ESAP CHAPTER 5

DEVELOPMENT AND SUSTAINABILITY GOALS: AKST OPTIONS

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Key Messages

1. If the current trend in soil, water and forest degradation is to be arrested, productivity and environment sustainability must be addressed in an integrated fashion. While part of the solution may involve the application of technologies, a comprehensive solution depends on appropriate institutional arrangements and policies to ensure an integrated approach to natural resources management. One option is to provide systems of incentives that promote sustainable resource use.

2. If the poverty associated with rainfed agriculture is to be reduced, policies and resources will need to be extended to agriculture in arid, semi-arid and upland areas. Policies might include the use of locally adapted varieties and conservation agriculture such as moisture conservation and zero or minimum tillage.

3. A variety of agricultural technologies will need to be applied in an integrated, site-specific manner if agricultural, environmental and development goals are to be realized. Low input technologies such as organic, traditional and local systems and integrated nutrient and pest management can capitalize on the expanding domestic and global demand for food produced in ways that minimize costs to human and environmental health and can reduce fossil fuel dependency. Such technologies are especially advantageous to rural producers constrained by access to credit, external inputs and extension services. Transgenics, nanotechnology and precision agriculture may positively affect natural resource and human welfare by reducing pesticide use and providing inexpensive vaccine delivery, but may only be advantageously deployed under site-specific scientific and social monitoring within a stringent biosafety framework.

4. To improve agricultural performance and rural livelihoods, availability and access to information and communication technologies that facilitate the rapid dissemination and exchange of information will need to be enhanced. Frameworks for information exchange among farmers, extension workers, researchers and policymakers need to be flexible, adaptable, inter-related and science-based with a capacity to incorporate as well as develop new knowledge streams. This may be accomplished through decision tools and those such as e-learning modules, market information systems accessible through mobile technologies and computer kiosks as evident among producers in Bangladesh, China, India and the Philippines.

5. Integrating the complementary expertise of actors involved in AKST will be necessary if the rural sector is to respond and benefit from the growing complexity of regional agricultural development. To benefit from the opportunities offered by public-private

partnerships, potential patterns of interaction need to be identified and current constraints overcome. Stakeholder meetings, institutional reforms, funding and other fiscal policy measures offer opportunities for promoting such collaboration.

6. If community livelihoods and the rural economy are to be enhanced, discriminatory barriers that limit the participation of women, indigenous peoples, certain caste groups, religious and ethnic minorities need to be identified and eliminated. This may be accomplished through the development and implementation of policies and governance structures, anti-discrimination legislation and ensuring access to public services and markets.

7. The capacity of women agricultural producers, as holders of AKST, needs to be strengthened if household and community livelihoods are to be improved. Given the feminization of agriculture and women's limited access to resources and markets, this may be accomplished by empowering women to secure access to and manage land, knowledge and technologies that recognize their economic contribution to agricultural production, ensure wage parity and providing women with vocational and technical training.

8. To help ensure equitable access to environmentally sustainable and appropriate technologies, differences in technological capacity and the specific needs of countries in the development of Intellectual Property Rights (IPRs) policies will need to be recognized. IPRs may create barriers to trade and limit the capacity of developing countries to move up the science and technology ladder. The appropriateness and fairness of the patent system when applied to biodiversity and traditional and local knowledge are urgent concerns in the conservation of natural resources and access of the poor to them.

9. The capacities of various actors requires strengthening if the opportunities arising from global trade integration, information and communication revolution and representation among the private and NGO sector in agriculture are to work to the benefit of the rural economy. The capacities of farmers, researchers, local governments, extension workers, financial institutions, local entrepreneurs and market agents, agroindustry and NGOs may be enhanced through training, professional exchange and vocational education. Efforts in the areas of research, policy and governance, extension and training could include: a) traditional and emerging technologies, b) international regulations, IPRs, trade negotiations, institutional reforms, c) support systems not limited to production such as organizational, marketing, entrepreneurship to farmers, producer groups and NGOs and d) the non-farm rural sector.

10. If economic development is to become sustainable given increasing global competitiveness, member states will need to develop their external trade relations taking into account that the latter can affect the achievement of development goals. This can be accomplished by a) configuring and phasing sub-regional integration in ways that enable the development of a global, non-discriminatory trading system, b) ensuring that Agreement on Agriculture (AoA) reforms take into account their impact on the divergent agricultural sector/s in the region, c) improving the quality and coherence of regional trade policies and decision-making and monitor the impact of competitive trade regimes that address environment, health and labor and d) assessing and adopting alternative mechanisms, including 'marketization' (e.g.; carbon trading), to respond to conflicting interests. Such broad-based interventions will likely avoid extensive rural unemployment and sociopolitical dislocations that may result from increased competitiveness, technological obsolescence and trade rivalries.

11. If hunger and poverty are to be reduced through accelerated agricultural growth, rural investment needs to be increased and priorities changed. Such changes should address a) the mix of agricultural activities (e.g., in favor of rainfed crops and those grown by the poor), b) agricultural research, extension and science and technology infrastructure and support infrastructure (e.g., farm to market roads), c) enhancement of the value chain including postharvest technologies, agroindustries and markets. In addition to public funding and donor support, investment in the foregoing areas can be enhanced by innovative means such as competitive (contract) research grant schemes, commodity cesses or levies.

12. Global consensus is necessary to achieve food security and natural resource conservation given the challenges posed by climate change and increasing bio-fuel dependence. Climate variability and change will emerge as threats to the agricultural sector in most of the ESAP region, while agriculture in high to mid-latitude parts of the region may benefit from climate change. The increasing dependence on biofuel crops such as oil palm, *Jatropha*, sugarcane and traditional food crops such as batata and cassava will increase land and water pressures, pose threats to natural ecosystems such as forests and potentially have negative impacts on food security and prices. A major challenge is to ensure that the development of biofuels meets sustainability goals.

13. To realize economic development and environmental sustainable, the region needs to capitalize on the emerging global knowledge economy through enhanced capacity of national innovation systems. This involves establishing and strengthening links between networks in the knowledge economy. The state can play a critical role as sponsor or champion of

this process by identifying the actors and organizations, encouraging collaboration and developing enabling institutions and policies to build an effective system.

14. Policies that address the linkages between agricultural and non-farm rural employment need to be developed if the poverty associated with limited rural employment opportunities is to be reduced. These might include a focus on local value addition opportunities such as agroprocessing and non-timber forest products. Included as well could be wage employment programs to enhance rural infrastructure.

15. If rights over competing use of water are to be equitably resolved, coherence is needed among administrative functions and policies. Resolution mechanisms might include the establishment and strengthening of inter-ministerial coordination, multistakeholder consultations/management and multi-sectoral dialogue. To ensure the effective design of national and regional water policies and the choice of appropriate technology basin-wide management is also required.

5.1 Context

The pursuit of development and growth in the ESAP region has generally been undertaken without sufficient consideration to sustainability and in some cases with poorly supported assumptions about the sharing of benefits that result from economic growth. Appropriate decision-making processes need to consider equity and sustainability issues while also assessing the gains to be garnered from productivity and growth. Factors that can influence the achievement of broad social and political goals ought not to be restricted to science and technology or AKST. Rather, such goals will depend on resolving social issues that are shaped by factors that can alter relations of power and control and affect entitlements and access to resources. Thus, facilitating innovation is not only a question of developing and transferring concrete, science-based innovations, but also about facilitating innovative processes.

Technological advances in realizing development goals for much of ESAP unfold through social dialogue and interaction that have implications for the dynamics of policy making. Social goals include reducing poverty which we understand to mean a human condition characterized by low income, lack of voice and sustained deprivation of capabilities, choices and power that are necessary for the enjoyment of fundamental human rights. Poverty corresponds to the inability to access the full range of rights, standards of social equality and non-discrimination, as well as to be protected by the state and other development actors, including civil society organizations, community management bodies and corporations (Narayan et. al, 2000; Hulme and Mckay, 2005).

This chapter begins with a discussion of the institutional and organizational context in which humans strive to produce and survive in ESAP. Parts of the region are characterized by social exclusion and inequality, particularly of women who constitute the majority of agricultural workers. Exclusion also characterizes access to the fruits of such economic growth including public services, markets and governance structures. Coupled with the challenges of climate change, water scarcity and petroleum dependence, countries in the region need to undertake effective measures for inclusive and equitable growth and put in place context-specific regimes for intellectual property rights and ethical and fair trade. They also need to capitalize on the emerging global knowledge economy and enhance the capacity of AKST actors and institutions to meet the broad goals of improved agricultural growth and capacity, sustainability and livelihood options.

In the section on technologies, we argue for an integrated approach to agriculture, using best management practices that blend traditional knowledge and organic practices with conventional and emerging technologies to help improve rural livelihoods and human health. This integrated approach will help to ensure consistency with the goals of greater productivity on the one hand

and sustainability and equity, on the other. We recognize the potential of biotechnology, nanotechnology and precision agriculture to improve human welfare and preserve natural resources when these technologies are deployed appropriately, with site-specific scientific and social monitoring and within a stringent biosafety framework. We suggest that the development of organic agriculture can also supply a growing regional demand while helping to improve rural livelihoods and human health. Despite the inroads of information technology in many parts of Asia, information asymmetry remains a serious challenge, even recognizing that the information and communication technologies gap between expert and layperson has shrunk. Improvement in the availability and outreach of information is still required to strengthen adaptability and science based capacity to build and support new knowledge streams.

The chapter concludes with a discussion of institutions and policies and trade and markets, covering a range of issues, including public–private-community partnerships and networks, organizational reforms and enabling environments including decentralized and community-based entities with experience in science and technology generation and management. Further, technical and funding assistance from development partners can offer opportunities to galvanize efforts to reduce the mismatch between economic growth and poverty, vulnerability and inequality throughout the ESAP region. The section closes with an examination of trade policies and the steps required to ensure their consistency with development and sustainability goals.

5.2 Emerging Challenges

To feed the anticipated world population of approximately 9-12 x 10^9 people by 2050, 99% of whose growth will be in developing countries, food production will have to be trebled on dwindling arable land and freshwater resources (Population Reference Bureau, 2002). Options for increasing food production while reducing dependence on water resources and contributing to sustainable environmental practices are limited (Serageldin, 1999; Chrispeels, 2000; Vasil, 2003). Per capita available arable land area will be reduced by 50% over the next 50 years, with prime land being lost to industrialization and urbanization in a number of rapidly growing ESAP countries (Krattiger, 1998). Further, yield gains from the input and seed-oriented technologies utilized since the 1970s are stagnant or declining and unlikely to be able to keep pace with increasing population pressure in the region (Bouis, 1993; Cassman et al., 1995). The conversion of marginal areas into productive land, expansion of low-cost irrigation and trait modification and improved management through transgenic and nanotechnologies offer only limited potential (Crosson and Anderson, 1992; Peng et al., 1994; Carruthers et al., 1997; Rosegrant, 1997; Huang et al., 2002) while increasing the productivity of agricultural systems in ESAP continues to be complicated by climate change, animal and human diseases, social inequalities and the need for changes in institutional and governance practices.

5.2.1 Natural resources

The ESAP region's natural resources (soil, forests and water) are being degraded in intensive as well as non-intensive agricultural systems, from both the over- and under-utilization of inputs. In the developed countries in the region, high rates of inorganic and organic fertilizer have led to soil and water contamination (NRC, 1989; Conway and Pretty, 1991), while in the developing countries, population pressure, land constraints and poor soil management have reduced soil fertility with attendant biodiversity and functionality losses (Stoorvogel and Smaling, 1990; Tandon, 1998; Henao and Baanante, 1999). In the recently released 'National Development Programme Compendium of Science and Technology for Medium-Long Term (2006-2020), the Government of China recognized a range of resource management problems including eco-safety, land degradation and desertification, water shortage and water pollution. China's agricultural challenges also include serious surface water pollution arising from the improper use and disposal of some 3×10^9 tonnes of manure annually and the excessive application of pesticides and fertilizers (70 and 60%, respectively) on land and water.

Forests cover almost 30% of the land area in Asia, are critical for providing products and services and contribute to the cultural and spiritual heritage of much of the region's population (CFAN, 2004). Throughout the developing countries of ESAP, intensive timber harvesting, expanding commercial agriculture and the conversion of forests to rubber or oil palm plantations have contributed to forest degradation, primarily in Indonesia, Malaysia, Myanmar and Thailand (FAO, State of the World's Forests, 2003). Land and forest degradation, climate change, air and water pollution, water shortage and the loss of biodiversity are now the focus of new social and environmental movements (Krishna, 2004) which seek improved agricultural efficiencies and new policy measures.

Water shortages are common throughout rural and urban areas of the region. Although China has 28% of the world average per capita availability of water, it is estimated to have a shortage of 30×10^9 km^3 per year. While there may be sufficient water in much of the region for domestic as well as agricultural and industrial use, the poor are generally systematically excluded from access (UNDP, 2006). Among the poor, women and girls face a distinct disadvantage since they often sacrifice education and skill development to collect water. Moreover, lacking informal rights to land, women are excluded from irrigation systems management. These deep-seated inequalities; e.g. gender division of household labor, norms on women speaking in public and constraints on women's mobility, regulate women's decision–making in community management, farmers' associations and water user groups.

Addressing inequities in water access will require clear targets for reducing asset-based land and water inequalities and establishing regulatory systems for public-private-community partnerships to provide clean water and sanitation to households at affordable prices. The National Slum Dwellers Federation in India, Orangi Pilot Project in Pakistan and Total Sanitation Campaign in Bangladesh (adopted in Cambodia, Chain and India) are examples of community-government partnerships that have led to rapid increases in access to sanitation and water. However, efforts to address competing uses of water are frustrated by the separation of administrative responsibilities for water and agriculture. In many cases, building on local artisans and local joint management would help to expand water development technologies. There is also need for process monitoring to understand the logic of adoption and build coherence among administrative functions and policies to equitably resolve rights over competing water uses. Resolution mechanisms might include establishing and strengthening inter-ministerial coordination, multi-stakeholder consultations/management and multi-sectoral dialogue.

The marine environment, too, is being degraded in response to economic development (e.g., oil development and logging, dams), population growth and human activity, particularly in coastal areas. Marine ecosystems in the Vietnam Sea play an important role in the economic development of East and South-East Asia, but are subject to pollution from several nations, resulting in habitat loss and a declining resource base (Thahn, 2005). Resolving such problems, which are increasing despite conservation efforts, requires not only national action, but also regional cooperation and modified institutional arrangements that include the international aid regime. For instance, the sustainable harvesting of fish stocks might be most effective if Governments of the region cooperated to:

- Invest in integrated ecological socioeconomic assessment of fisheries to set sustainable goals and identify priority actions
- Improve tenure regimes to clarify roles and responsibilities for access and management of fisheries resources, as well as capacities for enforcement
- Pursue adaptive management based on sustainability goals

As current methods to prevent the collapse of fish stocks have not proved effective, action is needed to conserve stocks, such as ‘big eye’ and ‘yellow fin tuna’ in the Pacific and to increase marine food security. In pursuit of those goals, three major initiatives are needed in the medium and long term:

- Careful review and comparison of fisheries agreements, particularly the means employed to attract fleets and to raise revenues for small island states.

- Establish networks of 'fish parks' so that protected areas 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) and
- Complement fish reserves or parks with arrangements to disseminate monitoring data for internet use to engage citizens in policing activities (Clover, 2004).

5.2.2 Climate change

A daunting challenge in the ESAP agricultural sector is climate change and its predicted effects on productivity and livelihoods. Water is already one of the greatest constraints to agricultural productivity in much of the ESAP region and is likely to become more so as evidence reveals global warming-induced reductions in precipitation and accelerating glacier recession in the Himalayas (Duan et al., 2006; Singh et al., 2006; Kulkarni et al., 2007). The consequences of such changes are water scarcity as well as catastrophic flooding in mountain countries like Nepal, which are at risk of glacial lake outburst floods (Rai and Gurung, 2005). Unseasonal rains, debilitating droughts, excessive floods, devastating cyclones and storms and other extreme weather conditions seriously threaten agricultural, livestock and aquaculture production systems. Drought has consequences for 500 million farmers largely living on rainfed agriculture in India, Myanmar, Pakistan, Nepal, Thailand, Philippines, Australia and the Pacific Islands (UNESCAP, 1995). The Intergovernmental Panel on Climate Change (IPCC, 2007) projects a decline in grain harvest for tropical regions of 5-1% by 2020 and 11–46% by 2050, largely in response to global warming, with effects likely to be felt by large and small farmers throughout the ESAP region.

Reducing CO_2 emissions requires multiple approaches, including reductions in energy consumption, more efficient use of available energy, application of renewable energy sources and carbon sequestration (Han et al., 2007). At the field and farm level, new agricultural approaches and models are essential for higher productivity, energy efficiency and sustainability in view of climate change threats (Seguin et al., 2007). For instance, a field or farm-level decision to eliminate tillage operations can reduce production costs by 50%, save labor and decrease erosion, agrochemical contamination and fuel consumption (Huang et al., 2002). Moisture conservation technologies along with crop and cropping system diversification are important to lower risk in a variable climate scenario, improve production and sustain livelihoods, particularly in marginal areas (Lantican et al., 2003).

At the regional level, governments in ESAP also need to adopt strategies to prepare farmers, particularly those in the most vulnerable (drought and flood-prone) sectors, for the long-term impacts of climate change and variability. Increased investment in rainfed agriculture throughout the region is one necessary intervention, as is raising awareness and support for farmers and

affected populations to formulate mitigation and adaptation measures. Modern technologies in conjunction with traditional knowledge of water management and crop selection can support community-based adaptation efforts and account for the specific needs and conditions of particular populations. This is especially important in the low-lying deltaic areas of Bangladesh and the small-island developing states of the Pacific. With the exception of a few cases in Southeast Asia, irrigation intervention excluded women from access to water resources (Lambrou and Piana 2006a), thus generating especially adverse impacts of drought and climate variability for women. Yet, gender specific impacts are seldom noted in discussions related to the effects of climate change (Lambrou and Piana, 2006ab) suggesting that effective policy implementation to respond to climate change requires accounting for its differential effects on women and men.

As forest degradation is endemic throughout the region, it is useful to examine recent positive responses to curb deforestation and support reforestation. In China, for instance, the introduction of large scale tree-plantation schemes between 2000 and 2005 may be suggestive strategies for use in other areas of the ESAP region (UN, 2007). Forests currently store a substantial stock of carbon, amounting to 826 x 10^9 tonnes in trees and soil (Brown, 1998), an amount that exceeds the stock of carbon currently in the atmosphere. Sequestering carbon in forests through activities that expand forest cover through via plantations and agroforestry plantings and minimize deforestation, forest fires and soil disturbance can help mitigate the accumulation of greenhouse gases in the atmosphere (Adams et al., 1993; IPCC, 1996; Adams et al., 1999; IPCC, 2000; Roper, 2001). Mitigation strategies to address fossil fuel combustion and land use changes, particularly deforestation for agronomic purposes are also required since they have the greatest impact on the global carbon cycle (Janzen, 2004).

5.2.3 Biofuels/bioenergy

Biofuel as an energy source is traditionally used in many communities across the region, albeit on a small scale and often only by individual households. During the Japanese occupation in Southeast Asia, for example, rural communities with no access to kerosene, used oil extracted from *Jatropha curcas*, coconut and castor beans, for light and cooking. More recently, communities across the Pacific (the Marshall Islands and the Bougainville), use coconut oil to fuel vehicles (Cloin, 2007). Within these contexts, biofuels show promising potential to increase access to energy for the poor. Governments in the ESAP region are now assessing biofuels, or bioenergy as a solution to reducing dependence on expensive petroleum and curbing emissions of greenhouse gases that cause climate change. While many of the current sources of biofuels are derived from corn, root crops, coconut, groundnut, sugarcane, sweet potato and palm oil (Ohga and Koizumi, 2007), tree crops such as *Jatropha* and pongamia are also receiving

significant attention. A new generation of biofuels produced from agricultural and timber waste is being explored but is as yet not commercially viable.

Biofuel production promoted by regional governments is based on large scale industrial production that supplies energy for urban areas and industrialized countries, giving rise to competition between biofuel and food production on already strained natural resources. Even for biofuels produced from secondary food crops, such as China's announced shift to ethanol production from cassava, sweet potato and sorghum (Sun, 2007) and non-grain oil crops such as jatropha that can grow in marginal lands, massive production of biofuels production requires the conversion of agricultural, forest and public lands to grow these crops commercially. Commercial production of biofuels that require area expansion is therefore likely to substantively increase the agricultural demand for water, which is already at 78% of the available fresh water supply in Southeast Asia (ASEAN, 2006).

Further, the increasing demand for oil palm is expected to create additional pressure on the region's steadily declining forests. In Indonesia, for example, the government plans to convert some 1.5 million hectares of land to oil palm plantations and another 1.5 million for jatropha plantations, beginning with approximately one million hectares of land not productively used, including forestry concessions that have been abandoned by concessionaires (Haswidi, 2006). This conversion can potentially increase forest and land fires associated with oil palm plantations that can lead to the serious loss of biodiversity, ecological degradation and recurring transboundary haze that endangers human health and economic security. Apart from climate change concerns, deforestation threatens the survival of indigenous peoples, forest dwellers and the rural poor who depend on forests for their food, livelihood and cultural identity. Current debate on the environmental impacts of biofuels in ESAP also extends to biofuel production in input-intensive monoculture systems and genetically modified crops developed to accelerate the growth of biofuel crops and trees with little risk assessment analyses.

With increasing market demand, crops traditionally grown for food, feed and oil are expected to shift to biofuels. This will likely increase food prices, especially if supplies remain the same, as is already evident in the current corn price trends worldwide. Rising grain prices and the diversion of local carbohydrate and protein sources to the energy market could represent a market opportunity, but also a threat for the region's poorest (Brown, 2006). High feedstock prices could drive small livestock and poultry producers out of business, depriving millions of families of their livelihood. The joint announcement by Malaysia and Indonesia to allocate 40% of their combined annual palm oil output for biodiesel production, is expected to increase the price of edible oil, making it expensive for both food and energy users. In response, countries like the Philippines

have adopted measures to ensure that ethanol production does not compete with food production, requiring prohibitive distancing between sugar mills for food/feedstock production and biofuel processing. Root crops in particular often serve as secondary or even survival crops for many rural and indigenous communities across ESAP, so using them for biofuel production could directly impact food affordability.

Biofuels have the potential to provide food security and livelihoods for the poor in ESAP while attaining sustainability goals if their production is based on the sustainable use of local resources, the promotion of local energy efficiency, the provision off-farm income for rural communities, especially to women and the improved management of energy production and consumption. Supplying energy to urban areas and industrialized countries may offer short-term economic gains for developing countries in the region, but at high costs for the environment and for the capacity of countries to produce food that is available, accessible and affordable for the poor.

5.2.4 Urban-periurban agriculture

Urban and periurban agriculture (UPA) can contribute to reducing poverty and enhancing food security and involves the production of crops, livestock, fish and related goods and processing and marketing activities in and around cities and towns. UPA is distinguished from rural agriculture by its integration into the urban economic and ecological system where its objectives include income generation, contribution to urban dwellers' food needs, the urban landscape and environmental sustainability (van Veenhuizen, 2006). UPA can increase food availability and enhance the freshness of perishable foods reaching urban consumers a conclusion supported by case studies which show differences in nutrition, especially among children, when poor urban families farm. UPA also has the potential to efficiently recycle nutrients from municipal solid wastes and waste water (Hussain et al., 2002).

Despite potential efficiencies, there is a strong perception about the unsuitability of urban and periurban agriculture resulting in overlooking, underestimating and under-reporting UPA practices. Concerns arise over competition for land, water, labor energy resources and its incompatibility with urban life (smells, noises, pollution). Though many of these concerns arise in rural agricultural production, two important differences are of concern in the urban environment: proximity to greater numbers of people and high existing stresses on the natural resource base. In the absence of appropriate management and monitoring of resources, the negative environmental and health effects of UPA are critical concerns.

In order to enhance the positive consequences of UPA for urban livelihoods, resource utilization and the environment, research must bridge the gap between UPA research and practice and

between urban planning and policy (CIP, 2005). Other constraints to UPA in urban areas of the ESAP region include limited and declining land, polluted irrigated systems and waste-water contamination. As municipalities play an important role in urban planning, their involvement is critical for promoting UPA for its potential contributions to improving the urban environment.

5.2.5 Human, animal and zoonotic diseases

HIV/AIDS: The current situation of HIV/AIDs-infected and affected people in the region remains grim; 4.3 million people were newly infected in 2006, with East Asia host to one of the fastest rates of infection. Most infected people in South and South East Asia (Cambodia, China, India, Nepal, Pakistan, Thailand and Vietnam) are reported to acquire HIV through unprotected sex with sex workers (United Nations, 2007). Almost half of those living with HIV in the region are women, with an increasing number being married women and youth between the ages of 15 to 24 years (Mehta and Gupta, 2005). Gender inequality and economic imbalances continue to drive the 'feminization' of the HIV epidemic (United Nations, 2007). In the absence of accessible, affordable health care and social acceptance, HIV has the potential to affect not only individuals, but entire communities and economies—as witnessed in large parts of Africa.

Key interventions to control infection have expanded in recent years; however, they are not sufficient to arrest infection rates. Country-specific and region wide consultations (i.e. public hearings, women's court) are held with some success and include HIV-positive people's networks, local and international NGOs, experts and practitioners of HIV control initiatives and international development partners. Additional interventions could include such enabling strategies as ensuring employment opportunities for HIV infected and affected people, the implementation of policies to protect women's inheritance and property rights (Bhatla et al., 2007); dignity–based access to health care, education, skill development programs, training and an inclusive community-based approach to overcome the local world of shame and social stigma often experienced by HIV infected/ affected people.

Avian flu: The 2004 avian flu outbreak of the deadly H5N1 strain of avian influenza in East Asia resulted in the extermination death of 140 million domesticated poultry and birds (WHO Global Influenza Program Surveillance Network, 2005; Webster, 2006). The outbreak also proved that avian flu may be transmitted from birds to humans, with 130 human cases, including 70 fatalities, of avian flu in Vietnam, Thailand, Cambodia and Indonesia (Webster, 2006).

The damage caused by the epidemic made apparent that despite intermittent outbreaks since the 1990s, most ESAP countries are not adequately prepared to cope with this disease. Few governments have rapid response mechanisms to warn the public—prepare the poultry sector on possible culling campaigns or offer appropriate compensation in the event of mass culling of

poultry flocks (Martin, 2006). A document created in response to the 2004 avian flu outbreak provides guidance on establishing mechanisms and programs for surveillance, monitoring and diagnostics of avian influenza and creating regional networks to share information and early warning systems (Fao, 2004).

These outbreaks have severely tested the capacity of national agricultural extension systems across the region. The Thai experiences of 2004 showed the weakness in the capacity of the extension systems to timely and efficiently report outbreaks. Communication systems need to be improved to ensure that reports of local outbreaks are transmitted to appropriate authorities at the national level to ensure immediate surveillance and diagnostics to arrest further spread to other areas (FAO, 2004). Public funds must be mobilized to improve the capacity of local extension workers to conduct surveillance and detection, as well as to handle outbreaks. Such training programs need to target poultry-raisers, especially those small backyard producers who comprise the majority of the poultry sector in the developing ESAP countries. Regular capacity building programs on preparedness for veterinary diseases need to include avian flu outbreaks, even in countries that have yet to be affected by the virus.

Public awareness and education on avian flu, especially among segments of the population involved in handling poultry, is also critical. Indonesia was severely hit by the 2004 outbreak and has now invested heavily on public education, while Thailand implemented a national public education program focusing on preventing virus transmission (Olsen, 2005). Awareness of law enforcers regarding the risks and costs of avian flu outbreaks need improvement, as well as coordination between appropriate authorities and law enforcers. Prevention measures such as fencing poultry populations to keep them away from wild birds suspected of carrying highly-pathogenic avian flu virus need to be considered and supported, possibly through incentive mechanisms to encourage cooperation from those for whom fencing costs may be prohibitive, especially in countries where free-range raising of chickens and ducks is traditionally practiced (Martin, 2006).

Governments also need to allocate emergency funds to provide immediate and fair compensation for culling affected poultry flocks, especially to backyard poultry raisers whose livelihoods depend primarily on small-scale poultry raising (Martin, 2006). For example, during the 2004 outbreak, Thailand allocated a budget of US $132.5 million for direct compensation to affected farmers (Tiensin, 2005). Compensation in the form of outright cash payment or check for backyard raisers may be an effective strategy to encourage cooperation of affected sectors to culling programs with a ceiling for the amount of compensation clearly established in order to avoid conflicts and erosion of trust in government programs. Countries may also consider investing in vaccination of

poultry against avian flu, but while vaccination may be a possibility for large-scale poultry raisers, it is largely inaccessible to backyard raisers dependent on government support to access such measures. Investment must also take into account the resources needed to develop the extension worker capacity to properly and safely handle vaccines from the source to the farms. In considering various options it is crucial to account for the impacts on animal and human health of veterinary vaccines and antibiotics (Ho, 2007).

5.2.6 Institutional and governance practices

As agriculture in the ESAP region is changing rapidly, organizations must continuously evolve appropriate institutions and governance systems to respond to new challenges. Designing, evaluating and implementing institutional reforms will be a continuing challenge for managers in Research, Development, Training and Extension (RDTE) and related systems if agriculture is to meet sustainability and development goals. It may be important to implement institutional changes in rules, norms, conventions and habits within RDTE and related organizations to enhance exchange among various stakeholders. A learning-based approach appropriate to each specific institutional context is one creative option to meet this need.

Developing appropriate policies, too, is important, but having sound policy does not ensure compliance with guidelines for improved performance. First, many of the small countries in the region have limited capacity to implement policies as exemplified by the gaps in the capacity of several nations 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 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 with alternative ways 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.

The implementation of appropriate agricultural policies and programs requires collaboration among a large number of organizations that involves the creation of appropriate forums for partnership (e.g., working groups, steering committees) and the development of mechanisms to ensure collective decision-making. Organizations with a tradition of working in isolation may find it difficult to adjust to inclusive governance mechanisms and may invite opposition. Yet, skills in managing transitions and working through consultations, experimentation and learning can contribute to a collective ownership of change.

5.2.7 Actors and organizations

Agricultural development in the region depends upon the performance of a large number of actors and organizations; those involved in RDTE, as well as those involved in the generation and distribution of inputs, supply of credit, value addition and marketing and the development and implementation of policies with attention to the institutional context that shapes the interaction among these different constituencies. Though many people are present in the different ESAP countries, there is a wide diversity in their number, capability and performance, with implications for planning agricultural development interventions. First, importing models of technological change that may have been successful elsewhere, may not adequately address agricultural development in this region indicating the need for country and region-specific interventions and approaches. Second, the development or application of new technologies need not be the starting point for agricultural development. Instead, complementing new technologies with institutional innovations may more adequately address the complex interaction of agricultural development and environmental sustainability.

Donor funds and expertise from CGIAR centers and the FAO, for example, have facilitated the development of infrastructure, extension services and human resources in most ESAP countries. However, many of the small countries in this region do not have adequate capacity to adopt emerging technologies, exploit the potential of ICTs, respond to new challenges from integration of trade and enforce protocols related to biodiversity and biosafety. Research and development efforts need to be strengthened in biotechnology, post-harvest technology, IPRs and food legumes and minor fruits and vegetables. Currently, international donors including the World Bank, Asian Development Bank, FAO, IFAD and international networks such as CGIAR, ACIAR, GFAR, JAIC and APAARI support select countries in agricultural development, along with regional networks such as CLAN, CORRA, RWC, TAMNET,and GoFAR. Increasing the funding levels of these international and regional networks could greatly increase their reach.

There has also been a decline in public support for research and extension leading to vacancies and reduced operational funding. Concurrently, private sector investments in agricultural research and extension have increased. Apart from private input companies and agribusiness firms, several other actors are increasingly intervening in research and extension, including producer cooperatives, farmer associations and NGOs. Media (print, radio and television) also have increased their role in the dissemination of information on agricultural practices and technologies, development programs and market arrivals and commodity pricing. The internet, too, is and emerging source of agricultural information, although its use varies widely within and between ESAP countries.

Though a large number of organizations with complimentary skills and expertise exist, they have yet to collaboratively address new and existing agricultural challenges. Innovation is the process by which new knowledge, information, or technology is made available and put into productive use, occurs best when different actors in innovation systems share knowledge and work in partnership. Though efforts have been made to promote such collaboration, they have yet to alter how organizations function. New forms of interaction, organization and agreement between multiple actors ought to be encouraged if agriculture is to be environmentally and economically sustainable in the ESAP region.

5.2.8 Social exclusion and gender inequality

Social exclusion derives from exclusionary relationships based on power and hierarchy and intersects with other aspect of social disadvantage, such as gender, caste, ethnicity and religious minority status. Exclusion 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 (Beall et al., 2005). Further, exclusionary relationships are nurtured and maintained through systemic violence and the denial of rights that contributes to sustained poverty.

Most of the region's poor live and work in rural areas, making agriculture and land rights central to the struggle against poverty. To date, debate over land rights has brought rural and urban populations and industrial interests and farmers into violent confrontation as inequalities in decision-making has denied villagers access to traditional lands in bids to facilitate industrial expansion. In China, where the average land available per capita is only 40% of the global average, some 227,000 ha are lost to urban and industrial construction annually.

Reviews carried out between 2000 and 2006, noted that throughout the ESAP region, countries have improved their development policies, consequently scoring higher on indicators relating to the MDGs (UN 2007). However, they also reveal that highly unequal countries – India, Pakistan and Philippines – do worse in efficiency than more equal ones – China and Viet Nam (UNDP, 2006). It is perhaps unsurprising that the most noticeable policy improvements are related to gender and efficiency of resource mobilization for poverty reduction even as large groups of rural women and indigenous peoples continue to be excluded from economic and social institutions (Narayan et al., 2000).

Of the estimated 300 million indigenous/tribal peoples in the world, about 70% live in Asia and are generally among the most marginalized communities in almost every country with high levels of landlessness, illiteracy, malnutrition and no access to health services. Many of these communities

experience social discrimination, economic exploitation and political marginalization (www.ifad.ord/pub/factsheet/ip/e.pdf). Among indigenous/tribal peoples, women are further marginalized as they have little representation or voice in village councils. This is true even in matrilineal communities as in Meghalaya, India and among the Mosuo in Lijiang, China. Even when new state-sponsored organizations like Joint Forest Management councils are created, indigenous/ tribal women continue to be excluded (Kelkar and Nathan, 2003).

Widespread gender-based inequalities in access, control and ownership of productive resources characterize relations the region in ways that hinder development and is inextricably linked to poverty outcomes (Mason and King, 2001). Exclusion from skills, capabilities, assets and recognition, for example, is one consequence of labor market restructuring. Thus, it is hardly surprising that 70 to 80% of informal workers are women who are employed in low-paid jobs with long working hours. Further, their exclusion from formal employment and forms of informal work has demined women the dignity of livelihood.

Cultural norms that govern women's work and mobility play a significant role in women's work relations. Increasing the participation of women and indigenous in community governance is a matter of drawing upon their labor, skills and knowledge to enhance resource management and AKST and their development choices and rights. Sustainability can thus be said to depend on allocating resources to excluded groups in ways that enable them to negotiate with government, private sector and civil society and where gender specific approaches can overcome the marginalization of women in the governance of community resources. The capacity of women agricultural producers, as holders of AKST, also needs strengthening if household and community livelihoods are to be improved. Given the feminization of agriculture and women's limited access to resources and markets, this may be accomplished by empowering women to secure access to and the management of land, knowledge and technologies in ways that recognize women's economic contribution to agricultural production and can ensure wage parity and provide women with vocational and technical training.

Thus, if community livelihoods and the rural economy are to be enhanced, discriminatory barriers that limit the participation of women, indigenous peoples, certain caste groups and religious and ethnic minorities need to be identified and eliminated. This may be accomplished through the development and implementation of policies and governance structures, anti-discrimination legislation and ensuring resource equity.

5.3 Existing and Emerging Technologies in the ESAP region

5.3.1 Local and traditional knowledge and practices

Through millennia, local and traditional knowledge played an important role in maintaining and improving the livelihood of farming and indigenous communities—from producing food and providing shelter, to achieving control of their lives. Traditional knowledge systems are often 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. Although the low-input nature of these systems can have positive ramifications for biodiversity and soil and water resources, productivity is low in the absence of sufficient organic inputs. The valuable contributions made by these systems to global knowledge will continue only with appropriate and adequate support, based on the recognition of their dynamic nature and interdependence with the environment where they evolved.

Traditional knowledge is both cumulative and dynamic, building upon the experience of earlier generations and adapting to the new technological and socioeconomic changes of the present (Johnson, 1992). In cropping systems, traditional knowledge includes indigenous indicators to determine favorable times for each phase in crop production, land-preparation practices, indigenous ways to propagate plants, seed storage and processing, sowing and intercropping), seedling preparation and care, farming and cropping systems ,crop harvesting and storage, food processing and marketing and pest management systems and plant-protection methods (Grenier, 1998).

5.3.1.1 Impact

Traditional knowledge of crops and medicinal plants contribute much to the present understanding of cropping systems in the ESAP region and may be adapted even 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 scientific findings based on macronutrient content (Tamang, 1993). 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, with conservation and innovations involving plant genetic resources practiced by farming communities for about 100 years (Rerkasem and Rerkasem, 2002; Nagarajan et al., 2006). For instance, a centuries-old seed management system allows farmers in Nepal to grow and protect their seeds (Timsina, 2000; Upreti and Upreti, 2002).

Traditional knowledge of crops has also contributed greatly to modern medicine and biopesticidesin the region and beyond. 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 (Arnason et al., 1985; Prijono and Hassan, 1993; Gajalakshmi and Abbasi, 2004). Neem is currently marketed as a modern biopesticide proven to be effective against malaria and internal worms and is reportedly used by 500 million Indians in brushing their teeth, as well as for making soap. Another example is *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 have potential in treating AIDS (Nader and Mateo, 1998; Vermani and Garg, 2002). It is estimated that in 1985, US $43,000,000 worth of plant-based medicines (many of which were used first by indigenous peoples) were sold in developed countries (Principe, 1989). 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.

Similarly, local and traditional knowledge and practices in animal agriculture systems include indigenous methods of animal breeding and production, traditional fodder and forage species and their specific uses, animal-disease classification and traditional ethno-veterinary medicine (Grenier, 1998). A recent study in India 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 (De et al., 2004). While modern veterinary medicines were found to provide quicker cure than traditional treatment and preparations, the latter are cheaper and locally available to farmers, especially in remote areas.

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, 2000). Rice-fish systems are also traditionally practiced across Southeast and East Asia where they have provided numerous benefits to farming households beyond additional and diversified sources of food and nutrients. 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, 2000). The diversified and integrated nature of rice-fish farming has also provided a natural system of protection against crop pests and diseases.

Indigenous peoples in the region have practiced sustainable forest utilization and management techniques for centuries. Indigenous knowledge in forestry includes 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 (Grenier, 1998). The indigenous Hani communities in Mengsong, Xishuangbanna, in China's Yunnan province have developed a system of classifying forest systems according to their function and products. In Sri Lanka, forestry has traditionally been combined with cropping and animal rearing, such as in the classical Kandyan Forest Gardens where the agricultural system simulates a tropical rain forest involving small land units averaging about 1 hectare consists of a mix of as many as 30 perennial and semi-perennial trees and shrubs (UNESCAP, 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.

Indigenous practices of importance include the traditional use of fire in forest management and conservation, facilitating crop production and pest control and preventing unplanned burns (Jackson and Moore, 1998). 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.

Traditional knowledge systems continue to contribute in the development of agriculture throughout the ESAP region, largely because they are often inexpensive to implement and can be paid for in goods or services and they are readily available and accessible even to those who do not have cash incomes (Fernández, 1994). In most cases indigenous knowledge systems are socially desirable, economically affordable, environmentally sustainable and involve minimal risk to rural farmers and producers. Since they evolved gradually within the community and are under its control, local and traditional knowledge systems are considered more directed towards self-reliance and self-sufficiency than are modern technologies imposed from outside (Fernández, 1994).

5.3.1.2 Challenges

Traditional agriculture is considered labor intensive which may be a disadvantage or advantage depending on the social circumstances. The labor requirement may keep people from engaging in other economic activities, but it can also provide employment for the rural populace which might otherwise migrate to urban areas. Indigenous knowledge and traditional agricultural systems have much to offer in the future development of sustainable agricultural systems in ESAP countries. The role they play should be in response to specific local needs and conditions 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. Government policies must not ignore people's knowledge and must recognize that traditional knowledge plays an essential role in development, hence documented in a coherent and systematic fashion (Warren, 1991). An enabling environment that supports the conservation, use and promotion of traditional knowledge, as well as its interaction with modern agricultural systems, must be put in place in order to maximize the potentials of these knowledge systems as they are adopted by farmers to respond to specific needs and conditions.

Increasing population and the accompanying pressure on productive resources such as water and land brought about by the expansion of modern agriculture and industrialization, pressures from modernization and cultural homogenization are posing serious challenges to the viability of traditional agricultural systems and knowledge in many ESAP countries (Doane, 1999). An appropriate response might lie in providing monetary and infrastructural support to indigenous peoples and practitioners of traditional agriculture. Protection of traditional knowledge should also involve equity considerations anchored on the principles of conservation, preservation of traditional lifestyles, promoting use and development and adequate recognition and compensation.

5.3.2 Organic agriculture

While there is no single definition of organic agriculture, the term is generally understood to represent a suite of farm management practices rooted in using natural rather than synthetic materials to enhance soil fertility and combat plant disease (Raynolds, 2000). Organic agriculture fosters processes and interactions occurring in natural ecosystems, encouraging internal stability rather than relying on external control measures.

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, salinization and desertification have significantly reduced yields and threaten future agricultural use. The incorporation of organic matter into the soil also improves water-holding capacity, which is essential in areas of poor/erratic rainfall that may result from global warming. While some evidence suggests higher above and below-ground biodiversity and improved biochemical characteristics in organic systems (Bengtsson et al., 2003; Melero et al., 2006), 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., 2003). 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; Torstensson et al., 2006).

Organic animal agriculture practices include soil management techniques based on appropriate stocking rates and sympathetic grazing regimes to minimize compaction, provision of good quality drinking water and organically grown feed, 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 and the use of natural health remedies (BIO-GRO, 2001).

5.3.2.1 Impact

Overall, organic agriculture's emphasis on the sustainable use of local, often free, resources makes this system particularly important for the rural poor in the ESAP region, especially those in marginal areas with access to organic inputs not allocated towards other needs such as fuel. Organic agriculture is particularly beneficial for 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 (UNESCAP, 2002).

In addition to its potential for marginalized areas in the region, 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 Australia and New Zealand as well as many other ESAP countries. There is also growing demand for organic food in the ESAP urban centers and the premiums paid for this food could offer an opportunity for increased incomes for the rural poor, especially in areas largely untouched by Green Revolution technologies (IFAD, 2002). Overall, the organic market in Asia is currently growing at the rate of 10-20% annually, making it the fastest growing sector in the region's agriculture market (Yussefi and Willer, 2003). A number of countries in the region have adopted policies on the promotion of organic agriculture to take advantage of the growth in market demand and these authors place the area under organic management in Asia at around 2.9 million ha, while in the Pacific (largely Australia and New Zealand) it is around 11.8 million hectares.

Similar to traditional agriculture in the region, animals in organic systems are incorporated into a mixed animal agriculture/cropping enterprise, often with the addition of forestry. Yields from organic dairy systems in New Zealand average around 5% lower than their conventional counterparts but with higher returns and lower input costs resulting in little change in overall returns to the farmer (Christensen and Saunders, 2003). Organic aquaculture in the ESAP region

has lagged behind the development of other kinds of organic agriculture. New Zealand is one of the largest producers of organic fish and mussels outside Europe, with Indonesia, Viet Nam and Thailand for shrimp and Australia for salmon production. One constraining factor is the requirement that 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, removal of this constraint can considerably increase the production of farmed organic aquatic plants and molluscs.

Organic systems may require more labor than other systems, which can be negative or positive, depending on the availability of labor and income-generating activities. The question of yields from organic versus conventional systems remains controversial, but there is clearly a niche for organic crops in the ESAP region, particularly when combined with nitrogen-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 region that have reported yield increases and social benefits after conversion to organics (FAO, 2002). In Asia a positive relationship was noted between organic farming and improvements in rural livelihoods, including positive effects on employment, income and household food security (UNESCAP 2002a). 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.

Organic agriculture can reduce fossil fuel dependence through reductions in petrol-based inputs. This may not hold true if organic inputs and products are transported over great distance, but this is an unlikely scenario in most of this region, particularly for small farmers. Calculations on comparative energy use in OECD countries indicate that energy consumption on organic farms is 64% that of conventional farms (Haas and Kolke, 1994; Lampkin, 1997), while other research in Iran and Switzerland puts this figure as low as 30-50% (Zarea et al., 2000). In a three-year comparative study on organic and conventional strawberry production in China, 98% of the energy inputs in the organic systems were from renewable sources such as animal manure and biogas, whereas 70% of the energy inputs in the conventional system were non-renewable such as electricity and chemical fertilizers and pesticides (FAO, 2002). In New Zealand, the mean annual energy input was considerably lower under organic management systems than under conventional management (Nguyen and Haynes, 1995). While fossil fuel consumption can be substantially reduced in organic systems, these energy savings must often 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).

5.3.2.2 Challenges

Among the biggest obstacles to organic agriculture in the ESAP region are those imposed by the frequent insufficiency of organic input amount and quantity and the cost of the organic certification demanded by markets. Shortages of organic soil amendments are common throughout the region (Husain and Raina, 2004), especially where high population pressure, cropping intensity, or small land holdings 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 macronutrient ratios that are not optimal for crops. 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. However, 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).

The present scale of organic agriculture in the region is still considered small, partly because development and uptake by farmers has been hampered by a lack of supportive government policy in many countries (UNESCAP, 2002). While organic certification paves the way for producers to take advantage of the growing market demand for organic products, the costs involved work to the disadvantage of resource-poor farmers. The weak bargaining power in setting the price for agricultural produce in general, poor farm-to-market support infrastructure and lack of clear policies in the marketing of organic products all contribute to the limited access of poor farmers even to the domestic organic markets. Government policies in promoting organic agriculture therefore need to address these problems to ensure that poor rural producers will directly benefit from the socioeconomic potentials of this system. Measures should also be adopted to ensure that the expansion of organic agriculture cultivation in response to market demands do not sacrifice local food security and the environment.

Despite the potential and proven benefits, 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.

5.3.3 Conventional technologies and practices

Agricultural technologies and practices generated by formal institutions and research centers which might involve combining indigenous knowledge, organic practices and relatively new innovations or technologies are termed ‘conventional’ or ‘modern’ and have contributed to substantial gains in global agricultural productivity. The best known of these technologies, developed and disseminated in the 1960s and 70s after a decade of food shortages and famines, is known throughout Asia as the Green Revolution and depends almost entirely 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.

The Green Revolution led to the introduction of stronger-stemmed and higher yielding ‘modern’ varieties of the major cereal crops rice, wheat and maize, fueling an explosion in their yields 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) and enabled double and triple cropping in areas that previously produced only one or two crops per year (Umetsu et al., 2003; Gupta and Seth, 2007). A great majority of all recent gains in crop yields are attributable to these conventional breeding-induced improvements targeting the physiological yield potential of crop plants and their tolerance to biotic and abiotic stresses (Khush, 2005; Reynolds and Borlaug, 2006). Not only did productivity increase as a result of these improvements, but yield per unit area was increased, resulting in less land devoted to agricultural crops and an increase in the conservation and expansion of forests and woodlands by 21% between 1963 and 1999 (USDA, 2003).

Other conventional technologies include those of Integrated Pest Management (IPM) and Integrated Nutrient Management (INM), which draw substantially upon indigenous knowledge and organic practices. IPM is an environmentally sensitive approach to pest management that relies on a suite of pest management options that may include a combination of synthetic and organically certified pesticides and/or biological control agents. It differs from organic systems in that the latter limit the use of pesticides to those that are produced from natural sources, as opposed to the synthetic chemicals that may be used in IPM. INM is a suite of practices designed to integrate the use of organic and inorganic sources of crop nutrients, so that agronomic productivity increases in an environmentally sustainable manner, without compromising soil resources. INM relies on a number of factors, including appropriate, balanced nutrient application, soil and nutrient conservation practices such as low- and no-till farming, terracing, mulching, green manuring.

5.3.3.1 Impact

There is a large body of evidence to suggest that not only were millions of lives and rural livelihoods in the ESAP region saved, the view that the rich became richer and the poor even poorer as a consequence of the Green Revolution is over-generalized in a number of ESAP countries with diverse production environments and agrarian and policy structures (Acharya, 1982; Lipton and Longhurst, 1989; Paul, 1989; Kar, 1991; David and Otsuka, 1993; Edmundson, 1994; Osmani, 1998). While pesticide dependence undoubtedly had negative implications for environmental quality and human health, the increased unit productivity engendered by Green Revolution technologies reduced the need to bring natural ecosystems under cultivation by about a billion hectares of land for 1999 levels of productivity globally (Borlaug and Dowswell, 2005). Adoption of the Green Revolution package was largely focused on irrigated and high yield-potential areas to the neglect of marginal areas (IFAD, 2002) where a large percentage of the rural poor live. However, adoption since 1977 has increasingly been in rainfed and abiotic stress-prone areas—particularly in the case of wheat (Byerlee and Moya, 1993; Heisey et al., 2002; Lantican et al., 2003).

Advances in animal breeding and health have increased both the quantity and quality of animal protein available to consumers in the region. Livestock plays a vital role in economic development and in the life of Asian farmers. Animal products such as meat, milk and eggs provide daily cash income to farmers and also provide much required nutrition to rural population. It also contributes to draft power in farming and the dung adds not only to soil fertility but also as a material for house construction and cooking fuel. For the poor, livestock has multiple uses and this perspective needs to be kept in focus, while designing and promoting livestock sector interventions.

Although it is commonly viewed narrowly as the “intensive culture of salmon and shrimp to provide high value products for luxury markets”, conventional aquaculture actually comprises diverse systems of farming plants and animals in inland and coastal areas, many of which have relevance for the poor (Edwards, 2000). The ESAP region was responsible for about 91% of the world’s aquaculture production in 2003, with China alone accounting for almost 71% (FAO, 2005). Nine of the top ten aquaculture production countries are in this region, with China, India and the Philippines topping the list (FAO, 2006). Thus, aquaculture contributes to both the overall growth of many states and to the livelihoods of the poor in many parts of Asia where it is traditional practice. It is a major foreign exchange earner in addition to being a source food and nutrition and of employment for the poor. Although shrimp farming has been criticized for its environmental consequences, it can provide gainful employment for those who would otherwise be without

gainful employment. In Thailand, for example, shrimp farming is dominated by small farmers (Apu and Middendorp, 1998).

Conventional aquaculture and fisheries offer options for employment worth exploring for landless laborers. These options include cage and pen culture, enhanced fisheries in large communal water bodies (e.g., grass carp in Vietnam, Chinese carps in Nepal) and farming molluscs and seaweeds in coastal bodies (Indonesia and the Philippines). Inland aquaculture systems may have the greatest potential for expansion because aquaculture can be integrated with existing agricultural practices of small farmers, resulting in increased overall production through the synergies of integrated practices. Aquaculture can utilize irrigation systems as well as saline areas and swamps which would otherwise be of marginal use to agriculture (Edwards, 2000). In general, technologies generated by formal institutions 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 labour 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.

5.3.3.2 Challenges

Conventional practices—particularly those placing high dependence on pesticides and improved seed—may have unintended economic, social and environmental effects (Bautista, 1997; Whitten and Settle, 1998). Although risk of crop failure is generally lower with such practices, the risk of disease outbreaks is higher. The economic outlay required for seed and pesticide and fertilizer inputs to maximize success is high and translates to a greater risk undertaken by farmers with much to lose if crops should fail. These technologies too often did not focus on ways to achieve increased food production in a resource-efficient manner that is environmentally benign.

Regardless of how the Green Revolution is viewed, there is no doubt that yields throughout the ESAP region have begun to stagnate or drop despite increased inputs, reflecting declining soil biological activity, fertility and structure (Harrington et al., 1989; Abrol and Gill, 1994; Kijne, 1994; Singh and Paroda, 1994; Huang et al., 2002). The rice yield in Asia declined sharply during the 1980s from annual growth rate of 2.6% in the 1970s to an annual growth rate of 1.5% in the 1990s (Pingali and Rosegrant, 1994; Gruhn et al., 2000; Gupta and Seth, 2007). 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 recognized. The negative effects of insecticide use on human health, the environment and on beneficial insects have been documented (IRRI, 1994; Way and Heong, 1994; Pingali and Roger, 1995). 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 (UNESCAP, 2002).

Much of the previous effort in livestock farming focused on breed improvement and development of vaccines. Competition from both developed and developing countries and more sophisticated and changing sets of domestic and international trade norms and standards are putting increasing pressure on developing country producers. Throughout the region, the cost of feed is an important constraint to increased livestock production, along with poor-quality and fluctuating feed supplies (FFTC, 2007). Deterioration of common property resources and an increasing shift towards cash crops have adversely affected fodder availability and the use of indigenous feed resources, especially for the poor, landless and pastoralists. If the poor have to benefit from livestock market opportunities, they need technical, infrastructural and institutional support.

Similarly, a number of social, economic and institutional issues must be confronted if aquaculture is to fulfill its potential in the ESAP region. Since the 1990s protests by NGOs, researchers and environmental have focused on the environmental and social impacts of aquaculture. The criticisms, centered on concerns about mangrove destruction, pollution and social conflict generated by aquaculture and were convincing enough cause funding to India and Thailand in particular to be halted in the 1990s. Recent solutions to address these issues tend to favor capital-intensive technical interventions, sidelining small farmers. Furthermore, they bring attention to farm-level solutions, which may reduce environmental impact at that level, but overlook interactions with activities in related sectors, which is necessary to eliminate the non-technical dimensions of the concerns. Policies for aquaculture need to be cross-sectoral, integrated and wide-reaching (Dene, 2005), with policy guidelines that specifically target the poor to encourage development and explore participatory community management in aquaculture (Edwards, 2000).

As the resource systems in question are both complex and dynamic in their biophysical and human aspects, it is not always possible to understand how a system works or to predict the outcome of management actions (Arthur, 2005). In such circumstances, the standard approach of government guidelines based on ‘best practice’ in management is unhelpful since not only are

best practices uncertain or unknown but the resources to implement are also lacking. An 'adaptive learning' approach has therefore arisen which takes these constraints as a starting point and seeks to build on whatever knowledge is available with the aid of planned management experiments and the development of knowledge sharing networks which seek to reduce uncertainties. This approach has yielded fruitful results in the rice-fish systems of West Bengal, India and in the fisheries, including reservoirs, in Lao PDR, Cambodia, Vietnam and Thailand (by MRAD Ltd., WorldFish Centre, Mekong River Commission, Indian Central Inland Fisheries research Institute and the State Government of West Bengal).

The challenge for post Green Revolution crop, livestock and aquaculture systems in the ESAP region is to improve productivity without the negative ecological and social side effects experienced during and after the Green Revolution. 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 and incentivizing ways to minimize these inputs – for health, environmental, as well as economic reasons. Similarly, incentives for improved water use efficiency and rain harvesting measures and training, credit and infrastructure (e.g., for cheaper fuel and energy) for increasing organic inputs are critical as the natural resource base in the region becomes more and more oversubscribed and degraded. More attention and investment in the public and private sectors needs to be devoted to integrated pest and nutrient management (IPM and INM) 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.

5.3.4 Transgenic technology or "the gene revolution"

Humans have been knowingly or unknowingly modifying the genetic make-up of plants for thousands of years, but transgenic technology to produce crops, pharmaceuticals (pharming), food vaccines and genetic use restriction technology (GURT) is one of the newest and most controversial developments to do so. Transgenic technology uses genetic engineering to produce crops with a variety of properties, including herbicide tolerance and insect resistance, micronutrient enhancement and vaccine production. Despite arguments for a cautious approach as should be adopted for any extensive change in agricultural practices (NAS, 2003), land planted to transgenic crops is expanding rapidly (James, 2005). There are fourteen biotech countries in which more than 50,000 ha are planted to transgenic crops, nine are "resource-poor", of which three are in the ESAP region: China, India and the Philippines (James, 2005).

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. 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). On small-scale farms in China and India Bt cotton yields were significantly higher with pesticide use reduced by up to 70% (Huang, 2002; Qaim and Zilberman, 2003; Hossain et al., 2004; Wu and Guo, 2005). Although herbicide-resistant crops presuppose the availability of affordable herbicide and represent an economic risk for farmers who are dependent on seed and chemicals, they have the potential to improve yield. From the perspective of a mechanized agroecosystem, 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.

Transgenic technology is being used to develop crops resistant to abiotic stresses such as drought, soil acidity and salinity, although the value of these modifications in the field has yet to be established (de la Fuente-Martinez, 1997; de la Fuente-Martinez and Herrera-Estrella, 1999; Liu et al., 1999; Zhang and Blumwald, 2001; Zhang et al., 2001; Garg et al., 2002; Singla-Pareek et al., 2003). Work on improving storage stability and manipulating ripening and processing-related factors aims 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. Much of this has been limited to transgenic tomatoes (Fromm et al., 1993; Grierson, 1994; Picton et al., 1995; Kalamaki et al., 2003ab; Powell et al., 2003) and potatoes (Greiner et al., 1999). 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. Micronutrient-enriched staple crops have also been developed to target the most vulnerable—resource-poor women and children (Combs Jr. et al., 1996; Bouis, 2000).

There is increasing interest in the potential for transgenic plants to produce pharmaceuticals and vaccines through molecular farming (“pharming”). Vaccines can be used to prevent or combat many of the diseases that cause illness and death in low-income countries, but are expensive, 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). Transgenic plants are also being evaluated for a variety of non-food applications, including bioremediation, modification of fiber content and biodegradable plastics (Haigler and Holaday, 2001; He et al., 2001; Poirier, 2001; Scheller et al., 2001).

Genetic use restriction technologies (GURT) are based on regulating gene expression to restrict plant propagation from a second generation of seed. Unlike variety-specific (V-GURT; "terminator technology") which results in sterile seed, specific trait, or 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).

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. 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.

Transgenic crops and GURT offer a promising means to increase agricultural productivity in cropping systems. However, like any introduced agricultural practice, these technologies have the potential to affect human and animal health, have substantial social and economic impacts on grower communities and to significantly alter agricultural ecosystems through effects on the environment. Despite human health concerns, several studies with animal models and a range of transgenic crops have failed to show any toxic, allergenic, or nutritional effects of the transgenic crop tested (Noteborn et al., 1995; Hammond et al., 1996; Harrison et al., 1996; Hashimoto et al., 1999ab; Folmer et al., 2000; Momma et al., 2000; Sidhu et al., 2000; Teshima et al., 2000; Ash, 2003; Donkin et al., 2003; Stanford et al., 2003; Hammond et al., 2004; Kan and Hartnell, 2004). These findings in no way negate the need to apply rigorous standards to health risk assessments of individual technologies; in addition, comparative risk assessments with alternative control regimes will be needed.

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. Transgenic technology can significantly

affect the cultural and economic situations of producers—as can conventional plant breeding—but at a faster rate than the latter. 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.

Potential environmental effects of transgenic technology include: (i) adverse effects on non-target organisms, (ii) gene flow into wild plant communities or soil organisms and (iii) development of resistance by target pests. Non-target 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. Most of the insecticides used for the control of rice stem borers and leaffolders have been found to harm beneficial insects, while multiple Bt rice lines show no significant non-target effects (Chen et al., 2006). An evaluation of direct toxicity or indirect food chain-related effects on a large variety of insects and crops indicates no adverse impacts (Lopez and Ferro, 1995; Orr and Landis, 1997; Pilcher et al., 1997; Riddick and Barbosa, 1998; Volkmar et al., 2000; Zwahlen et al., 2000; Bourguet et al., 2002; Cowgill et al., 2002; Al-Deeb et al., 2003; Cowgill and Atkinson, 2003; Dutton et al., 2003; Jorg et al., 2003; Volkmar et al., 2003). Although most 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) and transgenic corn resulting from event 176 had adverse effects on Lepidoptera (butterflies), arguing for case-by-case evaluations (Losey et al., 1999; Jesse and Obrycki, 2000; Hellmich et al., 2001; and Stanley-Horn et al., 2001; Zangerl et al., 2001).

Although 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), the data are difficult to interpret and tie to ecosystem function and a large number of studies have shown no effect on these soil populations or their processes (Al-Deeb et al., 2003; Blackwood and Buyer, 2004; Devare et al., 2004; Wu et al., 2004; Fang et al., 2005; Devare et al., 2007).

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). Pollen -mediated crop-to-crop transgene flow in rice can be maintained at negligible levels with short spatial isolation (Rong et al., 2007). 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).

5.3.4.1 Impact

Transgenic crops can increase agricultural productivity while reducing pesticide use in the ESAP region. In 347 Chinese rice fields farmers growing non-transgenic rice, small and poor farm households benefited from 6-9% higher transgenic rice yields and reduced pesticide use by 80% (Huang et al., 2005). The negative impacts of insecticide use on the environment and on the control of pests by beneficial insects have been extensively documented (Way and Heong, 1994; Pingali and Roger, 1995). Recent reports on several farming systems incorporating these insect resistant (IR) crops confirm increases in beneficial insects and a return of song birds (FAO, 2004; Morse et al., 2004). IR crop growers are likely to also see savings in fuel and greenhouse gases (Phipps and Park, 2002).

Micronutrient-enriched crops can do much to improve human health in the region. While the consumption of green-leafy vegetables and unpolished or brown rice can mitigate the effects of vitamin A deficiency which is common throughout the ESAP region 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), these are not always consumed in the region for a variety of reasons including lack of irrigation, poverty and lack of knowledge (Mishra, 1996; Pee et al., 1998; Khadka, 2001; Faruk et al., 2003). Rice, chosen because it is a staple in the ESAP region and engineered to overproduce pro-vitamin A or beta-carotene can greatly reduce Vitamin A deficiency (Ye et al., 2000), Rice is also being targeted to address iron deficiency, identified as a contributing factor in over 20% 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, through the elimination of toxins as for cassava (Siritunga et al., 2003) and increases in nutrients or antioxidants (Regierer et al., 2002; Bovy et al., 2002).

5.3.4.2 Challenges

Transgenic technologies can increase crop yields and lower pesticide use, but can also threaten livelihoods and cropping systems if biodiversity is reduced and farmers unable to profit after committing scarce resources to these expensive agricultural packages. In many ESAP countries where seed saving is common practice, farmers can save traditional seeds and other public varieties, but would have to expend resources in the purchase of improved, transgenic seed. While economic loss from the inability to save seed may be recouped by productivity gains from increased yield and quality and reduced input costs, transgenic crops confer an economic advantage only in the presence of the stress they are engineered against. If the risk and debts incurred by growers of transgenic crops are to be minimized, access to low-interest loans needs to be greatly improved and market and infrastructure instabilities effectively minimized.

Most regulatory frameworks dictate that transgenic crops not be grown in areas where wild relatives are endemic and often advocate a high dose strategy and the use of refugia. These precautions are considered to limit gene flow and delay resistance development in target insect populations and will need to be enforced. This is likely to be a challenge in many ESAP countries which do not have strong regulatory and monitoring infrastructures. Thus, the risk of out-crossing is likely to be increased in these countries. A case in point is the ‘stealth seeds’ phenomenon in India, which involved farmers multiplying, crossing and selling Bt cotton seed which was viewed as desirable but expensive to legally obtain. Although conventional breeding has already led to significant reductions in biodiversity via the replacement of land races with hybrids, such a result is of at least equal concern for transgenic crops. ESAP countries urgently need to invest in and enforce stringent biosafety protocols to assess the risk of gene flow and mitigate the cultural and biodiversity implications of ‘genetic pollution’ and the potential ecological consequences accompanying the creation of ‘superweeds’. To be effective, these protocols will need to include local agronomic, socioeconomic and ethical considerations.

5.3.5 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). There are growing concerns regarding the safety and the long-term impacts of nanotechnology on food and agriculture and its long-term prospects in large-scale replication and production of biological material such as proteins. The specific genetic modification of life-forms through nanotechnology to give enhanced properties is also 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.

The agricultural application of nanotechnologies is primarily focused on the seed and pesticide industries. In the area of seed development, researchers are experimenting on techniques that use nanoparticles to manipulate native DNA or insert foreign DNA into plant cells without being passed on the next generations, thus avoiding cross-pollination concerns (Dalke, 2003). Thai researchers at Chiang Mai University announced research that involved drilling a hole through the membrane of a rice cell to insert a nitrogen atom that would stimulate a rearrangement of DNA, resulting in grain color change and potentially other characteristics such as maturity period (Ranjana, 2004). The world's major agrochemical companies have already started commercially marketing pesticides formulated at the nanoscale, which 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). Some of these pesticides are emulsions containing nanoscale droplets and micro-encapsulated formulations.

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 developing a "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 potential of "smart dust" which involves the development of autonomous match head-size sensors with the ability to detect light, temperature and vibration, communicate with other sensors or "motes" in the vicinity and self-organize into ad hoc computer networks capable of relaying data using wireless technology (ETC Group, 2004). Smart dust or nanosensor technology is already being applied in engineering and microclimate sensing. Other emerging nanotechnology applications with long-term implications for AKST include the development of nanowater which involves the use of nanotubes to filter pollutants and saline particles from water for human consumption and agricultural uses.

Despite the fact that some products of nanotechnology have already reached the commercial stage, there are few studies on the potential health and environmental impacts of nanotechnologies. Nanoparticles can be inhaled, ingested or pass through the skin. Once in the bloodstream, there are concerns that nanoparticles can elude the body's immune system and penetrate the blood-brain barrier (ETC Group, 2002). The increased reactivity of nanoparticles

could harm living tissue, perhaps by giving rise to “free radicals” that may cause inflammation, tissue damage or tumors (ETC Group, 2005).

Buckyballs (precursor of nanotubes) can cause rapid onset of brain damage in fish (Oberdörster, 2004). Researchers at the United States National Aeronautic and Space Administration (NASA) reported that when injecting commercially available carbon nanotubes into the lungs of rats caused significant damage (Raloff, 2005). In other studies, researchers reported substantial DNA damage to hearts and aortic arteries of mice exposed to carbon nanotubes and increased susceptibility to blood clotting in rabbits inhaling nanotech buckyballs (ETC Group, 2004). Buckyballs clump together in water to form soluble nanoparticles and can harm soil bacteria even in very low concentrations, raising concerns about how these carbon molecules will interact with natural ecosystems (ETC Group, 2004). In recognition of the knowledge gaps and the health concerns arising from available toxicological studies, it has been recommended that factories and research laboratories treat manufactured nanoparticles and nanotubes as if they were hazardous and reduce them in waste streams. The report further suggests that the use of free nanoparticles be prohibited in environmental applications such as groundwater remediation (UK Royal Society and Royal Academy of Engineering, 2004).

5.3.5.1 Impact

Research and development in nanotechnologies have been receiving substantial investments from both the public and private sectors. Most of the world’s major seed and agrochemical companies have a substantive stake in nanotech research and development. The European Commission estimates the current global investments in nanotechnologies at around €5 x 10^9, with €2 x 10^9 from the private sector (UK Royal Society and Royal Academy of Engineering, 2004). Civil society groups monitoring development in nanotechnologies have placed the combined investments of the public and private sectors in 2004 at $10 x 10^9 (ETC Group, 2004). 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 and patents involving nanotechnologies have jumped from 521 in 1995 to 1,976 in 2001 (UK Royal Society and Royal Academy of Engineering, 2004). In the ESAP region, Japan, China and India are the leading investors in nanotechnology. Japan invested US $800 million on the technology in 2003, while India has allocated US $22.8 million under its current 5 year plan (Barker et al., 2005). The substantial financial and technological investments required in nanotechnology applications limit the capacity of many developing countries in the region to tap its potentials in agriculture.

Some nanotechnology applications such as the development of nanowater have great potential to improve water for human and agricultural uses. The Indian Institute of Technology (IIT) is about to

commercialize its nanofilter technology in water purification at the household level, while US universities and the International Water Management Institute (IWMI) are advancing research to remove arsenic from groundwater in Bangladesh to render it potable (Barker et al., 2005). Future developments in the search for cheaper and renewable energy sources through the use of nanotechnologies may also have strategic implications on AKST in the region.

5.3.5.2 Challenges

Arguably, the most imminent concern over nanotechnology for the ESAP region is its impact on trade in agricultural commodities. Nanotech products in the global market such as synthetic textiles and nanotech rubbers are projected provide stiff competition and affect world prices, posing a threat to cotton and rubber industries and the livelihoods of millions of farming families in the region.

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 in nanotechnology research and development, the private sector has a significant advantage through products already in the market and/or the pipeline. More policy attention is required on regulation and standards in nanotechnology at the national and international levels and on controversial social and ethical issues such as their role in the modification or production of living material.

ESAP governments that decide to adopt nanotechnology for agricultural development will need to take into account its potential risks to human, animal and environmental health, as well as its socioeconomic and ethical implications. Adequate precautionary measures will need to be put in place, from the production process to commercialization and consumption. Biosafety measures must be formulated and adopted for nanotechnology research and development activities, in consultation with and the active participation of various stakeholders. Countries may consider adopting a legally-binding international standard or protocol on the assessment of nanotechnology products and processes to ensure safety for human and animal health and the environment. Biosafety measures and assessment standards must also take into account the socioeconomic and ethical considerations in the technology.

5.3.6 Precision agriculture

Precision agriculture is a comprehensive system designed to optimize agricultural productivity while minimizing production costs, fertilizer, pesticide and water inputs and adverse environmental effects through the application of crop information, advanced technology and management practices (NRC, 1997). The main ideas behind precision agriculture are

understanding spatial variability of soil properties, crop status and yield within a field; identifying the reasons for yield variability; making farming prescription and crop production management decisions based on variability and knowledge; implementing site-specific field management operations; evaluating the efficiency of treatment; and accumulating spatial resource information for further management decision making (Wang, 2001). Simply put, this translates to using the appropriate inputs at the optimal times in the appropriate ways.

A crucial characteristic of precision agriculture is that it represents the convergence of multiple technologies with applications for several management practices. Precision agriculture may include the integration of geographic information systems (GIS) 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 (Cox, 2002). The suite of technologies currently used include GIS hardware and software, variable-rate application equipment for seed, fertilizer and pesticide, grid soil sampling, low-volume irrigation, soil fertility and weed population sensors, yield monitoring capability and remote sensing imagery. Attention to soil quality, efficient water management, IPM, INM and efficient postharvest management are all important in precision farming (Persley and Doyle, 1999).

5.3.6.1 Impact

Most formal and informal agricultural research and extension systems in the ESAP region currently provide blanket fertilizer and pesticide recommendations for large productions areas. Yet, on-farm studies in double and triple-rice cropping systems in India, Indonesia, Thailand and Vietnam present evidence of huge field-to-field variation in native soil nitrogen (N) supply where the variation was not associated with soil organic matter content, total N, or other measures of soil N availability (Olk et al., 1999). Given this variation, field-specific nutrient and pesticide management is not only a more efficient option, but one that could have very positive economic and human and environmental health ramifications (Cassman, 1999). Precision agriculture allows management practices to be modified based on spatial and temporal needs. Although there is a potential for benefits from precision agriculture, these have not yet been well-documented (Auernhammer, 2001). As most of the technologies involved are expensive as well as data- and knowledge-intensive, their implementation and adoption is likely to be slow and variable in the developing countries of ESAP.

5.3.6.2 Challenges

As expected, adoption of precision agriculture has been relatively slow even in developed ESAP countries such as Australia, Japan and New Zealand. Causes of slow adoption in Australia

include: (1) cost of adoption, (2) lack of perceived benefit from adoption, (3) unwillingness to be early adopters and (4) lack of technology delivery mechanism (Cook et al., 2000). These obstacles are likely to impede adoption in developing countries as well, but lack of reliable information and data (GIS coverages, satellite imagery, soil maps) as well as expertise and equipment and small land holdings can represent important barriers.

As with the dissemination of almost any new technology-oriented intervention, precision agriculture is likely to be adopted first by resource-rich farmers in areas with high yield potential, with poorer farmers and particularly women, benefiting later, if at all. However, it may be possible to improve rural livelihoods in rainfed and marginal areas in the ESAP region by disseminating elements of precision agriculture that do not call for sophisticated technologies like GIS, but rely on quick, easy to use, cheap tests and measures of soil, crop and pest infestation parameters. Such low-investment, low-technology interventions could improve production efficiencies through a combination of conservation agriculture practices such as IPM and INM and efficient post-harvest management. Public and private sector investment will be needed to develop scientific capacity and technology transfer and support mechanisms (Cassman, 1999). It will also require educating extension agents and farmers to use locally-adapted seed, diagnose limiting factors, predict yields and input requirements and modify management regimes accordingly.

5.3.7 Information and communication technologies (ICT)

Limited access to information has been a major hurdle facing low-income farmers, extension agents, civil society organization workers and others in the agricultural sector throughout the ESAP region. Possibilities for ICT application in agriculture include facilitating the access of rural communities to information on efficient farm management and the market through radio and TV shows as well as computer kiosks. GIS and related tools not only make precision agriculture possible as described above, but by providing information on land use/land cover, water quality, productivity, tidal influence and coastal infrastructure, can also increase the efficiency and sustainability of coastal fisheries and shrimp farming (Rajitha et al., 2007). New and emerging agricultural technologies depend heavily on advances in ICT and would not be possible without ICT applications that support high-throughput genetic and genomic work and the manipulation, analysis and interpretation of large sets of data. Further, ICT has resulted in “knowledge management” (KM), involving the creation, dissemination and utilization of knowledge by combining organizational dynamics and knowledge engineering with ICT (Flor, 2001). Much of KM experience has been limited to the private sector, but organizations such as the World Bank, FAO and CGIAR have also launched knowledge management initiatives.

The proliferation of ICT in the form of radios, telephones, televisions and computers and more recently, GIS, remote sensing and the use of information technology in climate forecasting and modeling is helping disseminate information to the benefit of ESAP agriculture. Improved climate forecasting and extreme climatic event mitigation abilities in the face of global warming effects on ESAP agriculture are essential if effective coping strategies are to be devised (Verdin et al., 2005). 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).

5.3.7.1 Impact

The effective dissemination and adoption of ICT in the region can be critical to economic and social development in this information age—akin to electrification in the industrial area (Castells, 1999). The correlation between access to information and poverty is widely acknowledged, for reasons 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. 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 HPI, the lower the number of ISPs, telephone lines, PCs and TV sets per 1000 persons. Similarly, the higher the ICT indicator value, the lower the HPI—as in the case of Singapore, Brunei and Malaysia.

Research from Thailand, South Korea, India and China also 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 development and sustainability 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).

Knowledge management offers great promise to poverty alleviation initiatives in ESAP countries, 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. A regional knowledge network enabled by information and communication technology is now being proposed to share best practices and lessons learned from these projects and more effectively address marine resource depletion.

International organizations have forged linkages to facilitate database information collection and sharing within the ESAP region through the creation of decision support systems, expert systems and similar initiatives to help farmers and other users make informed decisions. Two prominent examples of such efforts are the International Rice Research Institute's internet or computer-based "Rice Doctor", a field diagnostic to identify factors limiting rice crop growth in the Tropics. Another is the multi-agency (GTZ, DFID, ACIAR, CSIRO, CIAT, ILRI and Queensland Government) "Tropical Forages"—an interactive, computer-based selection tool that brings together in one package accumulated information on the adaptation, use and management of tropical and subtropical forage species.

Yet another notable knowledge initiative to improve the lives of Filipino farmers and fisherfolk is the K-AgriNet program (Knowledge Networking Towards Enterprising Communities), jointly-implemented by a number of government agencies. It aims to modernize the agricultural sector by utilizing ICT to access information, modern technologies and indigenous knowledge. The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), with its e-Consortia and e-Farm components establishes a digital community by interconnecting the Farmers Information and Technology Service (FITS) centers that serve as the ICT/ICE kiosks for agricultural information, technology and other interventions.

ICT has allowed women and disadvantaged groups in the ESAP region more scope to project themselves. For example, the organization IT for Change, in partnership with Mahila Samkhya (women's collectives) is implementing a development strategy called Mahiti Manthana to institutionalize ICT- based innovations in the state of Karnataka (India) using radio–, video- and tele- center- based initiatives. This initiative focuses on adult learning, health care, the responsibilities of Panchayats (village governance bodies) and gender mainstreaming in local development processes (IT for Change Report, 2006). However, despite such benefits, 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.

Despite the digital divide being a concern, there has been some success in ensuring equitable access to ICT within the region. The founder of Bangladesh's Grameen Bank, Professor Muhammad Yunus, embarked on an innovative undertaking based on a simple but elegant idea (Flor, 2001). The bank has initiated a cellular phone project, through which the Grameen Phone

Company has put a mobile phone in approximately 45,000 Bangladeshi villages, greatly increasing villagers' access to ICT. Each mobile phone is acquired through a small bank loan and becomes a village telephone service provider, earning income for the owner and 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 a very low-cost email and Internet service to villagers. A simple form of e-commerce will also been initiated by this system, allowing farmers to check market prices and study the list of wholesalers in Dhaka by surfing the Web.

In a similar development, the Philippines government established a Short Message Service (SMS) using cellular phones to gather and disseminate knowledge about agriculture. The Philippine Rice Research Institute or PhilRice established the "Open Academy for Philippine Agriculture" and embarked on e-learning modules for basic and advanced agricultural practices. Lifelines India (Soochana se Samadhan), uses a phone-based platform and a web-based interface to respond to the agricultural information needs of small-scale Indian farmers. By so doing, it bridges the information gap that currently prevents them from leveraging sustainable and efficient farming methods, integrating with global markets and improving quality of their lives.

Another innovative program is Village Knowledge Centers set up in 1998 by the M.S. Swaminathan Research Foundation, in 22 villages in southern India. Two major features of the project were the development of Tamil language Software and gender sensitivity in assessing the information needs of local people. The National E-Governance Action Plan of the Government of India has emphasized community computer and internet kiosks in rural areas. For example, in the state of Tamil Nadu alone, 600 rural kiosks are functioning to deliver services such as health care, education, agriculture and communication (voice mail and e-mail). Most of these kiosks are run by self-employed entrepreneurs and NGOs; but women SHGs are increasingly beginning to manage them. However, existing social and cultural norms can be a major obstacle to the diffusion of such IT technology. Recent research in Tamil Nadu, India, noted that although the technology itself may be gender-neutral, women often lack the literacy, time, decision-making power and financial resources to fully avail themselves of the kiosk services (Best and Maier, 2007).

A last example from Thailand involves the struggle against the forced relocation of Akha villagers in Huay Mahk village of Northern Thailand in 2000. The problems of this isolated people were communicated via internet to mobilize support and the villagers were able to retain their homes, lands and forests, thereby avoiding the drugs, crime and poverty cycle that has affected other relocated communities in the region (Satyawadhana, 2001).

5.3.7.2 Challenges

The biggest barrier to regional knowledge networking is the lack of defacto standards for information sharing and data exchange. This barrier will need to be eliminated if technology transfer and sharing of best management practices across the region is to be facilitated for the common good at a relatively low investment from any given country. Knowledge-based products, services and systems will need to be coordinated and integrated into usable formats such as: information, education and communications materials (publications and instructional materials at the community level – flyers, primers, technology bulletin); information management services (database and subject information networks); and documented records of local knowledge in the form of stories, case studies and plays.

In pursuing the fruits that ICT offers, it is important that farmers' information needs are not overshadowed by technological enthusiasm (Meera, 2004). Although they function within the dominant interests of the market and the state, ICT can help redefine traditional, social, cultural and gender norms within the region and support a media of information, understanding and knowledge in which interests, voices and rights of the rural poor, women and excluded social groups are taken into account, but only if they are equitably and widely disseminated (Kelkar et al., 2005; Ng and Mitter, 2005; Patel, 2006). Initiatives such as those described above provide models which are well worth pursuing throughout the ESAP region.

5.4 Technologies: Ramifications and Options to Achieve Development and Sustainability 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. One mitigation strategy to cope with climate change-induced variability and extreme events is to increase the resilience of agricultural systems (Scheffer et al., 2001) through crop diversification, shifts to low input, no-till or organic agriculture where possible and the use of crop species and varieties that can withstand extreme weather conditions. The integrated use of inorganic fertilizers, green manures and organic materials has been proven to increase productivity and yield stability for a variety of vegetable and grain crops

over that attained from using only inorganic or only organic inputs (Kanwar and Rego, 1995; Tandon, 1995; Satyanarayana et al., 2002; Paul et al., 2005; Chatterjee et al., 2006; Singh, 2006; The et al., 2006).

While organic inputs are desirable, significant trade-offs to be contended with and addressed when considering policy options that favor such inputs. For example, replacing inorganic fertilizer with manure or a combination of manure and compost at recommended rates for rice generally presupposes the availability of close to 10 tonnes ha^{-1} of the manure and compost. Further, manure is generally subject to competing uses throughout much of the rural ESAP region: more used in the field generally means less available as cooking fuel. Similarly, green manures are an excellent way to add organic matter and nutrients to the soil; however, such a cover crop requires sufficient land holdings to dedicate to a non-food or cash crop and is too often not a practicality for small holders or subsistence farmers.

The integration of local knowledge and socioecological context in the design of agricultural technology are critical if sustainability and efficiency are to be attained and technological interventions are to succeed. A clearer understanding various traditional or organic systems would be valuable, enabling the utilization of this knowledge to develop more sustainable production systems for use by future farmers. In contrast with the knowledge systems generated by universities, research institutions and private firms, indigenous knowledge is usually seen as residing locally within the farming community where it is applicable, with transfer of knowledge from farmer to farmer rather than scientist and extension agent to farmer. New paradigms in agricultural extension programs have recognized that local people conduct research in their own farms; it is even argued that their experiential knowledge is derived from their skills as experimenters (Stanley and Rice, 2003).

Although the absence of formal and rigorous methodology employed by formal institutions such as robust statistical design make analysis and interpretation of farmer experimentation difficult, such paradigms are increasingly becoming acceptable to the scientific community. An example is the agroforestry project of the International Institute of Rural Reconstruction (IIRR) in the Philippines, in which scientists worked 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).

Achieving sustainable agriculture in the region will require the integration of agricultural knowledge systems, practices and technologies through the provision of financial and infrastructural support to facilitate research, dissemination and constrain-specific utilization of all available technologies. Specifically, this will include but not be limited to:

- Increasing support for and applying traditional and low-input systems that function productively and in a socially inclusive manner, particularly in low productivity areas throughout the ESAP region.
- Augmenting indigenous knowledge with appropriate modern practices that can enhance the system, such as microbial inoculations, appropriate scale mechanization and small-scale technology—such as gravity-fed technology for sprinkler and drip irrigation for vegetable and fruit cultivation.
- Integrating elements of traditional and organic practices (such as rotational, trap and intercropping and agroforestry) in modern agricultural settings to maximize system productivity and natural resource sustainability.
- The application of emerging technologies such as bio and nanotechnology that have been rigorously 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 commercialization of new agricultural technologies such as 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 will need to 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 consequence of biotechnology adoption by farming communities.

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 (Nuffield Council on Bioethics, 2003). Adoption of such a model in the ESAP region may include

data sharing to satisfy regulatory needs and similar extensions of prior findings, all of which could substantially reduce unwarranted restrictions and improve the benefits of these technologies for resource-poor farmers, as long as their socioeconomic 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.

Facilitating the access of rural communities to information through a range of ICTs and knowledge bases can lead to an increased understanding of the consequences of various management practices and the adoption of appropriate and sustainable agricultural and aquaculture management practices. The use of ICTs can improve the reliability of climate forecasts and the prediction of extreme weather events as well as their likely effects on agricultural ecosystems and rural livelihoods—both of which are invaluable in devising coping strategies. The adoption of common, regional standards for sharing information will facilitate technology transfer and proliferate best management practices across the ESAP region for a relatively low R and D investment on the part of any given country.

The ESAP region accounts for about two-thirds of the world's rural poor, primarily concentrated in sparsely populated arid or marginal lands and forests of South Asia (CGIAR, 1999; Fan and Kang, 2004). Data on poverty distribution by land type for India and China indicates that in the 1990s, over 80% and 60% of the rural poor lived in low potential or rainfed areas of India and China, respectively (Fan and Hazell, 1999; Fan et al., 2002). Despite high rates of out-migration from these areas, populations continue to grow, often with increasing poverty and degradation of natural resources (Hazell et al., 2000). Government and donor investment in the past favored areas of high yield potential, leading to better infrastructure, schools, health facilities, credit programs, production pricing policies and access to agricultural technologies and services in these areas (Fan and Kang, 2004). Funding for public agricultural research and development grew at an annual rate of about 8.7% in the 1970s; this slowed to 6.2% annually in the 1980s and has likely been decreasing since, as have investments in new irrigation infrastructure (Gruhn et al., 2000).

Improving agricultural productivity and halting the degradation of the region's natural resource base will require that appropriate institutional arrangements, policies and investments be put in place to address the combined utilization of a variety of tools and technologies in optimal as well as marginal areas. Both the rates and levels of investments will need to increase if technologies

are to address development and sustainability goals in the region. Further, enabling a more integrated approach to the use of the suite of agricultural systems and technologies described above to improve agricultural productivity at minimal cost to human health and the natural resource base will require a clear understanding of the complexities and regional variations that govern agriculture in the ESAP region. Thus, to truly address development and sustainability goals, investments must target not only agricultural research, technologies, services and capacities, but also infrastructure interventions that improve credit availability, health facilities and programs, roads, markets and electricity and fuel access and affordability.

5.5 Gender Inequality and Social Exclusion in ESAP Region Agriculture

Social exclusion derives from exclusionary relationships based on power and hierarchy and intersects with other aspects 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. Given increasing feminization of agriculture, the widespread gender-based inequalities in access to and control of productive resources throughout the ESAP region will be discussed here. 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.

Many labor market inequalities, the process of informalization, the lack of security and voice and the discriminations to which particular groups are subject are aspects of social exclusion. Thus, effectively addressing social exclusion 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.

5.5.1 Feminization of agriculture

Although the phenomenon of increasing feminization of agriculture within the ESAP region has drawn policy attention in recent years, its causes, extent and impact on women and productivity have not been sufficiently considered in policy implementation. Insufficient attention has been paid to areas where women are most active, such as crops and vegetable cultivation, forest regeneration and wasteland and watershed development, resulting in womens' contributions and concerns remaining invisible in planning and ignored in AKST institutions (Sujaya, 2006). Further, the stress on self-employment and dependence on institutional credit in most land-based economic activities has meant that women, who are mostly landless in many ESAP countries, are generally not eligible for assistance.

Rural women have an important role in the livestock sector (such as animal care, grazing, fodder collection, cleaning of animal shed, processing of milk and sale of livestock products). However, their control over livestock and products is minimal and these activities have been conventionally viewed as an extension of domestic work. With some regional variations, women account for 93% of employment in dairy production in India, yet 75% of dairy cooperative membership is male (World Bank, 1991; Sujaya, 2006). Introducing taxes and limits to overgrazing, uncontrolled burning and deforestation (largely caused by the expansion of livestock sector) are likely to prove effective steps for increased productivity and sustainability of this sector.

The Gender Assessment Report of China (IFAD, 2005b) indicated that women constitute about 70% of the agricultural labor force and perform more than 70% of farm labor in China. 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% of cultivators and nearly 47% of agricultural workers are women (Vepa, 2005) (Table 5-1). 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, 2006). Throughout the region women are more likely than men to work in agriculture. Manufacturing tends to employ a fairly large number of women followed by trade, hotel and restaurant businesses.

[Table 5.1]

The feminization of agriculture model in ESAP is determined by two major factors. First, compared to men, women have much poorer access to and control over 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 where male farmers predominate, with poor farmers, mainly women, lacking access to credit and appropriate technologies. Second, rural society structure 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 this group and when men leave to become temporary laborers in cities, they are left behind to take care of the land, children and elderly. Thus, they have the compounded burden of productive and reproductive work. Although its impact on agricultural productivity is unclear, increasing feminization of agricultural labor is likely to have deep and wide ranging effects. It may rank as one of the leading foci for AKST policies centered on capacity development of (women) farmers, extension outreach, training in agricultural technologies and women's effective rights to land, trees, water bodies and other assets.

5.5.2 Gender wage differentials

Gender wage differentials in agriculture and related industries are generally but not always due to differences in educational attainments and work skills between women and men are reflected in wage differentials (Zhao and Zhang, 1999; Gustafsson and Li, 2000). According to the National Census of China in 2000, women have an average of 1.1 years less schooling than men, but the unexplained gender wage differential against women in rural areas has been constant, with some decline in the period 1988-95 (Rozelle et al., 2002). The major share (93.5%) of the wage differential between women and men is attributed to discrimination rather than to capital differences between the genders (Wang and Cai, 2006). 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 (Hirway, 2006). The wage differentials between women and men agricultural workers therefore appear to be based on a pre-assumed gender character. Employers or contracts simply lower women's wages regardless of job performance. In a pervasive climate of social and economic neglect, women have no better options and work longer and harder to make ends meet, leading to exhaustion and injuries from stress and overwork.

A large proportion of women in ESAP countries are not able to retain their earned income: over 40% in Bangladesh and Gujarat, India and over 70% in Indonesia. In China only 53% of women said that they alone decided how their income is spent; this proportion was far less in Bangladesh and India (IFAD, 2005b). Thus, it is not sufficient to stop analysis at the point of household income level, but is necessary to examine how much control women have over that income and work out measures to increase their control over it.

5.5.3 Microfinance groups

Microfinance reaches over 10 million members of savings and credit groups in the region, nearly 90% of whom are women (Donaghue, 2004). Whether or not microfinance has increased the economic agency of members is debatable (Goetz and Sen Gupta, 1996). There is, however, a continuous creation of new norms and social contexts in favour of women as income earners and their access to resources, as evident in a study of four districts in rural Bangladesh (Kelkar et. al., 2004). The rise of women's Self-Help Groups (SHGs) or women's micro-finance groups, in India and other ESAP countries, 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 discriminatory 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 markets, schools and training. Although women's production activities are still largely confined to the homestead, or the hamlet, 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 establishing social and economic equality.

The roles that women in microfinance 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 microfinance groups can thus serve as agencies to introduce new and advanced energy technologies to villages and as links to the world.

The SHG concept can be used throughout the region to foster women's agency and extend to community-based organizations of women whose members often struggle for adequate supplies 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).

5.6 Institutions and Policies

Agricultural development is dependent upon the performance of a large number of actors/organizations. It includes not only those involved in Research, Development, Training and Extension (RDTE), but also those involved in a range of other activities, such as input generation and distribution, credit supply, value addition and marketing and policy development and implementation. It also depends on the overall institutional context shaping 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 science and technology. Firstly, importing models of technological change, which might have been successful elsewhere, is not the way to address agricultural development in this region. In other words, country and region-specific approaches for agricultural development need to be designed. Secondly, development or application of new technology need not necessarily be the starting point for agricultural development. While technologies do play an important role, there could be other areas for intervention (institutional innovations) that may better address agricultural development and sustainability and these needs to be explored.

5.6.1 Institutions

There has been an increasing realization that "institutions"—the rules, norms, habits, practices and routines that determine how different actors interact with each other and respond to new challenges and opportunities—influence the performance of the agricultural innovation system. 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 (World Bank, 2006). However, the different actors in this system often do not sufficiently interact, collaborate, or share knowledge in most ESAP nations unless policy and practice address the institutional and related issues underpinning this situation. Several policies dealing with agriculture and allied sectors potentially affect agriculture and how AKST is deployed for agricultural and socioeconomic development. Policies influence or shape how programs are designed and operated. Exploring institutions and policies therefore assumes critical importance in strengthening AKST arrangements in the ESAP region.

Finding new ways of working and collaborating among large numbers of organizations is absolutely essential if sustainability and development challenges in the region are to be effectively addressed. Development of appropriate institutions will therefore assume great importance as these will facilitate the ability of the various actors to link with other sources of expertise and knowledge and enable timely and successful responses to new challenges and opportunities in the region. Many 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 will continue to be important, organizations involved in RDTE will need to develop partnerships with a large number of other actors (farmers, NGOs, producer organizations, input agencies, agroprocessors, agribusiness houses, traders, retailers and even consumers (van Mele et al., 2005; Hall, 2006). Developing wider links will be essential not only to

improve the performance of organizations involved in RDTE, but also to facilitate rural innovation—where new knowledge, information and technologies may be made available and put to socially and economically productive use.

Several institutional barriers currently constrain the development of appropriate working arrangements. 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 in the ESAP region. 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 is organized, funded, managed or evaluated. Organizational reforms within public sector research and extension organizations—such as decentralization and interface meetings with wide range of stakeholders—will need to go further if underlying paradigms governing the way research or extension is implemented in the region are to change.

Many organizations have narrow mandates that prevent them from working with others. For instance, the agenda, constituency and training opportunities available to those in the extension sector need to expand if it is to support the producers who need more diverse support. Public sector extension in ESAP countries is focused only on the dissemination of technologies to farmers. It will need to move beyond its restricted mandate of technology dissemination to helping producers cope with new challenges, including the provision of organizational, managerial and entrepreneurial support (Sulaiman and Hall, 2003). Its client base will also need to expand to include NGOs, producer associations, rural entrepreneurs, agricultural labor and women. If extension is to play these roles, it must develop new partnerships and capacities, including technological (new knowledge and skills) and institutional (new patterns of collaboration, new habits and practices) capacities.

Agricultural science and technology arrangements in the ESAP region need 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 they relate to other actors in the wider innovation system. Evaluation parameters in research and extension agencies also need re-examination. Evaluating performance based on number of technologies released has restricted scientists from engaging in other equally important aspects such as technology adaptation and problem-solving. Similarly exclusive focus on technology dissemination has restricted extension from engaging on

other important institutional innovations that are required for raising farm incomes. The role of social scientists also needs to change from measuring impacts to experimenting with new institutional arrangements and learning from them.

The need for partnering with the various other organizations involved in agricultural development has been evident in many ESAP nations since the 90's. There have been increasing calls for public-private partnerships in agricultural development in the last 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. Fostering such interaction and increased collaboration among multiple partners will require the identification and elimination of the mistrust between potential partners and organizations in both, public and private sectors. Box 5.1 synthesizes the lessons from analysis of partnership experiences from the crop post-harvest sector of South Asia.

[Insert Box 5.1]

The increasing complexity of agricultural development and the rapidly changing external environment necessitates that all actors in the agricultural innovation system including those directly dealing with AKST embrace partnerships as an organizational principle. It is increasingly clear that there cannot be a blue print for promoting partnerships, but development of partnership arrangements could be facilitated through funding arrangements designed to promote and support stakeholder meetings and handholding development of joint collaborative activities. These need to be supplemented with efforts to reflect on partnership progress and lesson-learning to direct the much-needed institutional changes among different actors in the innovation system. Some of the key recommendations that have emerged through a joint analysis by different stakeholders who have participated in four NRM projects in India are relevant to those interested in promoting partnerships in RDTE and are shown in Box 5.2. The projects examined include: (1) integrated management of land and water resources (DFID/NRSP-ICAR); (2) improved livelihoods through a consortium approach (ICRISAT); (3) promotion of zero-tillage (Rice-Wheat Consortium) and (4) community development (Aga Khan Rural Support Project).

[Insert Box 5.2]

Agricultural innovation occurs when all these different actors in the innovation systems interact and share knowledge and work in partnerships (Figure 5.1). While understanding and planning agricultural development interventions, it is worthwhile to use the conceptual framework of "innovation system". Its attraction is that it recognizes that innovation is not a research driven process simply relying on technology transfer. Instead innovation is a process of generating,

accessing and putting knowledge into use and is complicated and context-embedded. Consequently, its main determinates are the interactions of different people, the ideas they have and the social setting of these interactions and relationships. Its other important insight, which is now widely recognized in the development sector, is that institutions really matter. Thus, the attitudes, habits, practices and ways of working that shape how individuals behave have an enormous impact on whether or not innovation takes place (Hall, 2006). Addressing these issues related to governance and partnerships in AKST assumes primary importance in programs aimed at strengthening AKST in the ESAP region.

Conventional approaches to strengthening capacity in agriculture focused only on science and technology. This is important and will continue to be important especially for countries with limited science and technology capacity. Emerging frontiers of new knowledge will 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 play important roles and their efforts will need to be strengthened. However, science and technology capacity alone will not enough to bring about better knowledge uptake and use; applying new knowledge will necessitate the development of several kinds of capacities among several actors. Capacity to develop and implement policies, experiment and evaluate new approaches and address issues related to quality, standards and markets will all need to be upgraded throughout the ESAP region.

To attain the development and sustainability goals of AKST, organizations require a wide range of capacity–broadly called innovation capacity. Innovation capacity is 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. It comprises the context-specific range of scientific and other skills and information held by individuals and organizations, practices and routines (institutions) and the patterns of interaction and policies needed to create and put knowledge into productive use in response to an evolving set of challenges and opportunities (Hall, 2007).

[Figure 5.1]

Options for action are as follows:

- Capacity development will involve diagnosing the existing innovation system, including exploring the actors, their knowledge and skills, roles, patterns of interaction, the habits and practices and the policy environment. An innovation systems framework could be used as a diagnostic tool to understand the existing innovation system and also as a framework for planning interventions (World Bank, 2006). Learning from the emerging institutional arrangements in the region necessitates 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 kinds of institutional changes were made, how were they implemented, were they sustained at the end of the specific initiative and why?

- Not many organizations have a culture of learning. Opportunities will need to be created and specifically funded to bring in this change of culture. It will be useful to bring staff together to reflect on lessons learned and discuss how goals could be better achieved. The concept of institutional learning concerns the process through which new ways of working emerge. 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)
- Opportunities will need to be created that bring different actors together and develop joint activities and long-term relationships. These will need to be mentored and have funding and other resources.
- Capacity development workshops with actors within the innovation system will need to be organized to enhance the ability of all the actors to think and act in a more systemic sense. These could also be used as a platform to share results of the diagnosis and identify the nature of interventions that are required to strengthen innovation capacity.
- Implementing a series of institutional changes (i.e., 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 will be necessary if ESAP governments want 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.

5.6.2 Policies

A large number of policies affect agriculture and how AKST is deployed for agricultural and socioeconomic development in the face of stagnating grain yields, declining water and land availability, new threats and opportunities from WTO, emergence of supermarkets, increasing private sector participation, emerging concerns on food safety and the need for standards in production and processing. Policies influence the ways programs are designed and operated. In particular, policies related to agricultural R&D (IPR, biosafety), agriculture and allied sectors (livestock, fisheries etc), natural resource management, input use (seeds, fertilizer etc), trade, gender, conservation and utilization of genetic resources, biodiversity etc, are critical for attaining the sustainability and development goals of AKST in the region and need to be developed and implemented by 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 in the ESAP region to implement policies related to biosafety, IPR and food quality standards. For instance, countries intending to implement transgenic and other developing technologies will need to ensure that their infrastructure is sufficient to support the safe development, transfer and application of these technologies with special attention to developing relevant policies, information systems and training in biotechnology risk assessment and biosafety procedures. Methods and results of environmental risk assessments, as well as a model policy framework could be shared between countries that have similar agricultural environments, thus reducing the burden of proof for any one country.

Secondly, quite often the policy is only prescriptive, without taking into account everything needed to get it implemented. To be effective, a 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 with alternative ways 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. Thirdly, implementation of good policies and programs require collaboration among a large number of organizations. This is especially so as most of the innovations needed in agriculture today have collective dimensions; i.e., they require new forms of interaction, organization and agreement between multiple actors (Leeuwis and van den Ban, 2004).

This essentially means that all organizations involved in the agricultural innovation system need to operate within a policy framework and have the capacity to produce and integrate new knowledge and apply it in their specific contexts to deal with challenges. For instance, the agenda and constituency of extension will need to expand beyond its current mandate of technology dissemination to help producers cope with new challenges,.and expand its client base to include NGOs, producer associations, rural entrepreneurs, agricultural labor and women. For extension to play these roles, it will need to develop new capacities, including technological (new knowledge and skills) and institutional (new patterns of collaboration, new habits and practices) ones.

5.7 IPR

Governments extend legal measures to protect intellectual rights over AKST to protect the rights of innovators from misappropriation and reward and encourage innovations. Intellectual rights protection for AKST in the ESAP region generally falls under intellectual property rights (IPR) systems such as patents and the more plant-specific plant variety protection. There is emerging

consensus in international discussions that the current IPR regime may only be appropriate for innovations generated by formal institutions, particularly involving conventional AKST and emerging frontiers in AKST and is not an appropriate system to protect traditional and informal knowledge systems. There are ongoing efforts to address this issue, such as the multilateral platforms of the World Intellectual Property Organization (WIPO) to develop an appropriate system of intellectual rights protection over these knowledge systems (CIPR, 2002; Tauli-Corpuz, 2003; Khor, 2004).

Some governments in the ESAP have adopted policies and laws that specifically provide for protection of traditional knowledge and resources. Thailand enacted its Farmers Rights and Plant Variety Protection Law in 2000, providing protection to farmers' traditional varieties through registration under the name of the local community and mandating benefit-sharing on new varieties derived from endemic varieties. India has a Farmers' Rights and Plant Breeders' Rights Law (1999) which exempts farmers' varieties from plant breeders' rights protection and allows farmers to use, exchange and even sell protected varieties. Malaysia's Plant Variety Protection Act was passed in 2004 and provides for separate category and criteria for farmers' varieties.

There is contentious debate on whether or not the IPR regime promotes innovations. The UK Commission on Intellectual Property Rights (CIPR) comprised of international IPR experts who looked into the role and impacts of the IPR on developing countries. They concluded that patents in particular are not considered important determinants of innovation even in developed countries, except in such sectors as pharmaceuticals (CIPR, 2002). There are concerns among international and national public research institutions that the stringent application of IPR has impeded free exchange and flow of germplasm needed for research and development efforts. This has resulted in calls to review the appropriateness of the current IPR systems in protecting innovations while at the same time ensuring continuing innovation and exchange of germplasm. ESAP governments need to strike a balance between intellectual protection over innovations and ensuring that innovations and genetic materials are continuously available for further research and development for public interest.

Over the years, concerns have been raised by various sectors in the region about the threats posed by the current IPR regime in misappropriating traditional knowledge and resources through biopiracy. Controversial regional biopiracy cases include several from India: the neem tree whose insecticidal properties have been patented by W.R. Grace, a traditional chickpea variety covered by plant breeders' rights in Australia and turmeric, patented in the US for post-operation wound-healing; and Thailand's plau noi patented by a Japanese company. The Indian government won a petition for the revocation of the turmeric patent in the US in 1999 and Indian civil society

organizations won a petition for the revocation of the W.R. Grace patents on the neem tree in 2005. Such biopiracy issues have been brought to the attention of the Convention on Biological Diversity (CBD) which serves as the major multilateral forum to address the issues access to biological and genetic resources. The CBD has been discussing mechanisms and negotiating for the regulation of access to genetic resources and benefit-sharing arising from the commercial utilization of these resources.

In compliance with their commitment to the WTO Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), some countries in the ESAP have already adopted or formulated their own patent laws or sui generis systems for plants and plant varieties. However, most of these countries still lack the capacity to address the complex issues surrounding this agreement (Hossain, 2004). As of 2006, only a few countries in the ESAP had actually adopted sui generis legislations for the protection of plant varieties (PVP) as mandated in TRIPS 27.3(b). There are debates that surround this system of plant variety protection, with some authors claiming that the sui generis PVP system is a form of IPR (Evenson, 2005) while others assert that it is not a form of IPR but actually a model to balance the monopolistic tendencies of IPR regimes (Khor, 2004). The most notable sui generis plant variety protection laws were enacted by India (1999), Thailand (2000), Pakistan (2002) and Malaysia (2004). While the Philippines (2002) and Indonesia (2002) have also adopted their own PVP laws which they claim as sui generis, their laws may be more akin to the conventional plant breeders' rights model promoted by the Union for the Protection of New Plant Varieties (UPOV). There are systems of intellectual rights protection that are evolving outside of the conventional IPR regimes and even the sui generis system that developed from TRIPS' Article 27.3b. One such concept is farmers' rights which developed under the FAO's International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

The ESAP has shown examples of civil society-led initiatives to evolve a specific system of intellectual rights protection for traditional knowledge and resources. Indian civil society organizations have pioneered the concept and practice of Community Registry involving the documentation and formal local registration of community knowledge systems and resources (Khor, 2004). The Community Registry model is replicated in Nepal by a formal institution which has expanded the model beyond AKST and covered traditional knowledge and resources in such areas as forestry. The model has been widely replicated and has since evolved in other parts of ESAP, such as Bangladesh, Thailand and the Philippines. There are also ongoing efforts that attempt to combine useful and workable traits of the conventional IPR regime while at the same time exploring the potentials of alternative systems of intellectual rights protection. Other efforts involve the extension of the provisions on geographic indication provided in the TRIPS to

agriculture as a system of protecting traditional and conventional AKST. These national initiatives may be considered as “hybrid” IPR since they assert the rights of communities over specific AKST and products of AKST by maximizing the opportunities available in the current IPR regime.

5.8 Trade and Markets

5.8.1 Domestic regional markets and trade

The importance of trade in discussions of technological change lies in the relationship between efficiency and/or productivity change and export growth and vice versa. On the one hand the productivity gap between economies is posited as the basis for international trade, while on the other hand there is a contention that trade liberalization will enhance factor productivity. This debate has important implications for agricultural modernization, tariff policies and technological priorities. Economic arguments can be mustered to support causality in either direction. Further liberalization of world trade could improve the efficiency of the agricultural sector for countries which enter agricultural export markets for the first time. However, only in very few countries does increased productivity trigger sustained export growth (Arnade and Vasavada, 1995; Suhariyanto and Thirtle, 2001).

The ESAP region’s development over the last two decades has been closely linked to economic reforms and trade opportunities. The policy reforms have been triggered by many changes or crises which have affected domestic markets as well as regional and international trade patterns. Additionally, transport and related infrastructure as well as non-transport logistics and market arrangements can influence how these economies react to policy changes. It has been estimated that in East Asia non-transport logistics impose heavier trade penalties than do transport inadequacies and that domestic market arrangements can constrain diversification and impede international trade (Carruthers, 2003). Thus, the pattern of development so far experienced in the region is dependent on continuing improvements in transport, storage, distribution and processing. The prevalence and quality of non-market measures which characterize the region’s trade will also determine the nature and direction of its growth.

Although there remain marked differences in the policy regimes across the region, one factor that will influence ESAP’s future policies and trade patterns is liberalization. China and Vietnam are in the process of opening their economies in response to their new WTO obligations. The liberalization which has already taken place in the region has been contemporaneous with both increased food production and greater food availability. In that sense at least, the liberalization strategy may be said to have worked so far. Nonetheless, food availability remains a major problem for hundreds of millions in the region and in such circumstances the dependence on an international market entails risks. Consequently, there is a need for public intervention by

governments to address the risk of variations in availability, chronic poverty and household food insecurity. The policies undertaken in pursuit of these ends often compound the original problems; one study of the China grain market, for example, concluded that Government action destabilized rather than abetted the market. Since such action is costly and often leads to scarcity and food insecurity the search for more stable policies will be a feature of future action (Findlay, 2003).

Liberalization has itself contributed to extensive diversification of production away from the 'old order' of growing and marketing cereal crops in a subsistence farming system. There has been considerable diversification of the region's production stimulated by trade in high value commodities, particularly in horticulture for urban and peri-urban areas (rather than in the hinterlands and near-urban areas). This trend, the extent and impact of which differ across the region, is expected to continue in response to increasing urbanization, rising per capita incomes, further trade liberalization and supporting strategies and the removal of restrictions on foreign direct investment in the food sector.

Other developments with important implications for the region's future are changes in lifestyles, a rapid changes in dietary preferences from cereal-based to high-value commodities and dramatic growth (10-90% in recent years) in the number of supermarkets and other food retail shops; the rate of growth of food through supermarkets varied from 5% in Bangladesh and similar low income states to 50% in others such as Thailand and the Philippines (Bayes, 2005).

The removal of restrictions on foreign direct investment in the food sector has been associated with important institutional changes. These have resulted in new developments involving bilateral cooperation in the reorganization of the supply chain in some states such as China. Such restructuring will continue to be critical if the potential of the various states and their endowments is to be fully exploited without income and food crises. In the process of this regional diversification and cross-border investment, China has been shifting production from grains, cotton and sugar to more labor-intensive crops such as fruit and vegetables in which it would appear to have a comparative advantage and is importing Thai cassava, logans durians and prawns. The specific cross-border arrangements in the case of China, Japan and Korea have been quite innovative, centering on linking producers with agribusinesses in the form of cooperatives, the domestic private sector and TNCs. They have been responsible for initiatives in niche areas and include contract-growing of perishables for competing NGOs, agroprocessors and supermarkets (Bayes, 2005). These arrangements have had a favorable impact on production by providing or enhancing access to assured markets and reliable information,

reducing transaction costs, providing means to handle market risks and increasing producer profits and may be models to explore for other countries in the region (Bayes, 2005).

The emergence of such marketing arrangements has not been an unmitigated blessing for small farmers and distributors, however (Humphrey, 2006). Many studies have already been devoted to devising guidelines for policy makers in this context and Governments may wish to consider them (Reardon et al., 2006; Altenburg, 2006). Another problem arising from these developments in trade includes wildlife endangerment. For instance, the rapid transformation of the Chinese economy and the allied increase in consumer purchasing power implies growing pressure on individual species over the coming years (von Moltke, 2000). Increasingly, ESAP states will need to address domestic as well as international concerns on this front.

5.8.2 Poverty and the liberalization of international trade

The impact of liberalization on the levels and prevalence of poverty is a highly contentious issue in the region. The process of liberalization may involve higher risks for national producers and labor than for consumers. The analysis of poverty is especially difficult due to the simplifications of the theory, the fact that the category 'poor' is both diverse and dynamic (i.e., changing over time, even seasonally) and the challenges of measurement.

The theory points to positive net results and many assessments confirm this although they acknowledge that for some groups such as small farmers and farmers in less favored areas incomes may deteriorate (CGPRT, 1999). There is, however, no shortage of studies which are unequivocally pessimistic about the overall outcomes of these reforms (Rodrik, 2001; SAPRIN, 2002; Patnaik, 2004).

> "While theory may suggest that the liberalization of trade policies will result in net benefits to the liberalizing country and while there may be a growing collection of empirical studies to support the theory, it is also clear from the preceding discussion that the benefits of liberalization will not necessarily be achieved and even where they are, some groups of individuals within some countries are likely to be disadvantaged. In a concise and convincing paper, Winters …..argues that although he believes that trade liberalization aids economic growth, it "may have some adverse consequences for some – including some poor people – that should be avoided or ameliorated to the greatest extent possible". He suggests that rather than using this as a reason for resisting reform, it should "stimulate the search for complementary policies to minimize adverse consequences and reduce the hurt that they cause". It is clear that there is no clear consensus that liberalization results in economic growth, despite a number of major research programmes investigating this relationship. It is therefore important to understand the types of reform that have had the greatest impact on economic growth in each country." (FAO, 2003)

In essence, the impact of trade reform on employment and hence on poverty is context specific. There are guidelines to the questions that need to be answered in order to accurately anticipate its net impact (Bussolo et al., 1999; Kanai, 2000).

5.8.3 Bilateral and regional agreements and their implications

Pascal Lamy, the Director General of the WTO, is reported to have anticipated 400 preferential trade agreements being signed by 2010. The reasons for the continuation of this trend have been well documented and analysed and are numerous (Sagar, 1997; Gilbert et al., 2001; Hilaire and Yang, 2003; Bhagwati et al., 2005; Menon, 2006). The Asia-Pacific region, including the smaller island states, has been particularly active in the drive to so-called 'new regionalism' (Figure 5.2) (Ethier, 1998; Majluf, 2004). Bilateral and preferential agreements involving at least one Asia-Pacific state rose from 57 in 2002 to 176 in October 2006, about 70% of which have yet to be implemented. Furthermore, the region can be expected to be even more active in this regard as a result of post WTO-entry initiatives by China and Vietnam. The agreements have distinctive product coverage, time lines and varying rules etc so future harmonization of these agreements would be very difficult. Given the current activities of larger economies in the region including China, Japan and India, there is clearly the risk that a hub-and-spoke system will dominate, with these leading economies as the hubs. While ASEAN may also include hub contenders, this is muddied by individual ASEAN members also pursuing BTAs, especially with the USA and Japan. The resulting 'spaghetti bowl' of agreements and rules can enormously complicate the life of international traders, so that an exporter can enter another market under different sets of preferences, multiple agreements may exist, preferences may be prohibited from being realized and MFN entry may appear to be the least costly action.

[Insert Figure 5.2]

The negotiation of bilateral agreements is often politically easier than multilateral or regional approaches; however, some are sanguine about the prospects of such agreements eventually being aggregated to a wider grouping. Several options exist, including those of linking individual 'spokes' under a single PTA to create de facto regionalism and reduce trade diversion and 'open regionalism' (as per the APEC 1994 Bogor Declaration) in which BTA preferences are extended to non-members (Strutt and Lim, 2003).

The challenge for ESAP governments is to configure and phase the transition along the spectrum of bilateral/sub-regional to multilateral integration in ways that enable the development of a global, non-discriminatory trading system from which the agricultural sector can benefit. A comprehensive set of guidelines has been suggested by the Asian Development Bank whereby the adoption and effective implementation of ten basic principles would minimize the potential

damage from bilateral agreements while allowing for trade and investment creation and efficient behind-the-border reforms. While this agenda would be best adopted at the multilateral WTO level, will require strong political support. Asia could play a significant leadership role by adopting these principles and by incorporating them in its bilateral and regional trade agreements.

5.8.4 Agriculture in the liberalizing process

Since agriculture is among the most sensitive of the products in such arrangements its treatment can be problematic. Although tariff barriers in the ESAP region are generally being rapidly dismantled, there has not been a parallel attempt to provide for timely removal of barriers to agricultural trade. Of the six preferential trading arrangements which are in force in ESAP only one has a significant number of eligible agricultural products. All but one of those provides for non-tariff barriers (NTBs) to be employed against agricultural imports and none of the agreements constrain domestic support subsidies (Parakrama and Thibbotuwawa, 2006). Many of the states with low tariff barriers in agriculture actually have NTBs against agricultural commodities. It comes as no surprise therefore to find that agricultural trade flows show relatively little buoyancy. For ASEAN, what agricultural export expansion there is has been mostly due to extra-ASEAN agricultural trade and is less than that of intra-ASEAN trade for industry.

ASEAN member states impose higher agricultural tariffs than they face abroad. Nevertheless, some agreements are relatively liberal and the Early Harvest Program – China ASEAN, for example, provides for substantial inclusion of agricultural products in the liberalization exercise. A majority of the agreements do make provision for the eventual inclusion of most agricultural products, albeit with long transitional periods. The major agreement, AFTA, is the least liberalized of all the trading arrangements listed in a multilateral liberalization index of agricultural measures (Table 5.2). Thus, AFTA is not considered to be as good a building block for agricultural trade as it is for trade as a whole.

[Insert Table 5.2]

5.8.5 The region and the WTO

The realization of minimal benefits in return for unprecedented intrusiveness into the domestic sovereignty of developing states has triggered an attack on the multilateral trading system and its legitimacy (Srinivasan, 2002; Aksoy et al., 2004). Despite this and the adverse consequences of WTO membership several states are waiting to join this body (Bello, 2003). Both China and Vietnam have sought to join the WTO in spite of their political philosophies and in recognition of the cost of staying out. Burma and most Pacific Island states have yet to join.

The rules governing global markets and the management of those markets are of great importance to the ESAP region because they can affect the region's access to other markets and the sharing of the gains from expanded trade. At the same time, the price of late entry can be high, especially for small states which tend to be open and highly trade-dependent. Many developing countries need policy flexibility to support and promote their enterprises, investments in production and marketing and export expansion and diversification for this reason. Nonetheless, latecomers to WTO membership now face more stringent policy conditions than earlier ones. Under its accession terms, Tonga, for example, is committed to lowering trade barriers, expanding market access for foreign goods to bind all tariff lines at a level lower than most other developing countries. Moreover, extensive concessions were also made with regard to services in sectors such as health, education, finance and telecommunications. Oxfam described these accession concessions as 'eye watering' and 'the worst terms ever offered to any country' (Manduna, 2006). Concern about similarly harsh terms caused Vanuatu to baulk at signing the accession agreement after negotiating entry in 2001.

Apart from terms of entry, smaller states face many difficulties in spite of arrangements to render them technical assistance and in spite of the range of agreements which pay special attention to them such as EBA, the GSPs of the US and Japan, SAPTA (SAARC Preferential Trading Arrangement), the Bangkok Arrangement, the Thailand-Bangladesh Preferential Trade Arrangement and the AFTA. Writing on the challenges of the Rules of Origin in particular, the Centre for Policy Dialogue has suggested that ESAP LDCs and Bangladesh and Cambodia in particular, engage more pro-actively in the negotiations on agriculture.

For the region as a whole, leaders will need to ensure that changes, including the AoA reforms, take into account their impact on the divergent agricultural sector/s in the region. Additionally, ways will need to be found to make the process of liberalization politically palatable in circumstances where it inevitably generates winners and losers. Provision of technical assistance by the more advanced states to the less advanced is one way of approaching this need because it is usually the latter which can ill-afford to bear the costs.

However, states are not the only parties in need of assistance. If the desired changes in the global trade environment namely, liberalization, global trade integration and the information and communication revolution, are to work to the benefit of the rural economy, the capacities of various actors and especially the poor will need to be strengthened. The increasing complexity of these trading and marketing activities will challenge the resources of the traditional actors involved in trade and in economic policy in the region. In order to be in a position to successfully survive in such an environment, the capacities of all the stakeholders in the region will need to be

enhanced, including those allowing stakeholders to take advantage of the market, to react to new or changing marketing opportunities, to meet changing health standards to communicate in the domain of the internet etc. Capacities of farmers, researchers, local governments, extension workers, financial institutions, local entrepreneurs and market agents, agroindustry and NGOs may be enhanced through training, professional exchange and vocational education.

Efforts in the areas of research, policy and governance and extension and training could include: a) traditional and emerging technologies, b) international regulations, IPRs, trade negotiations, institutional reforms, c) support systems not limited to production such as organizational, marketing, entrepreneurship to farmers, producer groups and NGOs and d) the non-farm rural sector.