that they can find complementarities in an increasingly diversified environment in ways that enhance the collective performance of the sector as a whole.

Policy options. Increasingly ESAP's primary concern is now becoming not only productivity but long term management of the agricultural (physical biological, and ecological) base; in a situation where that base is under threat and being eroded there would appear to be a need for:

- Encourage the expanded use of low input practices to mediate the environmental impacts of agricultural production and to meet safety concerns. In this effort, attention should be given to the constraints that may be posed by limited land resources and the possibility of low land productivity
- Develop 'resource conserving technologies' in crop agriculture to improve incomes via efficient input use, crop diversification, and the maintenance of productivity levels through more extensive use of innovative technologies including precision agriculture in difficult ecological environments and nanotechnologies for the delivery of inputs.
- Restructure agricultural extension services and rewrite their mandates with a view to ensuring that they serve as a catalyst for enhanced productivity through the establishment of an integrated and dynamic scientific and technological environment that recognizes the diverse goals of its constituents and increasingly competitive markets.

Apply appropriate water and nutrient management techniques to fisheries and aquaculture in order to enable these sectors to fulfill their potential to contribute to the food security and well being of the region's poor people.

Innovation

- **Encourage an open approach to the generation of innovations** and, in particular, in recognition of the needs of multiple (often) competing groups with different influence and power, put in place measures to support them
- **Promote private collaboration with public sector** as regards investment
- **Share information about knowledge**, technology providers and clients, goods & services needed by farmers

- Re-direct national agricultural research focus away from its a most exclusive concern with ‘gifts’ of public goods, such as seeds for small farmers, and to the **production of technology and knowledge that encourages innovation**
- Promote new processes. ‘such as ‘Learning selection’ via:
  - the devotion of attention to self organizing networks which generate knowledge and technology (rather than focusing on diffusion agents or specific groups)
  - the encouragement of co-development of promising prototype technologies rather than by financial inducements.
  - The explicit management of patents (in a functional way) in order to stop individuals pre-empting innovations and arresting the process of development
  - **Seek and promote (utilize) divisible technologies**, such as ground water irrigation, In the interest of small farmers

NRM

- Devote greater attention to rainfed agriculture especially in non-rice agriculture via
  - green (soil) water management and
  - the development of HYVs that are able to withstand unreliable rainfall, pests and diseases and,
  - accelerate the development of moisture conservation land management techniques such as zero or minimum tillage

Explore and promote new approaches, such as adaptive learning, based on knowledge sharing networks, which:

- recognize that natural the environment is often complex and dynamic and that reliance on best practices is dysfunctional in such circumstances because the workings are not clear and outcomes are not necessarily predictable.
- the embrace of Community-based NRM is often simplistic in its assumptions about partnership. It can be problematic basis for justice in some circumstances. Is necessary to recognize that the factors which determine collective action varies with context:
  - proximity to market and religious centers and
  - the power of the prestigious and influential in some cases.

Sustainable Fisheries are required to conserve stocks and increase food security (threat to big eye and yellow fin tuna in the Pacific). In pursuit of those goals three major efforts will be needed in the medium and long term

- Address and define the issues of subsidies (vs fees) in this context

- Increase the area of the ocean which is restricted from the current level of only 0.5% to 20-30% via a ' network of protected areas as proposed by the international academy of sciences
- centrally review all agreements with third parties such in relation to the sustainable management of the various fisheries (such as the west central Pacific).

Biodiversity

- develop paddy irrigation as an instrument to this end (para 2.2.1)
- pursue more non-timber development of the sector
- employ more realistic tools in the area of community management

Livestock – diseases and their transmission

Incomplete

GMOs

- GM technology could be made pro-poor if it meets certain conditions as regards not only:
- Safeguards but also
- decision-making, which should lay the basis for balanced public debate recognizing the
  - Undue influence of some groups such as foreigners, NGOs and commercial farmers
  - The need to empower consumers and farmers

ICTs

- Seek the extension of the WTO agreement (ITA_1 agreements) on information technology under which there can be the provision of fiscal incentives for ICTs
- Seek to make greater use of initiatives such as the IBRD global development gateway – distance development education and sharing best practices
- Develop regional cooperation on regulatory harmonization especially as regards public private partnerships

5.1 Introduction

Over the last three decades ESAP has managed such economic growth that it is the only region whose population has experienced a decline in rural poverty. That decline is attributable in large measure to a number of policies and reforms starting with the radical land reforms of the 1950s. In some member countries such reforms have continued in recent decades. It is difficult to discuss these reforms in general terms without being specific about the countries and the measures since they are different in scope, have been launched at different times in different countries, and have lasted different periods. It is safe to say that during that time, AKST, through the application of research from high yielding seed varieties, improved farm management and the containment of insect and pest depredations, has enabled farmers to substantially increase the region's agricultural productivity. The World Development Report shows that for East Asia and the Pacific food production index (with a base year of 1989-91) moved from 67.0 in 1979-81 to 152.1 in 1996-98. South Asia moved from 70.4 to 122.1 over the same period. In the case of S Asia the table shows that agricultural machinery, in the form of tractors per thousand agricultural workers, increased from 2 to 5 over a similar period (1979-81 and 1995-97). The figure remained the same, 2, for E. Asia and the Pacific region over the period (IBRD: Selected World Development Indictors, Environment, p289).

In spite of the differences between the approaches of the Governments in the region there have been some common elements with land re-distribution and tenurial reforms being the most obvious. These two measures have had the effect of tempering monopolistic ownership and protecting the rights of tenants. Both have been less extensive or radical in impact than planned or promised. However, taken overall they have contributed to the improvement in rural welfare mentioned. They have been underpinned by two important sets of programs affecting rural development:

1: Rural infrastructure such as roads and irrigation

2: Social reforms including:

- Group mobilization through micro finance in rural areas
- Farmers' training centres, though to a limited extent, and
- Heightened community consciousness

The most successful land reforms have led to increased land productivity in China and the Republic of Korea. Agricultural reforms in general have been most substantive and radical in Korea and Taiwan (Pyakuryal, 2001, p5). Taiwan's radicalism contrasts markedly with the pace of Thailand and Indonesia. In China the reforms have been spread over three phases since the 1950s and have included private ownership, collectivization (until 1978) and most recently the household responsibility system. This most recent phase which has also been characterized by more open economic policies also involved increases in rural support services, including infrastructure and, the development of township enterprises in rural areas. This last phase, whilst transforming China, has been characterized by the overexploitation of soils; land fragmentation and the stagnation of land improvements. India's reforms have concentrated on land structure reform. The results have been mixed with remarkable success being experienced in west Bengal with its 'Operation Barga', for example in contrast with the dismal experience of states such as Bihar. In India's case there was investment in rural infrastructure which was mentioned earlier as being characteristic of most of the region as well as in agricultural research. Social mobilization was also achieved and attributable to the partially successful Integrated Rural Development program. In contrast, neighboring Nepal, although experiencing some increases in land productivity and achieving significant improvements in the mobilization of savings for farmers' use, did not undertake much infrastructural investment or land reform.

Although the economic growth associated with the measures captured above have been impressive, agriculture is still the dominant source of employment and incomes. Some three quarters of the absolutely poor still live in rural areas and for them land is 'the' source of income and employment which delivers abominably low average level of well being.

For the region as a whole, the implementation of agrarian reform may therefore be considered an unfinished task which to some extent has been pushed onto the back burner by the shift to globalization and market reform.

Under this shift to trade liberalization the region enjoyed the fastest rate of growth in merchandise trade and services between 1990 and 2001 in the world. Trade as a percentage of East Asia and the Pacific GDP increased from 45 to 81%; similarly in the case of S. Asia the equivalent movement has been from 20 to 34%. Furthermore, the off-shoring of IT services and ICT connectivity contributed to the expansion of infrastructure and the recognition of the region's rural potential. Cross border trade was accompanied by the migration of low skill women and men. Almost 10% of Philippines' and some 12% of the labor forces of Sri Lanka went in search of such work overseas. Their remittances contributed not only to the region's annual GDP growth of more than seven% but also to the decline in poverty. This was reflected in a staggering 250 million person decline in the number of persons existing on less than US$1.00 per day of (UNDP, 2006:3).

Nonetheless, these developments have been accompanied by many undesirable changes. In addition to failing to provide universal primary schooling for girls and boys, particularly in the south Asia region, for example, there is the persistent shadow of hunger hanging over the region. Asia, with over 510 million hungry people, is the world's worst case (see also chapter 1).

The overlooking, or even neglect, by regional governments of agriculture in their pursuit of new 'economic fads' is evident in the low levels of investment in rural development infrastructure such as irrigation, village electrification and rural markets and roads (UNDP, 2006: 4-9). The rate of unemployment among the young (15-24 year old age group) who constitute approximately one fifth of the region's labor force reflects this neglect; this situation is even worse for the region's rural women and is compounded by social exclusion. Women are the worst victims, along with Dalits and indigenous peoples.

Exclusionary relationships based on power and hierarchy often intersect with and reinforce other aspects of social disadvantage such as gender, caste, ethnicity, religious minority status. This multi-layered process prevents individuals and groups from participating in the governance of national and local institutions and from accessing public services such as health care and education. Development and poverty reduction approaches reinforce their economic and social dependency through the household or its head. Typically, such institutional exclusion tends to be reinforced or underpinned by systemic and violent denial of rights. It ought to be obvious that the existence of such systemic hurdles would be worse for the rural disadvantaged and would serve to deny rural citizens the opportunity of sharing the benefits of growth that might otherwise be expected to trickle down or spread. Herein lies the cause of the contradiction of rapid growth alongside growing dispossession, destitution, gender based disparities and social inequalities.

In these circumstances the challenge facing policy makers in particular, and stakeholders in general, is to fashion not only increased productivity but also socially inclusive growth and development. There would therefore appear to be virtue in explicitly fashioning and regularly assessing the design and impact of the technologies that are intended to lift the agricultural sector. In this latter endeavor it must follow that seats at the 'tables' of the decision-making fora have to be found for the effective participation of the hitherto excluded.

5.2 Local and traditional knowledge and practices

Through the years, local and traditional knowledge has played an important part in maintaining and improving the livelihood of farming communities—from producing food and providing shelter, to achieving control of their lives. In fact, it has become the basis for local-level decision-making not only in agriculture, but also in health care, food preparation, education, natural resource management, and a host of other activities in rural communities (Warren, 1991). Local and traditional knowledge systems tend to be low-input, maximizing organic inputs and minimizing chemical ones, with positive ramifications for human health, biodiversity, and soil and water resources. These systems have made valuable contributions to global knowledge, and can continue to do so with appropriate and adequate support.

5.2.1 Crops and medicinal plants

Traditional knowledge has evolved in response to the pressing concerns of farmers and indigenous people over their environments. Before modern agricultural knowledge and practices were developed, local communities had already devised methods for ensuring the success of their agricultural endeavors. In cropping systems, traditional knowledge may include (Grenier, 1998):

- indigenous indicators to determine favorable times to prepare, plant, and harvest gardens;
- land-preparation practices;
- indigenous ways to propagate plants;
- seed storage and processing (drying, threshing, cleaning, and grading);
- indigenous methods of sowing (seed spacing and intercropping);
- seedling preparation and care;
- farming and cropping systems (for example complementary crop groupings);
- crop harvesting and storage;
- food processing and marketing; and
- pest management systems and plant-protection methods.

Traditional knowledge of crops and medicinal plants can contribute much to our knowledge of cropping systems, and can be adapted and/or commercialized for use in non-traditional systems. In Nepal, hill farmers have a ranking system for the nutrient value of manure from different animals in terms of its use as fertilizer—from bat to buffalo—which corresponds well with the scientific findings based on macro-nutrient content (Tamang, 1993 as cited by Andersen, 2000). The knowledge of this range of indigenous fertilisation practices can be appreciated when developing appropriate programs for pest and soil management that are within the capabilities of farmers, and do not cause adverse effects on either the community or the environment (Varisco et al., 1992).

Local and traditional knowledge and practices are important in attaining food security as well as conserving genetic diversity. In Nepal, a centuries-old seed management system is still allowing farmers to continuously grow and protect their seeds (Ghale and Upreti, 1999 as cited by Timsina and Upreti, 2002). For instance, farmers use intercropping, crop rotation, and crop intensification for seed security purposes. They also employ multiple cropping to minimize total crop failure.

Indigenous post-harvest management systems like storing the cleaned and dried seeds in clothes, earthen pots, tin and bamboo materials, and hanging dried spikes wrapped in plastic in an open protected area are commonly practiced. Placing several herbs and mixing different type of grains (i.e. maize and millet), as a means to protect the stored seeds and maintain storability and quality, have proven effective in ensuring that seeds are kept and passed on from one generation to another (Timsina and Upreti, 2002).

In addition, modern plant breeding also owes much to the landraces bred, conserved, and developed by traditional communities over the millennia. These local varieties have been a continuous source of genes used in the development and improvement of high-yielding varieties. Before modern agricultural scientists arrived on the scene, conservation and innovations with plant genetic resources by farming communities had already been practiced for about 100 years (Hossain, 2002).

Traditional knowledge of crops has also contributed greatly to modern medicine and biopesticides. For example ground neem (Azadirachta indica) seeds have been widely used in India as a natural insecticide and fertilizer, while the leaves are used to protect grains stored in local containers (Davis, 1998). Now neem is marketed as a modern biopesticide used in many countries. Neem also appears to be effective against malaria and internal worms. To maintain personal hygiene, neem was reportedly used by 500 million Indians in brushing their teeth, as well as for making soap. Another example is the Conospermum, commonly called smokebush in Australia, used traditionally by Aboriginal peoples for a variety of therapeutic purposes. In the late 1980s the plant was found to contain a substance called Conocurvone, reported to be a potential cure for AIDS (Davis, 1998).

In fact, it is estimated that, in 1985, US $43 billion worth of plant-based medicines (many of which were used first by indigenous peoples) were sold in developed countries (Principe, 1989 as cited by Posey and Dutfield, 1996). As advances in biotechnology broaden the range of life forms containing attributes with commercial applications, the full market value of traditional knowledge will certainly increase.

5.2.2 Animal agriculture

Similarly, local and traditional knowledge and practices in animal agriculture systems include (Grenier, 1998):

- indigenous methods of animal breeding and production;
- traditional fodder and forage species and their specific uses;
- animal-disease classification; and

- traditional ethno-veterinary medicine.

In India, the importance of animals goes beyond agriculture: it is not only a part of the farming system but is also closely linked with religion and culture, and management systems need to be understood in that context (Rangnekar, 1994). Indigenous technical knowledge in animal husbandry is considered as old as the domestication of various animal species. A recent study in India has revealed that traditional health control and treatment systems were effective in curing a number of ailments in animals including dysentery, arthritis, dog bites, coughs and colds, anoestrus, wounds, bloat, and diarrhea (Reference?). And although modern veterinary medicines were found to give a quicker cure than traditional treatment and preparations, nevertheless, the latter are cheaper and available locally to farmers, especially in remote areas (De Amitendu et al., 2004).

In another study in north Gujarat and south Rajasthan in India development strategies, to improve feeding and management practices suitable for more productive animal agriculture systems, were formulated as a result of information gathered from women tending animals in the area. The results showed that local women possess valuable information about local feed resources and a working knowledge of animal behavior, feed preferences and production characteristics and that, through experience, they have developed feeding practices that suit different types of animals, identified beneficial feed resources ranging from farm by-products to forest products, and developed ways of conserving useful feed materials during periods of scarcity (Rangnekar, 1994).

5.2.3 Aquaculture and fisheries

Aquaculture systems integrated into cropping systems and utilizing indigenous knowledge and traditional practices—such as the rice-fish systems in Bangladesh—can contribute to food security and food diversity (Pretty and Hine, 2001). They can also provide other benefits: for example the introduction of larva-eating fish into rice fields in Quanzhou County, Jiangsu Province, China has increased rice yields, reduced pesticide use and significantly reduced the incidence of malaria (Pretty and Hine, 2001). (need to elaborate on this section)

5.2.4 Forestry

Indigenous peoples have practiced sustainable forest utilization and management techniques for centuries. Indigenous knowledge in forestry includes (Grenier, 1998):

- management of forest plots and their productivity;
- knowledge and sustainable use of forest plants (and animals); and
- understanding the interrelationships between tree species, improved crop yields, and soil fertility.

A study by Jackson and Moore emphasizes the role of indigenous people and practices, particularly the traditional use of fire in forest management and conservation. The study argued that although forest fire is often perceived as destructive, the indigenous use and management of fire plays a significant role in shaping forest ecosystems to regenerate landscapes, facilitate crop production and pest control, and prevent unplanned burns (Jackson and Moore, nd). For instance, annual fires as practiced by local people in Sumbawa, Indonesia are intended to maintain grasslands in a condition that favors grazing animals and enables wild herbivore populations to be maintained at higher levels than they would be without fires. Similarly, in Nepal, local communities use fire extensively to promote the regeneration of grass for animal agriculture. In central and northern Australia, aboriginal communities have sophisticated applications of fire that take into account seasonality, patterns of burning, specific effects on wildlife and plants, and exclusion of fire from particular areas and vegetation types (Braithwaite, 1991 as cited by Jackson and Moore, nd). Aboriginals also use fire to encourage the regrowth of grasses for target wild animal species (especially kangaroos and wallabies).

Another example of the importance of traditional knowledge in forestry is the unique systems of managing natural resources and forests of the indigenous Hani communities in Mengsong, Xishuangbanna, in China's Yunnan province. These communities have developed a system of classifying forest systems according to their function and products, such as forests that produce building materials (lieshugejo) or cash crops (naqiluogo), forests that enhance the landscape (puchang), forests used for graveyards (nagbiong) and protected rattan forest (Sangpabawa). They also employ a selective management of rattan and other plants, to protect biodiversity and natural water sources.

In Sri Lanka, forestry has traditionally been combined with cropping and animal rearing, as for example in the classical Kandyan Forest Gardens. Here the agricultural system simulates a tropical rain forest, but on small land units averaging about 1 hectare. It consists of a mix of as many as 30 perennial and semi-perennial trees and shrubs (ESCAP, 2002). The farmers who practice this system are reported to enjoy a relatively better living because of returns from both cash crops and subsistence products, and improved health and longevity (Jacobs and Allen, 1987 as cited in ESCAP 2002).

In general, there is a growing realization that indigenous knowledge and traditional agricultural systems have a great deal to offer in terms of genetic resources, food, medicine, clothing, shelter, tools, techniques, and crop and animal protection. They possess two powerful advantages. First, these systems are often inexpensive to implement, and can frequently be paid for in goods or services. Second, they are readily available and accessible even to those who do not have cash incomes. In most cases indigenous knowledge systems and technology are socially desirable, economically affordable, sustainable, involve minimum risk to rural farmers, and producers, and often conserve natural resources. Since they evolved gradually within the community and under its control, they are considered appropriate to the needs of the local people (Appleton, 1991 as cited by Rouse, 1999). Local and traditional knowledge systems therefore are more directed towards self-reliance and self-sufficiency than are modern technologies imposed from outside (Fernandez, 1994).

Although traditional agriculture was able to feed people over centuries under a range of bioclimatic conditions, it could not keep pace with the significantly increased population pressure, as witnessed by the great famines of the 1950s, 60s, and 70s in China, India and Bangladesh, for example (ref Medha). But although traditional systems, for example of rice production, appear to be unable to provide a sufficient quantity of food for current urban populations, it would be a mistake to view these systems solely in terms of their output for the commercial market. They are generally able to provide a diversity of products that may be of equal or greater total biomass production per unit of area than conventional equivalents whilst conserving scarce resources, and providing food security to the actual producers (FAO, 2002). The typically higher biological diversity of these agricultural systems is also desirable, as this biodiversity can provide a buffer against adverse climatic and pest events (FAO, 2002).

Traditional agriculture is very labor intensive, and this may be seen as either a disadvantage or advantage depending on the social circumstances. For example the additional labor requirement may keep people from engaging in other economic activity if it is available. On the other hand it can provide meaningful employment for those rural people who would otherwise migrate to urban areas, creating diverse social effects such as leaving behind a household without its male head and potentially contributing to urban unemployment and poverty.

Today about 70 percent of the world’s indigenous peoples live in Asia and the Pacific, and in all countries in the region indigenous peoples are a major subgroup of the rural poor (Reference?). The marginalization and poverty of many indigenous communities is closely linked to their being deprived of the ability to lead the kind of lives they value (IFAD, 2002a). Maintaining and improving the productivity of indigenous agricultural systems is integral to ensuring the sustainability of these communities into the future, and in improving their health status.

Indigenous knowledge and traditional agricultural systems have much to offer in the future development of sustainable agricultural systems, and the role they play should be in response to the specific needs and conditions of farmers to maintain food security and improve micronutrient content of food with minimal human and environmental health consequences, taking into account gender equity and equitable access to resources.

5.3 Organic Agricultural Systems

Organic agriculture systems were developed initially in Europe, New Zealand and Japan (ESCAP, 2002), although the impetus for this development came, in part, from European exposure to traditional agricultural processes in India (IFAD, 2002). These systems fall somewhere between traditional and conventional agricultural systems, sometimes coming close to the former, and sometimes to the latter, varying from augmented traditional systems to modern monocultures. They tend to resemble traditional systems in that they are based on complex integrated systems that employ a range of cropping techniques, aiming to replace external chemical inputs with ecosystem functions and produce a range of outputs (FAO, 2002). Organic agriculture fosters processes and interactions such as those occurring in natural ecosystems, encouraging internal stability rather than relying on external control measures. It aims to recycle nutrients, conserve energy, soil and water resources, and preserve biodiversity (BIO-GRO, 2001).

While some evidence suggests that above and below-ground biodiversity is typically higher in organic systems (Bengtsson et al., 2005; Mader et al., 2005), neutral outcomes are also reported from long-term experiments (Franke-Snyder et al., 2001). Species richness has been shown to increase among some organism groups while others are unaffected (Bengtsson et al., 2005). The impacts of organic agriculture on biodiversity depend on factors such as crop rotation and tillage practices, quantity and quality of organic amendments, and the characteristics of the surrounding landscape. Although some studies suggest reduced environmental losses of nutrients like nitrate nitrogen in organic systems (Kramer et al., 2006), most evidence suggests that nitrate losses are not reduced in high-yielding organic systems when contrasted to conventional production systems (Kirchmann and Bergstroem, 2001; DeNeve et al., 2003; Torstensson et al., 2006).

The rising demand for organic products and often-higher financial returns for farmers, is driving a conversion of conventional farms to organics, and increased institutional research in the ESAP region. Organic systems are increasingly blending appropriate modern agricultural techniques with traditional methods, and represent a growing food production niche in several ESAP countries.

5.3.1 Organic crops and medicinal plants

Cropping techniques generally practiced in but not confined to organic systems include (BIO-GRO, 2001):

- selection of crops and varieties that best suit climatic and agroecological conditions and have disease resistance or tolerance;
- management of planting dates;
- crop rotations, including farrowing and herbal leys;
- intercropping and use of undercrops for weed control and beneficial insects habitat;
- soil solarisation;
- animal manures, green manures especially legumes, turning in of crop residues, composts, and use of effective microorganisms;
- mulching;
- minimal tillage operations such as hand although mechanical cultivation are often necessary;
- the use of approved mineral-bearing rocks and foliar fertilizers as an adjunct to the return of nutrients in organic matter, if necessary;
- biological pest management employing biopesticides like neem, and parasitic insects;
- mechanical barriers;
- grazing by animals to control weeds and enhance fertility.

The area under organic cultivation in Asia and the Pacific is small, and lags behind other areas like Latin America, partly because development and uptake by farmers has been hampered by a lack of supportive government policy in many countries (ESCAP, 2002). However, it can contribute towards the goals of sustainability and development in the Asia and Pacific region, particularly in marginal lands, and especially for the rural poor with few resources to spend on chemical inputs. Additionally the higher diversity of crops and animal agriculture on organic farms leads to an improved distribution of food and income throughout the year (ESCAP, 2002).
Soil organic matter is critical for maintaining soil quality and agricultural productivity. Through its emphasis on building soil structure and fertility by the incorporation of organic matter, organic agriculture can play a role in the rehabilitation of degraded agricultural lands where erosion, compaction, salinisation and desertification have significantly reduced yields and threaten future agricultural use (FAO, 2002). The incorporation of organic matter into the soil also improves water-holding capacity, which is essential in areas of poor/erratic rainfall and potentially higher evapotranspiration which may result from global warming (World Bank 1992, as cited in IFAD, 2002a; FAO, 2002).

A comparison of the soil under conditions of organic and conventional management in kiwifruit orchards in New Zealand revealed that the organic orchard soils had higher pH, higher soil cation exchange capacity, more calcium and magnesium but lower phosphate, more potentially mineralisable nitrogen and biomass carbon, greater size and activity of the microbial population, and higher earthworm populations (Pearson et al., 2005).

However, shortages of organic soil amendments are common throughout the ESAP region (Husain and Raina, 2004), especially where high population pressures and cropping intensity preclude rotations with N-fixing legumes and there are competing uses for animal manures (e.g. for cooking fuel). Some of the most common organic inputs such as cereal stover are of poor quality, having low nutrient concentrations and macro-nutrient ratios that are not optimal for crops.

Organic agriculture's emphasis on the sustainable use of local, often free, resources also makes this system of agriculture particularly important for the rural poor in Asia, and especially women-headed households because of women's greater difficulty in accessing financial resources to purchase seeds, fertilizers and pesticides. It also removes the exposure to pesticides, which have had a significant impact on the health status of the rural poor (Rengam, in press; ESCAP, 2002).

The question of yields from organic versus conventional systems remains controversial, but there is clearly a niche for organic crops, particularly when combined with N-fixing legumes, livestock systems which represent reliable organic inputs, or the availability of sufficient crop residues. There are a number of organic conversion projects throughout the Asia Pacific region that have also reported yield increases and social benefits as a result of conversion to organics (FAO, 2002). The ESCAP (2002) report, Organic Agriculture in Asia and Rural Poverty Alleviation, found a positive relationship between organic farming and improvements in rural livelihoods, including positive effects on employment, income, and household food security. For example, an improvement in the health status of members of the Nayakrishi Andalon organic movement in Bangladesh, which includes more than 65,000 families, was observed.

In addition to its potential for marginalized areas and populations, organic agriculture is developing into a lucrative export market-driven sector—as well as a thriving domestic market sector, with produce increasingly being sold at local farmers markets In both Australia and New Zealand. There is also growing demand for organic food in the urban centers of many Asian countries, and the premiums paid for this food offer an opportunity for increased incomes for the rural poor, especially in areas largely untouched by the Green Revolution technologies (IFAD, 2002). However the greatest limitations to organic agriculture are those imposed by the costs of the organic certification demanded by markets, and the availability of organic inputs.

5.3.2 Organic animal agriculture

In organic systems that are similar to traditional approaches to agriculture, animals are incorporated into a mixed animal agriculture/cropping enterprise, often with the addition of forestry. At the other end of the spectrum are large mono-animal enterprises, such as those found in New Zealand's dairy industry. To the unpracticed eye these may look like conventional farms. The difference lies largely in the organic management of pasture, appropriate disposal of manure, inputs that are permitted, as well as practices that affect the animals' ability to express their innate behavior.

Organic animal agriculture practices include (BIO-GRO, 2001):

- soil management techniques based on appropriate stocking rates and sympathetic grazing regimes to minimize compaction;
- provision of good quality drinking water;
- provision of organically grown feed;
- giving all animals conditions of life that allow them to perform all aspects of their innate behavior, including free access to graze and range on a wide variety of pasture and browsing species;
- adequate housing to ensure the animals' welfare and well-being;
- use of natural health remedies as much as possible, with resort to synthetic veterinary medicines as a last resort to prevent suffering.
- Intensive rearing of animals on feedlots and cage confinement are not permitted in organics.

Yields from organic dairy systems in New Zealand average around 5 percent lower than their conventional counterparts with higher returns and lower input costs resulting in little change in overall returns to the farmer, with the level of returns projected to increase as consumption of organic dairy products increases (Christensen and Saunders, 2003).

5.3.3 Organic aquaculture and fisheries

Organic aquaculture has lagged behind the development of other kinds of organic agriculture. Organic aquaculture can take place in freshwater, brackish water, and in the sea, producing fish, crustacean, molluscs and plants. New Zealand is one of the largest producers outside of Europe, with one salmon farm producing 500-800 tonnes of organic salmon. Other organic aquaculture in the region includes shrimp in Indonesia, Viet Nam and Thailand, mussels in New Zealand, and salmon in Australia. One constraining factor is the sourcing of acceptable nutrients for the farmed species (FAO, 2002).

Conventional shrimp farming in southeast Asia has caused a great deal of concern regarding negative social and environmental effects, and the challenge for organic aquaculture is to provide much-needed protein-rich food without creating these negatives externalities. It requires that the food for the farmed species is obtained from sustainably managed fisheries, derived from locally-available fishery products not suitable for direct human consumption, free from synthetic additives and contaminants, and only fed to farmed aquatic species with naturally piscivorous feeding habits (FAO, 2002). However, FAO concludes that with the “introduction of appropriate water and nutrient management techniques, the prospects for the increased production of farmed organic aquatic plants and molluscs is considerable” (FAO, 2002, p172).

In addition to human health and environmental benefits resulting from reduced pesticide use, organic agriculture has the potential for considerable social benefits. Although expensive to implement, standards for organic certification address issues of social justice and rights, as well as aspects of production, and in this respect may be considered likely to improve the lot of women in the ESAP region. As organic agriculture does not require the purchase of expensive inputs it becomes more accessible to poor rural women who are unable to obtain credit. On the other hand, as organic systems need to be developed over a number of years to reach maximum productive capacity, women’s often insecure access to long-term control over land may be a hindrance (FAO, 2002). Organic systems may require more labor, and this can be negative or positive, depending on the availability of other, locally available income-generating activities.

As peak oil approaches, it is important to be cognizant of the use of fossil fuels—through the production, transport, and use of fertilizers, pesticides and fuels. Organic agriculture may reduce the use of fossil fuels via reduced inputs, although this may not hold true if organic inputs are transported over great distance. It may also use more fuel for cultivation. However, calculations on comparative energy use in OECD countries indicate that energy consumption on organic farms is 64 percent that of conventional farms (Haas & Kolke, 1994a and Lampkin, 1997 as cited in FAO, 2002), whilst other research in Iran and Switzerland puts this figure as low as 30-50 percent (Zarea et al., 2000 and Fliessbach et al., 2002 as cited in FAO, 2002). In a three-year comparative study on organic and conventional strawberry production in China, 98 percent of the energy inputs in the organic systems were from renewable sources (such as animal manure and biogas), whereas 70 percent of the energy inputs in the conventional system were non-renewable (such as electricity, and chemical fertilizers and pesticides; Xi et al., 1997 as cited in FAO, 2002). In New Zealand, Nguyen and Haynes (1995) found that the mean annual energy input was considerably lower under organic management systems than under conventional management (as cited in Fairweather and Campbell, 2001). While fossil fuel consumption can be substantially reduced in organic systems, these energy savings must be balanced against productivity reductions (Dalgaard et al., 2001). For organic systems with substantially lower yields than conventional alternatives, enterprise energy efficiency (energy output per unit energy input) can actually be lower than the efficiency of conventional systems (Loges et al., 2006).

The impetus for private sector research in organic agricultural research has been largely absent for several reasons, including the presumption that organic agriculture is lower-yielding, the relatively low market share of organic products in ESAP countries, and the reliance on inexpensive, rather than expensive inputs. It is posited that if funding levels were to increase, organic production could be increased substantially, improving the social conditions of the rural poor of Asia, thus going a long way to meeting development and sustainability goals.

5.4 Conventional technologies and practices

The role of agricultural technologies and practices generated by formal institutions and research centers, and termed 'conventional' or 'modern' have contributed to substantial gains in global agricultural productivity. These technologies, developed largely over the last sixty years, and known throughout Asia as the Green Revolution package, centre depend upon: plant breeding to produce high-yielding varieties, mineral fertilizers, irrigation, synthetic pesticides for weed, disease and pest control, animal breed improvement and intensification of feeding, and mechanization (Herz, 1996). They were focused on irrigated and high yield-potential areas, resulting in the neglect of marginal areas (IFAD, 2002) where a large percentage of the rural poor live. These technologies have both positive and negative effects.

5.4.1 Crops and medicinal plants

Advances in crop production, plant breeding and crop protection have been responsible for rapid growth in the yield of food and other agricultural products. In the mid-1960s, after a decade of food shortages and famines, the 'Green Revolution' of the 1970s and 80s, led to the introduction of stronger-stemmed and higher yielding 'modern' varieties of the major cereal crops rice, wheat and maize.

These varieties required higher additions of water and fertilizer, together with new plant protection measures such as synthetic pesticides, in order to reach yield potential. In addition, much effort was devoted to developing varieties with tolerance to biotic (insect and disease) and abiotic (salt, drought, heat and cold) stresses. Along with the release of higher productivity varieties was a range of technologies for fertility management ('bag' fertilizer recommendations), mechanization (land preparation, seeding, harvesting and storage) and pest management (weeds, diseases, pests, rodents etc.). The development of early-maturing varieties, particularly of rice, enabled double and triple cropping in areas that previously produced only one or two crops per year (USDA, 2003).

About half of all recent gains in crop yields are attributable to genetic improvements targeting the physiological yield potential of crop plants and their tolerance to biotic and abiotic stresses (ref Medha). Not only did productivity increase as a result of these improvements, but yield per unit area was increased, resulting in positive impacts in some countries beyond the agricultural system per se. In India for instance, less land devoted to agricultural crops contributed to an increase in the conservation and expansion of forests and woodlands by 21 percent between 1963 and 1999 (USDA, 2003).

The Green Revolution fuelled an explosion in the yields of rice, wheat and maize on lowland, intensively irrigated land: cereal production in Asia more than doubled from about 313 million tonnes in 1970 to about 650 million tonnes in 1995 (IFAD, 2002). However, in recent years yield growth rates have begun to stagnate or drop—the rice yield in Asia declined sharply during the 1980s from annual growth rate of 2.6 percent in the 1970s to an annual growth rate of 1.5 percent (Pingali and Rosegrant, 1994). Long-term continuous cropping trials conducted by IRRI in the Philippines indicate that even when using the best cultivars and scientific management techniques, yields decline over the long term if inputs are held constant (Pingali and Rosegrant, 1994).

Clearly productivity cannot be sustained in the long term in such intensive cereal monocultures by using increasing levels of chemical inputs. Additionally, the adverse livelihood-related and environmental consequences resulting from the mismanagement of Green Revolution technologies are now well recognised. The indiscriminate and unsafe use of pesticides has had significant impact on farm family health. A survey of farmers in the Philippines indicated that health problems including eye abnormalities, skin problems, and respiratory ailments among farmers seemed to be correlated with insecticide use (IRRI, 1994). The negative effects of insecticide use on the environment and on beneficial insects have also been documented (Way and Heong, 1994; Pingali and Roger, 1995). The Asian Development Bank has estimated that about one third of Asia’s agricultural land has been degraded over the last thirty years through water-logging, salinisation, erosion and desertification (Kaosa-ard & Rekasem, 1999). Many farmers entered a spiral of debt precipitated by rising costs of inputs and falling prices for outputs: rice farmers in the Philippines were found to be economically better off before they shifted away from the mixed cropping enterprises to the high-yielding monocultures (ESCAP, 2002; IFAD, 2002).

5.4.2 Animal agriculture

Advances in animal breeding and health have increased both the quantity and quality of animal protein available to consumers.

5.4.3 Aquaculture

In general, technologies generated by formal institutions contrast with indigenous knowledge in that the latter is context-specific, that is, it is adapted to specific biological, ecological and climatic conditions that may be inoperable and inappropriate in environmental conditions other than those in which they have been developed (Rouse, 1999). The former are designed to suit a wide range of environments, and may prove beneficial in changing agroecological environments. High input, mechanized, increasingly consumer- and market-driven systems have substantially increased the productivity of agricultural and animal systems in the ESAP region while resulting in substantial labor savings. This often translates to less time expended in physically demanding work for the women who are the primary agricultural workers in the ESAP region, and a decreased need for the entire family including children to be involved in field work. This may be a positive or negative effect depending on the level of income generated by the farm and the availability of other means of income generation.

However, one failing of the Green Revolution is that it did not result in an equitable distribution of the benefits, with resource-rich farmers benefiting more than poorer ones. Although risk of crop failure is generally lower with conventional practices, the risk of disease outbreaks is higher. The economic outlay required for seed and pesticide and fertiliser inputs to maximize success is high, and translates to a greater risk undertaken by farmers with much to lose if crops should fail. Conventional technologies too often did not focus on ways to achieve increased food production in a resource-efficient manner that is environmentally benign.

The challenge for post Green Revolution agricultural systems is to improve productivity without the negative ecological and social side effects experienced during and after the Green Revolution, particularly improving the food security and sustaining the livelihoods of the rural poor as well as providing food for urban populations. It needs to address the problem of diminishing supplies of oil and escalating prices of fuels and petrochemical products such as fertilizers and pesticides, finding ways to minimize these inputs – for health and environmental reasons as well as economic reasons. It needs to move towards improved water use efficiency as water supplies in the ESAP region become increasingly scarce and oversubscribed, and to find ways to replenish degraded agricultural soils. Consequently, increasing attention and funding in the public sector has been devoted to integrated pest and nutrient and resource management (IPM and INRM) technologies. These approaches hold promise for optimizing agricultural productivity and environmental sustainability while minimizing adverse effects on human health by combining low input approaches with the judicious and timely use of reduced chemical applications.

5.5 Emerging Frontiers of Science and Technology

Food production will have to triple to feed the anticipated world population of approximately 12 billion by 2050 (Population Reference Bureau, 2002). Much of the worldwide arable land and freshwater resources are already strained, leaving few viable option for increasing food production, foremost among them: to increase yields on available land, despite diminishing water resources and increasing environmental degradation (Serageldin, 1999; Chrispeels, 2000; Vasil, 2003). Krattiger (1998) estimated that per capita available arable land area will be reduced by 50 percent over the next 50 years. The newest and most controversial developments on the frontiers of science such as biotechnology—including transgenic technology to produce crops, pharmaceuticals (pharming), and food vaccines—genetic use restriction technology (GURT), and nanotechnology are attracting great scrutiny as tools to meet world food needs using stagnant or declining land and water resources. These are evaluated here for their benefits as well as their risks.

5.5.1 Transgenic technology or "the gene revolution"

Among the most contentious biotechnologies is the application of genetic engineering for the production of transgenic crops with a variety of properties, including herbicide tolerance and insect resistance, micronutrient enhancement, and vaccine production. Efforts to insert genes or modify gene expression for the production of pharmaceuticals in animals from mice to larger animals are also underway, with some products either on or close to market.

Transgenic crops can maintain or improve agricultural productivity on existing land and water resources, reduce the impact on farmers of biotic (e.g. pest) and abiotic (e.g. drought) stresses, prevent or reverse soil and water degradation through reduced tillage and pesticide applications, and improve human health through reduced pesticide use and crops engineered for improved nutritional content or vaccine delivery (Ervin et al., 2001; James, 2003). The most common traits introduced into transgenic crops are herbicide tolerance, accounting for about 71 percent of transgenic acreage, with 18 percent planted to insect resistant Bt crops, and 11 percent to stacked genes for the two traits (James, 2005). Physiological enhancements such as delayed ripening, improvements in nutrient and/or vitamin content, and drought resistance are traits under development in decreasing order of importance (Hunter, 2000; James, 2003).

The primary concerns about transgenic crops relate to potential environmental, human health, and socio-economic effects. Fears about potential consequences argue for a cautious approach, as should be adopted for any extensive change in agricultural practices (NAS, 2003). Despite this, rush to commercialization of transgenic crops has proceeded rapidly, with robust science often following, rather than preceding it, and the rapid expansion of the land area planted to transgenic crops continues, fueled by a demand that saw the global area of biotech crops increase by 11 percent between 2004 and 2005 (James, 2005). Just as most farmers will resort to pesticides and fertilizer inputs when available and feasible to protect their livelihoods, they will embrace new 'technological fixes' that do the same. It is up to the scientist creators of these technologies to ensure minimal long-term consequences, a stance that is made murky by the vast profits riding on their commercial release.

According to James (2005) there are currently fourteen biotech mega-countries in which more than 50,000 hectares are planted to transgenic crops, nine of which are considered resource-poor. Of these, three are in the ESAP region: China, India, and the Philippines. In 2005, about 90 percent of the 8.5 million transgenic crop growers were poor or subsistence farmers, a majority of them in the ESAP region: about 6.4 million in China, 1 million in India, and about 50,000 in the Philippines.

5.5.1.1 Productivity, human health and nutrition

Agricultural productivity. Transgenic crops can increase agricultural productivity, either by improving the yield potential of plants with existing or lower input levels (Peng et al. 1999, Taylor et al. 2001, Regierer et al. 2002) or by their control of biotic and abiotic challenges to agronomic productivity. In 2005, almost 90 percent of the global transgenic crop area planted was to herbicide and insect-resistant crops (James 2005). Studies by Huang (2002), Hossain et al. (2004), Wu and Guo (2005), and Qaim and Zilberman (2003) on small-holder farms in China and India have demonstrated that Bt cotton yields were significantly higher while reducing pesticide use by upto 70 percent. Weeding in most poor countries is an arduous and time-consuming endeavor, generally accomplished by women and children (Krattiger, 1998). Although herbicide-resistant crops presuppose the availability of affordable herbicide, they have the potential not only to improve yield, but to allow women to pursue income-generating activities and children to perhaps attend school. From an agroecosystem perspective, use of herbicide-tolerant crops allows reduced and zero-till practices to work more effectively. The resulting decrease in soil disturbance is beneficial for retaining soil organic matter, improving soil structure, reducing soil compaction and improving soil water relations. On the other hand, however, herbicide tolerant crops require the application of herbicide, with potentially adverse consequences for human health, livelihoods, and the environment.

Insect-resistant (IR) crops can decrease losses due to pest infestations, and also positively influence the health of farmers through reduced exposure to insecticides. Several disease-resistant transgenic crops have been or are being developed to address pest losses, including peppers (Rowell et al., 2001), sorghum (Krishnaveni et al., 2001), potatoes (Murray et al., 2002; Sharp et al., 2002), oilseed crops (Lu 2003), tomatoes (Lee et al., 2002), and wheat (Gerhardt et al., 2002). Use of IR crops also results in reduced insect damage, which not only improves yield, but demonstrably lowers contamination of crops by mycotoxins produced by opportunistic fungi that normally infect crops in the wounds made by grazing insects (Munkvold et al., 1999; American Phytopathological Society, 2001). Mycotoxin contamination can be a serious issue in poor countries where contaminated food is often consumed, with particularly high levels of the Fusarium mycotoxin moniliformin measured in maize samples from Gambia and South Africa (Sharman et al., 1991).

Transgenic technology is being used to develop crops resistant to abiotic stresses such as drought, soil acidity, and salinity, and to provide improved storage stability, delayed ripening, and other changes to increase flexibility in distribution and/or facilitate juicing or other processing for greater economic benefit. Advances in resistance to abiotic pressures will allow crops to be grown in marginal, low productivity areas, while increased storage stability and delayed ripening will certainly benefit those with few resources to invest in refrigeration and other equipment to increase the shelf-life of agricultural produce.

Drought is most likely to be limiting agronomic productivity on a global scale, while salinity affects about 33 percent of irrigated land worldwide, much of it in the ESAP region (Kelemu et al., 2003; Chen et al., 2006). Although improvements in the resistance of crops to abiotic stresses through conventional breeding have been limited, genetic manipulation of this complex trait has proven more successful (Nguyen et al., 1997). Using advances in molecular technologies, a variety of drought and/or salinity and aluminum-resistant crops have been created (de la Fuente-Martinez, 1997; de la Fuente-Martinez and Herrera-Estrella, 1999; Liu et al., 1999; McLean et al., 2000; Zhang and Blumwald, 2001; Zhang et al., 2001; Garg et al., 2002; Singla-Pareek et al., 2003). However, the value of these modifications in the field has yet to be established. Much of the work on improving storage stability and manipulating ripening and processing-related factors has been limited to transgenic tomatoes (Fromm et al., 1993; Grierson 1994; Picton et al., 1995; Kalamaki et al., 2003a and b; Powell et al., 2003) and potatoes (Greiner et al., 1999).

Micronutrient and nutrient value enhancement. Over three billion people, mostly in the world’s poorest countries, are currently afflicted with micronutrient malnutrition (Mason and Garcia 1993; Welch et al., 1997; WHO 1999), while almost two-thirds of childhood mortality is associated with nutritional deficiencies (Caballero, 2002). Micronutrient-enriched staple crops developed through genetic modification target the most vulnerable—resource-poor women and children (Combs Jr. et al., 1996; Bouis, 2000). For instance, vitamin A deficiency is common in at least 26—mostly ESAP region—countries where the diet is dominated by rice, and causes over 1 million deaths and partial or complete blindness in 0.25 – 0.5 million of the poorest children each year (Conway and Toennissen, 1999; Hunter, 2000). Rice engineered to overproduce pro-vitamin A or beta-carotene is expected to greatly reduce these numbers (Ye et al., 2000). Rice is also being targeted to address iron deficiency, identified as a contributing factor in over 20 percent of post-partum maternal deaths in Asia and Africa (Conway, 1999; Goto et al., 1999; Lucca 1999).

Transgenic crops can have an enormous impact through direct positive effects on health and nutrition. For instance, cassava, widely used in areas of SE Asia, contains the toxic cyanogenic glucoside, linamarin. Transgenic cassava root has about 1 percent of the toxin present in the non-transgenic isoline, obviating the need for processing to eliminate cyanogen toxicity (Siritunga et al., 2003). Starch in potatoes and antioxidants known as flavonols in tomatoes have been increased via genetic manipulation (Regierer et al., 2002; Bovy et al., 2002).

Reduced pesticide use. By replacing chemical sprays that farmers generally rely on to control pests, insecticide-resistant crops such as those with insecticidal genes from the bacterium Bacillus thuringiensis (Bt) can reduce or eliminate adverse effects of such insecticides on human and environmental health (Jeyaratnam, 1990, Gray et al., 1993; Gray, 2000, Huang et al., 2002; Qaim and Zilberman, 2003). Phipps and Park (2002) estimate that pesticide use in the European Union would decrease by 14.5 million kg of formulated product resulting in a savings of about 21 million liters of diesel and a reduction of about 73,000 tons of carbon dioxide if just 50 percent of the corn, cotton, oil seed rape, and sugar beet grown in the EU were genetically modified varieties. Such estimates are not available for either the ESAP region or the rest of the developing world where inputs are likely to be less than for the European Union. However, based on these numbers, transgenic crop growers in the developing world are highly likely to see savings in pesticide and fuel.

Krattiger (1997) speculates that Bt products could save farmers about 2.7 billion of the global USD 8 billion or so spent annually on insecticides, although this is difficult to verify. He estimates that insecticide use in rice to control the stem borer alone costs over one billion USD worldwide, much of it in the poorest countries of Asia. Significant health problems among farmers have been correlated with insecticide use (IRRI, 1994), a large portion of which are hazardous Category I and moderately hazardous Category II chemicals, many banned in most developed countries (Warburton et al., 1995). Transgenic Bt rice resistant to the stem borer is one alternative to insecticides, and is currently undergoing field testing in Asia (IRRI, 1997; Datta, 1999; Skerritt, 2000).

Recent reports from South Africa and elsewhere (FAO, 2004; Morse et al., 2004) are confirming reduced environmental harm and increased yields with the use of insect resistant crops that are targeted against specific insect pests; in many farming systems incorporating these crops, an increase in beneficial insects and a return of song birds has been noted. The negative impacts of insecticide use on the environment and on the control of pests by beneficial insects have also been extensively documented (Way and Heong, 1994; Pingali and Roger, 1995). Yet, farmers continue to use them in the absence of alternatives; farmers not using Bt crops generally rely on insecticides to control the target pest (Gray et al., 1993; Gray, 2000; Qaim et al., 2003).

Pharming. There is increasing interest in the potential for transgenic plants to produce pharmaceuticals and vaccines through molecular farming ("pharming"). Pharming provides the hope of cheaper production, and easier delivery and use to segments of the world's population that are both most needy and most resource-poor. Proteins currently produced via pharming include therapeutic proteins such as thrombin and collagen, industrial proteins characterized by the need to be produced in large quantities such as enzymes catalyzing biomass conversion to ethanol (Hood et al., 1999, 2003; Bailey et al., 2004), and monoclonal antibodies (also known as "plantibodies") including an anti-cancer antibody expressed in rice and wheat grain and recognizing lung, breast, and colon cancer cells (Stoger, 2000). Vaccines can be used to prevent or combat many of the diseases that cause illness and death in low-income countries, but they are often expensive to produce and use, for they must be refrigerated and administered by trained personnel, and require sterile delivery through needles that are often difficult and expensive to obtain. Although research in this area is in the early stages yet, vaccines against some infectious gastro-intestinal diseases have been produced in potatoes, bananas, and corn (Thanavala et al., 1995; Lamphear et al., 2004). Table 5.2 lists some pharming products anticipated to be on the market soon.

Non-food applications. Transgenic plants are being evaluated for a variety of non-food applications, including bioremediation, modification of fiber content, and biodegradable plastics. Tobacco has been engineered to carry the MerA gene from E. coli, allowing engineered plants to detoxify mercury (He et al., 2001). Modification of lignin content in crops to render them more digestible by animals has been attempted; engineered alfalfa with reduced cinnamyl alcohol dehydrogenase resulted in increased digestibility, as determined by chemical methods. Improved cellulose production is also being pursued (Haigler and Holaday, 2001), as is the expression of spider silk protein in tobacco and potato (Scheller et al., 2001). Transgenic crops, particularly oilseed rape, are being evaluated as alternative biodegradable plastic production systems to the more expensive bacterial fermentation processes, particularly for poly-beta-hydroxybutyrate (PHB) and poly-beta-hydroxyvalerate (PHV) production (Poirier, 2001).

5.5.1.2 Genetic use restriction technologies (GURT)

The expression of genes is generally regulated by internal factors like proteins or other products of metabolism, or external factors like climate. GURT refers to biotechnology-based methods to regulate gene expression, primarily to restrict plant propagation from a second generation of seed. There are three distinct aspects of these technologies: use restriction, environmental containment of transgenic material, and agricultural productivity (FAO, 2001). There are two types of GURT: variety-specific (V-GURT), resulting in sterile seeds and earning the ‘terminator gene’ or ‘terminator technology’ labels, and the controversial use restriction of a specific trait (T-GURT), requiring external inducers to activate gene expression (Oliver et al., 1995; UNEP/CBD/SBSTTA, 1999).

Unlike V-GURT, T-GURT would enable farmers to save their own seed, but lack access to the added traits in the absence of payment for chemical activators. In addition to their use restriction properties discussed above, GURTs represent an environmental containment strategy through their ability to eliminate the spread of transgenic seed (V-GURT) or transgenes to wild plant relatives (T-GURT). For instance, this technology could potentially eliminate the problems of “volunteer” plants that appear from seed left in the field after harvest. Volunteer plants must be eliminated before the next crop is planted because they are hosts for pests and pathogens and can nullify the benefits of crop rotation. As with any growth regulator applied to crops, environmental or human health issues may be associated with the use of chemical activators (i.e., tetracycline, copper, steroids) and hence the effects of these need to be addressed.

Potential productivity advantages from GURTs include T-GURTs enabling a farmer to restrict the expression of a trait when there is an advantage in doing so; for example, at a specific phase of development or during periods of biotic or abiotic stress (FAO, 2001). Productivity gains from V-GURTs include the ability to safeguard the integrity of adapted maternal breeds or to prevent pre-harvest sprouting.

5.5.1.3 Potential risks of applications involving transgenics and GURT

Although transgenic crops and GURT offer a promising means to increase agricultural productivity in cropping systems, particularly those subject to stress, they are by no means risk-free. Like any introduced agricultural practice, these technologies have the potential to significantly alter agricultural ecosystems through effects on the environment, to affect human and animal health, and to have substantial social and economic impacts on grower communities. The discussion on potential risks will focus on transgenic technology where the evidence is strongest, although consequences of the other technologies—which have not yet been disseminated—will also be addressed.

Environmental concerns. Potential environmental effects of transgenic technology include: (i) adverse effects on non-target organisms, (ii) gene flow into wild plant communities or soil organisms, (iii) persistence and spread of transgenes, and (v) development of resistance by target pests.

(i) Non-target effects: Entomophagous insects and parasitoids in their fields are invaluable in integrated pest management approaches employed to control outbreaks of insect pests, and larvae of insects such as butterflies are one link of many in the food web that sustains them. In the case of Bt corn, although the transgenic lines created by events Bt11 and MON810 showed no undesirable consequences in non-target Lepidoptera (butterflies), lines resulting from event 176 had adverse effects on these organisms (Losey et al., 1999; Jesse and Obrycki, 2000; Hellmich et al., 2001; and Stanley-Horn et al., 2001; Zangerl et al., 2001). Event 176 Bt corn pollen has significantly higher levels of the Bt protein than Bt11 or MON810 Bt corn (Koziel et al., 1993), and was not re-registered with the US EPA in 2001, primarily due to concerns about resistance management (Shelton and Sears, 2001; Groot and Dicke, 2002). Thus, it is important to evaluate potential effects of transgenic crops on a case-by-case basis, and with attention to the details of methods used in engineering the transgene and its expression in the plant.

An evaluation of direct toxicity or indirect food chain-related effects on a large variety of other insects, many of them beneficial, also indicates no adverse impacts of Cry1Ab Bt corn (Orr and Landis, 1997; Pilcher et al., 1997; Bourguet et al., 2002; Zwahlen et al., 2000; Al-Deeb et al., 2003; Dutton et al., 2003), herbicide-tolerant transgenic sugar beets and oilseed rape (Volkmar et al., 2000; Volkmar et al., 2003), transgenic wheat with enhanced fungal resistance (Jorg et al., 2003), transgenic potatoes expressing protease inhibitors (Cowgill et al., 2002; Cowgill and Atkinson, 2003), and Cry3A Bt potatoes (Lopez and Ferro, 1995; Riddick and Barbosa, 1998). Although the majority of the evidence suggests that transgenic crops do not have direct effects on beneficial insects, adverse effects of Bt proteins on beneficial insects via compromised food quality of their prey have been reported (Hilbeck et al., 1998; Schuler et al., 1999; Meier and Hilbeck, 2001; Ponsard-Sergine et al., 2002).

Transgenic crops may also affect soil microorganisms, which are indispensable in nutrient turnover and maintaining soil structure and fertility. Field studies with a variety of transgenic crops have demonstrated changes in microbial, protozoan, and nematode populations in soil (Donegan et al., 1995; Di Giovanni et al., 1999; Donegan et al., 1999; Griffiths et al., 2000; Lukow et al., 2000; Marroquin et al., 2000; Cowgill et al., 2002). However, the data are difficult to interpret and tie to ecosystem function, and other studies have shown no effect of Cry3Bb Bt corn on nematodes (Al-Deeb et al., 2003), or on bacterial and fungal activity or community diversity in the field (Devare et al., 2004; Devare et al., in press; Londono et al., in preparation; Xue et al., in preparation), and of Cry1Ab Bt corn on bacterial communities in the greenhouse (Blackwood and Buyer, 2004) or field (Fang et al., 2005). Bt rice has also been shown to have no negative effect on a range of microbial indicators (Wu et al., 2004), as have transgenic potatoes expressing cystatins on free-living nematodes in the soil (need ref).

(ii) Gene flow: Gene flow between crops and their wild relatives is common and, between plants capable of hybridizing, inevitable if grown within the crop's pollen dispersal range (Ellstrand et al., 1999). Although use of border rows containing non-transgenic isolines or trap crops or use of perimeter fallow zones is strongly suggested, it is generally accepted that complete containment of transgenic pollen in male fertile lines is impossible, and genes will move (Snow, 2002). How far and how fast will be determined by prevailing weather patterns and conditions at the time pollen is shed, the method of dispersal (e.g., wind or insects), the amount of pollen produced and its longevity, the distance between the donor and compatible recipient and whether the crop out-crosses or is self-pollinated.

The two more controversial aspects of transgenic crops are the cultural and biodiversity implications of 'genetic pollution' of natural landraces or neighboring crops should gene flow occur, and the potential ecological consequences accompanying the creation of 'superweeds' by the transfer of genes conferring enhanced survival and fitness to recipient plants. Although conventional breeding has already led to significant reductions in biodiversity via the wholesale replacement of land races with elite line monocultures, such a result is no more, nor less, of a concern with the use of transgenic crops.

Most regulatory frameworks that have been developed dictate that transgenic crops not be grown in areas where wild relatives are endemic, specifically, to limit gene flow and the potential for 'genetic contamination'. Such restrictions are unlikely to be enforced in countries without a strong regulatory and monitoring infrastructure. Thus, the risk of out-crossing is likely to be increased in resource-poor countries, the consequences of which are poorly known. A case in point is the 'stealth seeds' phenomenon in India, which involved farmers multiplying and selling Bt cotton seed which were viewed as desirable but expensive to legally obtain.

(iii) Insect resistance management: Insect resistance to Bt has been demonstrated in laboratory trials, but despite Bt crops being grown on more than 15 million ha worldwide, an increase in the frequency of resistance caused by exposure to Bt crops in the field has not yet been reported (Fox et al., 2003; Tabashnik et al., 2003). Resistance has been slowed in pest populations by having a high dose of Bt toxin expressed in plant tissues which decreases the likelihood of survivorship, ensuring that insects are not exposed to sublethal doses that might promote development of resistance. This high dose strategy has been combined with the use of refugia which serve to maintain susceptible insect populations that delay resistance (Roush, 1994; Tabashnik, 1994).

Health concerns. Although transgenics and GURT have the potential for health benefits through reduced exposure to pesticides, improved access to micro-nutrients and plant-based vaccines, and reduced incidence of mycotoxins, health concerns of these technologies must be carefully evaluated on a case-by-case basis before release. The two greatest fears are toxicity and allergenicity, particularly for transgenic crops. Mammalian toxicity of transgenics requires binding sites, and neither such receptors (Noteborn et al., 1995; EPA, 2000) nor toxicity have been identified (Skerritt, 2000; Kuiper et al., 2001; Perr, 2002; Shelton et al., 2002).

Several controlled feeding studies in rats, mice, and animals use in agricultural systems with a range of transgenic tomato (Noteborn and Kuiper, 1994), potato (Hashimoto et al., 1999 a and b), rice (Momma et al., 2000), soybean (Hammond et al., 1996; Harrison et al, 1996; Teshima et al., 2000; Ash, 2003; Stanford et al, 2003), corn (Folmer et al., 2000; Sidhu et al., 2000; Federation of Animal Science Societies, 2001; Hammond et al., 2001; Donkin et al., 2003), and wheat (Kan and Hartnell, 2004) have failed to show any toxic, allergenic, or nutritional effects of the transgenic crop tested. While these findings in no way negate the need to apply rigorous standards to health risk assessments of individual technologies, it is important to also compare these risks with those of the pesticides which might be used in their absence.

Food prepared from transgenic crops is generally processed or refined (e.g., oils, meals), or cooked prior to consumption by humans (e.g., meat exposed to transgenic feed). Protein and DNA are destroyed during food processing, but some proteins like the Cry9C present in Star Link corn (Aventis Corp.) remain stable even at high temperatures (EPA, 1999). Star Link Bt corn containing Cry9C was therefore only certified for animal consumption, but was found to be a contaminant in over 50percent of the US corn supply in 2000. Although there is no evidence that the protein can act as a toxin in any but the target organism, there are very legitimate concerns about its potential allergenicity (Kuiper et al., 2001). The Star Link case highlights the need to be extremely cautious in the regulation of biotechnologies.

Socio-economic concerns. Transgenic and genetic use technologies have the potential to increase economic returns via improved crop yields under stress conditions and reduced chemical inputs, while preventing the spread of transgenes in the case of GURT applications. However, it is critical to recognize that biotechnology applications in agriculture bring with them significant cultural and economic implications. Livelihoods of the poor depend on ecological integrity. The threats of biodiversity reduction through 'genetic pollution' and 'superweed' creation are scenarios with far-reaching negative consequences for livelihoods and cropping systems.

Further, the technologies are expensive, and commit farmers to regular financial outlays for improved seed or chemicals each season that may not be achievable. Small farmers generally collect seed at harvest and use it as the next year's planting stock. In many ESAP countries where seed saving is common practice, farmers will still be able to save their traditional seeds and other public varieties, but would have to expend precious resources each year in the purchase of improved, transgenic seed. Economic loss from the inability to save seed may be recouped by productivity gains to the farmer from increased yield and quality and reduced input costs. However, transgenic crops confer an economic advantage only in the presence of the stress they are engineered against. The absence of stress could result in significant financial losses due to the substantially higher expense of transgenic vs. conventional seed. In general, the risk and debts incurred by growers of transgenic crops, particularly those without access to low-interest loans, is extremely high given the market and infrastructure instabilities common in developing countries. The consequences can be disastrous—as has been demonstrated by farmer suicides resulting from an inability to repay high-interest loans taken for non-transgenic, improved seed varieties and supporting inputs in the Indian states of Punjab, Andhra Pradesh, and most recently, Maharashtra.

5.5.2 Nanotechnology

Nanotechnology is defined as the "the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale." (UK Royal Society and Royal Academy of Engineering, 2004, p. 5; ETC Group). There are growing concerns on the emerging convergence of nanotechnology and biotechnology over safety and the long-term impacts on food and agriculture (ETC Group, 2003; could probably find more refs).

The long-term prospects of the potential application of nanobiotechnology in large-scale replication and production of biological material such as proteins or the specific genetic modification of life-forms to give enhanced properties is a subject of heated debate (ETC Group, 2004; UK Royal Society and Royal Academy of Engineering, 2004). International civil society groups monitoring developments in nanotech project that the impacts of nanobiotechnology in food and agriculture will surpass that of the Green Revolution and farm mechanization in a couple of decades (ETC Group, 2004).

The agricultural application of nanotechnologies is already underway, with some manufactured food products already in the market, both in industrialized and developing countries involving both the private and public sectors.

5.5.2.1 Potential benefits of nanotechnology

Nanotechnology in seeds. Researchers in the US are experimenting on techniques that use nano-particles to inject foreign DNA into millions of plant cells without being passed on the next generations, thus avoiding concerns on cross-pollination (Dalke in Genome News Network, 2003). Thai researchers at Chiang Mai University announced its research on atomic modification of rice varieties to improve traits. Researchers "drilled" a hole through the membrane of a rice cell in order to insert a nitrogen atom that would stimulate the rearrangement of the rice's DNA, thus changing its color and potentially, other characteristics such as maturity period (Ranjana in Bangkok Post, 2004).

Nanotechnology in pesticides. The world's major agro-chemical companies have already started commercially marketing pesticides formulated at the nano-scale. Some of these pesticides are emulsions containing nano-scale droplets and micro-encapsulated formulations. Pesticides produced at nano-scale are claimed to be more easily dissolved in water, more stable, optimally target pests, and completely absorbed in the plant's system (ETC Group, 2004).

Nanotechnology in precision agriculture. The convergence of nanotechnologies with information and communication technologies also has wide applications in agriculture. Among these applications is in the field of "precision farming," or the site-specific farm management involving a bundle of new information technologies applied to the management of large-scale, commercial agriculture (ETC Group, 2004). The US Department of Agriculture (USDA) is working to promote and develop a total "Smart Field System" that automatically detects, locates, reports and applies water, fertilizers and pesticides through nanotechnologies. Companies and the public sector in the US are experimenting on the potentials of "smart dust" which involve the development of autonomous match head-size sensors with the ability to detect and then communicate with other motes in the vicinity, and self-organize into ad hoc computer networks capable of relaying data using wireless technology (ETC Group, 2004). The "smart dust" or nano-sensors technology is already being applied in engineering and microclimate sensing.

Nanotechnology products and agricultural commodity trade. The most imminent concern over nanotechnology is its impact on trade in agricultural commodities. Nanotech products already in the market such as synthetic textiles and cotton, and nanotech rubbers are projected to pose serious threats, through stiff competition and impacts on world prices, to the cotton and rubber industries in developing countries posing a threat to the livelihoods of millions of farming families.

Other Nanotechnology applications relevant to AKST. Some emerging applications of nanotechnology that may have long-term implications on AKST pertain to the development of nano-water which involves the use of nanotubes to filter pollutants and saline particles from water for human consumption and agricultural uses. Future developments in the search for cheaper and renewable energy sources through the use of nanotechnologies may also have strategic implications on AKST.

Current investments in nanotech. The European Commission estimates the current global investments in nanotechnologies at around €5 billion, with €2 billion coming from the private sector (as cited in UK Royal Society and Royal Academy of Engineering, 2004, p. 1). Most of the world's major seed and agro-chemical companies have put their substantive stake in nanotech research and development. Civil society groups monitoring development in nanotechnologies have placed the combined investments of the public and private sectors in 2004 at $10 billion (ETC Group, December 2004). Research and development in nanotechnologies have been receiving substantial investments from both the public and private sectors. The current investments are aimed at taking their share in the projected value of nanotech products by 2011-2015 estimated at around US$1 trillion (UK Royal Society and Royal Academy of Engineering, 2004). In 2004, the European Commission has placed the investments of the European Union in nanotech research and development at €1 billion; Japan at US$800 million in 2003; the UK at £45 million for the period 2003-2009 under its national nanotech strategy; and the USA at $3.7 billion for the period 2005-2008 under its 21st Century Nanotechnology Research and Development Act of 2003 (as cited in UK Royal Society and Royal Academy of Engineering, 2004, p. 1).

The enthusiasm of the public and private sectors in nanotech research and development can also be clearly gauged from the trends in patents involving nanotechnologies. From 521 patents in 1995, the figure jumped almost four-fold to 1,976 in 2001 (UK Royal Society and Royal Academy of Engineering, 2004).

5.5.2.2 Potential risks of applications involving nanotech

Health and environment. There are a few studies on the potential health and environmental impacts of nanotechnologies, particularly nanoparticles. Nanoparticles can be inhaled, ingested or pass through the skin. Once in the bloodstream, nanoparticles can elude the body's immune system such as the blood-brain barrier (ETC Group. 2002). Another concern is that increased reactivity of nanoparticles could harm living tissue, perhaps by giving rise to "free radicals" that may cause inflammation, tissue damage or growth of tumors (ETC Group, 2005).

A study published in July 2004 found that buckyballs (precursor of nanotubes) can cause rapid onset of brain damage in fish (Oberdörster in Environmental Health Perspectives, July 2004). In 2005 researchers at the United States National Aeronautic and Space Administration (NASA) reported that when commercially available carbon nanotubes were injected into the lungs of rats it caused significant lung damage (Raloff in Science News Online, 19 March 2005). In another study, researchers at the United States National Institute of Occupational Safety and Health reported in 2005 substantial DNA damage in the heart and aortic artery of mice that were exposed to carbon nanotubes (cited in ETC Group, 2004).

In 2005 US researchers at the University of Rochester found that rabbits inhaling nanotech buckyballs demonstrated an increased susceptibility to blood clotting (cited in ETC Group, 2004). Another 2005 study shows that buckyballs clump together in water to form soluble nanoparticles and that even in very low concentrations they can harm soil bacteria, raising concerns about how these carbon molecules will interact with natural ecosystems (cited in ETC Group, 2004).

Recognizing the knowledge gaps and the health concerns arising from available toxicological studies, the UK's Royal Society and Royal Academy of Engineering, in its report on nanotechnologies in July 2004, recommended "as a precautionary measure that factories and research laboratories treat manufactured nanoparticles and nanotubes as if they were hazardous and reduce them in waste streams and, that the use of free nanoparticles in environmental applications such as remediation of groundwater be prohibited" (UK Royal Society and Royal Academy of Engineering, 2004).

Social-ethical issues. Most of the social and ethical concerns surrounding nanotechnologies revolve around control, transparency and governance. While governments in industrial countries have substantially invested financial resources on research and development in nanotech, the private sector has significant advantages on products that are already in the market and/or the pipeline, as discussed above. Despite the commercial release of a number of nanotech products, there is very little attention paid by policy makers at the national and international levels on regulation and standards in nanotechnology.

The most controversial social and ethical issues in nanotechnologies involve its convergence with biotechnology, cognitive science and information technology. Ethical issues are on top of the discussions surrounding the development of human machines which involves the merging of living and non-living organisms, as well as on information gathering vis-à-vis privacy and individual rights.

5.5.3 Information and communication technologies (ICT)

ICT has been playing a critical role in ESAP region agriculture through the dissemination of radios, telephones, televisions, and computers since the mid-1900s, in a variety of ways (Reference needed). These might involve facilitating the access of rural communities to information relating to efficient farm management and market information through radio and TV shows as well as computer kiosks. They may also include the integration of geographic information systems or remote sensing technology with farm management and technologies to improve crop and livestock production, in terms of product quality, environmental issues and the welfare of people and livestock in what is known as precision agriculture or precision farming (Cox, 2002). The new and emerging technologies in agriculture discussed above would not have been possible without advances in ICT that made possible high-throughput genetic and genomic work and the manipulation, analysis, and interpretation of large sets of data. ICT can facilitate the rapid transfer of technology between regions within ESAP, or be utilised to develop a Decision Support System (DSS) for sustainable land management at the farm, village, watershed, and regional scale (Rais, 1997; Craswell et al., 1998).

The effective dissemination and adoption of ICT has been shown to be a pre-requisite to economic and social development in this information age—akin to electrification in the industrial area (Castells, 1999). Research from Thailand, South Korea, India and Taiwan indicates that growth rates of ICT consumption correlate well with growth in productivity and GDP (Mody and Dalman,1992; Kraemer and Dedrick, 1998). Research for India in particular—which showed an average growth rate in IT-related investment of 22.21% per year--shows a strong correlation between growth in ICT consumption, and productivity and GDP between 1984 and 1990 (Kraemer and Dedrick, 1998). ICT can have an impact on poverty alleviation and meet AKST goals by educating rural and disenfranchised communities about their circumstances and rights, and by providing access to health-related and agricultural and natural resource management information, among other issues (Pigato, 2001).

ICT has resulted in “knowledge management” (KM), a relatively new discipline that combines organizational dynamics and knowledge engineering with ICT to manage intellectual assets (Flor, 2001).

Much of KM experience has been limited to the private sector, but the World Bank embarked on a KM Program in 1997. Knowledge management offers great promise to poverty alleviation initiatives, particularly in the realm of policy, strategic planning, and monitoring and evaluation. For instance, Southeast Asia, home to the two largest archipelagos in the world, Indonesia and the Philippines, is rich in marine biodiversity. However, coastal resources in the region are being depleted, largely because of mismanagement, and as a result, countries within the region have embarked on several resource management projects. A regional knowledge network enabled by information and communication technology is now being proposed to share best practices and lessons learned from these projects. Similarly, the World Bank is now funding the National Water Information Network in the Philippines.

The biggest barrier to knowledge networking at the regional level, is the lack of defacto standards for information sharing and data exchange.

Despite the great potential for good, the role played by ICT in stimulating agricultural development in ESAP countries is a double-edged sword. The correlation between access to information and poverty is widely acknowledged, for the following reasons as outlined by Flor (2001): information leads to resources; information leads to opportunities that generate resources; access to information leads to access to resources; and access to information leads to access to opportunities that generate resources. Thus, uneven distribution and access to ICT has given rise to the “digital divide”, a widening gap between the information-rich and information-poor, creating yet another form of social exclusion. Data from the Human Development Report (UNDP, 1999) database on four major ICT indicators (internet hosts per 1000 persons, telephone lines per 1000 persons, personal computer ownership and television ownership) were compared with the human development index (HDI) and the human poverty index (HPI) for ten ESAP countries, showing a strong correlation between ICT and poverty. The higher the HDR rank, the higher the ICT indicator values, and the higher the HPI, the lower the number of ISPs, telephone lines, PCs and TV sets per 1000 persons. Similarly, the higher the ICT indicator value (as in the case of Singapore, Brunei and Malaysia), the lower the HPI.

The challenge for the effective adoption of ICT to address AKST goals is to bridge this digital divide. There has been some success in doing this within the ESAP region. The founder of Bangladesh’s Grameen Bank, Professor Muhammad Yunus, has again embarked on an innovative undertaking based on a simple but elegant idea (Flor, 2001). The bank has initiated a cellular phone project, the Grameen Phone Company, putting a mobile phone in approximately 45,000 Bangladeshi villages, giving residents access to ICT. Each mobile phone may be acquired by taking a small loan from the bank. This phone then becomes a village telephone service provider, earning income for the owner besides providing a much-needed utility to the community. Professor Yunus is following this up with an experimental Village Computer and Internet Program or VCIP, which would provide an email and Internet service to villagers. Instead of paying for phone calls, the villagers will now be able to avail themselves of email for a fraction of the cost of a long distance call. A simple form of e-commerce will also been initiated by this system, allowing farmers to check out market prices and study the list of wholesalers in Dhaka by surfing the Web.

If correctly and widely disseminated, the data on ICT and poverty alleviation shows that ICT can play an important role in achieving AKST goals in the ESAP region. Initiatives such as the Grameen Phone Company in Bangladesh provide models which are well worth pursuing throughout the ESAP region. The adoption of standards for sharing information through knowledge networks can facilitate technology transfer as well as share best management practices across the region, resulting in the common good for a relatively low R and D investment on the part of any given country.

5.6 Ramifications of Various Technologies and Knowledge Systems for AKST Goals

It is important to recognize that there is no one ideal agronomic/forestry/aquaculture system. For instance, modern best practice guidelines for conventional production systems advise the full use of all indigenous fertility sources (composts, crop residues, and animal manures), with mineral fertilizers employed as a complement to bridge deficits between crop needs and indigenous supplies (http://www.knowledgebank.irri.org/ssnm/) The ideal agricultural system may be context-dependent, combining elements of traditional, organic, conventional, and emerging practices and technologies in a locality and constraint-specific manner to maintain food security and improve micronutrient content of food with minimal adverse environmental consequences and maximum improvement in social inclusiveness. Traditional knowledge is assumed to reside locally within the farming community where it is applicable, and hence transfer of knowledge is more in the realm of farmer to farmer than from scientist and extension agent to farmer. A description and understanding of what makes various traditional systems stable would be valuable, enabling the utilization of this knowledge to develop more sustainable production systems for use by future farmers.

While indigenous knowledge is usually seen as contrasting with the knowledge systems generated by universities, research institutions and private firms, there have been increasing instances in the ESAP region where both systems converge and interact. Examples? Traditional knowledge is increasingly becoming acceptable to the scientific community. In fact, new paradigms in agricultural extension programs have recognized that local people conduct research in their own farms although the absence of formal and rigorous methodology employed by formal institutions such as robust statistical design make analysis and interpretation of the results difficult. It is even argued that their experiential knowledge is derived from their skills as experimenters (Stanley and Rice, 2003). In addition, many technological projects failed as a result of lack of knowledge and understanding of the local practices of the beneficiary community.

On the other hand, technologies generated by formal research institutions can complement and sometimes improve existing indigenous methods. Various examples can be cited from ESAP countries where sustainable development goals were successfully attained after the recognition of the complementation of traditional and scientific methods. One such example is the agroforestry project of the International Institute of Rural Reconstruction (IIRR) in the Philippines. Scientists decided to work with village farmers after a failed nursery operation that relied on exotic species. Local people were then asked to identify locally growing species (indigenous and introduced) according to criteria considered by the community as important--such as hardiness, fire resistance, general utility, and seed availability. The exercise resulted in the formulation of community action plans for reforestation (IIRR, 1996 as cited by Grenier, 1998).
There are a number of different ways in which the various agricultural knowledge systems and technologies may be integrated or interact to assist the development of sustainable agriculture, as exemplified by IPM and INRM (Reference?):

1. Increased support for and application and replication of traditional and low-input systems that function productively, sustainably, and in a socially inclusive manner, particularly in low productivity areas throughout the ESAP region.
2. The augmenting of indigenous knowledge with appropriate modern practices that can enhance the system, such as microbial inoculations, and appropriate scale mechanization. Another example is the addition of appropriate small-scale technology—such as gravity-fed technology for sprinkler and drip irrigation for vegetable and fruit cultivation—which could enhance their production and income-generating ability (ESCAP, 2002, p.43).
3. The application of traditional practices to modern agricultural settings to maximise system productivity and natural resource sustainability. Instances of this include the augmenting of modern agricultural systems and technologies with practices from traditional and organic systems, such as rotational, trap and intercropping, and agroforestry.

Agronomic applications of emerging technologies such as bio and nanotechnology need to be evaluated in comparison with existing or developing technologies not only on the basis of potential gains in productivity, but on their ability to maintain ecosystem integrity, human and animal health, and social and economic well-being in adopting communities and countries. It is absolutely critical that unbiased science precedes, rather than follows the commercialisation of genetic engineering and nanotechnology applications. Each new transgenic product has potential for unintended impact; hence each new technology should be evaluated on a case by case basis (NAS, 2000), acknowledging farmer needs and conditions, within a stringent biosafety framework and enforcement, and in conjunction with rigorous site-specific scientific and social monitoring. ESAP countries intending to implement new technologies should ensure that their infrastructure is sufficient to support the safe development, transfer and application of the technologies with special attention paid to developing relevant policies, information systems and training in biotechnology risk assessment and biosafety procedures. Gene flow and resistance management issues in particular, among others, still warrant caution and long-term monitoring in the field, along with a holistic assessment that includes analysis of the social and economic consequences of biotechnology adoption by farming communities.

The Nuffield Council on Bioethics (2003) has suggested that methods and results of environmental risk assessments could be shared between countries that have similar agricultural environments, thus reducing the burden of proof for any one country; a model that could be adopted in the ESAP region. Data sharing to satisfy regulatory needs, and similar extensions of prior findings could substantially reduce unwarranted restrictions and improve the benefits of these technologies for resource-poor farmers, as long as their socio-economic and cultural environments are also considered alongside the agricultural. While there may be reason to be optimistic about the potential for a variety of bio and nanotechnologies to be beneficial in increasing agricultural productivity while reducing some inputs, there is also an imperative to exert the highest scientific, regulatory, and policy standards to ensure negligible long-term ecological and human impact prior to their deployment.

5.7 Enabling Environments: Institutions, Organizations and Partnerships

Agricultural development is dependent upon the performance of a large number of actors/organizations. It include not only those involved in Research, Development, Training and Extension (RDTE), but also those involved in a range of other activities, such as generation and distribution of inputs, supply of credit, value addition and marketing, development and implementation of policies and the overall institutional context that shapes the interaction among these different actors/organizations. Though many of these actors are present in all the different ESAP countries, there is a wide diversity in the number, capability and performance of these actors. This diversity stems from the historical pattern of governance (colonization and independence), ideologies (role of the state and other actors), stage of development, distribution of holdings and share of population involved in farming.

This diversity has several important implications for planning agricultural development interventions including agricultural S&T. Firstly, importing models of technological change which might have been successful elsewhere, is not the way to address agricultural development in this region. Or in other words, better approaches for agricultural development, needs to be designed based on the particular features of the country and the region. Secondly, development or application new technology need not necessarily be the starting point for agricultural development. While technologies do play an important role, there could be other points of intervention (institutional innovations) that may better address agricultural development and sustainability and these needs to be explored.

5.7.1 Actors and organizations in AKST

Except for the small island states in the Pacific and mountain states in the Himalayas, most of the countries in ESAP have a well-established public sector research and extension system. Research and extension infrastructure and development of a cadre of trained agricultural research and extension manpower received adequate support in all these countries. Domestic funding and international support facilitated development of this capacity. Most of the countries have a reasonable infrastructure and human resources to deal with agricultural development issues, though these are organized top-down, depends fully on the state for funding and with moderate to weak links with extension. Extension arrangements are centrally designed and implemented and have weak links with research. Inadequate technology adoption has been generally attributed to weaknesses in research-extension linkages, although several measures to address this have been taken during the last two decades (Sharma, 2002). Over the years there has been a slackening of public support for research and extension and this has led to large number of vacancies and reduced operational funding. International donors such as the World Bank, Asian Development Bank, FAO, IFAD and international networks such as CGIAR, ACIAR, GFAR, JAIC do support select countries in agricultural development initiatives.

While the public funding has been going down, private sector investments in agricultural research and extension has been on an increase. Apart from private input companies and agri-business firms, several other actors have also started to increasingly intervene in research and extension. This includes producer co-operatives, farmer associations and NGOs. Media (print, radio and television) have also started playing an important role in dissemination of information on agricultural technologies, development programs and market arrivals and prices of commodities. Increasingly internet is also emerging as an important source of information on agriculture.

As mentioned earlier, apart from actors and organizations involved in RDTE, development and sustainability of agriculture depends also on the market arrangements, value addition opportunities, infrastructure (road, air links, storage, cold chains etc), availability and access to credit at reasonable terms and enforcement of standards, certification and policies that respond adequately to changing agricultural situation. General economic policies, country development plans, specific agricultural policies and plans, international agreements all determine the direction and pace of agricultural growth. Quite often, these different stakeholders influence plans, programs and policies and the wider institutional environment and these in turn influence interaction and inter-relationships between different stakeholders including those outside the RTDE system. In other words, agricultural innovation (the process by which new knowledge, information or technology is made available and put into socially and economically productive use) happen when all these different actors in the innovation systems interact and share knowledge and work in partnerships. The elements of an agricultural innovation system are illustrated in Figure 5.1. An innovation system could be defined as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into social and economic use, together with the institutions and policies that affect their behavior and performance. The innovation system concept embraces not only the science suppliers but also the totality and interaction of actors involved in innovation (World Bank, 2006). But quite often, the different actors in this system do not sufficiently interact or share knowledge or work together unless policy and practice address the institutional and policy related issues underpinning this situation.

5.7.2 Innovative institutional arrangements- what do we learn from them?

There is an increasing realization that the Research-Extension-Farmer paradigm of agricultural development is insufficient to address the new and rapidly evolving challenges to agricultural development. Attempts to refine this linear paradigm started with ensuring farmer participation at different stages of technology development and promotion. Though it brought farmer perspectives into the process of agricultural technology development, several other important actors whose decisions also influence technology demand, promotion and uptake were left out. Moreover, most of the decisions on technologies were taken by the researchers and there has not been any change in the way science was organized, funded, managed or evaluated. The need for partnering with the various other organizations involved in agricultural development began to be realized since the 90’s. There has been increasing calls for public-private partnerships in agricultural development in the last one decade and several efforts were made to promote this approach. Several innovative institutional arrangements involving a wide range of partners emerged in response to the realization that agricultural development involves interaction among a wide range of actors. These are discussed in chapter 2. Box 5.1 synthesizes the lessons from analysis of partnership experiences from the crop post-harvest sector of South Asia. .

[Insert Box 5.1: Lessons on partnership experiences in South Asia]

Some of the key recommendations that emerged through a joint analysis by the different stakeholders who have participated in four NRM projects in India is given in Box 2. The projects examined include: a integrated management of land and water resources (DFID/NRSP-ICAR), b. improved livelihoods through a consortium approach (ICRISAT) c. Promoting zero-tillage (Rice-Wheat Consortia) and d. Community development (Aga Khan Rural Support Project). All those interested in promoting partnerships in RTDE may find these very relevant.

[Insert Box 5.2: Encouraging effective R and D partnerships: Lessons learnt from the Indian Experience]

The increasing complexity of agricultural development and the rapidly changing external environment necessitate all actors in the agricultural innovation system including those directly dealing with AKST to embrace partnerships as an organizational principle. But what is increasingly clear is that there cannot be a blue print for promoting partnerships, but development of partnership arrangement could be facilitated. Experiences have shown that funding for agriculture could be potentially used to facilitate development of partnership arrangements. Funding arrangements could be potentially designed for promoting and supporting stakeholder meetings and handholding development of joint collaborative activities. But these have to be supplemented with efforts to reflect on progress of such partnerships and lesson learning so that these lessons direct the much needed institutional changes among the different actors in the innovation system.

[Insert Figure 5.1: Elements of an agricultural innovation system]

5.7.3 New frameworks

Source: Adapted from Arnold and Bell (2001:279).

There is an increasing realization that agricultural science and technology arrangements needs to be assessed not only in terms of number of research institutions, technologies released, or number of scientists or extension workers, but also in terms of how it relates with other actors in the wider innovation system. While understanding and planning agricultural development interventions, it would be worthwhile to use the conceptual framework of “innovation system”. Its attraction is that it recognizes, that innovation is not research driven process simply relying on technology transfer. Instead innovation is a process of generating, accessing and putting knowledge into use and is a much complicated and context embedded. Consequently its main determinates are the interactions of different people and the ideas that they have and the social setting of these interactions and relationship. Its other important insight and again one which is now widely recognized in the development sector, is that institutions matter. This is to say that the attitudes, habits, practices and ways of working that shape how individuals behave have an enormous impact whether or not innovation takes place (Hall, 2006). Therefore addressing these issues related to governance and partnerships in AKST assumes primary importance in programs aimed at strengthening AKST in the ESAP region.

5.7.4 gender equality and social inclusion

Evidence from many countries in the region shows that there are widespread gender-based inequalities in access, control and ownership of productive resources. These inequalities are linked with women's lower access to employment opportunities, social structures and institutions of governance and public services, such as healthcare, education, and training for skill development.

5.7.4.1 Feminization of agriculture

The phenomenon of increasing feminization of agriculture has drawn policy attention in recent years. However, the causes, the extent and its impact on women and productivity have not received sufficient concern in policy and practice throughout the ESAP region (IFAD 2005). Insufficient attention to some work sites where women are most active, such as cultivation of crops and vegetables, regeneration of degraded forests, wasteland development and watershed development, has meant that women's contributions and concerns remain invisible in planning and thus are ignored in AKST institutions (Sujaya, 2006). Further, the stress on self-employment and dependence on institutional credit in most land-based economic activities meant that women, who are mostly landless in many ESAP countries, were not eligible for assistance beyond the rearing of livestock for income.

Although it has been recognized that rural women have an important role in livestock (such as animal care, grazing, fodder collection, cleaning of animal shed, processing of milk and sale of livestock products), their control over livestock and product is minimal. With some regional variations, women account for 93 percent of employment in dairy production in India. But 75 percent of dairy cooperative membership is male (Sujaya, 2006). Women's livestock activities have been conventionally viewed as an extension of domestic work around the house, sometime women can fit in their work, no economic incentive to introduce improvement. There is, however, one exception of dairying, whose distribution of milch cattle became one of the main activities in poverty reduction programs in India.

A Gender Assessment Report of China for IFAD (2005) indicated that women constitute about 70 percent of the agricultural labor force and perform more than 70 percent of farm labor, though it varies from place to place. A general pattern is that the poorer the area, the higher women's contribution, largely as subsistence farmers, who farm small pieces of land, often less than 0.2 hectares. In India, close to 33 percent of cultivators and nearly 47 percent of agricultural workers are women (Vepa 2005). This feminization of agriculture is caused by increased casualization of work, unprofitable crop production and distress migration of men "for higher casual work in agriculture and non-agriculture sectors", leaving women to take up low paid casual work in agriculture (Sujaya 2005: 5).

In both China and India, the major economies of ESAP region, there is traditional patriarchal ideology which maintains the institutional masculinization of government, market, society and household; and in numerous cases with the complicity of women themselves. As has been well documented elsewhere (World Bank 2001) gender inequality in assets/resources and economic opportunities hinders development and is inextricably linked to poverty outcomes.

The feminization of agriculture model in ESAP is determined by two major factors. First, compared to men, women have much poorer access, control and ownership of land and other productive resources and they have inadequate access to public services, such as training, extension and credit. Technologies are often designed for irrigated land in favorable areas and for male farmers. Poor farmers, mainly women, lack appropriate technologies. Women and women-headed households represent a disproportionate share of the poor farmers in many ESAP countries. Second, the present structure of rural society makes it difficult for all members of the household to migrate, since cities have even more limited resources for masses of asset-poor, who lack not only income but production-related assets, human capabilities, social capital and physical assets. Women constitute the majority of such people. As a consequence, men leave to become temporary laborers in cities. Women are left behind to take care of agriculture and land (a kind of insurance for migrant workers), children and the elderly. Thus, they have the compounded burden of productive and reproductive work. Its impact on agricultural productivity and on AKST is yet to be determined.

5.7.4.2 Gender wage differentials

There is another important question of gender wage differentials in agriculture and related industries. One possible explanation is that the differences in educational attainments and work skills between women and men are reflected in wage differentials (Zhao and Zhang 1999, Gustafsson and Li 2000). That if women's education and skills are significantly lower than men's, then there is likely to be a systematic wage differential between the two genders. According to the

National Census of China in 2000, women have an average of 1.1 years less schooling than men in the country as a whole. But the unexplained (gender discrimination) factor in the gender wage differential in rural areas has been constant, with some decline in the period 1988-95 (Mason, Rozelle and Zhong 2000). What is important to note, however, is a recent study by Wang and Cai (2006), who in their analysis of China's urban labor market, conclude that the major share (93.5 percent) of the wage differential between women and men, is attributed to discrimination rather than to capital differences between the genders. Hirway (2006) arrives at a similar finding in her study of the labor market in India. That the wage differential is largely due to gender discrimination which encourages women's engagement in low levels of occupation, like unskilled and semi-skilled work, low level management work and other related productive work.

The wage differentials between women and men agricultural workers are based on a pre-assumed gender character. Employers or contracts simply lower wages to women, regardless of their performance on the job. In the given situation of social and economic neglect, women have no better options. They must work longer and harder to make ends meet, leading to exhaustion and injuries from stress and overwork, a common problem reported by numerous agricultural workers.

In Asia, "a large proportion of women are not able to retain their earned income – over 40 percent in Bangladesh, over 40 percent in Gujarat, and over 70 percent in Indonesia". With regard to control over the way their income is spent, "in China only 53 percent of women said that they alone decided. In Bangladesh and India, far fewer could make their decisions" (ILO, 2004, p.96). What this shows it is not sufficient to stop analysis at the point of income in household income; it is further necessary to look at the manner in which women do or do not have control over that income and work out measures to increase their control over it.

5.7.4.3 Microfinance groups

Notwithstanding the above, the rise of women's Self-Help Groups (SHGs) or women's micro-finance groups, in India and other countries of South Asia, has made women's income a permanent component of household income and weakened patriarchal gender relations, reducing women's dependency on the male provider.

The weakening of gender relations has been noted in a number of ways: (1) women's greater presence in the market as buyers, though very restricted (in South Asia) as sellers; (2) women's participation in various types of agricultural field work; and (3) women's unescorted movement, though often in a group and not alone, to the markets, schools and training. It is true that women's production activities are still largely confined to the homestead, or at best the hamlet, and that if women were to move out into non-homestead activities, it is likely to have a greater impact on seclusion norms. When women engage in activities outside their households and/or villages, the increased interaction they have with the outside world goes a long way towards social and economic equality.

The roles that women in micro-finance groups can play in development need not end with instilling new cultures of savings and repayment. In India, SHGs have gone beyond savings and individual loans to take up management of community-based projects – contracting to construct minor irrigation or undertake soil conservation works. Unlike men's groups doing the same tasks, they have saved considerable amounts of capital and used their savings to invest in tractors, and other forms of mechanization. In a village in Andhra Pradesh, India, SHGs have even invested in electricity generation with diesel saving pongamia seed oil, and sold the carbon saved in the international market. Women's micro-finance groups can thus serve as agencies to introduce new and advanced energy technologies to villages and links to the world.

It has been suggested that the SHG concept should be used to foster women's agency and extended to community based organizations of women, with members srugglling for adequate supply of food, water, housing, and employment. An innovative model in this regard is the Rajasthan Ekta Nari Sangsthan, with a membership of 16,000 low-income single women who help each other to reclaim land rights and stop domestic and social violence (Planning Commission, 2005).

5.7.4.4 Information technology

There has been an undeniable improvement in the social mobility and work participation rate of women in the IT industry. The nature of work (such as flexi-time, tele-working and working from home), the tools (such as email and internet) and the individualization of capacities required by information technology make women more capable of taking decisions on their own and construct greater scope to enhance their agency.

Civil society groups in various parts of Asia are able to keep in touch with each other and with groups in other parts of the world through email and other such communication systems. The resulting networks of such organizations are able to work in close coordination to conduct campaigns on various issues affecting women. Indigenous women's groups, indigenous people's organizations, organizations protesting against large dams – such groups are now networking in a manner made possible by the new communication technologies. The transformation of information technology does not end power inequality, but it does allow women and disadvantaged groups more scope to project themselves.

A recent example includes the IDRC-supported innovative program for Village Knowledge Centers set up in 1998 by M.S. Swaminathan Research Foundation, Chennai, in six villages in Pondicherry, India. Two major features of the project were the development of local language Tamil Software and gender sensitivity (for example, considering the health needs of impoverished rural women) in the assessment of the information needs of the local people (MSSRF, 2002). The National E-Governance Action Plan of the Government of India has placed great emphasis on Community Computer and internet kiosks in rural areas. For example, in the state of Tamil Nadu alone, 600 rural kiosks are functioning to deliver a host of services such as health care, education, agriculture and communication (voice mail and e-mail). Most of these kiosks are run by individual self-employed entrepreneurs and NGOs; but increasingly women SHGs are coming forward to manage them. However, the existing social and cultural norms were noted to be a major obstacle to the diffusion of such IT technology. A recent research carried out in Tamil Nadu noted: '….though the technology itself is considered gender-neutral, women in the households often lack independence, the decision-making power, and financial resource to make use of the kiosk services fully' (Rajendra Kumar, "Bridging the Rural Digital Divide", The Hindu, April 12, 2005).

Another example from Thailand involves the struggle against the forced relocation of Akha villagers in Huay Mahk village of Northern Thailand in 2000. The Internet was used to communicate the problems of an isolated people and mobilize support from others around the world. In a breakthrough for community rights, the villagers were able to retain their homes, lands and forests, thereby avoiding the drugs, crime and poverty cycle that has hit other relocated communities in the region (Satyawadhana, 2001).

IT does therefore, constitutes the basis of the redefinition of traditional gender norms and supports a media of information, understanding and knowledge in which women's interests, opinions and rights are taken into account. Nevertheless, they function within the dominant interests of the market and the state. This provides a non-threatening mobilization of women's labor for the benefit of their families and communities. It has not yet been possible for women in the IT sector to challenge and transform structural inequalities and gender relations.

5.7.4.5 Inclusion/social exclusion

Social exclusion derives from exclusionary relationships based on power and hierarchy, and intersects with other aspect of social disadvantage, such as gender, caste, ethnicity, religious minority status. It is a multidimensional process that prevents individuals or groups from access to institutions of governance, public services like health care and education, and economic resources as well as factors of production. Furthermore, exclusionary relationship are nurtured and maintained through systemic violence and denial of rights and have a causal dimension not only of poverty but also the factor leading to poverty.

[Insert Figure 5.2]

Gerry Rodgers (2006) underlines that many decent work deficits can be regarded as labor market exclusion. "Many of the inequalities of the labor market, the process of informalization, the lack of security and voice, the discriminations to which particular groups are subject, can be understood as aspects of social exclusion; and the goal of social inclusion correspondingly requires action within the labor market."

Exclusion from formal employment may lead to open unemployment or to different forms of informal work and under-employment, denying the dignity of livelihood in numerous cases. Moreover, as labor markets are shaped by global forces, exclusion from skills, capabilities, assets and recognition becomes a critical factor in non-inclusion or inclusion at very adverse terms. It is not surprising; therefore, that 70 to 80 percent of the workforce in the informal sector are women, employed in low-paid jobs with long working hours.

5.7.5 Policies, programs and institutions

A large number of policies potentially affect agriculture and how AKST is deployed for agricultural and socio-economic development. Policies influences or shapes the ways programs are designed and operated. Policies related to agriculture and allied sectors (livestock, fisheries etc), natural resource management, R&D especially agricultural R&D (bio-safety, IPR, partnerships), input use (seeds, fertilizer etc), trade, gender, conservation and utilization of genetic resources, bio-diversity etc, are critical for attaining the sustainability and development goals of AKST. Policies to address these issues/sectors needs to be developed and implemented by the national governments (and inter-governmental organizations wherever necessary).

Having a sound policy however does not ensure better compliance to guidelines or better performance of the system. Firstly, the countries in the region vary in their capacity to implement policies. There are significant gaps in the capacity of several countries to implement policies related to bio-safety, IPR and food quality standards. Secondly, quite often the policy only prescribes what to do, without taking into account what all needs to be done to get the policy implemented. Ideally, the policy should also facilitate change, through a process of experimentation, reflection and learning so that it develops the capacity of the various stakeholders to identify bottlenecks, experiment alternative way of working and evaluate performance. The actors in the policy system thereby learn what needs to be changed or modified and how to develop better policies. And thirdly, implementation of good policies and programs require collaboration among a large number of organizations. And "institutions" determine the way the different actors interact with each other and respond to new challenges and opportunities.

Exploring policies, programs and institutions therefore assumes critical importance in strengthening AKST arrangements in the ESAP region. This is especially so as the nature of farming in this region (and elsewhere too) is changing rapidly. Plateauing grain yields, declining water and land availability, new threats and opportunities emerging from WTO, emergence of supermarkets, increasing private sector participation, emerging concerns on food safety, need for standards in production and processing have all made production and marketing of agricultural produce more complex. Addressing these issues needs new ways of working and that too through the involvement and collaboration among a large number of actors/organization. This is especially so as most of the innovations needed in present day agriculture have collective dimensions- ie they require new forms of interaction, organization and agreement between multiple actors. (Leeuwis and van den Ban, 2004).

This essentially means that all the organizations involved in the agricultural innovation system need to have the capacities to produce and integrate new knowledge and apply them in their specific contexts to deal with these challenges. For instance, the agenda and constituency of extension needs to expand if it has to support the producers who need a more diverse support. Public sector extension in ESAP countries so far has been focusing only on the dissemination of technologies to farmers. It needs to go beyond its restricted mandate of technology dissemination to help producers cope with new challenges and this include provision of organizational, managerial and entrepreneurial support (Sulaiman and Hall, 2003). Its client base should also expand to include NGOs, producer associations, rural entrepreneurs, agricultural labor and women. If extension has to play these roles, it has to develop new capacities and this include, technological (new knowledge and skills) and institutional (new patterns of collaboration, new habits and practices) capacities.

Development of appropriate "institutions" assumes more importance as these would facilitate or constrain the ability of various actors to link with other sources of expertise and knowledge which are required to better respond to these new challenges and opportunities. Much of the previous efforts in improving the functioning of AKST arrangements focused only on improving the links between research and extension. Though research-extension linkage would continue to remain important, there is an increasing realization that organizations involved in research, development, training and extension (RDTE) need to develop partnerships with a large number of other actors (farmers, NGOs, producer organizations, input agencies, agro-processors, agri-business houses, traders, retailers and even consumers (van Mele et al, 2005, Hall, 2006). Developing wider links is not only essential for improving the performance of organizations involved in RDTE but also for rural innovation to happen-where new knowledge, information and technologies are made available and is put to socially and economically productive use.

Though a large number of organizations exist in most of these countries, the nature of interactions between these different organizations needs to be improved for optimum use of AKST. Organisational reforms within public sector Research and Extension organizations such as decentralization and interface meetings with wide range of stakeholders hasn't really changed the underlying paradigms governing the way Research or Extension is implemented in the region. Several institutional barriers currently constrain agricultural innovation. Institutional hierarchies, high levels of mistrust, a linear approach to technology development and promotion and a centralized approach to funding, implementation and evaluation are some of them. (These are discussed in detail in chapter 2) and addressing these is important for achieving the developmental and sustainability goals of AKST.

There is a case for implementing a series of institutional changes (ie changes in rules, norms, conventions and habits within these organizations and the way it relates to other stakeholders) in the RDTE system and others related to RDTE if the governments are keen to improve the performance of this system. This has to be a learning based approach appropriate to the specific institutional context and this process needs to be facilitated. Roling (xxxx) informs us that facilitating innovation is not a question of developing and transferring concrete, science-based innovations, but of facilitating innovative processes. It is contented that the theory which informs such policy is not about technology and its transfer but about human learning and adaptation-creating the conditions for learning.

5.7.6 Trade and markets

The growing importance of ESAP producers in world markets as well as the growth of GDP and per capita consumption beyond certain thresholds are rapidly making ESAP both a magnet for transnational producers and a trading rival to other regions.

International trade will continue to serve as a catalyst in the economic and social development of the ESAP Region in the coming three or four decades. It will do so for a number of reasons. First, the region is of growing importance as a market for consumer goods, primary products and as a source of cheap labor. In 2025 India's population will be an estimated 1.395 mn and China's

1.441mn and by 2030 the Indian population will exceed that of China (UN, 2004). At the same time prodigious GDP growth driven by unprecedented increase in personal incomes are expected to continue. This continued growth will have implications for the type of consumer products and food, for example, which will be in demand. The implications of these changes are very interesting in that even as they make the region more attractive to foreign exporters it is already contributing to concerns about competitiveness in the global and the regional market. We shall return to this point.

The other matter of importance relates to the measures that the region will find it necessary to take in defense of its interests. Sometimes discussion of liberalization is cast as though there is the option of standing outside and above the general trade and economic framework without an opportunity cost in terms of market access or the terms on which trade between insiders and others would be conducted. The fact that recently both China and Vietnam found it in their interests to join the WTO is a sign of their acknowledgement of that cost - not in spite of their economic success but because of such success. It is also evident from what we will show later that a high price can be extracted from latecomers to the system. These points have implications for the role that the region can be expected to play in the WTO in time.

Thirdly, international trade can undertaken without the intervention of governments and international framework but there are clearly advantages to having such a framework. The international embrace of international trade is such that the international agencies involved in aid and development finance have been seeking to force Developing States to liberalize their markets. The justification being that trade is an important contributor to the elimination of poverty.

5.7.6.1 Regional Markets

The search for markets beyond national borders is a logical and common reaction to expanded productive capacity and growth in output. In circumstances of intense global competition it is common for producers to seek to secure regional markets in which they can enjoy some degree of protection in addition to exploiting economies of scale. Over the last two decades there has been a global explosion in regional groupings. The reasons for this phenomenon are many but in ESAP they are related to efforts:

- To form sub-regional groupings large enough to support large modern capital intensive industries. to capitalize on large regional market such as ASEAN’s 600mn population
- In the case of ASEAN to counter competition from large neighbors, such as China
- They involve efforts to protect traditional industries in circumstances where exports in particular are destined for a singe market or set of markets as is the case with Fiji and its sugar exports to the UK.

In the ESAP region there have been a number of efforts to establish regional trade agreements but given current state their future intentions are far from clear.

- In 1993 members agreed to establish a FTA with CET and a reduction of tariffs on all intra-ASEAN trade in manufactured and processed agricultural goods within 5 year) (Farrell, M 2003). Subsequently, ASEAN's ten members announced a plan to create a customs union (without India and Pakistan) by 2020 to be better able to complete globally. In the interim they propose to liberalize services in the region by 2015. To date ASEAN has signed a protocol with China to amend the framework agreement on comprehensive economic cooperation. In December 06 these ASEAN states signed 4 amendments to the ASEAN Economic Integration Agreement undertaking to accelerate liberalization in 11 priority sectors as part of the process of expanding integration. The priority sectors include agriculture, fisheries, forestry, rubber products and textiles. They also plan to conclude a free trade agreement with the EU in the not too distant future.
- APEC which includes PNG aims to establish free trade an investment among its members between 2010 and 2020.
- PICTA, a Pacific Islands Trade Agreement encompassing the 14 members of the PACIFIC Island Forum
- PACER Pacific Agreement on Closer Economic Relations which is an economic cooperation agreement involving the members of the FORUM along with Australia and New Zealand (Kumar, J 2002)

Two of the issues likely to pose the greatest challenges to the region are how to adjust to changing intra-regional trade capacities and the emergence of China in particular, and designing the regional trade cooperation architecture. The latter is particularly problematic because of the multiplicity of regional groups which many states have joined (Pacific Islands Forum Secretariat 2001). For the smaller of these states this is a special risk because of their dependence on international trade and the consequential vulnerability to even slight changes in access and pattern (Kelsey 2005). One option as regards the architecture is a (Japanese) proposal for an East Asian Economic Community which would include India, Australia, and NZ in a FTAAP embracing all 21 members of the APEC (Asia Pacific Economic Cooperation Forum) and free all trade and investment in the pacific rim.

5.7.6.2 The competitive 'threat' posed by China

It has been suggested that China would significantly crowd out ASEAN exports in most western and non-east Asian economies by 2020. 'Concern about China's competitive threat is widespread (in developed economies such as the Unite States) as well as developing ones such as the Mexico), but is strongest in East and South East Asia. China's burgeoning exports – backed by cheap and productive labor, a large stock of technical manpower, huge and diversified industrial sector, attractiveness to foreign investors, use of industrial policy, and now, freer access to world markets under World Trade Organization (WTO) – lead to apocalyptic visions of export losses. China is most threatening to neighbors that rely primarily on low wages for their export advantage. As it upgrades its export structure, however, the more advanced economies (Singapore, Hong Kong, Korea and Taiwan) also fear for their competitiveness….. Domestic markets are also threatened by China, but so far most attention seems to have been on exports.…… Offsetting the threat are the promise of the dynamic Chinese market (WTO accession is only one of several initiatives to liberalize regional trade) and potential for collaboration with it to export to the rest of the world (Lall et al 2004).

Lall argues that the factors fuelling the drive for regional exports to China will continue to exceed its export growth and that China' s demand for primary products from its neighbors will continue into the foreseeable future. Consequently, he contends that with appropriate restructuring to match new competitive needs, its neighbors should be able to maintain high rates of export growth.

5.7.6.3 WTO membership

The rules governing global markets and the management of those markets are of great importance to the ESAP region because they can affect its access to other markets and the sharing of the gains from expanded trade. In spite of horror stories concerning the adverse consequences of membership (see for example, Bello 2003, Oxfam 2005) there is a long line of states waiting to join this body. Both China and Vietnam, for example, have joined the WTO, in spite of their political philosophies and stellar success in recent economic growth and export performance. The reason is simple, as a state becomes more important as an exporter it is more sensitive (a captive of?) to the actions of the trade architecture and rules. If it sits outside of the framework not only do others define those rules but they can be applied in a discriminatory manner to non-members. Vietnam has been at the receiving end of such actions in the case of catfish exports, its dominant position in world market for coffee, rice, pepper, rubber and tea also leaves it vulnerable. In December 2004 the US Government sought unsuccessfully to impose threat-based textile safeguards against China.

Most Pacific Island states and Burma have yet to join the WTO. Entry to the WTO is not an easy exercise for some states and seems set to get less so in the future (Kelsey, 2005). UNCTAD has argued that although it is recognized that developing countries need policy flexibility to support and promote their enterprises, investments in production and marketing, and export expansion and diversification, "latecomers now face more stringent policy conditions than those which prevailed previously." Under its accession terms, for example, Tonga is committed to lowering trade barriers and expanding market access for foreign goods over a one year period and by 1 January 2007, to bind all tariff lines at 15 or 20%, a level lower than most other developing countries. Moreover, on services, extensive concessions were also made with regard to services in sectors such as health, education, financial and telecoms. Oxfam described Tonga's accession concessions as 'eye watering' and 'the worst terms ever offered to any country'. (Manduna, C 2006)) Worried about similarly harsh terms Vanuatu, after negotiating terms, had in 2001 baulked at the last moment when they were supposed to sign the accession agreement.

At the same time, the problem of the erosion of preferences for countries such as Tonga, which currently benefit from preferential agreements is not addressed by any of the tariff reduction formulas that have been included in the various reform proposals.

That the ESAP region itself has conflicting interests in international trade cannot be denied. A perusal of the following table demonstrates that two regional states, Korea and Japan are amongst the states most responsible for measures giving rise to the most serious examples of trade distortion.

5.7.6.4 International trade

The multilateral trading system set up under GATT/WTO over 50 years ago progressively liberalized trade through successive negotiating rounds under a Rules-based non-discriminatory trading system

However, the entire multilateral framework is facing new challenges (Dixit et al 2001) posed by:

- growing membership
- expanding trade agenda
- the rapid spread of regional trade agreements

International trade theory would have us believe that all liberalisation is net trade creating and welfare improving. In spite of a 36% cut in agricultural and food tariffs decided during the Uruguay Round, it is widely accepted that little improvement in market access actually took place. The reason is the many technicalities that have made it possible to get around the spirit of the Uruguay Round discipline.

[Insert Table 5.1: OECD estimates of support to agriculture, average 2002-04]

In addition to the anti-dumping and countervailing measures already mentioned, of special interest to the region are elements of an UNCTAD report which contend that:

- "Whilst trade barriers in the main markets are now generally low for most trade of developed countries, in the present system there is a lack of equal opportunities for developing countries' exports such as textiles which are often subject to high import barriers, including non-tariff barriers.
- This support for agricultural production and exports in developed countries can have significant distorting effects, particularly on developing countries. And high protection for the domestic food industry in some developed countries hampers diversification and value-added production in developing countries.
- "WTO rules are stringent with respect to subsidies primarily used by developing countries. Also, anti-dumping measures and counter-vailing duties are used by many countries in sectors where exporters from developing countries are competitive.
- "Finally, there is asymmetry between liberalization of trade in goods and services on the one hand and labor-intensive services on the other, which particularly affects developing countries."

The document also notes that many developing countries continue to experience difficulties with sanitary and phytosanitary standards set in their export markets. The dynamism of niche products in the agricultural sector have also faded away after initial success, because of restricted import periods or the application of anti-dumping and countervailing duties.

The WTO members agreed that under the DDA (Doha Development agenda) to look at 3 key pillars of agric trade reform:

- Market access
- Domestic support
- Export competition

The process of liberalization carries with it risks for national producers. It can lead to the elimination of uncompetitive producers, the narrowing of the production base and or greater specialization. If competition policy is properly managed there should be the advantage of lower consumer prices. But whether those consumer welfare gains will be enough to offset employment and capacity losses will depend on a variety of factors. The latter include whether and how Governments address the skewed allocations of support and investment in agriculture, how they deal with the needs of crops of importance to local consumers and low income/small-scale producers vis a vis grain and plantation crops, for example.

5.7.6.5 Trade and poverty

Following failure of Washington Consensus MFIs introduced competition from trade as a means of improving performance and linked these to loans and PRSPs (Hewitt, A 2002). One of the most widely trumpeted measures in this regards is the EBA initiative of the EU. This is also intended to assist the poor via trade through the instrumentality of market access. Its results are however minimal as far as intended beneficiaries are concerned but that gain which they experience are largely at the expense of other low income preference receiving countries (Cernat et al 2003). It should be acknowledged that analysis of poverty is especially difficult due to the simplifications in the theory and the fact that the category 'poor' is both diverse and changing over time. But the impact of trade reform on employment and hence on poverty is context specific (IDS 2003 & Bussolo et al 1999). It depends on:

- comparative advantage
- previous patterns of protection
- asset distribution
- labor market situation

In order for trade liberalization to benefit the poor, the latter like the aspiring lottery player have to interact with markets and they need to:

- own the right products or services to sell
- and be not handicapped by market and access problems

The theory and experience of trade liberalization and its poverty links may be summarized as follows:

- Trade liberalization affects trade flows which in turn affects the markets of goods and labor, inter alia,
- economic growth and income distribution income will in turn be affected
- the beneficial effects of the liberalization may only be felt by the poor in the long run; indeed in the short and medium term their situation may worsen
- the poor may experience increased income risks while, and after, they switch from say subsistence products to marketable ones
- trade liberalization involving tariff reductions and a switch from dependence of Government on trade taxes to other forms of revenue. However, those social expenditures which tend to protect the poor may be vulnerable when revenues from trade taxes shrink (Bussolo op cit).

5.7.6.6 Implications of proliferation of bilateral and regional agreements

Whereas in 1990 there were 50 FTAs, by the end of 2004 the WTO had received 250 FTA notifications - regional and bilateral agreements. The US alone is currently involved in bilateral trade accords with 12 countries, already competed with another 12. An estimated are 60 being negotiated.

A quarter of global tariff cuts between 1983 and 2003 are the result of UR (IBRD 2005). However, only a tenth have been due to regional and bilateral deals. There is a widespread belief that the gains from multilateral trade are far greater than those from bilateral and regional deals that they are not in the interest of the weaker states – due to negotiating power and incapacity to handle fiendishly complicated Rules of Origin. The prospect of a rapid growth in their numbers is therefore viewed as undesirable. Bhagwati, (2005) for example, has described the process as resulting in ¨a 'spaghetti bowl' of rules, arbitrary definitions of which product comes from and a multiplicity of tariffs depending on source¨ (Bhagwati et al 2005).

More importantly, Bhagwati has contended that ¨bilateral FTAs are being used to advance the agendas of domestic lobbies, agendas which are not related to trade……;the process of trade liberalization is becoming a sham, the ultimate objective being the capture, reshaping and distortion of the WTO in the image of American lobbying interests¨ He contends that the MFN rule ensuring equal treatment in the WTO is being undermined by a process in which one-on-one agreements with small countries are used as models for other multilateral trade agreements. IN the process coalitions of developing countries will be fragmented as each abandons its legitimate objections to the inclusion of extraneous issues in trade treaties. Having abandoned these objections in a bilateral deal with the US, how can these countries pursue them in WTO negotiations? (Bhagwati, op cit). The author may have singled out the US but it is not alone in this endeavor.

The Pacific Islands enjoy preferential assess to the EU market under the Lomé and Cotonou Agreements. The EU formerly the EU extended non-reciprocal market access to the Pacific Islands along with the other members of the ACP Group. Under the Cotonou framework which will run from 2008 to 202 the EU proposes to have free trade agreements or EPAs to eliminate duties and other trade restrictions on 'substantially' all trade with the ACP. However, the agreement includes provisions on the liberalisation of investments, public procurement, intellectual property rights, competition and, dispute settlement procedures. In such areas the EU's position in the international economic and political arena places it at an advantage vis a vis the ACP in the negotiations.

[Insert Table 5.2: Appendix III: Pacific Island forum country participation in trade agreements and groupings 2004]

5.7.6.7 Managing regulatory rivalry

There has been a growing trend in OECD states towards the modification or introduction, of new regulations ostensibly to protect specific public policy goals (health, safety, environment, etc arising from legitimate differences in national preferences, culture, customs and history of each country). National competition has therefore been intensifying and is hard to eliminate although collective action is needed to deal with the cross-border externalities and the preservation of global goods. We are witnessing, in other words, the growth of regulatory competition.

Under the aegis of bilateral agreements many of these states are seeking to coerce developing states to adopt their rules. The EU commissioner for example threatened in November 2006 to integrate labor standards and sustainability objectives into trade agreements with India, South Korea and East Asian states. It should be borne in mind that the EU has revoked trade privileges for Belarus in 2006 and Burma earlier for infringing ILO standards. This seems to foreshadow the approach these states are likely to take in the future.

The multilateral framework of WTO rules, while contributing to a stable and predictable environment, in certain cases has narrowed the range of policy options for Governments, this has been evident in the case of Tonga referred to earlier. The commitments undertaken under IMF/World Bank structural adjustment programs have further reduced the remaining policy options. But the problem does not end there. There are a host of environmental and other agreements which the majority of developing states may have signed but will not be in a position to implement.

5.7.6.8 Mushrooming agreements and the burden of their obligations

One question of growing concern in this regard is whether the process of regulatory reform does not entail unjustifiable costs and investments relative to the interests and priorities of these countries. Indeed, a major problem is that the costs associated with complying with certain WTO disciplines can be significant in two senses

- the cost associated with satisfying the rules themselves,
- the ancillary investments that are required to allow the rules to be applied. This would be especially the case for pacific LDCs.

UNCTAD has observed that there are several issues (government procurement, trade facilitation, electronic commerce) on which multilateral negotiations may either be premature or in which developing countries require considerable assurance that the necessary capacity to implement them is put in place before an agreement is reached.

The second and equally contentious issue with implications for the future is the criteria to determine the appropriate international jurisdiction. Most developing states are hostile to these matters being added to the WTO portfolio not only because it has deemed to be already too powerful but because its governance structure and modus operandi are such that to date it has not been able to ensure fair treatment of all parties.

As general rule any regulatory system should be determined as closely as possible by the communities to which it refers. However for all the above reasons although a regulatory issue might be trade-related the WTO need not be the most appropriate forum to address these issues - it is already overburdened. For this reason the argument that allocation of jurisdiction should be made on a case by case basis according to the principle of subsidiarity, is very persuasive.

5.7.6.9 Other outstanding issues

The CAP reforms, the EU GSPs and the related US reforms in relation to cotton and textiles, for example, carry many risks for a state such as China. Other issues to be negotiated internationally and to be of future importance to the region's exports are geographical indications (GIs) and TRIPs

[Insert Table 5.3: Typology of TRM misappropriation]

One of the areas with the potential to create additional barriers to the transformation of developing states and to their capacity to start higher up the science and technology ladder is that of IPRs. Intellectual Property Rights relate to the use and ownership of innovations. It stands to affect a wide range of activities ranging from the development of indigenous knowledge to the exploitation of processes developed in the low-income states. Consequently, it is likely to attract increasing attention in the international negotiating fora over the medium-term. Table III on the typology of traditional medicines tries to show the application of the IPR principles as they apply to traditional medicine. Table III on the relevance of IPRs shows that many of the wide range of objectives which IPRs seeks to pursue in the context of traditional medicine may conflict and that there are a range of other tools available, some of which might be more appropriate in achieving the goals in question. More generally, whilst intellectual property is the cornerstone of the modern knowledge economy , one of the main forms, the patent, system is criticized as discriminating against developing countries by placing too much emphasis on property and too little on rights. It has had the effect of cordoning off inventions funded by taxpayers or charities and denies them exposure to the public domain (Jaffe et al 2003, Scotchmeer, S 2003). Table IV provides a schema based on case studies of circumstances of the appropriation of knowledge under IPRs. The negotiation of these agreements as well as their final form will have serious implications for different states in the ESAP region due to the likely patterns of development and the likely dependence on natural resource based industrialization as well as reserve of knowledge in traditional medicine. Equitable resolution of these interests will depend on attention to the intra-regional differences in capacity and need. One fruitful avenues for the future may be respect for the principle that elements enshrined in international pacts will not be allowed to over ride public interest or development needs. This is in essence the basis of the 2001 agreement affirming developing country rights to give public health priority over drug patent protection and it has found support around the world. An approach which seeks to teat this area along the lines of the creative commons may yield the region useful fruit.

[Insert Table 5.4: Protection of TRM: how relevant are IPRs?]

Apart from this, there is the 'normal' challenge arising from technological advances. In the not-too-distant future, for example, ESAP textile and rubber producers will come under pressure through world prices with the expansion of products dependent on nanotechnologies- unless of course they adopt first - or establish a niche for themselves in the market.

[Insert Table 5.5: Pacific Island Membership of Selected International Environmental Agreements, by Country]
[Insert Table 5.6: Current Environmental Issues in PACIFIC ACP Countries]
[Insert Table 5.7: Illustrative matrix of technology]
[[Insert Table 5.8: International Reform Initiatives for Agricultural Advisory Services)]

5.7.7 Developing capacity- How to go forward?

Conventional approaches to strengthening capacity in agriculture focused only on Science and Technology. This is important and would continue to be important especially for countries with limited S&T capacity. Emerging frontiers of new knowledge would necessitate organizing special training programs in such select areas. Knowledge and information exchange among different countries is required to bridge the gaps in capacity to develop and apply new knowledge. CGIAR centers and international and regional donors do play an important role in this. These efforts need to be strengthened. S&T capacity alone is not enough to bring about better knowledge uptake and use. Applying new knowledge necessitate development of several kinds of capacities among several actors. Capacity to develop and implement policies, experiment and evaluate new approaches, address issues related to quality, standards and markets all needs up-gradation.

To attain the development and sustainability goals of AKST, organizations require a wide range of capacity- which could be broadly called as innovation capacity. Innovation capacity is defined as the ability of the network of actors in an innovation system to address problems and to identify, test and implement solutions, in other words to innovate. The options are as follows:

1. The starting point for developing any kind of capacity is to have a diagnosis of the existing innovation system and this include exploring the kind of actors, their knowledge and skills, roles, patterns of interaction, the habits and practices and the policy environment. Innovation systems framework could be potentially used as a diagnostic tool to understand the existing innovation system and also as a framework for planning interventions (World Bank, 2006).
2. Learning from the emerging institutional arrangements in the region. This would necessitate a detailed analysis of cases where the various actors in specific contexts came together and collaborated to solve particular problems or address new challenges. What kind of institutional changes were made and also understand how these changes are sustained or why these couldn't be sustained after the end of the specific initiative?
3. All organizations do not have a culture of learning. Opportunities needs to be created and if need be specifically funded to bring in this change of culture. It would be useful to bring the staff together to reflect on the past, what they learnt and what needs to be done to do the same job better? The concept of institutional learning concerns the process through which new ways of working emerges. It concerns learning how to do things in new ways. It specifically asks the questions, what rules, habits and conventions have to be changed to do a new task or to do an old one better? (Hall et al, 2005)
4. Create opportunities to bring different actors together and develop joint activities. These can potentially help in developing long term relationships. Development of joint collaborative projects needs to be mentored over a period of time and need specific resources. Funding could be potentially used to facilitate development of joint collaborative projects.
5. Organise capacity development workshops with actors within the innovation system to enhance the capacity of all the actors to think and act in a more systemic sense. This could also be used as a platform to share the results of the diagnosis and identify the nature of interventions that are required to strengthen innovation capacity

The role of policies and regulations in achieving D&S goals through AKST:
The discussion of public policy has a long vintage and the approach one takes in analyses of policy is necessarily dependent on the conceptual framework within which the policy choices are being examined. (CTA - Braun, p. 5). That framework is in turn a function of the part played by

various actors in the political process, their role and motivations. Agricultural policy and technology policies are therefore to be understood as part of the workings of a political system. Policy can therefore be expected to vary in keeping with the nature of the political regime.

Promoting science and technology infrastructure. Many studies have pointed to the critical importance of S&T infrastructure, including R&D, in enhancing technological capacity-building. Indeed, science and technology (S&T) has been described by Huq as the core of capacity building and that importance is due in large measure to its positive correlation with per capita GNP. Without adequate Government policies market failure would prevent technology deepening and widening in developing states (Huq, M 2003?).

Facilitating human resource development. The importance of broad-based education and training should not be under-estimated in relation to technological capacity. A flexible and responsive technological capacity requires a labor force with a range of trained science graduates including research specialists.

Managing risks and vulnerability. There are two types of public policy responses with regard to vulnerability. The first are those strategies that aim to reduce risk and thus vulnerability. These are classified into: 1) risk reducing strategies, i.e. reducing the probability of a shock or negative fluctuations in income/output; 2) risk mitigating strategies, i.e. reducing the impact of a shock through anticipatory measures; and 3) risk coping strategies, i.e. minimizing the severity of a shock after it occurs (for detailed discussion, see Holzmann 2001; Gaiha and Thapa, 2005). The second are those strategies that aim to measure the capacity of individuals, households and groups to deal with vulnerability, which include social protection, social inclusion and redistribution of resources/benefits.

The risk management strategies, however, have been dismissive of gender relations. The “ignorance of gender differences has led to insensitive and ineffective relief operations that largely bypass women’s needs and their potential to assist in mitigation and relief work” (Ariyabandu and Wickramasinghe 2005: 47).
Addressing vulnerability is a long term process and requires overcoming deep-seated gender and social inequalities, like women’s poor income-earning opportunities, a lack of assets, pervasive discrimination and violence against women. Experience from Oxfam has shown that independent incomes of women are particularly important in reconstruction of Tsunami affected areas (Oxfam, 2005).

Knowledge is the critical factor in extending the capability space of individuals, as identified by Sen (2003) that the ‘descending households’ having poorer “human assets” development have also fewer physical and financial assets.

IFAD experience suggests that this problem can be deal with through: 1) expanding women’s capabilities to manage income, productive resources including knowledge and livelihood based consumption entitlements; 2) addressing gender-based barriers and patriarchal relations through organizing women’s groups like self-help groups, with added attention to the inclusion of the most poor and gender sensitization of the project staff and communities; and 3) promote women’s income-producing activities, their acquisition of assets and participation in the local markets as sellers and buyers.

Mechanisms for strengthening gender equality and social inclusion and gender equality. The strengthening mechanisms for gender equality and social inclusion requires: (1) proportional recruitment in public administration and technology institutions; (2) enhancing women’s independent, unmediated rights to agricultural land, agricultural animals, housing, and other productive assets; (3) doing away with the concept of the head of the household in agricultural, rural development and poverty reduction programs. More important is the attention to individualization of women’s capabilities and rights to knowledge and resources; (4) increased access to markets and promotion as a small entrepreneurs and sellers; (5) inter-agency coordination on ending domestic and social violence and increasing the opportunity costs of women’s labor; (6) vocational and technological trainings and creation of employment and self-employment for youth (women and men) from the socially excluded groups.

- Promoting change in culture and economy that permit poor rural women to increase their productivity and control over income and hence the value of their labor to economy and society. In the current situation of socio-economic change “economy is increasingly culturally inflected and the culture is more and more economically inflected. Thus the boundaries between the two become more and more blurred” (Lash and Urry, 1994: 64).

- Investing in **development infrastructure and energy** directed specifically at meeting rural demand to reduce drudgery through labor saving measures and increasing income-generating activities. Hence, there will be a significant positive impact on women’s practical needs and well being of the household. These include, for instance, provision of clean and fuel efficient energy for household, electric lighting, drinking water pumping; transport, roads, and shops for women sellers in the local markets.

- Technologies for empowerment. With the growing feminization of agricultural workers in Asia, it is important that development attention is given to **agricultural technologies** and enabling rural poor women to acquire farm equipment or/ and operate them, thus reducing human drudgery, increasing productivity and enabling women to manage technologies and the farms.

Markets and trade. Trade policies are increasingly being linked to poverty reduction strategies. The rural poor constitute the vast majority of the world's poor, hence there is a development need to see that mainstream trade policies do not create or increase inequalities in access to and control of economic and social resources (land, credit, and information), employment rights and influences over decision-making on trade issues. These issues are important in view of recent researches and civil society movements that have looked at key issues concerning agriculture and trade: rural-specific barriers to participation in trade and the impacts of trade on rural livelihoods. How can policy-makers, civil society promote gender equality and support rural access to the benefits of trade?

Government policies should encourage a wide range of skills in the SME sector as well as among the large firms operating on the cutting edge of technology.

An informed and trained private sector can be the basis of an economy characterized by flexible production and cost reduction capacity. In pursuit of this goal the state can use fiscal and other incentives to encourage cooperative research, pre-competitive research, commercialization of publicly-funded research, sponsorship of scientists-in-industry training and provision of joint or specialized training.

Successful management of resources for linkages is marked by the several characteristics: recognition of the importance of linkages by providing a budget for linkage mechanisms, a flexible attitude (for example, setting aside funds for contingencies), and timely release of funds. Reward systems currently in use are not generally compatible with the goals of technology systems. Managers should design new systems that reward technology generation and transfer, rather than scientific publication. Sabbaticals, training, and promotion should be based on the relevance and field success of the technologies developed, adapted, or packaged.

Problems resulting from differences in the status of researchers and technology transfer staff, within AKST systems, cannot be totally overcome because they are normally part and parcel of the institutional structure. They can be minimized, however, by changing the reward system. Some form of competition is necessary but this should be kept to a minimum by improving the resource-allocation process and making the incentive and reward systems more equitable.

In conclusion countries need to look into the need for separate trade and technology policies and to address the question of information failure. In the over viewing of national policy, one valuable element is consistency – consistency across sectors, over time and between the state and non-state actors. In this sense, the concept of a national innovation system is useful one requiring of all actors and the state in particular, the need to fashion and maintain a system that is sensitive to and proactive to national needs and changing international conditions. The challenge of the state is to manage its business so that a wide range of actors is brought into a de facto knowledge networking arrangement as possible – involving management of uncertainty, resolution of conflicts, the promotion of trust among groups and provision of information. Policy action should be geared always to establishing, nurturing and upgrading sectors into systems and learning entities.

[Insert Table 5.9: Policy options by country]

Policy options

This section is supposed to capture the major implications from the foregoing and to highlight the types of policies that might address the problems identified. A useful starting point for this exercise has been the work of an IBD team which deliberated on related matters and reported in 2002. We have taking the liberty of taking the foregoing summary table entitled ‘Policy Options by Country Grouping’ which identifies four broad sets of policies around which an AKST might be constructed. It is especially useful because it presents in a structured way the approaches which might be regarded a as representing a reasonable consensus of the analysis to date. It also tries to go beyond the the broad generalities and classifies the countries and their S&T levels so that a distinction can be made between the different types of policies which might be applicable. The categories of policies are to be directed to:

- human resources development
- stimulating demand for knowledge in the productive sector
- supporting S&T
- increasing ICTs

The states of the region are classed into scientifically proficient, developed and lagging. The proficient would include China, India NZ etc. Indonesia and Pakistan are captured among the Developing group whilst the scientifically lagging are Malaysia, Nepal, Vietnam, Philippines, Sri Lanka etc. The accuracy or adequacy of the classification is open to debate but need not detract from the approach itself which largely finds an echo in the findings of the Interim Report of the Millennium Group.

The report at hand may be seen as building on this and especially seeking to elaborate the last two rows of the table.

The findings of the foregoing chapters of the report have highlighted many factors and trends. It is hardly surprising that the implications of all are not clear. One general clear message is that ESAP's primary concern is now becoming not only simply the enhancement of productivity but long term management of the agricultural (physical biological, and ecological) base. In the face of threats to the latter appropriate policies would need to be managed so as to:

- Encourage the expanded use of low input practices to mediate the environmental impacts of agricultural production and to meet safety concerns. In this effort, attention should be given to the constraints that may be posed by limited land resources and the possibility of low land productivity
- Develop 'resource conserving technologies' in crop agriculture to improve incomes via efficient input use, crop diversification, and the maintenance of productivity levels through more extensive use of innovative technologies including precision agriculture in difficult ecological environments and nanotechnologies for the delivery of inputs.
- Restructure agricultural extension services and rewrite their mandates with a view to ensuring that they serve as a catalyst for enhanced productivity through the establishment of an integrated and dynamic scientific and technological environment that recognizes the diverse goals of its constituents and increasingly competitive markets.

Innovation

- **Encourage an open approach to generating innovation** and, in particular, recognize and consider the needs of multiple (often) competing groups with different influence and power
- **Promote private collaboration with public sector** as regards investment
- **Share information about knowledge**, technology providers and clients, goods & services needed by farmers
- Re-direct national agricultural research focus away from its almost exclusive concern with 'gifts' of public goods, such as seeds for small farmers, and to the **production of technology and knowledge that encourages innovation**
- Promote new processes. 'such as 'Learning selection' via:
    - o the devotion of attention to self organizing networks which generate knowledge and technology (rather than focusing on diffusion agents or specific groups)

- o the encouragement of co-development of promising prototype technologies rather than by financial inducements.
- o The explicit management of patents (in a functional way) in order to stop individuals pre-empting innovations and arresting the process of development

- In the interest of small farmers seek and promote (utilize) divisible technologies – such as ground water irrigation

NRM

- Devote greater attention to rainfed agriculture especially in non-rice agriculture via
  - o **'green (soil) water management** and
  - o the development of **HYVs** that are resistant to unreliable rainfall patterns, pests and diseases and,
  - o **Seek to accelerate the development of moisture conservation land management techniques** such as **zero or minimum tillage**

Explore and promote new approaches, such as adaptive learning, based on knowledge sharing networks, which:

- recognizes that natural the environment is often complex and dynamic and that reliance on best practices is dysfunctional in such circumstances because the workings are not clear and outcomes are not necessarily predictable. In such circumstances the info and resources for best practices are absent or far from obvious.
- the embrace of Community-based NRM is often simplistic in its assumptions about partnership. It can be problematic basis for justice in some circumstances. Is necessary to recognize that the factors which determine collective action varies with context:
  - o proximity to market and religious centers and
  - o the power of the prestigious and influential in some cases.

Rural Community Forestry groups are one of most rapidly growing forms of collective action in developing world but in relation to gender it has been found that ¨"the outcome of group functioning are determined especially by rules, norms and perceptions, in addition to household endowments and the personal endowments and attributes of those affected. These factors can work to the disadvantage of women, both separately and interactively. To what extent they can be changed in women's favour will depend on their bargaining power in relation to the state, the community and the family." The actions needed include(Agarwal, B 2003).

- Develop the role of NGOs, forestry officials and donors in strengthening women's bargaining position

- The formation of separate women's groups whilst important and necessary runs the danger of segregation and exposure unless they are either:
    - Integrated in mixed CFGs or
    - form women's groups in each CFG and have discussion of women's particular concerns pre meeting with subgroup in each
- Finally, policies should be framed so as to transform mixed CFGs into more gender egalitarian institutions

Current methods of trying to prevent the collapse of fish stocks do not appear to be very effective. Radical action is needed to conserve stocks and increase food security (such as threat to big eye and yellow fin tuna in the Pacific). In pursuit of those goals three major efforts will be needed in the medium and long term:

- Undertake a careful review and comparison of fisheries agreements in the light of evidence of damaged marine stocks and in particular to look at the tools employed to attract fleets and to raise revenues for small island states in particular. One of the issues arising from such a review would be the treatment of fees and licenses on which many small states have an inordinate dependence and their link to sustainable management of the various fisheries (such as the west central Pacific). A definition of subsidies will need to be agreed in light of the call by some states to have them banned - an issue raised in 2004 by New Zealand at the WTO Negotiating Group on Rules (allowing for a list of defined exceptions and transitional arrangements). Western subsidies were an estimated US$15-30bn in 2002. (Scidevnet 17/6/04).

- Establish a network of 'fish parks' so that the protected area (Economist 2001) of the ocean can be increased from the current level of only 0.5% to 20-30 % as proposed by the international academy of sciences – (Balmford et al 2004)

- Complement the fish reserves or parks with arrangements that allow the dissemination of data necessary for monitoring their use on the internet so that citizens can police activity (Clover, C 2004)

- In the case of non-marine fisheries, encourage the application of appropriate water and nutrient management techniques to fisheries and aquaculture in order to enable these sectors to fulfil their potential to contribute to the food security and well being of the region's poor .

Biodiversity

- Develop paddy irrigation as an instrument to this end (para 2.2.1)
- pursue the more intensive non-timber development of the forestry sector

- use more realistic tools in the area of community management

GMOs

- GM technology could be made pro-poor if it meets certain conditions (Schoones, 2005, Pomareom et al 2006) as regards not only:

- Safeguards but also

- decision-making, which should lay the basis for balanced public debate recognising the
    - Undue influence of some groups such as foreigners, ngos and commercial farmers
    - The need to empower consumers and farmers (Masood, E 2005, Panos Institute)

ICTs

- ESAP should seek the extension of the WTO agreement (ITA_1 agreements) on information technology under which there can be the provision of fiscal incentives for ICTs
- Seek to make greater use of initiatives such as the IBRD global development gateway – distance development education and sharing best practices
- Develop regional cooperation on regulatory harmonization especially as regards public private partnerships

References

Agarwal, B (2003) Community forestry groups and gender inequality in South Asia. id21 Research Highlight. Feb.

American National Centre for Ecological Analysis and Synthesis in Santa Barbara , California cited in Economist (2001) Net benefits. Marine Conservation. Science and Technology. Feb 24th, p93.

Bello, W (2003) Miltilateral punishment: the Phillipines in the WTO, 1995-2003. http://www.focusweb.org/PDF/multilateral-punishmnt.pdf

Bhagwati, J and Panagariya, A (2005) Bilateral treaties are a sham. Financial Times. July 14th. Page 3.

Bimmer et al (2006) From ¨best practice¨ to ¨best fit¨. A framework for analyzing pluralistic agricultural advisory services worldwide. IFPRI. Discussion Paper. August. Washington.

Bussolo, M and Lecompte, H-B (1999) Trade liberaisation and poverty. ODI Poverty briefing 6. December.

Cernat, L et al (2003) The EU’s everything but arms initiative and the least-developed countries. World Institute for Development Economics Research (UNU/Wider).

Considerations for African, Caribbean and Pacific (ACP) Countries. AFRICA REGIONAL WORKSHOP ON WTO NEGOTIATIONS. 10-11 April 2006. Cape Town, South Africa.

Correa, C. M (2002) Protection and promotion of traditional medicine. Implications for public health in developing countries . university of Buenos Aires. Aug.

Clover, C (2004) The end of the line.

CTA (2003) Strategies for the effective management of the environment in ACP countries. Presented by Carl B. Greenidge (2003) Director, CTA. Technical paper prepared for the 1st ACP Ministers of the Environment meeting. Brussels. Oct. 2003.

Dalke. K. 2003. Inside Information: Nanofibers Deliver DNA to Cells. Genome News Network, 13 June 13. http://www.genomenewsnetwork.org/articles/06_03/nano.shtml

Dixit, P et al (2001) The current WTO negotiations: Options for progress. IATRC Commissioned Paper No. 18, St Paul. MN.

ETC Group. 2002. No Small Matter! Nanotech Particles Penetrate Living Cells and Accumulate in Animal Organs. Communique 76, May/June. Available on the internet: www.etcgroup.com.

ETC Group. 2003. Green Goo: Nanbiotechnology Comes Alive! Communique 77, January/February. Available on the internet: www.etcgroup.com.

ETC Group. 2003. From Genomes to Atoms; The Big Down; Atomtech: Technologies Convering at the Nano Scale. Available on the internet: www.etcgroup.com.

ETC Group. 2003. Nanotechnology Un-gooed! In the Grey/Green Goo Brouhaha – Industry's Second Blunder? Communique 80, July/August. Available on the internet: www.etcgroup.com.

ETC Group. 2003. No Small Matters II; The Case for a Global Moratorium: Size Matters! Occasional Paper Series 7:1, April. Available on the internet: www.etcgroup.com.

ETC Group. 2003. The Strategy for Converging Technologies: The Little BANG Theory. Communique 78, March/April. Available on the internet: www.etcgroup.com.

ETC Group. 2004. Down on the Farm: The Impact of Nano-Scale Technologies on Food and Agriculture. Available on the internet: www.etcgroup.com.

ETC Group. 2004. Jazzing Up Jasmine: Atomically Modified Rice in Asia? News Release, 25 March. Available on the internet: www.etcgroup.com.

ETC Group. 2004. The Little Big Down: A Small Introduction to Nano-Scale Technologies. Available on the internet: www.etcgroup.com.

ETC Group. 2005. A Tiny Primer on Nano-Scale Technologies and the Little Bang Theory. June. Available on the internet: www.etcgroup.com.

ETC Group. 2005. NanoGeopolitics; ETC Group Surveys the Political Landscape. ETC Group Report/Communique 89, July/August. Available on the internet: www.etcgroup.com.

ETC Group. 2005. Nanotechnology News in Living Colors. Communique 85. May/June. Available on the internet: www.etcgroup.com.

ETC Group. 2005. The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries. Trade-Related Agenda, Development and Equity (TRADE) Research Papers 4. South Center, November. Available on the internet: www.etcgroup.com.

Farrell, M (2003) The critical path towards regional integration and liberalisation – the thresholds. Source unknown.

Gustafsson, B. and S. Li, 2000. "Economic Transformation and Gender Earnings Gap in Urban China," Journal of Population Economics, 13 92): 305-329.

GY Associates and ICAR, 2006, Encouraging Effective R & D partnerships: Lessons Learned from the Indian Experience, Policy Brief, GY Associates, UK and Indian Council of Agricultural Research, New Delhi

Hall, A. J. 2006. Public-private sector partnerships in a system of Agricultural Innovation: Concepts and Challenges, International Journal of Technology Management and Sustainable Development, 5 (1)

Hewitt, A et al (2003). A review of the trade and poverty content in PRSPs and loan-related documents. ODI.

Hall, A.J., B Yoganand, Rasheed Suliaman V., Raina, R, Prasad, S, Niak, G and N.G Clark. (Eds) (2004) Innovations in Innovation: reflections on partnership and learning. ICRISAT, Patancheru, India and NCAP New Delhi, India

Hall, A.J, Rajeswari Raina, Rasheed Sulaiman V, Norman Clark, Shambu Prasad and Guru Naik. 2005. Institutional Learning and Change-A Review of Concepts and Principles, Policy Brief 21, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi.

Hirway, Indira, 2006. “Globalization, Labor Markets and Gender Inequality,” (unpublished) Study for UNDP asia-Pacific Trade and Investment Initiative.

IDS and ODG DEV (2003) Can trade reform reduce global poverty? Policy Briefing on Globalisation and poverty. Issue 19. August.

IBRD (2002) Strategic approaches to science and technology in development. June 26. Washington. Final Discussion draft.

IBRD Global Economic Prospects 2005.

IFAD. 2006. Gender Assessment Report: Impact of IFAD’s Commitment to Women in China and Insights for Gender Mainstreaming, (Report No. 1640), International Fund for Agricultural Development, Rome.

ILO, 2004. Economic Security for A Better World, Geneva, ILO.

Jaffe, A and Lerner, J (2003) Innovation and its discontents: How our broken patents system is endangering innovation and progress and what to do abut it. Princeton UP.

Juma C and Lee Y.C. 2005. Innovation: Applying Knowledge in Development. UN Millennium Project Task Force on Science, Technology, and Innovation. Available on the Internet: http://bcsia.ksg.harvard.edu/BCSIA_content/documents/TF-Advance2.pdf

Kuman, J (2002) PICTA and PACER. 5th Roundtable meeting for Pacific Isand Countries on WTO Agreement Provissions. 8-12th April. Wellington, NZ.

Lall, S and Albaladejo, M (2004) China’s competitive performance: a threat to East Asian Manufactured Exports? World Development Vol. 32. No. 9, pp 1441-1466.

Leeuwis, C and A.W. Van den Ban, 2004, Communication for Rural Innovation- Rethinking Agricultural Extension, (Third Edition) Blackwell Science,UK

Leo A. 2002. The State of Nanotechnology. Technology Review, June.

Li, S, R. Zhao and P. Zhang, 1999. “Theoretical Explanation and Empirical Analysis of China’s Income Distribution Changes,” in Zhao, S. Li and C. Riskin, editors, Restudies on Income Distribution of Chinese Residents, China Financial and Economic Publishing House, Beijing.

Maclurcan, D.C. 2005. Nanotechnology and Developing Countries, Part 2: What Realities? AZoNano – Online Journal of Nanotechnology, October 19, 2005. Available on the internet: http://www.azonano.com

Manduna, Calvin (2006) The results of the 6th WTO Hong Kong Ministerial Conference – Considerations for African, Caribbean and Pacific (ACP) Countries. AFRICA REGIONAL WORKSHOP ON WTO NEGOTIATIONS. 10-11 April 2006. Cape Town, South Africa.

Mason, A. S. Rozelle and Li Zhang, 2000. Gender Wage Gaps in Post-Reform Rural China, CCAP Working Paper Series WP-00-E25. Beijing, Chinese Academy of Sciences.

Oberdörster, Eva. 2004. Manufactured Nanomaterials (Fullerenes, C60) Induce Oxidative Stress in the Brain of Juvenile Large-Mouth Bass. Environmental Health Perspectives, 112:10, July.

Oxfam:http://www.matangitonga.to/article/spnews/pacificislands/wtoterms161205.shtml last viewed 18/02/06.

Pacific Islands Forum Secretariat (2001) Sharing capacity: the Pacififc experience with regional cooperation and integration. October. Suva, Fiji.

Planning Commission (Government of India). 2005. Chapter 4, Women, Children and Development, New Delhi.

Raloff, J. 2005. Nano Hazards: Exposure to Minute Particles Harms Lungs, Circulatory System. Science News Online, Week of 19 March, 167:12.

Raloff J. 2005. Nano Hazards: Exposure to Minute Particles Harms Lungs, Circulatory System. Science News Online, Week of March 19, 2005; Vol. 167, No. 12.

Ranjana, W. 2004. Thailand Embarks on the Nano Path to Better Rice and Silk. Bangkok Post, 21 January 2004. Available on the Internet: http://www.smalltimes.com/ document_display.cfm?document_id=7266

Rodgers, Gerry. 2006. Decent Work, Social Inclusion and Development, Institute for Human Development, Delhi.

Russell E. n.d. Foods of Tomorrow: The Nuts and Bolts of Nanoscience. International Food Ingredients. Available on the Internet: http://www.ifi-online.com/Tmpl_Article.asp?contentType=3&ContentID=225

SciDevNet:http://www.scidev.net/

Scotchmer, S (2003) Innovation and incentives. MIT Press. 2005.

Sharma, R 2002.Integration of Agricultural Research and Extension, Report of the APO Study meeting on Integration of Agricultural Research and Extension, Philippines, 18-22 March 2002 (Asian Productivity Organisation, Tokyo). http://www.apo-tokyo.org/00ebooks/11.AgriResearchExt.htm

Sujaya, C.P. 2006. Climbing A Long Road: Women in Agriculture in India: Ten Years After Beijing, M.S. Swaminathan Research Foundation, Chennai.

Sulaiman, V.R. and Hall, A.J. (2003). India: The emergence of Extension-Plus: Future for Extension Beyond technology transfer? In 'Rivera, WM and Gary Alex (eds.) Extension and Rural Development'. (The World Bank, Washington, D.C.)

UK Royal Society and the Royal Academy of Engineering. 2004. Nanoscience and Nanotechnologies: Opportunities and Uncertainties. The Royal Society and The Royal Academy of Engineering, London, July. Available on the Internet: http://www.nanotec.org.uk/finalReport.htm

UN World Population prospects 2004.

Van Mele, P. A.Salahuddin and N.P.Magor, eds., 2005, Innovations in rural extension; Case Studies from Bangladesh, Wallingford, CABI Publishing.

Vepa, Swarna. 2004. “Feminization of Agriculture and Marginalization of their Economic Stake,” in Economic and Political Weekly, Vol. XL, No. 25 June 18-24.

Wang, Meiyan and Fang Cai, 2006. “Gender Wage Differentials in China’s Urban Labor Market, UNU-WIDER, www.unu.wider.org

World Bank, 2001. Engendering Development: Through Gender Equality in Rights, Resources and Voice, World Bank and Oxford University Press.

World Bank, 2006 Enhancing Agricultural Innovation: How to go beyond strengthening agricultural research systems, The World Bank, Washington, DC

Zan Huang, et al. 2004. International Nanotechnology Development in 2003: Country, Institution and Technology Field Analysis Based on US PTO Patent Database. Journal of Nanoparticle Research, 6:4, 325-354. Cited in ETC Group. 2005. The Potential Impacts of Nano-Scale Technologies on Commodity Markets: The Implications for Commodity Dependent Developing Countries. Trade-Related Agenda, Development and Equity (TRADE) Research Papers 4. South Center, November: p. 17. Available on the internet: www.etcgroup.com.