ESAP CHAPTER 4

AGRICULTURAL CHANGE AND ITS DRIVERS: A REGIONAL OUTLOOK

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Key Messages

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1. **Demographic changes will have a significant impact on labor supply and the nature and capacity of the agricultural labor force.** The population of the ESAP region constitutes about 56% of the global population. The demography of the region is changing rapidly. In India and some other developing ESAP countries, the younger generation will continue to dominate the labor force. In China, Japan and the Republic of Korea, however, the labor force will be characterized by an increasingly ageing population. Economic development and rural-urban wage differentials will encourage rural to urban migration. Increasing migration in response to local stress, opportunities for education and employment will contribute to acceleration in rural depopulation. The implication is that in the developing ESAP countries, the rural labor force will increasingly be relatively less educated, largely female, and consequently have less access to AKST.

2. **Poverty, malnutrition, social and political problems will continue to be significant in ESAP despite the prospects for economic growth, with South Asia performing the worst unless corrective measures are implemented.** Although there will be economic growth and improvements in nutrition status, within a decade South Asia will be home to nearly half of the malnourished children in the world. ESAP is an epicenter of domestic and regional political tensions and will need concerted regional cooperation to ensure peace, prosperity and opportunities for economic growth. Increasingly, ESAP countries will realize that it is the capacity of public enterprises and organizations to respond to the needs of the poor, provide for social security where it is lacking, generate public and private investments in infrastructure and social development programs, enable pro-active civil society participation in economic decision-making, and engage actively with emerging threats to impoverished rural livelihoods in order to promote political stability, economic growth and social justice.

3. **Globalization, economic and trade liberalization pose both challenges and opportunities for AKST in addressing the development goals.** Although the contribution of agricultural GDP to national incomes is declining, the agriculture sector will remain significant to economic growth, employment and rural livelihood. The opportunities from globalization and trade liberalization include enhanced access to markets and increased flow of commodities, technology, labor and/or knowledge and skills. One of the major challenges in developing ESAP countries will be the capacity to address in a timely manner, the issue of maintaining access to appropriate quantity and quality of food for under-privileged sections of the population. In the developing ESAP countries, the existence of small-scale and marginal farmers will demand capacities to address scale issues and in developed ESAP countries the removal of trade barriers/subsidies will present potential opportunities. The capacity of governments to influence

trade and AKST outcomes will be affected by the magnitude of global private sector control over agri-business and trade. Increasing integration of the ESAP region with the global economy, especially through technology/knowledge sharing and greater infrastructural investments will enhance employment and income in the ESAP region.

4. **Degradation of natural resources and environmental systems will have adverse implications for achievement of each of the development goals.** Natural resources, especially freshwater and arable land, will increasingly be subject to serious pressure from competing sectors. Along with continuing increase in agricultural production, intensive agriculture and overuse of agrochemicals will worsen current trends of degradation of soil and water quality as well as loss of biodiversity in many parts of ESAP. Rapid urbanization and industrial expansion will place increasing pressure on demands for land and water. Water transfers to intensive irrigation based agriculture and urban areas are placing substantial ecological and political pressure on water resources and in the absence of new technological and policy options, this trend will become more severe in the future. Industrial and agricultural effluents will affect water quality across the region. In addition, intensive agriculture will further reduce the areas available for fisheries and livestock production. AKST has the technologies but may require appropriate institutional arrangements to enable sustainable natural resource management.

5. **Climate change and climate variability will emerge as threats to the agricultural sector in most of the ESAP region. However, some parts of the region may benefit from climate change.** The IPCC projections show that occurrences of natural hazards are likely to increase globally. The frequency and magnitude of these events in developing countries that are already vulnerable to these hazards and dependent on agriculture is of particular concern. The outcomes of these hazards may be food insecurity and worsening poverty, increases in average temperature, changes in precipitation patterns, sea level rise and resulting inundation in the coastal areas, increases in soil and water salinity, and new and more favorable environments for pests and diseases; these will have ramifications for agricultural productivity and livelihoods. There are many technological and institutional options to help mitigate and adapt to climate change. Climatic change may have some beneficial effects for agriculture in some parts of the ESAP region.

6. **The agricultural sector will continue to compete with other sectors for energy and a range of other goods and services. Biofuels and renewable energy sources will provide additional energy supply and utilization opportunities within a wider portfolio of energy sources.** Rapid economic growth will substantially increase energy demand in the ESAP region over the next few decades. The gap between energy demand and supply is growing and is likely

to be partly met by biofuels and other renewable energy sources. Developing countries of the ESAP region will invest in and utilize alternative energy sources to meet increasing local demands. Biofuel production may result in competition for land, water and energy within economies, with implications for local food security. There are options for collaboration between AKST organizations (public and private) and wider energy systems R&D which can help address the development goals.

7. **Existing national and international institutions, and educational and R&D organizations will be inadequate to address the multiple roles and functions of agriculture.** The balance between public and private sector investments and capacities for innovation will continue to shift towards commercial interests. Current linear R&D models and technology transfer approaches will be increasingly inadequate to address emerging concerns/challenges. Increasing capacities within public sector AKST organizations will depend on the development of flexible institutional arrangements. Multiple and varied demands of the agriculture sector will increase the pressure on current educational and R&D organizations to evolve to work with a diverse range of partners. There will also be demands for the skill base of AKST to include social, political and legal knowledge. Local and traditional knowledge systems (for example medicinal and aromatic plants) will become mainstream in parts of some ESAP countries, but will continue to decline in other areas (for example, tribal and mountainous communities). Availability and affordability of advanced information and communication technologies will enhance effectiveness of AKST. Increased investment in science and technology, and enhanced innovation capacity, will play an increasingly important role in providing adaptive responses for agriculture to stressors such as climate change, increasing natural hazards, HIV/AIDS, avian flu, SARS and malaria.

8. **The capacity of political, administrative and scientific systems to learn from past evidence of the impacts of AKST and to adapt to emerging challenges will be crucial for the achievement of the development goals.** There are both uncertainties and predictable aspects to the evolution of drivers that influence the future of agriculture and AKST. Some ESAP countries will assess the capacity of existing systems and their flexibility in responding to past challenges, while many will continue to address crises on an ad hoc basis. Pro-active investment in learning and capacity building within local, national and international organizations will facilitate flexibility and adaptation. Poverty and un-/under-employment, demographic shifts, trade and economic liberalization, natural resource degradation, climate and other stresses are all crucial challenges in many ESAP countries. The inter-related nature of these challenges suggests that achievement of the development goals will also depend on policy choices and decisions beyond the immediate agricultural sector.

4.1 Context for looking forward

The economic and social structures of South and South East Asia and the Pacific islands are unique. The economies of most of the countries are highly dependent on agriculture. Only a few countries are industrialized and a few others are in transition. In recent years, the contribution of the agriculture sector to overall GDP in all ESAP countries has declined as a result of increasing contributions from the manufacturing and services sectors (ADB, 2006b). However, the agriculture sector still provides employment to the largest section of the population in ESAP. Agricultural sector employment in South Asian countries is in the range of 43-52%. Overall employment in the agriculture sector in South East Asia (except for Malaysia) is in the range of 37-58%, which is slightly lower than in South Asia (ADB, 2006b). The ESAP region's agricultural sector is characterized by small peasantry, with small and marginal farms accounting for almost 86% of the farming sector in some countries like India (Hobsbawm, 2006).

Over the recent decades the agriculture sector provided impressive yields and great services to reduce hunger and poverty in many parts of the ESAP region, especially in South and South East Asia. Despite successes in food grain production, the sector has been largely unable to reduce hunger and poverty in Asia. Despite the steady growth of ESAP agricultural trade, intra-regionally and globally, the region is marked for the highest incidence of malnutrition, especially among children. The contribution of agriculture to employment, income and food notwithstanding, it is now a major polluter of land, water and atmospheric systems in Asia. Some of the worst cases of gender disparities and marginalization of indigenous and tribal people are evident in ESAP. Some specific features of the ESAP region are:

(1) Land degradation has become a serious threat to agriculture. A global assessment of the extent and form of land degradation showed that 57% of the total dryland area in China and India are degraded (UNEP, 2006).

(2) The gap between water demand and supply is increasing due mainly to increased demand from agriculture, rapid urbanization and industrialization.

(3) Natural hazards –floods, droughts and coastal inundations have become regular threats to agriculture. Floods and droughts damage enormous quantities food crops every year. Storm surge and tidal inundations cause crop losses in the coastal areas. Climate change is emerging as a new threat to cropping in terms of excessive flood related inundation, shrinking cropping seasons, and temperature related yield losses.

(4) Globalization has multi-dimensional effects on agriculture: withdrawal of subsidies makes agricultural products less competitive with highly subsidized developed country agriculture, however deregulation and liberalization also bring more opportunities for investment.

(5) In spite of the green revolution and per capita increases in income driven by globalization efforts, food insecurity remains a major problem in many ESAP countries. There are many causes: the poorest of the poor have not yet attracted targeted policies for education and healthcare; the population growth rate exceeds the growth rate of food production; there are growing disparities among the poor and the rich; increasing prices of food commodities are putting them out of reach of the poor because of limited income; and gender disparity.

Given this context, the key question for decision makers who have to invest in or promote agriculture and AKST, is: what will be the future outlook for agriculture in the ESAP region and in particular, what will be the role of AKST in meeting the development and sustainability goals of reducing hunger and poverty; improving nutrition, health and rural livelihoods; and facilitating social and environmental sustainability?

To analyze this question based on currently available knowledge, the key issue was deconstructed into a series of more specific questions:

- What will be the future of food systems, agricultural products and services?
- What are the major uncertainties of the drivers and projections?
- What are the implications for AKST in the future?
- What will be the implications for development goals?

4.1.1 Approaches of scenarios development and impact assessment

The specific questions identified above can be addressed by either developing plausible futures based on socioeconomic, technological and political assumptions, or by extrapolating agricultural or related variables, based on assumptions made about the baseline period. Each driver might take different shapes in the future based on these assumptions. Recently many studies developed scenarios to help decision-makers see different plausible futures with reference to climate change, ecosystems, environment and agriculture. These scenarios considered various timelines for the projections (Table 4-1).

Insert Table 4-1. Approaches for scenario development and impact assessment

Conventional impact assessment of agricultural science and technology (S&T) has been conducted mainly by social scientists- especially economists, in national and international agricultural research organizations or policy making agencies. The explicit purpose of such assessments is to understand how S&T as a major driver of agricultural growth (productivity and production) brings returns and thereby legitimizes investments made already as well as the scope for further investments in S&T, The global assessments such as MEA, IPCC and so on (See Table 4-1) have been conducted to enable a better understanding of drivers and processes of change in the ecosystem or global climate regimes, in order to identify options for action to address the drivers of change and/or the processes. These assessments have been conducted by large groups of people with a variety of expertise and experience, drawing upon a variety of natural science and social science disciplines as well as regional/local experiences.

4.1.2 Assessment approach for ESAP

This chapter presents an assessment of agricultural change and its drivers from the existing literature (national and international) based on historical trends and future projections of key drivers of change and expected changes in future policies and politics and modeling (Global Chapter 5). The assessment is based on a list of key drivers of change of agriculture and AKST relevant to the ESAP region. A driver is defined as "any natural or human induced factor that directly or indirectly causes a change in AKST" (MA, 2003). The IAASTD framework (ESAP Chapter 1) illustrates this as the mutual interaction of direct and indirect drivers, as well as the effect of each of these drivers on innovation, knowledge and learning, mediated through actors/networks and processes/rules and norms. However, given the nature of the drivers and the complex relationships between drivers of change in the ESAP region, a classification listing of direct and indirect drivers of change would be an academic exercise of little relevance to decision-making. What is more important is to explore how the individual drivers will evolve in the future; how the drivers of change relate to each other; and how these inter-relationships and changing contexts will shape AKST in future.

A lacuna in current global decision-making and negotiations on globalization or climate change or poverty or any such international processes is that they "take place in compartmentalized sectors such as trade/finance/development aid/health," and do not question or assess the inter-relationships and impacts of each of these on the other global processes (see WCSDG, 2004). In this chapter we present some trends in the major drivers of change that are important for plausible decision-making in the future. We refer here to a large body of work on trends or projections of each driver of change. Much of this work has been attempted for different purposes, by different authors/agencies, with different ideological orientations and values. Wherever possible we refer to certain time points such as 2015, 2020, 2030, or 2050 to allow for some comparability across the different drivers discussed here.

4.2 Drivers of agricultural change

4.2.1 Demographic change

4.2.1.1 Population growth

The Asian population reached 3.7 billion in 2000. The population of the ESAP region constitutes about 56% of the global population. It is projected that the ESAP population will increase continuously to reach 4.8 billion in 2025 and 5.0 billion in 2050, which will be 56% and 54% of the world's population respectively (UN, 2001). The ADB (2001a) shows that South Asia has 40% of the region's population and one of the highest rates of population growth. China has 39% of the region's population and the lowest population growth rate. The slowing down of population growth is due to rising levels of education, increased female participation in the work force, and greater use of contraceptives. Countries such as the Philippines and Bangladesh continue to maintain high birth rates - with challenging implications for job creation, food security, and environmental stress.

Together, the combined populations of China and India currently constitute about 38.5% of global population, and 73% of the ESAP population. The demography of the ESAP region is changing rapidly. The population of India will exceed that in China by 2035 (UN Economic and Social Council, 2004). India's population is projected to reach 1.25 billion by the year 2015 and 1.53 billion by 2050 (UNDP, 2003) (Figure 4-1).

FIGURE 4-1. Asian population trends (Source: DESA, 2006).

FAO projections show a continuing slowdown in the growth of the world's population. Since the peak population growth rate of 2.04% a year in the late 1960s, the growth rate has fallen to an average of 1.35% a year and is expected to fall further to 1.1% a year in the period 2010 to 2015 and to 0.8% a year over the period 2025 to 2030. Absolute global population will also fall from a growth peak of 86 million a year in the late 1980s through current annual additions of around 77 million a year to 67 million a year on average between 2025 and 2030 and 43 million a year between 2045 and 2050 (FAO, 2002).

The SRES storylines constructed for the Asia region reflect a range of socioeconomic scenarios. The population corresponding projections for Asia are, 1.54 billion people in 2050 and 4.5 billion people in 2100 (IPCC, 2007). Overall, despite variations in the different population projections, the future is one of increasing population pressure in South Asia. In terms of sheer numbers, the population of South Asia is likely to be a major concern driving the decisions made for agricultural and rural development both globally and within nations.

4.2.1.2 Demographic factors

Demographic factors have shaped agricultural expansion and growth over the centuries. The Green Revolution in the ESAP region is the prime example of how population growth or the rhetoric of population growth and associated projected food shortages led to a planned and rapid increase in food production and productivity. Over the next 20-25 years, South Asia will be the most populated part of the world and by 2025 will be home to about 46% of the population in the Asian region (Hussain et al., 2006).

The two key elements of demographic transition, fertility rate and population growth rate, have implications for economic growth (and prospects) in rural areas, agricultural growth rates, education levels (especially female literacy and educational attainments), and per person incomes (Hussain et al., 2006). Crucial among the determinants in Asia are, fertility rate and the prospects for a well-nourished population.

Fertility rates (births per woman) in South Asia (SA) and the East Asia and Pacific (EAP) countries are expected to change from the current rates of 3.1 and 2 (in 2000-2005) to 2.1 and 2.0 (in 2045-50) (World Bank, 2005). The decline in fertility rate in SA being not as rapid as expected is because of a slow expansion and relatively poor access to medical/health care and prevailing weaknesses in child health care systems.

Maternal mortality will continue to be highest in South Asia as a regional cluster – the only exceptions being Bangladesh and Sri Lanka, where the figures are expected to be lower. The marginal increase in fertility rates in East Asia and Pacific is explained by the decreasing infant and maternal mortality rates in a large number of Pacific island countries, and improvements in health services in general. Fertility decline in rural areas in general will be slower than in the urban regions.

Child malnutrition will be difficult to eradicate even by 2050 – and in the SA region it is likely that child malnutrition may increase from current levels given the degradation of ecosystems and increasingly limited access to ecosystem services for the poor (MA, 2005) , if status quo continues. Even with estimates of increasing health and sanitation and better access to and availability of food, 46% of children in South Asia will still be malnourished in 2020 (Rosegrant and Malik, 1995). In 2020, South Asia will account for 48% of the world's malnourished children. Progress in improving nutrition is expected to continue, though more slowly than in the past.

Average per capita food consumption in developing countries is projected to rise by 6.3%, from 2680 kcal in 1997-99 to 2850 kcal in 2015. The proportion of undernourished people is anticipated to fall from 20% in 1990-92 to 11% by 2015 and 6% by 2030. However, the 2015 target of halving the total number of undernourished people will probably only be reached in 2030 when the numbers are expected to fall to 440 million. This delay is a result of rapid population growth associated with lagging economic growth as well as the fact that many countries are starting from extremely low national average food consumption levels. The proportion of global population living in countries with per capita food consumption under 2200 kcal per day will fall to only 2.4% in 2030. However, in South Asia, the fraction could fall by 40% from 1997-99 to 2030 and in East Asia the number could halve by 2030 (FAO, 2002).

The number of malnourished children under the age of five in the developing world is projected to decline by 21% between 1997 and 2020. Although child malnutrition is expected to decline by 31% in South Asia, India will still be home to 44 million malnourished children in 2020, representing 34% of the total in the developing world. China will have the largest decline, with a 54% reduction in the number of malnourished children by 2020 (IFPRI, 2002)

4.2.1.3 Age structure

The demographic data show ageing in developed countries and increasing proportion of younger population in most of the developing countries. In India and some other ESAP countries, the younger generation will continue to dominate the labor force for decades. But in China, Japan and the Republic of Korea, family planning policies and improvements in health care will contribute to an ageing of the populations. An ageing population is now one of the crucial social problems being addressed in China (Yuankai, 2007). In the rural areas in particular, the Government is being forced to acknowledge the need to support millions of senior citizens. Over 60% of China's aged live in rural areas. China's rural senior citizens population (over 60 years old) will reach 120 million in the next 20 years.

Asia is one of the world's fastest ageing regions, with the percentage of elderly projected to double between 2000 and 2030 (Kaneda, 2006). Japan, Australia and New Zealand are expected to see rapid rates of ageing and by 2050 the proportion of people over 60 is projected to be 25% of the population. Ageing presents challenges to agricultural sector productivity and innovation adoption and raises concerns of poverty among the rural elderly and women. Asian developing countries have relatively large youthful populations that require strategies to balance their aspirations with opportunities. A population age structure dominated by youth in developing countries suggests the potential for labor migration to regional developed countries. It also has implications for strong national urban development.

The outlook for the future in the Asian region is for the younger population to increase slowly to 685 million in 2040, when they would account for 14% of the total population. Moreover, while the growth in the young adult population will continue over the next two decades in the region, in most OECD nations their numbers will decrease (Hugo, 2005). For agriculture, the implications of an increasing proportion of the population being young and with development aspirations, as well as malnourished (4.2.1.2), is worsened by the emerging gender ratios in the region.

4.2.1.4 Gender composition

A declining labor force (and in particular a declining male labor force) will be available for agriculture, particularly on small to medium farming enterprises, and the available labor force will be dominated by women. Due to out-migration of male heads of households, the pressure of maintaining the farm and household will fall on the women left behind despite the constraints they face such as lack of access to land, new seeds and technical knowledge (Paris et al., 2005). The current trends in declining fertility rates are associated with a reduction in family size. Along with improvements in the population sex ratio and the potential for increased matriarchal households and stress on family labor, these trends present a mixed picture for agriculture (United Nations, 2001). The region demonstrates a decreasing trend in agricultural employment rates with increasing importance of non-farm work for income security.

Over the past half-century, women's participation in the labor force has increased steadily in many Asian countries, particularly in the rapidly growing economies of East and Southeast Asia. In 1999, half or more of women in the age groups 15 - 64 were employed in all sectors, including agriculture, in nine Asian countries (ADB, 2001a) (Figure 4-2).

FIGURE 4-2. Status and future projection on percentage of women age 15-49 in some Asian countries and regions.

The female contribution to the overall economy is high throughout the ESAP region, particularly in terms of labor input into agriculture. Bangladesh, Bhutan, Cambodia, China, India, Myanmar, Nepal, Pakistan and Vietnam have particularly high percentages of women employed in the agricultural sector, with estimates ranging between 60 and 98%. Indeed, in most Asian countries the number of women employed in agriculture as a percentage of the EAP is higher than that of men (Garcia et al., 2006). Female members from farming households will play will increasingly play important roles as key agents of change by serving as extension agents to other women farmers and laborers. Experiences in Bangladesh demonstrated that including women in training in specific technology in which they were actively engaged and in all the overall production system contributed more to their decision-making. Several successful women-led projects included promotion of post-harvest and storage technologies and video-centered learning. Rural women will become the direct recipients of village level training courses which deal with knowledge-intensive agricultural technologies (crops, livestock, fisheries, agroforestry) crop and livestock (Paris et al., 2005).

4.2.1.5 Rural-urban and inter-regional migration

Rural to urban migration still dominates migration flows in most Asian countries because of the high proportion of the population living in rural areas (DESA, 2006). According to the 2005 Revision of World Urbanization Prospect, the global proportion of urban population increased from 13% in 1900 to 49% in 2005 and is expected to reach 60%, or 4.9 billion people, by 2030. While urbanization continues to be on the rise, rural populations are still significant and are currently growing. However, a gradual decline in rural populations is expected to commence in 2019, reaching slightly less than the current 3.3 billion by 2030. In 2005, 71% of all rural dwellers lived in Asia, primarily in India, China, Indonesia and Bangladesh. At the same time, the Asian urban population has reached over 1.5 billion. This is projected to rise to over 2.6 billion by 2030 (Figure 4-1).

Two other estimates show slightly different trends. According to DESA (DESA, 2006) from 2005 to 2030 the Asian urban population is expected to rise by 2.12% annually. At the same time, rural populations are anticipated to decline by 0.2% annually. The Asian Development Bank estimates that there are likely to be 2.2 billion rural Asians by the year 2020, and that this rural population will have much lower access to health and education, and a lower level of general well being (ADB, 2001b).

Since 1950 countries such as Australia, China, Fiji, Indonesia, Japan, Korea DPR, Republic of Korea and the Philippines have recorded negative population growth in rural areas. Yet many developing countries in the region still have a larger percentage of rural population compared to urban population. In particular, countries that depend heavily on agriculture as economic drivers register less than 30% of their total population as urban –for example Bangladesh, Bhutan, Cambodia, India, Lao PDR, Nepal, PNG, Sri Lanka, Samoa, Solomon Islands, Vanuatu and Vietnam Nam. For China, the projection is that by 2030 the urban population will reach around 60.5% of the total population and hence exceed rural population (UNDP, 2003).

Urbanization, with almost 35% of Indians living in urban areas, is likely to pose a major labor market concern as well as environmental concerns (Dyson et al, 2004). Countries such as China, Thailand, Sri Lanka and Malaysia will face issues of caring for an ageing population, while India will still have to grapple with the problems of educating and finding jobs for a significant younger population (Hussain et al., 2006).

Besides domestic rural-urban migration, international and intra-regional migration, is on the rise in ESAP though there is a marked difference among the educated and unskilled migrants in destination countries. Increasing movements in search of economic mobility brings mixed migration impacts; a combination of human resource flight through loss of skilled and semi skilled labor, and capital gains through remittances.

Lower costs of transport and information have increased both domestic and international labor mobility, such that workers are more sensitive to international wage differences and no longer consider only wage differentials between rural and urban areas within their own country. The migration pattern between Cambodia and Thailand for example, has been shown to be affected by cross border wage differentials, job availability and work opportunities in each country (Acharya, 2003). Implications for agriculture are that labor shortages can be offset by migration of human capital from other countries. Continued regionalization and reductions in the cost of transport imply a move toward a common labor market in the ESAP region.

Likely regional implications for ESAP will be a smaller, more educated and wealthier rural class characterized by an agricultural sector adopting more efficient farming processes. Skilled individuals who pursue off-farm employment may provide remittances back to rural communities and provide skills to assist in the incorporation of new farming technologies and farming practices. Rural communities that incorporate mechanization as a substitute for labor will provide individuals with more time to devote to higher paid work, thus assisting in the alleviation of poverty.

The projected future of demographic change is one of increasing population pressure in the region, with malnourished children concentrated mainly in South Asia, increasing share of younger population in developing countries and ageing population in developed countries, declining and mostly female rural labor force, increasing urbanization and inter-regional migration.

4.2.2 Economic drivers

Many of the economies of the ESAP region are economies in transition and are highly agriculture dependent. In most studies of development, a typical pattern that emerges is that as economies undergo demographic transition, total agricultural output increases but dependence on agriculture tends to decline. The recent historical development pattern for the most part in the ESAP region has shown a declining dependence on agriculture, and an increasing dependence on associated structural shift toward manufactures and services (ADB 2005).

Economic growth is itself a function of many variables, including demographics, factor endowments, international trade, savings and investment, institutional capacity, and technical progress.

4.2.2.1 Gross domestic product

Projections of GDP are often difficult to compare between studies, since regional aggregations typically vary with respect to country inclusions. For this reason, care should be exercised in drawing broad conclusions from the studies reported here for regional growth rates.

The scenario approach adopted in the IPCC SRES (IPCC, 2000) resulted in four main 'marker' projections for economic growth within each of the scenario families: A1, A2B1, A2B1 and B2 (Box 4-1). Growth rates for Asia were projected to span a range of 3.9% (A2) to 6.2 (A1) per annum over the period 1990-2050. Longer term projections for 1990-2100 indicated a GDP growth rate range for Asia of 3.3 (A2) to 4.5% (A1) per annum.

Box 4-1. SRES storyline summaries

The Asian Development Bank (Roland-Holst et. al., 2005) projected real GDP growth rates by country over the period 2005-2025. These projections are underpinned by assumptions about continued rapid productivity growth and capital accumulation (Figure 4-3). The greatest growth potential relative to the baseline scenario occurs under assumptions that all tariffs and non-tariff barriers within Asia, as well as all export subsidies in Asia (Roland-Holst et al., 2005). This scenario results in aggregate income differentials relative to the baseline in 2025 of between 8.1% for Japan and 116.6% for Malaysia.

OECD-FAO (2006) growth projections are more aggregated with respect to regional reporting and indicate an average annual growth rate of 3.13% for Asia for the period 2006-15. Oceania is projected to grow by 3.09% per year on average over the same timeframe. This compares to projections undertaken in 2003 by FAO indicating a 2.2% per annum growth rate for Oceania over the period 1999-2010, 5% for South East Asia, and 3.3% for South Asia (FAO, 2003).

FIGURE 4-3. Baseline growth projections by ADB.

The World Bank (2007) projections of income growth per person (2010-30) were developed for central and high growth scenarios. In the central scenario, mid term GDP growth projections for East Asia and the Pacific, and South Asia are projected to be higher than for any other region. Income growth per person in East Asia and the Pacific is projected at around 4.4% per annum on an annual average basis for 2010-2030 in the central scenario and 6.8% in the high growth scenario. The corresponding figures for South Asia are around 3.4% and 5.1% respectively.

4.2.2.2 Agricultural productivity

Output can be increased either by using more factors of production, using those factors more intensively, or by increasing the productivity of those input factors. In all cases, improvements in education are important.

As discussed above, and in line with regional population projections, labor supply in developing ESAP countries is expected to continue to grow over the next two decades. However labor supply growth in the Australia and Japan is expected to slow along with a marked ageing in population. The case is particularly severe for Japan, whose labor supply declines over the entire projection period. China, South Korea and Chinese Taipei are all expected to have negative growth in labor supply by 2030-50 (UNDP, 2003; Matysek et al., 2006). However, significant improvements in education and literacy rates are expected to raise labor productivity, particularly in South and South-East Asia (Table 4-2). This could have either beneficial or negative implications for agriculture, depending on the level of development of the country and its economic structure, inter alia.

Insert Table 4-2. Sources of productivity (Source: Roland-Holst et al., 2005).

Progress in agricultural mechanization has varied significantly across the ESAP economies. In recent times, mechanization has increased most strongly in South and South-East Asia and China. By contrast, the mechanization trend has been stagnant or in slight decline in Australia and New Zealand (FAO 2003). However the use of capital intensification as a proxy for technological change and productivity improvements can be misleading. For example, although mechanization intensity in Australian broad acre cropping is expected to continue to decline over time relative to levels observed two decades ago, this reflects adoption of new techniques such as no-tillage agriculture, which not only has beneficial implications for reducing land degradation but is typically productivity enhancing and more profitable (in the absence of herbicide resistance issues) (McTainsh et al., 2001; D’Emden et al., 2006).

Other factors that will influence the level of agricultural productivity into the future include, but are not limited to, the level of public investment in agricultural research and rural infrastructure, improvements in inputs such as fertilizers, irrigation and genetically modified crops, environmental degradation and climate change. This is not an exhaustive list of the influences on agricultural productivity, nor should it be interpreted that the listed factors are of equal importance with respect to their potential effects on productivity into the future.

In all Asian economies, the predominant source of growth over the coming decades will be attributable chiefly to improvements in capital and total factor productivity rather than labor inputs. However, it is difficult to disentangle the relative contributions of capital and labor productivity.

Higher levels of education tend to promote mechanization. Substitution toward capital inputs from labor in farming is expected to further increase the importance of R&D in agriculture. Several countries within the ESAP region including Australia, Philippines, India and China will be able to exploit their comparative advantage in research and jointly benefit from each other. Their commitment toward the continued development of their rural sectors will most likely benefit from joint R&D projects that focus on the development and adoption of AKST.

Biological innovations that have resulted in improvements in total factor or partial factor productivity in the ESAP region include increases in investment in agricultural research and irrigation infrastructure. Returns to these investments have been highest in areas with significant land shortages but good institutional structures (Pingali and Heisey 1999).

IFPRI (2001) expects that the growth rate of areas harvested for agricultural production will decline from now through to 2020, along with decreased availability of arable land, increasing population pressures and land degradation. Given these limitations, yield growth becomes an important determinant of productivity growth. Of particular interest for this region is yield growth rates for cereals (including rice and wheat), which are projected to decline significantly in South Asia, Southeast Asia and East Asia over the period to 2020 (Figure 4-4).

FIG 4-4. Yield growth rates by region, all cereals (Source: Rosegrant et al., 2001).

Agricultural productivity growth will be crucial to ensuring adequate food supplies, however this will be challenged over the coming decades by resource depletion, environmental degradation and increased market pressure to use food crops for ethanol feedstock. Agricultural research and development will be important in ensuring continued productivity gains of the magnitude required to limit local food security concerns.

At present some 1.5 billion ha of land is used for arable and permanent crops and a further 2.8 billion ha are to some degree suitable for rainfed production. However, a significant fraction of potential land is either locked up in other valuable uses or unsuitable for cultivation due to low soil fertility, high soil toxicity, high incidence of human and animal diseases, poor infrastructure, and difficult terrain. Accordingly, land expansion is expected to account for 20% of production growth with the remaining 80% resulting from intensification practices such as higher yields, increased multiple cropping and shorter fallow periods (Bruinsma, 2003).

In South Asia, almost 98% of suitable land is already in use. Thus, there is little capacity for expansion in area under cultivation and it is projected that more than 80% of the increase in production will need to come from yield increases. Furthermore, it is projected that about a third of the harvested area in developing countries in 2030 will be irrigated. By comparison, East Asia is by 2030 projected to be using 75% of their irrigable land and South Asia (excluding India) is expected to be using almost 90% (Bruinsma, 2003).

It is estimated that in Asia and Oceania, there are around 12 million hectares under certified organic production. Most of this land area is in Australia, with only a fraction of organic agriculture (OA) production attributable to Asia (Willer and Yusefi, 2005). Organic agriculture is of increasing interest to both NGOs and agribusinesses for the fact that it offers a new business opportunity but also provides a sustainable development opportunity. In addition, organic agriculture is considered to offer potentially higher incomes for lower energy, water and pesticide input costs, as well as buffer yield against drought (Pimental, 2005).

4.2.2.3 Commodity prices

In theory, it is expected that over time, the prices of primary food commodities decline relative to prices of manufactures as a result of i) wage and productivity differentials between low income countries that typically produce primary commodities and higher income countries that typically produce manufactures, and ii) lower income elasticity of demand for primary commodities (Prebisch, 1950; Singer, 1950). This globally worsening terms of trade in future portends progressive squeezing of the rural economies for ESAP where a majority of the population still ekes a living out of agriculture.

History reveals a downward trend in the prices of agricultural commodities as productivity in the agricultural sector and technological advances have been made, with some fluctuations caused by weather conditions. Particularly prior to the current resurgence of globalization since the 1990s, most developing countries kept their domestic food prices below global food prices, and artificially raised the price of manufactured goods above international prices. Gradual changes and reductions in tariffs, as well as new import and export regimes have changed these price regimes in the ESAP region

Commodity and energy prices are interlinked. High energy prices translate into higher commodity prices vis à vis manufactures. For example, highly energy intensive production of fertilizers can affect the prices of agricultural products by raising input costs (ADB, 2006b). High oil prices may also result in increased demand for biofuels, as consumers substitute between least cost fuel sources. This may have implications for local food security in some regions (4.9.1) if demand for biofuels is strong enough to displace traditional agricultural food crop production.

Projected real agricultural commodity prices are expected to fall by 2015, relative to 2001 levels. ADB (Park and Zhai, 2006) presents a range of commodity price projections to 2015 under three scenarios. The scenarios centre around a baseline, with assumptions about higher and lower agricultural TFP growth, energy efficiency and energy reserves. The disaggregated impacts of the softening and tightening variables are given alongside the aggregate impacts on commodity prices. Changes in agricultural productivity are associated with roughly equivalent percentage changes in world agricultural commodity prices. Energy security and environmental constraints represent two significant uncertainties that could affect projections of agricultural commodities prices into the future (see 4.2.7, 4.2.8 and 4.2.9).

4.2.2.4 Globalization, economic growth and agricultural markets

Industrialization in agriculture has resulted in the coordination, production and distribution of produce to a larger market. Improvements in transport and information networks have a tendency to increase mobility between suppliers around the world. The higher degree of access to a variety of goods has assisted in integration along the supply chain including between abattoirs, supermarkets and other retailers. This means that demand for farm produce is no longer restricted to nearby markets. Rather, industrialization has increased the accessibility of goods and services to include distant consumers and suppliers as well. These trends will accelerate in developing countries into the future. Globalization is also likely to result in greater product diversification to supply new and varied markets. Technological change in agricultural production, improvements in rural infrastructure and diversification in food demand patterns will trigger product diversification toward high value food products (Pingali, 2004). Demand for organic agricultural products has been growing faster than overall food markets, particularly in developed countries for some time, and the expected continuation of this growth trend into the future could have substantive positive implications for local land management, biodiversity, food security and rural livelihoods (UNCTAD, 2006; El-Hage Scialabba and Williamson, 2004).

The effects of trade liberalization could have significant growth benefits translating into poverty alleviation in developing Asia, reflecting the importance of agricultural incomes. The removal of tariffs and agricultural subsidies on agriculture and food is expected to significantly improve market access for developing countries (Anderson and Martin, 2006). Estimates of a 48% increase in exports of agriculture and food from China, a 17% increase from Indonesia, 13% increase from the Philippines, 88% increase from India, 24% increase from Bangladesh, 35% increase from other East Asia and a 10% reduction from Vietnam are reported (Hertel and Keeney, 2006). These improvements in market access are not without potential downsides; globalization involves the transportation of products over much greater distances and thus also increases the energy inputs required to move products from source to markets (see 4.2.9). There are visible trends of environmental degradation following in the wake of increasing globalization and trade liberalization, especially when production of high-value crops or commodities draw upon limited water resources, use chemicals or pesticides in excessive doses, add to energy consumption in agriculture, and worsen employment opportunities for women (unskilled) and marginal populations, forcing them to resort to further exploitation of fragile resources like ground water, forest land, protected species of wildlife etc. (UNEP, 2006; Nijam, 2005; MA, 2005) (see 4.2.5).

Moreover, if improvements in market access are limited, for example barriers to trade in agricultural products remain in place in the large EU and United States markets, this could have serious negative implications for developing countries including those in the ESAP region. A significant question moving forward in the liberalization negotiations is whether developing countries should aim for a reduction in barriers in developed countries or pursue maintained or expanded preferential treatment (Binswanger and Lutz, 2000).

4.2.3 Implications of growth for agriculture

The implications of economic growth prospects on poverty reduction will be significant over the period to 2030 (Table 4-3). Different assumptions about capital and labor mobility will influence future economic growth prospects in the ESAP region. Estimates of poverty reduction in Asia in the future will depend on key assumptions including (i) the nature of growth and redistributive policies, (ii) the benchmark of abject poverty (less than \$1 per day and less than \$2 per day), and (iii) the inclusion of China and the impact of its polices on poverty reduction (in contrast to India – where little effort or impact is evident). The projected decline in poverty in Asia as a whole is positively affected by the inclusion of China (and its policies) and negatively influenced by the relative inability of some developing countries to make the necessary investments for economic growth (Roland-Holst et al., 2005). If the ESAP member countries can sustain the rate of growth they experienced during the period 2000-2004, then it is likely that all the countries will be able to meet their income and poverty eradication targets by 2015 (ADB, 2005). Further, if these rates of growth are sustained over the next decade, then these countries can completely eradicate abject poverty of less than $1 per capita per day by 2025 (ADB, 2005).

Table 4-3. Projections of poverty by region.

4.2.3.1 Food consumption and demand

Projections indicate that as population growth rates decline and countries become richer, demand for food will continue to grow, albeit at a declining rate. The annual average rate is projected to fall from 2% for the period 1989 to 1997-99 to around 1.4% on an annual average basis over the period 2015 to 2030 (FAO, 2002). This declining growth rate is expected to be more pronounced in developing countries, where the food demand growth rate is projected to fall from an annual average of 3.7% over the past 30 years to a mean of 2% a year over the next 30 years. This differential is attributable to the fact that daily food consumption in many large developing countries such as China is approaching that of industrialized countries. Once this level converges, the growth rate in total food demand will slow. Notably however, this trend is not expected in India because cultural traditions will hold back the country's demand for meat and animal feed well below that seen in China (FAO, 2002).

Rapid population and income growth in East Asia have been key drivers behind the rising demand for world food commodities (ADB, 2006b). Population and income growth in South Asia over the coming decades will contribute to this growing food demand, as will movement toward adequate food consumption levels and improvements in nutrition (FAO, 2006b).

Growing projected demand for agricultural commodities in the ESAP region suggests there will be significant challenges in achieving the Millennium Development goals. For example, while future economic growth is projected to raise per person incomes by 1.9% a year between 2000 and 2015, it is unlikely that the absolute impoverished population can be halved, with projections suggesting a more limited reduction from 1.27 billion in 1990 to 0.75 billion in 2015 (FAO, 2002).

To satisfy the projected increases in food requirements, an additional billion tonne of cereals will be needed each year by 2030. Using these projections implies that developing countries could be required to import 265 million tonnes of cereals annually (FAO, 2002). Trade liberalization will therefore be an important factor in ensuring adequate food supplies in the region as regional production falls short of regional food demands (Park and Zhai, 2006).

Developing Asia is increasingly influencing international commodity markets and prices. The rapid industrialization and structural change witnessed in China will continue to have enormous implications for global commodities demand and prices. Agricultural and light manufactures demand will increasingly give way to heavy industrial raw materials (ADB, 2006b). This process is expected to be repeated in India over the next few decades, with additional significant implications for energy and other raw materials demand, and further into the future, food demands that can only be met through imports from lower income countries (ADB 2006).

Increasing wealth over the past few decades within the ESAP countries has facilitated a change in consumption patterns toward higher value food products and imports. Wage income will increase at the fastest rate in East and South Asia of anywhere in the world (World Bank, 2007). As disposable incomes increase, demand for starchy staples is expected to decline, while demand for livestock products, fruits, vegetables and processed food products is projected to increase (OECD-FAO, 2006).

The implications of economic growth for food demand will depend on the relative wealth of countries. For low income Asian countries, changing diets will result in an increase in per person consumption of wheat and rice and a decline in consumption of maize and other coarse grains by 2020 (IFPRI, 2001). With additional growth and improvements in per person wealth, food demand will shift again.

A driver of changing import demand for cereals has been significant improvements in agricultural productivity as a consequence of the Green Revolution (Francks et al., 1999). Rapid urbanization has also contributed to changing dietary profiles. Urbanization often generates additional demand for higher value processed food and tropical beverages such as coffee (ADB, 2006b). In China and India, this has also led to significant shifts in food import demands. This trend has been particularly apparent in China, where wage rates have risen faster than in many other developing countries, and this has also created opportunities for agricultural exports from other low income countries (World Bank, 2007). In particular, changing dietary patterns have exerted an influence on the level and variety of imports for food products such as meats, vegetables, edible oil, and oil seeds (ADB, 2006b).

The fraction of the global population living in countries with per capita food consumption under 2200 kcal per day is projected to fall to around 2.4% in 2030. In South Asia, this fraction is expected to fall by 40% between 1997-99 and 2030 and in East Asia by 50% (FAO, 2002). Although child malnutrition is expected to decline by 31% in South Asia, India will still be home to 44 million malnourished children in 2020, representing 34% of the total in the developing world.

China is expected to have the largest reduction in malnourished children, with a 54% decline by 2020.

Daily calorific intake increases through time in both regions, however the composition of that intake varies between South and East Asia (Table 4-4). The key differences are that while demand increases for roots and tubers in South Asia, the trend in demand is downward for those commodities in East Asia. Meat consumption grows faster over the projection period in East Asia than in South Asia, and South Asian diets are far more heavily weighted toward milk and dairy products than in East Asia.

TABLE 4-4. Changes in the commodity composition of food demand (expressed in kcal/person/day).

The composition of aggregate cereals demand is expected to substantially change over the period to 2020. In Asia, the aggregate demand for rice is projected to decline by 4% and wheat demand to decline by 1% in total cereal demand between 1997 and 2020, while aggregate demand for maize as a percentage of cereal consumption will rise 6% (IFPRI 2001). However, per capita demand projections for cereals reveal a slightly different picture. Per person demand for rice in Asia is projected to remain constant over the period 1997 to 2020, while per person wheat demand is expected to rise 9%, and per person maize consumption is projected to decline by around 16%. These shifts are due to rapidly growing incomes and urbanization (IFPRI 2001).

At the sub-regional ESAP level, it is expected that in North India, Northern and Southern China, the current demand for rice will continue well into the future (FAO, 2006b). A gradual shift in demand from rice to wheat is taking place in South East Asia – especially in Thailand, Philippines, Malaysia and Indonesia. Although this trend is just starting in Viet Nam, and not yet evident in Myanmar, Laos PDR and Cambodia, it is expected that there will be an increasing shift in the ESAP region as a whole from rice staple diets to rice and wheat staple diets (FAO, 2006b). Pacific countries such as Samoa, Tuvalu, and Solomon Islands are projected to reveal an increasing preference for rice and wheat based diets in place of their conventional starchy roots and tubers. A notable exception is Bangladesh, which is expected to continue to maintain a heavy dependence on rice based diets well into the future.

While East Asian cereal demand will double and significantly exceed its production levels, a surplus of 73 million tonnes will be produced in the developed world between 1997 and 2020 (IFPRI, 2001). Unlike many other regions which will expand cereal cultivation areas, Asia will face limited development opportunities since approximately 80% of the potentially arable land in Asia is already under cultivation. In addition, rapid urbanization is will consume vast areas of potentially arable land.

Yield growth rates will therefore be more important for ESAP countries than some other regions. However despite the importance of improvements in cereal yield, rates of yield increase are expected to continue to decline to around 1.25% annually in South Asia, to 1.2% in South-East Asia and to 1% in East Asia over the period 1997–2020 (IFPRI, 2001).

Other crop markets will face similar futures. Aggregate roots and tubers demand in the developing world will increase by 55% between 1997 and 2020 but supply is expected to increase by only 51%. This is expected to result in a decline of exports in roots and tubers out of Southeast Asia of 10 million tonnes Southeast Asia will increase the regional surplus of edible oils, with production growth exceeding demand growth by 7 million tonnes between 1997 and 2020. East Asia will increase its edible oil imports from 4 million tonnes in 1997 to 10 million tonnes in 2020 (IFPRI, 2001).

Under a pessimistic scenario, Indian and Chinese cereal production declined 15% relative to the baseline scenario, resulting in significant trade deficits for both countries (IFPRI, 2002). However, the analysis indicates that world markets are capable of absorbing these large increases in imports without major price consequences. Under this scenario, Indian kilocalorie consumption in 2020 declined by 171 kcal per capita per day relative to the baseline scenario and Chinese kilocalorie consumption declined by 264 kcal per capita per day. The number of malnourished children is projected to increase by 2 million relative to the baseline scenario in both countries.

Access to water and sanitation remains a major concern in the ESAP region and governments may consider ensuring potable water as a basic input to ensuring food safety and health. Expansion of domestic markets for processed foods and beverages along with growth in agricultural trade has led to increasing awareness of food safety and quality in the region. Despite acceptance of international food safety regulations (the HACCP) many ESAP countries need to intensify efforts to implement and enable quality assurance systems. With the exception of a few countries like Japan, the consumers in ESAP are largely indifferent to questions of safety of biofortified and genetically engineered food (Hoban 2004), and reveal widespread acceptance of relatively low cost pharmaceutical products (drugs and vaccines) from genetically modified or cloned animals.

4.2.3.2 Implications of GDP growth for agriculture

In the past few decades, agriculture has experienced some stagnancy in growth compared with historical rates. The sector has also experienced lower investment in recent years; a trend that is likely to continue in future. Other issues that may affect the agriculture sector include withdrawal of subsidies, less priority for R&D and an aging labor force. The manufacturing sector, which has grown strongly in the past few decades, is by contrast receiving many incentives including tax exemptions, low import duties, and prioritized training. In future, this trend will likely intensify, especially in the large emerging economies of ESAP. In ESAP as in much of other developing regions of the world, the impact of an increasingly globalizing and industrializing food system will be evident as diverging rural worlds and increasing concentration of power in the hands of a few transnational actors (Pimbert et al, 2001).

The expected rapid growth of many of the ESAP countries will have significant implications for agriculture. Structural transformation of these economies is expected – while the absolute output of agricultural production from this region is expected to grow over time, the relative importance of agriculture will decline as manufactures and services become relatively more important sources of GDP. The largest contributors to the rise in developing country service exports over the past two decades have been East Asia and the Pacific and Europe and Central Asia (World Bank, 2007).

Although the agriculture sector is expected to continue to be a major employer in the region, labor will continue to be shed to other sectors and increasingly so as agricultural productivity improves and wage differentials grow in relation to other sectors. However, although there is a shift toward off-farm employment in South East Asia, agricultural output in the region has not fallen. In fact, agricultural production capacities in Indonesia, Malaysia and other countries in the ESAP region have been increasing in the past two decades (FAO, 2006a). A partial explanation lies in adoption of capital to offset labor shortages; the type of technology adopted is partially influenced by off farm employment (Mahmoud and Shively, 2004).

It can be expected that trade and investment liberalization and greater globalization will enhance allocative efficiency and enhance specialization along the lines of countries' comparative advantage. Globalization, or domestic policies that lead to more efficient allocation of resources, reduces production costs and thereby leads to significant increases in output and income growth. These effects are documented in the literature on the economic effects of trade liberalization (for example Anderson and Martin, 2006; Schneider et al., 2000). However, there are also predictions that agriculture in particular may be negatively affected by the pressures of globalization given that 60% of the farming community is small/marginal peasantry, for whom adjusting to global changes in resource efficiency will be difficult and cause heavy losses in the initial years (Ghosh, 2005; WCSDG, 2004).

4.2.4 Sociopolitical drivers

4.2.4.1 Economic liberalization and regulation

Economic liberalization and increasing globalization has benefited those countries and populations who have capital, entrepreneurial ability and education and skills (WCSDG, 2004). The poor populations of the world, illiterate and unskilled, with limited capital assets, have lost out. A good majority of this population being in Asia, especially South Asia, this region will face a crisis of employment and income generation, especially in rural and remote areas, amidst rapidly expanding urban growth and flourishing international trade in services and manufacturing. (WCSDG, 2004). Most countries in the ESAP region will meet their MDG targets of reducing poverty (target based on people earning less than US $1 a day), by half (between 1990 and 2015) (ADB, 2005). Some countries like China, Thailand, Sri Lanka have already halved or more than halved their population living in abject poverty (less than US $1 a day), and will continue to have lower shares of their populations living under these conditions.

What are the chances that economic liberalization in an era of globalization will bring more effective redistribution in unequal societies in some of the ESAP countries such as India, the Philippines, and Bangladesh? Overall it does appear that globalization and economic liberalization may create a new political cleavage between “cosmopolitans” who have skills and assets to adjust easily to changes in global markets (and consequently increasing political clout domestically) and “provincials” who are less mobile with lower labor market skills (Bowles and Pagano, 2006).

Economic liberalization and new labor and knowledge market regulations may enhance private investment – but to what extent these drivers will change investment in R&D is not known. In a region where fundamental labor regulations that protect basic rights of workers are ‘conspicuous by their absence’ or are never enforced (ADB, 2005), there is a significant opposition to any reform in the regulations governing input markets, trade or tariffs – largely voiced by the NGOs using the argument that the poor farmers cannot afford to pay for or purchase seeds and other technologies (see Chapter 3).

The impacts of globalization are likely to vary widely, from posing severe production and consumption constraints on small farmers and the agricultural sector in general in some countries (or parts that are not well resource endowed or without social security) to rapid growth in markets, commodity production and trade in some countries. Latecomers into processes of globalization are likely to be penalized with the burden of getting their domestic institutional structures and productive sectors to adjust to the new norms of tariffs, markets, and standards, as well as to compete with other countries that have been pre-disposed to such norms or have fewer people affected by these new norms (Nayyar, 2006). Given the uneven impacts of globalization, it is likely that developing countries may invest less of their scarce public sector resources on relatively long term investments like AKST, and may address more immediate issues like subsidies for small farmers to access inputs or price support mechanisms. These in turn may have negative consequences for agriculture in developing and developed countries in ESAP.

4.2.4.2 Political stability

Political issues that may significantly influence ESAP include disillusionment with economic liberalization, national Governments, and globalization. In most developing countries (including the ESAP region) the failures or lack of development commitment of the State are passed on as the ill effects of globalization (see, Bardhan, Bowles and Wallerstein, 2006; Przeworski and Meseguer Yebra, 2006). Given that the world over, developed countries (except the USA and UK) have enhanced and expanded the size of their government sector (ratio of government expenditures to GDP), it may be expected that the ESAP region will also respond in a similar way in the future – with governments playing a major role in poverty alleviation, macro-economic management, social insurance, and environmental protection (Bardhan, Bowles and Wallerstein, 2006). Politically, there may also be increasing diversity of institutions (policies) among nation states. The key message – for AKST institutions and organizations is that the capacity of economic liberalization and globalization to dismantle the barriers to economic opportunity faced by the poor depends critically on the capacity of public bodies to respond to the voices of the poor.

One of the major responsibilities of public bodies in the developing countries in Asia will be to find the resources and appropriate allocation of these resources to enable rural regeneration, as well as provide the much needed social security in rural areas. The Asian crisis of the late 1990s showed the vulnerability of the rural economy to urban-centered financial and economic crisis (Gerard and Ruf, 2001). When remittances from migrants decline, and many who lose their jobs return to the rural economy, agriculture becomes the mainstay of the rural economy. The burden, without government support or any risk coverage, falls on the rural economy, particularly on rural women (Nathan and Kelkar, 1999; Cook et al., 2003). Despite the existence of useful models of social security nets or investments by the State, rural Asia is likely to be lacking in these kinds of investments, because the pressure for other productive investments will outrun the demand for these in the near future. The Indian National Rural Employment Guarantee Act (NREGA - which provides a minimum assurance of up to 100 person-days of employment per household), the

Chinese continued ownership of land under the household responsibility system, and the Bangladeshi micro-credit systems (where NGOs, with financing support from the financing authorities, reschedule loan repayments, provide new loans and often undertake relief measures) play the role of safety net. With privatization of health and education services continuing at the current pace, there will be a large gap between these minimum incomes and what is needed to meet the social needs of Asia's impoverished rural populations (Ahmed, et al 1991). In parts of Asia, chronic poverty and the lack of safety nets drives people to organize around paths of violence.

The ESAP region is a hotbed of political crises of various sorts – largely domestic (ranging from secessionist parties, naxalite movements, terrorism – domestic and cross-border, communal tensions, totalitarian regimes, and anti-democratic legislations), in countries ranging from Sri Lanka, India, Nepal, Thailand, Bangladesh, Myanmar, East Timor, China, Viet Nam, Indonesia, Papua New Guinea, and some other Pacific countries. Political instability caused by such forces will reduce and even disable trade in agricultural goods and discourage learning and technology dissemination in these regions. It must be noted that there is significant cross-border trade and regular economic activities occurring all along a soft and self-negotiated border, among people living in different (political) nations but similar agroecological terrains. The soft borders and people negotiating these borders especially for exchange of agricultural produce or other rural goods in India's North-Eastern states, contributes to increasing economic prosperity and sharing of ecological and cultural resources (see Baruah, 2005; Hazarika, 2000). An important political message from these fungible border zones across countries in the ESAP region, is for nation states to recognize that people and their fundamental rights and access to regional or local natural resources and cultural activities can in future, be nurtured as a major instrument of peace in the ESAP region.

In the coming decades, a strengthening India-ASEAN relationship may add to political stability in the region in a wider sense. This depends on India's capacity to generate economic growth within its borders, and on its capability to enhance national resilience of ASEAN's regional member states, and thereby to promote regional resilience (Prasad, 2006). Politically, the view is that in the ESAP region, India will play a much greater role in ensuring regional integration, promoting relationships in the ESAP region with global powers (e.g., the USA) and allaying member country fears about Chinese expansion and potential control over their own markets (Tammen, 2006).

Political parties like the Chinese Communist Party are keen on improving the image of China in an increasingly globalizing world. The political agenda is to make sure that domestic development is endogenously driven, will enhance transparency in decision-making, and will combat corruption at all levels (Economic Daily, 2007). An important commitment for the future will be that the country will adhere to peace and peaceful processes for development in the region. Indian political parties – irrespective of their ideological differences, are all committed to (a) peace and friendly neighborhood relationships (b) industrialization as the mainstay of economic growth in future, (c) rural regeneration, and (d) infrastructure and energy investments. However, political strategies toward regional cooperation (especially in trade and labor mobility), domestic policies for poverty alleviation, health and education services, and rural industrialization, will depend significantly on whether the moderate and secular political parties or the right wing parties are in power in future. Political stability in the ESAP region will also be significantly affected by the power play between the USA and China as well as US interests and its allies' interests in the region (Christensen, 2007).

The impact of political stability on agriculture and AKST will mainly be in terms of enabling investments in cross-border infrastructure or natural resource management (such as water ways, mountain ecosystems, roads etc.). These are likely to bring long term improvements in the livelihoods, market opportunities and economic growth for people in these political border-lands in ESAP. Increasingly, the ESAP countries will realize that it is the capacity of public organizations to respond to the voices of the poor, provide social security where it is lacking, and engage constantly with emerging threats to impoverished rural livelihoods, that will lead to political stability and economic growth.

4.2.4.3 Deregulation

Deregulation has been attempted in many ESAP countries such as India, China, Thailand, and Indonesia, and developed ESAP countries (Australia, New Zealand and Japan) have taken the lead. While the impact of fiscal reform on AKST may not be direct, it is important to see that countries that have made structural changes have attracted a significant amount of private investment in AKST – especially in food processing and retailing, biotechnology, and specialized product development like organic agriculture.

Overall, the macro-economic policy reforms in South Asia began by liberalizing trade which had thus far been restrictive. The current scenario promises that this trend will continue well into the future – implementation focusing on deregulation and privatization (Kemal, 2007). The degree of openness in the economy will continue to be high in Sri Lanka – and India will be the most closed (relatively) for some time to come (World Development Report, 2006). This is however to be expected until employment growth rates match the growth rates of the economy; unemployment in an economy that is increasingly deregulated will remain a major concern for the Government.

In India, many argue that deregulation with trade liberalization, spells doom for the agricultural sector (Ghosh, 2005; Patnaik, 2005). Specifically for AKST, deregulation will imply that poor farmers will increasingly lack the resources to buy essential inputs, access relevant S&T inputs and information, participate in crucial export-market driven agricultural developments, and all these may lead to overall increase in hunger and poverty among the already poor in rural areas. Given the growth and diversification patterns in Indian and Chinese manufacturing and trade (including domestic trade) it appears that the apprehension that import liberalization might lead to a large-scale demise of domestic industries, is unwarranted (Mani, 2005; Veeramani, 2007) Domestic industry in the Asian region has been able to and will continue to compete and survive by specialization in narrow product lines (Veeramani, 2007).

There is a likelihood of increasing concentration of agricultural input and output actors with a few multinationals converging to control a major share of the global agricultural markets. Given the rate of growth of supermarkets and the increasing openness in Asian economies to FDI in food retailing, it is estimated that by 2010 there will be only 10 major global retailers of food (Vorley, 2001; Reardon et al., 2003). All food grain trade in the region will be controlled by a few major trans-nationals like Cargill, ADM (Archer Daniel Midlands), Conagra, Monsanto, Nestle and Atria (who now control over 90% of global foodgrain trade (Shrivastava, 2006). Cargill will steadily increase its investments in the oilseeds and edible oils market, and it promises to increase its share in the Asian vegetable oil market in the future.

Implications for the agriculture sector arising from increasing deregulation of the economy include massive growth of private investment in agri-business, especially in commodity markets and retail trade, and increasing standardization of agricultural produce from the region. What this implies for the diversity of food systems in Asia is not known yet, though it is likely that some provisions such as 'geographical indicators' may enable development of a market niche for select agricultural products like basmati rice, jasmine tea, or tussar silk. A direct positive impact of deregulation will be in increasing the linkages of the agricultural sector with other manufacturing and service sectors, thus expanding resources and facilities for growth.

4.2.4.4 Infrastructure

Infrastructure constraints affect economic growth in the ESAP region. If economic growth is considered important and is held as a key to poverty reduction, then all the ESAP countries will invest heavily in infrastructure provision and improvements. Currently there is a major gap between levels of infrastructure investments and access to basic infrastructure between the East Asian economies and South Asian economies. Significant improvements in infrastructure investments can add up to 0.85% per annum to economic growth in China (2005-2014), 0.80% in

Indonesia, 1.32% in India, and 0.45% in Bangladesh (Lanchovichina and Kacker, 2005). It is estimated that the Asian economies will have to invest at least 6.5 to 7% of their GDP on infrastructure provision during 2005-2010, without which there will be increasing infrastructure constraint to economic growth (Fay and Yeppes, 2003; Jones, 2006). Currently only China and Viet Nam seem to be investing at these rates. Countries like India, Indonesia and Philippines have fallen behind their own target investment levels, with the marginal increase in private capital investment in infrastructure not compensating for the decline in public investment over the 1990s and early 2000s (Jones, 2006). In all these economies, the overall macroeconomic orientation seems to follow the trend from the 1990s, with increasing FDI in infrastructure development, more relaxed norms and less formal approval regimes, special incentives for technological improvements or export oriented units (in industrial investments) encouraging private infrastructure investments.

Liberalization has had a direct impact on infrastructure development in the ESAP region. Investment levels have been high since the early 1990s in the entire region, with countries investing an average of 30% of GDP in various investments, with much of this (ranging from about 1-14%) share going into infrastructure development (World Bank, 2006c). The growth of rural infrastructure, especially rural roads, has been shown to have a positive impact on the growth of private extension in South India, electronic commerce and crop advisory services in the Deccan Plateau states of Andhra Pradesh, Maharashtra and Karnataka (Dhan Foundation, 2005; Prahlad, 2005). Another key infrastructural investment is in the water and sanitation front, creating immense opportunities for services and achievement of the broader MDGs (Farrington, 2006).

A major development that will transform infrastructure and development opportunities across Asia has been in the recent Intergovernmental Agreement on the Asian Highway Network (adopted in 2005) and the Intergovernmental Agreement on the Trans-Asian Railways (see www.unescap.org). These UNESCAP-led pan Asian infrastructure investments will lead to direct road access across South-East-Central and West-Asian countries and will also provide a land link to Europe, as well as dry ports which can consolidate and distribute produce, create employment locally, and provide port access to some of the hinterland production centers – especially in transporting perishable or delicate products. Besides, these projects will enable overall infrastructural improvements with shared technical standards across countries and sharing or collaboration with financial organizations.

Much of the infrastructural investments, however, continue to take place in urban or peri-urban areas and coastal China, metropolitan areas in Thailand, Indonesia, Viet Nam and India, leaving rural infrastructure relatively unattended (World Bank, 2006a). Urbanization is a major driver of infrastructure- with the likelihood of 50% of the East Asian population being urban in 2025, and 40% of this urban population likely to be poor (in 2025), there is an urgent need for public sector investment in urban infrastructure and delivery of essential services (piped water, electricity, communication, roads etc.) (Jones, 2006). The ESAP region also reveals a wide disparity in basic needs infrastructure such as water supply and sanitation – ranging from 93% access to rural sanitation in Thailand to 13% in rural Solomon Islands (World Bank, 2005). On average the investment in and access to basic infrastructure for water and sanitation is marginally better in East Asia and Pacific countries compared to South Asia. The South Asian countries are likely to invest more in infrastructure provision – especially in energy and energy trade across the border (Jones, 2006).

The growth of infrastructure, especially massive rates of growth of investments in urban or peri-urban areas promises little for rural areas and agriculture, where the lack of infrastructure will continue to be a major hurdle for further growth in yield, incomes and overall development. Private investment may always find it attractive to invest in areas of quick and assured returns – something that agriculture does not promise in the ESAP region. The increase in urban infrastructure may also pose increasing demands on agriculture which may add to the existing livelihoods and income opportunities for a rural population in ESAP. In South Asia which is already starved of essential water and sanitation services, the demand on rural environmental services due to rising urban infrastructure investments may become untenable. For AKST, private infrastructure investments are likely to add to private agricultural R&D investments and commercialization of technology in general.

4.2.4.5 Regional cooperation

Regional cooperation in infrastructure and service delivery is bound to increase in the near future all through the ESAP region. Investment in water and sanitation programs in many countries, including some small countries like Nepal and Sri Lanka seems to playing an important role in strengthening local democracy, by bringing people’s participation in the delivery and monitoring of water services. While increasing tensions over water along international borders seems to be a feature in all the ESAP border regions, there are several regional networks and cooperation agreements being confirmed or implemented. Despite increasing conflicts and contrariness in Government behaviour around key river basins – the Ganges, Brahmaputra, Mekong, Indus etc., the platforms for negotiation such as the Indus River Treaty, Ganges Water Treaty, or the Mekong River Commission have worked well and have the potential to evolve and expand into further infrastructure arenas as well as pro-active regional cooperation platforms. While the SAARC, APEC, BIMSTEC, and ASEAN are examples of regional cooperation, the Greater

Mekong Sub-region (initiated and facilitated by ADB) is an institutional innovation in international cooperation especially in infrastructure development and benefit sharing. The unique features of the GMS are its geography (with each country sharing at least three border areas), its economics (bordered by China and Thailand – both dynamic economies), the sponsorship (ADB playing the neutral facilitator and sponsor) and budget (ADB – from national allocations). The countries can opt into a '6 – x' agreement or choose not to enter the agreement/investment (Jones, 2006). Other regional cooperation initiatives that have emerged in this pattern and are expected to enhance agricultural trade are: the South-Asia sub-regional Economic Cooperation, and the Central and South Asia Trade and Transport Forum. In sectors like fisheries marked by heated conflicts within countries and between countries sharing seas/coastlines, regional cooperation and active academia-Government interactions with a wide range of stakeholders along with experiments with several institutional and policy options are emerging (Salayo et al., 2006; Gupta, 2006).

Regional cooperation in Asia has thus far focused on trade and economic cooperation, peace and security, and "less on deeper aspects of integration" (WCSDG, 2004). The SAARC regional cooperation is wanting in several key areas of cooperation not for limited investments or opportunities but because of a lack of political commitment – this must change bringing in a new 'social charter' for regional cooperation, addressing poverty and injustice, growing inequality, social disparity and environmental security in the region (Najam, 2005; Sobhan, 2005). However, recent developments in ASEAN point toward a move to deepening of regional integration over the coming decade (Sobhan, 2005). It is important to recall here that monetary cooperation among Asian countries increased substantially after the Asian financial crisis of 1997/98.

The tension between the two developed economies (Japan and Australia) in the ESAP region and their differing views on and expectations from Chinese economic growth is likely to increase in future. Cooperation in monitoring financial health of the Asia Pacific economies includes arrangements such as the Manila Framework Group and the ASEAN surveillance group. Most importantly the discussion on an Asian Monetary Fund has evolved (with Japanese initiation) in Chiang Mai, Thailand, into two liquidity funds – the ASEAN Swap Arrangement and the Bilateral Swap Arrangement. The Japanese and Australian economies have also contributed to setting up the Pacific Economic Cooperation Council, the Asia Pacific Economic Cooperation (APEC) etc. over the past thirty years (since the signing of the NARA treaty in 1976), which have become more meaningful since the financial crisis of the 1990s.

The ESAP region on one side has Japan with its mistrust of the Chinese growth and on the other side, Australia and its expectations of access to Chinese markets and mobilizing investments from China, both of which will continue to increase (Terada, 2006). Both as emerging industrial powerhouses and major investment markets, both Indian and Chinese growth patterns are likely to influence regional cooperation and rivalries.

It is also likely that trade and economic cooperation among countries of two regions (LAC and ESAP) will increase at the cost of ESAP-EU or ESAP-USA cooperation, with consequences like a domination of China in the Asian region, which may undermine US foreign policy in the region (Tammen, 2006). The call from the EU seeking ASEAN investors to invest in the new EU member States is an example of negotiating stakes for ASEAN in the EU (bilaterals.org, 2007). In today's hierarchy, the U.S. dominance is unchallenged, but U.S. preeminence is declining in relative terms, and will in two to four decades eventually dissipate (Tammen, 2006).

It is predicted that smaller trading groups will bring in much greater intra-group gains, though globally their share may not gain much. For instance, the predictions for increasing SAARC trade are:

- First, complete elimination of tariffs will increase intraregional trade by 1.6 times the existing levels. The volume of intra SAARC trade will increase from the present figure of US $5 billion to around 14 billion in 2015. As overall trade also increases, this does not necessarily represent an increase in the ratio of inter-SAARC trade to total trade by SAARC members.
- Second, dynamic gains are 25% more than static gains.
- Third, smaller member countries tend to gain relatively more than larger ones. The latter is stated as an empirical argument, but it is a theoretical one as well, and is borne out by the experiences of other FTAs elsewhere in the world (SFG, 2005).

Globalization and increasing intra-regional trade have played a significant role in enhancing regional cooperation in two sub-regions of the world – Latin American and Caribbean region and the Asia-Pacific region, as regions that have immense opportunity for development and also as regions that are late comers into the processes and institutions of globalized economies (Monata, 2006; Nayyar, 2006). This tendency of increasing trade relationships and regional cooperation between Asia and Latin America are likely to increase in the near future. Chinese investments and Chinese and Indian cooperation with African countries is another trend that will increase significantly in the near future, bringing the ESAP region the status of preferred development partner for the African countries. Chinese overseas investments are expected to grow to US $60 billion in 2010-2015 (GIBS, 2006).

Overall, regional cooperation presents a positive scenario for agriculture for all of ESAP. There are some major benefits of increasing environmental and agricultural and food security arising from regional cooperation, which are likely to redress the negative impacts of increasing pressures of globalization on small farmers, rural women, and other marginal production systems like coastal fisheries. There are issues of regional power politics and aggression –especially involving the big players in the region like China, India, Australia and Japan - that could turn the tide into extremely low levels of regional cooperation and a consequent decline in potential benefits for agriculture.

4.2.4.6 Agricultural trade

Trade in agriculture and allied products, has grown significantly in the region during the period 1991-2004 (FAO, 2006a). The ESAP region as a whole will continue to be a net importer of agricultural products (including forestry and fisheries). Current trends in net surplus production and trade surplus in sub-regions such as S.E Asia and the Pacific islands are likely to continue into the future (FAO, 2006a). South Asia and the developed Asian economies, particularly Japan and Singapore, will continue to be net agricultural trade deficit sub-regions. Many of the developing economies are likely to expend less of their foreign exchange reserves on import of cereals/other agricultural commodities, thus revealing relatively stronger agricultural trade positions. The impact of AKST on agricultural trade is evident in the fact that in the ESAP countries today (2002-2004), food/agricultural imports especially cereal imports account for less than 10% of foreign exchange reserves, compared to 1969-71, when cereal imports was to the tune of 40% to 120% of foreign exchange reserve in some countries (FAO, 2006a). For most ESAP countries therefore, the question of agricultural trade will continue to be tied to the issue of food security. After or if and when WTO regulations on domestic subsidies in agriculture are accepted or enforced, some of the current agricultural exporters may become importers – both of food and of labour to cultivate the food. The strength and resilience of multilateral treaties and multilateral organizations, as well as domestic policies to maintain economic growth and social justice will be tested in the context of agricultural trade in the ESAP region during the period 2010 -2020.

The current trend however is towards Preferential Trade Agreements (PTAs). Besides the overall economic growth, both India and China have increased their share in global trade and in various bilateral agreements and PTAs within the ESAP region. SAARC, SAFTA, PICTA and several other bilateral agreements have added to the flow of goods –especially agricultural and manufactured goods within the ESAP region. This trend is expected to continue well into the next two decades, taking the cue from China's growth in trade (accounting for 9% of the global increase in exports and 8% of the global increase in imports during the period 1995-2004), which compares favorably to India's (accounting for 2% of increase in global exports and imports during the period) (FAO, 2006b; World Bank, 2006a).

The ASEAN + 4 (including China, Korea, Japan and India) promises to be a powerful alignment for agricultural trade and economic development, with increasing intra-block trade share of each of these economies (+4), especially over the period 1995-2003 (Batra, 2006). In 2003, the intra-block trade for ASEAN+4 was 44% of the total value of trade in these countries; which is significantly higher than the intra-block trade in any other PTAs (such as NAFTA or Mercusor (Batra, 2006). The sharp decline in tariffs and non-tariff barriers has been a major factor that fuelled this intra-regional trade. Some protection afforded to selected commodities are often negotiated among members, especially among bilateral/preferential trade agreements – like palm oil (Malaysia), rubber (Thailand), fruits and vegetables (Thailand, China), sugarcane, wheat, oil seeds (India), etc.

One of the greatest fears in most ESAP economies is that farmers' distress will increase with increasing imports of critical crops and with removal of tariff barriers. It is evident that with globalization the domestic and international policies that govern the barriers to economic opportunity for the poor will change (Bardhan et al., 2006). The key question is whether a responsible public sector in the Asia-Pacific countries and human centric regional cooperation will help the rural poor and small farmers tide over the initial crisis and provide investments and incentives to better economic opportunities.

The environment is an area that promises widespread and well-negotiated regional and sub-regional collaboration in the ESAP region, following increases in agricultural trade. This is crucial in the Pacific region: the major trade and economic cooperation agreements, environmental, biodiversity and ethnic factors legitimize the need for sub-regional cooperation in ensuring sustainable development – especially for poor people in small island Pacific countries (UNESCAP, 2006). The Pacific countries are likely to face the greatest threat from global warming and climate change, with potentially disastrous consequences to natural and human life, and an end to any advantages in agricultural trade (See 4.2.8). The success of agricultural trade and its translation into sustainable economic development depends crucially on how individual Governments handle social security for the rural and urban poor who will face a crisis in production and consumption, and how the tradeoffs between agricultural production for trade and environmental costs are addressed, in the wake of increasing input prices and decreasing real prices of agricultural commodities.

4.2.4.7 NGOs and civil society

The ESAP region is perhaps second only to the LAC region in terms of intensity of NGOs and their articulation capacity of a wide range of issues that are of importance to or will shape social issues in the future. What originated as voluntary work in the immediate post-independence decades (1960s and 1970s) in the Asian countries, soon became organized non-government organizations (NGOs) (Tandon, 2000). Starting as small trusts and locally based civil society groups, they have taken on different organizational formats: the Asia Pacific Research Network (APRN) for instance is a collection of 37 member organizations, and has a mandate to exchange information on local and international issues that shape society in the region. These organizations are slated to grow into international and multilateral organizations in the near future; the World Social Forum paving a precedent already. Increasingly there is a trend among NGOs in the region to focus on efforts to build an Asia-Pacific community (Yamamoto et al, 1995).

From being the effective or people friendly implementation arm and partner of the State in development programs, the NGO sector in Asia will increasingly partner with several actors in arenas as diverse as agriculture, health, population, gender and empowerment, urban planning, water management, micro-credit, and insurance. A relatively new path that the NGOs are treading now, promises to grow into a powerful driver of change in the ESAP region; this is as partners of corporate sector and in leading the environmental movement in Asia (Yamamoto and Ashizawa, 1999; Korten, 1997; Barkenbus, 2001). There are also civil society networks that work towards building effective working relationships among countries. The South Asian Perspectives Network Association (SAPNA) is a prime example, pointing out future directions in development policies in the South Asian countries (Wignaraja, 2005). A key argument here is that South Asian countries will need a new praxis and management of knowledge systems in order to address their demand for development with equity. An emerging trend that promises to grow in the Asia-Pacific region is that of NGO involvement in and innovation in non-formal education (NFE) (UNESCO, 2003). Advances in NFE and NGO leadership in empowering local people (for example NFE and access to credit in Korean villages, functional literacy in rural China/Bangladesh etc.) have major implications for pluralistic agricultural extension practice and AKST in general (UNESCO, 2005; Sulaiman and Hall, 2005).

The Asia-Pacific NGOs however, have not really partnered with science – agricultural science in particular - in learning for, planning and implementing knowledge-based agricultural development. Mainly, their role in agricultural science and technology has been limited to technology dissemination. Though there are cases where NGOs have helped science to learn about local contexts, generate new/modified technologies, and find new ways of working, these are rarely acknowledged by formal public sector agricultural science (Rhoades, 2000). The trend of NGOs in this region to partner with research and non-research actors in the agricultural innovation system may be strengthened in the coming decades (Hall et al, 2004). While the NGO arm of corporate social responsibility is appreciated widely and is even considered an essential partnership as a check on unhindered exploitation and profiteering, there is increasing concern that NGOs funded by/co-opted by corporate sector may loose their capacity to articulate social and ethical issues in development when corporate strategies become forgetful of/ignore such implications.

Overall, the social and political drivers of change present a mixed bag of positive and negative impacts on the future of agriculture in ESAP. For AKST, while increasing investments and learning opportunities emerge from more social interactions and political changes, it is likely that many of these investments may be private sector investments in AKST given that public resources may be increasingly diverted to social security nets or other essential infrastructure investments. Social and political drivers also portend a change in the nature regional cooperation and the nature of actors who will ensure that AKST continues to generate useful technologies and that these technologies are accessible to and utilized by all segments of the farming communities and other rural producers. These new actors with new social and scientific skills will be from the private sector and NGOs, and therefore the importance of public sector AKST (constituting a large component of AKST in ESAP) must equip itself with increasing capacities to partner with these new actors and their demands.

4.2.5 Education, culture, ethics and health

Important social drivers like access to education and health, cultural norms – their resilience as well as their capacity for modernization and global human rights and value systems, can shape future AKST in the region. This occurs primarily through bringing more educated and healthy people to generate and utilize knowledge in the agricultural sector; and also to absorb global advances in S&T into local cultures or adapt local habits and practices, perceptions of risk, etc. to accept modern technologies or ways of working.

Standards of living in 2050 are expected to decline or reveal a negative trend in response to demographic transition, in countries such as New Zealand, Singapore, Japan and Australia, which are already experiencing a demographic transition to increasingly ageing populations (Ross, 2006). Whereas in countries such as Malaysia, Indonesia, and Philippines with a relatively young population now, the impending demographic transition (combined with appropriate saving responses) are likely to have massive positive impacts on standards of living for at least 50 years or more (Ross,2006).

4.2.5.1 Employment

Employment opportunities are also closely related to overall demographic composition and location; the ESAP population being predominantly urban and engaged in service or manufacturing activities by the 2030s. A decreasing share of the economic pie coming from the agriculture sector (World Bank, 2007), also reflects the changing and increasing skill base and employment opportunities in other sectors, to absorb the disguised rural unemployment/ surplus agricultural labor force (4.2.1).

A significant impact of the demographic profile of each country is evident in the estimates available for growth in labor force in the region. Asia's labor force will increase by 14% or by 245 million by 2015 compared to 2005. Though China will contribute to this labor force increase, the share of China in the increase will be rather limited – because of its internal fertility rate and population growth rate. By 2015 China will add a 7% additional labor to its current labor force. The corresponding figures for Bangladesh (25%) and Philippines (24%) are far higher.(ADB, 2005). Labor force participation rates will tend to lower in the South Asian region compared to East Asia and Pacific countries. Yet, the developing countries of the region will reap a 'demographic dividend" with the share of the young working population increasing (except in the developed ESAP countries and some like Sri Lanka or Thailand), and adding to the national income (ADB, 2005). This will nevertheless depend on the education and other opportunities for employment (including infrastructure and capital investments) that these ESAP countries will make to employ this young labor force.

Policies that will have the highest impact on full and productive employment in the ESAP region are growth-promoting policies (ADB, 2005). They are mainly:

1. policies to improve incomes in the rural economy and urban non-formal sector
2. policies to shift productivity gains into higher real wages and aggregate demand – such as – export push based not on low wages but on increased productivity, and
3. industrial policy, with government playing a major role in co-coordinating and monitoring industry.

Increasing economic liberalization and reduction in tariff rates in future (beginning with 2010) does cause concern about the demise of the domestic industry and widespread unemployment in the manufacturing sector in the Asian countries. But given the likely evolution of specialization in industry (as the driver of growth), there will not be any worker displacement/redundancy; with specialization, workers will move within industry rather than between them or out (Veeramani, 2007). But employment opportunities and incomes are likely to be highly differentiated in rural areas – with globally competitive farm entrepreneurs (Rural World 1) standing to gain at the cost of the falling fortunes of family farmers (Rural World 2) and the struggle for survival of the poor peasants and laborers (Rural World 3) (Pimbert et al., 2001). There will be increasing demand for labor/employment policies to ensure that different segments of the rural population can survive the pressures of globalized agricultural and food systems.

4.2.5.2 Education

Education, especially access to primary and secondary education is and will continue to enable the increasing migration of rural educated youth to urban or rural non-farm sector employment (IFAD, 2001; ADB, 2004). The linkages between demographic changes – fertility rate in particular and economic growth and education is most striking in the ways in which decline in fertility rates allows increased participation of women in the workforce. China for instance, faces the problem of gender disparity in education levels as well as in the corresponding opportunities for women in the labor market (Hussain et al., 2006; World Bank, 2007). This is a significant issue that the country will have to tackle since China has the highest female labor force participation in the world.

Gender and urban biases in education (see IFAD, 2001; ADB, 2004; UNESCO, 2006) will continue to be major problems in achieving the targets set for poverty reduction and better rural livelihoods in the Asia-Pacific region. Though gender gaps in primary education have been reduced in several countries, there is significant gender bias in secondary and higher education, as well as employment opportunities for women; and these are likely to grow in future unless addressed in focused and perhaps regional manner (IFAD, 2001; Fennel, 2006). Agricultural education investments are likely to decline in the formal University/Agricultural University set up (Byerlee and Echeverria, 2002). But investments in private and public sector higher education and research as well as investments in the form of Farmer Field Schools, training programs at various levels of participatory research and extension, and also most importantly in the form of functional education and non-formal education for sustainable development, are likely to increase in all the ASEAN, APEC, and SAARC countries (UNESCO, 2006). Investment in informal education in the Asia Pacific region is increasingly seen by donor agencies and governments, as a mechanism for (a) enhancing skills and capacities for better livelihoods and incomes, (b) enabling employment opportunities- especially non-farm rural employment, (c) reducing the gender bias and thereby poverty in rural areas and in agriculture, (d) increasing capacities for technology uptake – especially through functional education (IFPRI, 1995; Ooi, 2001; UNESCO, 2006) (Box 4-2).

Box 4-2. Points for future investment in human resources in Asia-Pacific region.

It is commonly agreed that formal education to improve literacy and numeracy improve farm productivity, since such skills increase the sources from which farmers may obtain information.

However, the consequences of higher education lead into the issue of rural to urban migration. Ironically, this means that policies targeting improved farm productivity through education may actually also instigate human capital outflow to off-farm employment. Contrary to current concern about labor availability in agriculture, this shift of skilled manpower to other sectors will be increasingly seen as a source of growth – opportunities for manufacturing sector growth.

In all these attempts, learning about local contexts, constraints in and opportunities for education that exist in rural areas in the ESAP region, does not emerge as an important issue. It is however, known that several gaps in our knowledge about food systems have to be addressed to ensure democratic and environmentally sustainable food systems in the future (Pimbert et al., 2001). The emerging argument being that AKST organizations are increasingly acknowledging their need to educate themselves about diverse contexts and their implications for S&T.

The trend to understand local knowledge systems and their role in shaping or utilizing the outputs of AKST will be strengthened in the ESAP region. Unfortunately democratic participation of the relevant actors/rural poor in shaping formal S&T systems will not be realized in the near future in ESAP countries. These trends of conducting farmer participatory research after the technologies have been proven in lab/station level trials, and of seeing farmers as tail end adopters of technologies, will continue for at least another couple of decades (if not more) despite social science research that has demanded different approaches to learning, technology generation and utilization (Fujisaka, 1994; Biggs and Matsaert, 2004; Hall et al., 2004; Biggs 2006). The basic problem within AKST, of poor social sciences limited to agricultural economics, with little or no inclusion of basic disciplines like anthropology to understand local contexts and enable poverty relevant science, may continue well into the 2020s in the ESAP region unless challenged by dynamic developments which the social sciences are compelled to study (Cernea, 1991; Raina, 2005).

4.2.5.3 Indigenous knowledge

There is evidence to show that basic education helps when farmers make the transition from traditional to modern agricultural practices. But the AKST actors – public sector R&D organizations, private firms and private R&D, NGOs/CSOs, policy makers and donors have made little attempts to explain these education-led changes in AKST uptake other than the usual technology adoption studies. Though AKST has made few attempts to validate or incorporate indigenous knowledge into knowledge systems useful for locally adapted agricultural and food systems, there is increasing interest among formal scientists to understand indigenous knowledge and use it for agricultural/rural development (Rajashekharan, 1993; Joshi, 1997; Talawar and Rhoades, 1998; Rhoades, 2000). Given rapid urbanization, corporatization of agriculture, this is a trend that will prevail in the region for at least 10-15 years. Note that indigenous knowledge, agroecological approaches to understanding and scientifically validating indigenous knowledge have been much analyzed and discussed topics for over twenty years now.(See Chapter 2). In the ESAP region many donor agencies and national governments will continue to support research for a better understanding of and integration of indigenous knowledge with modern scientific knowledge or ways of cultivation (see KIT, the Netherlands, DFID, U.K., GTZ, Berlin, Aga Khan Foundation, New Delhi, USAID, Washington, etc.). Given the projections that the majority (48%) of the world's poor will live in South Asia by 2020 (ADB, 2005) and a majority of them will be people living in mountainous or remote rural areas, relying entirely on their indigenous knowledge systems, markets and other local institutions (IFAD, 2001; ADB, 2005), there is a current demand for devoting greater investment and R&D attention to these people their crops and livelihoods.

Several traditional knowledge systems have been revived in recent years in agriculture and allied knowledge, rural skills/crafts such as herbal medicine, ayurveda, traditional toys and games, etc. These traditional knowledge systems have important economic implications (bioprospecting, IPM, health care, fisheries, etc.) and thereby pose challenges to IPR and knowledge piracy often indulged by Western pharmaceuticals (Pushpangadan, 2000). The demand for investments in NFE, traditional health care, organic agriculture, IPM etc. will continue to grow, bringing opportunities to acknowledge, revive and provide entrepreneurial growth opportunities to repositories/practitioners of traditional knowledge.

The ESAP region is also acknowledging the role of indigenous knowledge, women and their traditional knowledge of agricultural and natural resource management practices, and rural community histories in enabling environment friendly, location specific agricultural development. The role of CSOs/NGOs in ensuring green development, a sustainable growth pattern in Asia is increasingly being pushed into the policy arena (Barkenbus, 2001). CSOs will also play an increasingly strategic role in the campaign for the right to food and human rights for marginalized and tribal peoples, for whom the pressures for survival will increase with increasing pressures of globalization. Consequently, the demands to 'de-globalize' and invest in building local capacities for sustainable agricultural and food systems that can feed the resource poor people of Asia will also increase. (see Tyler, 2006; Foodjustice.net, 2003– statement by NGOs in 14 Asian countries, five years after the World Food Summit).

4.2.5.4 Human and ecosystem health

By 2020, the ESAP region will be home to massive numbers of the poorest and under-/mal-nourished people in the world. There will be more malnourished children in South Asia than in

Sub-Saharan Africa (Rosegrant, et al., 2001) Besides, the region will also see unprecedented growth in industrialization and urbanization, with the urban population expected to increase by 352 million people between 2005-2015 (APP&P, 2002; UNESCAP, 2005). Municipalities in 2025 will face a ten fold increase in solid waste burden - the largest increases in urbanization have already occurred in China, Philippines, and Indonesia. (Bass and Steele, 2006; quoting Ramirez, 2005). Consumer demand in China alone is expected to rise in the next decade (ending 2015) to the tune of 4 USAs – this includes demand for cement, timber, coal and steel (Bass and Steele, 2006). The health of both human beings and ecosystems will depend on how this urban population is fed and provided all the goods and services it needs.

It is a necessity that the ESAP region invests heavily in environment friendly and socially and ethically just development. It is important to note that environmental technology business in Asia will reach over $212 billion by 2015 (ADB, 2006a). It is worth noting that Japan with the launch of the 3R initiative in March 2005, and China with its commitment of resources to renewable energy (highest in the world) have already given due policy attention to developing a “Resource Saving Society’ (UNESCAP, 2005). China has pledged to generate 15% of its energy from renewable energy sources by 2020 (up from the current level of 7%) (Bass and Steele, 2006). Besides national strategies, one of the key elements of regional cooperation will focus on engaging public and private sector in Asian economies to build capacity for generating and utilizing environmental technologies. Generation and sale of power to public and private players has already begun in Bhutan, with other neighboring states especially India benefiting. The ESAP region – especially Australia, New Zealand, Japan, China, India, and some of the bigger and faster growing economies now propose to collaborate with and help develop action plans for sustainable development in the Pacific countries – some of the smallest countries in the world inhabited by some of the oldest ethnic populations, with unique biogeographical features (the Melanesian, Polynesian and Micronesian regions) (UNESCAP, 2005).

Despite lack of quantitative data, it is clear that land-improving investments are creating a number of “bright spots” in the developing world (Lele, 2006; Scherr and Yadav, 1997). Investments to prevent land degradation will lead to further rehabilitation of people and ecosystems in the ESAP region throughout the next couple of decades. Besides investments in organic agriculture, diversification into higher value perennial crops (in all ESAP countries), conservation farming (in Thailand, Philippines and other East Asian countries, also promoted actively by the CG centers like IRRI and CIMMYT through their Rice-Wheat Consortium across the five countries in the Indo-Gangetic Plains), water management (in all ESAP countries), agroforestry (in India, China, Thailand, and some East Asian and Pacific countries), resource conserving and pro-poor mechanization (by NAEF in Nepal), favorable property rights (Cambodia, Laos, Vietnam), and several community based NRM projects (in almost all ESAP countries) are on-going and will increase in scope and scale in the near future. (Scherr and Yadav, 1997; Seth et al, 2003).

A sector that has immense human health and ecosystem health/sustainability implications is the fisheries sector in the ESAP region. The sector has been experiencing a biological decline directly due to over-fishing, spread of virus in shrimp industry and other diseases. Conflict resolution among countries sharing the seas in the region, between poor fishing villages along the coast and the massive fishing industry (large gear operators) financed by global or domestic capital is now a major concern in the South Asian and South East Asian countries (Salayo et al 2006). Many international instruments such as the Code of Conduct for Responsible Fisheries of the FAO, the World Summit on Sustainable Development, and the International Plan of Action for the Management of Fishing Capacity, have all addressed these issues, specifically prescribing codes for safe-guarding the right to livelihoods for millions of fisherfolk and the critical issue of building and maintaining ecosystem health.

Human ecosystems are increasingly polluted – both air and water pollution being very high in some cities in Asia. In China, it is estimated that by 2025 pollution may reach intolerable levels; already 8 of the ten most polluted cities in the world is in China, accounting for a loss of about 3-6 million life years (Bass and Steele, 2006). In terms of agriculture, air pollution is likely to pose severe constraints to production and productivity gains (Marshall et al, 1997). By 2020, Asian emissions of SO2, NOx and NH3 will be equal to or greater than the combined emissions from Europe and North America (Galloway, 1995). Crop production adds to the N-load in the environment largely due to increased use of fertilizers. A prediction for 2020, using a Nitrogen balance model for east-Asian countries reveals that the N-load due to food production-consumption and energy production will increase by 1.3 to 1.6 times the current (2002) load (Shindo et al, 2006). The trend of high N concentrations in ground water in eastern and northern China and the Republic of Korea and Japan, will continue. It is predicted that N-pollution in the form of NH3, due to fertilizer use and domestic animal wastes from China will outrun the US N-emissions and environmental accumulation levels by 2020 (Galloway et al, 1996). The anthropogenic reactive nitrogen of Asia, most of which is accumulated in the environment, will dramatically increase from current levels of about 67.7 Tg N yr^{-1} in 2000 to 105.3 Tg N yr^{-1} by 2030 (Zheng et al, 2002).

Along with increasing demand for food and energy supplies, Asia witnesses a pathetic absence of effective measures to improve the efficiency of fertilizer nitrogen use, as well as effective measures for the prevention of NOx emissions from fossil-fuel combustion. However, environmental N pollution may be finally solved “by substituting synthetic nitrogen fertilizers with new high-efficiency nitrogen sources, but solutions are dependent on advances in biological technology." In the meanwhile, it is widely recognized that there is a need for open communication on current knowledge and uncertainties, among all levels of Government, industry and consumers (Hansen, 2002).

The tradeoffs between trade liberalization and the environment and poverty caused due to depleting natural resources are increasingly being recognized in Asia (UNEP, 2001). Generally, the economic benefits from trade liberalization are high, but the environment costs are high too. (see Chapter 3 and 4.2.4). In the ESAP region it will be increasingly important to have an assessment of the environmental and human livelihoods costs incurred for trade, and find ways of financing and technically supporting conservation measures to reverse the damage, along with compensation to affected livelihoods – say, small scale fisheries in response to depleting fish stocks due to deep sea trawling that destroys even fingerlings necessary for fish breeding and growth.

Many ESAP countries, desirous of conserving their agricultural biodiversity (plants and animals) attempt to comply with the Cartagena Protocol and CBD. While conservation responses range from mandatory assessment of the impact of all programs, technologies or development interventions on the biological resources and access of the major stakeholders (like farmers, herders, etc.) to these resources and natural environments in some countries, it extends to a ban on all genetically modified crops and organisms in others.

Increasing awareness of the erosion of genetic variability due to monoculture of major cereals and selective breeding of crops and livestock, the increasing importance of bioprospecting and patenting for industrial and pharmaceutical applications, and the inherent value of indigenous and traditional knowledge systems, will lead to increasing investment and legal assurances in conservation of biodiversity. To enhance local involvement and incentives to conserve agricultural biodiversity, governments, corporate sector and CSOs may encourage learning platforms as active repositories of indigenous practices of seed storage, cultivation and conservation. Alternative cultivation systems like ecological agriculture and ecotourism around the theme of genetic wealth, that recognize the relevance of these gene pools in local ecosystems and application in local diets/cultures may also be explored.

A key dimension of environmental decision-making is the costs involved – often directly translated into closure, relocation or rehabilitation of polluting industry and its workers. In agriculture, the tradeoff between environmental costs and the costs of laying-off land or entire production systems, are very high, complex, and involve millions of households that live entirely on agriculture. Many countries with shared resources will increasingly feel threatened by environmental security issues, adding to political tensions in ESAP (Nijam, 2005).

Many a resource conserving technology and production practice that is environment friendly stays unused for want of enabling institutional and policy arrangements (SaciWATERs, 2002; Raina and Sangar, 2004; Rhoades, 1999). The decisions made about the environment are also burdened by static assumptions and compartmentalized analyses. In a static sense, environmental regulations add to project cost. In a dynamic sense, if conventional waste products are also reused or captured within the production system, then there would not be an additional cost of disposal (Porter and van der Linde, 1995). On the contrary, total value of output would be larger. In a production system that involves synergies, decision-makers will have to look not at the single output/end product but at the range of joint outputs and their mutual dependencies. In such systems, it is predicted that the increase in productivity, can well cover for the increased costs in utilizing waste products in former production systems. Local value added in tea plantations can be much higher if the shade trees (silver oak being the most common one) are replaced by arhar (the red gram/ pigeon pea) which has a value in itself besides providing shade. Local employment opportunities – in rural areas is fairly high in environmental biotechnology – for instance production of bioplastics from agricultural wastes. There is significant opportunity for these industrial developments to start with local value addition or processing activities, involving a dynamic mutually beneficial environment-production relationship (Hatti-Kaul et al, 2007). These developments have major implications for multi-functional agricultural systems and AKST that caters to them.

AKST, being almost static, single commodity focused and weak in natural resource and social systems capacities, is not equipped in the near future, to handle such multiple products/functions, synergies and dynamic systems. For instance in the industrial agriculture (producing biofuel or bioplastics) and the pharmaceutical livestock farms (producing specific drugs – as isolates or as part of animal products), the entire chain of activities and relationships of supplies, finance, infrastructure, services etc. needed will have to be worked out – not by an individual scientist or even a research institute, but by a coalition of actors.

A major message here is that little is known about balancing the benefits and the pains of adjustment or change in farming practices and policies that will be essential to reduce sensitivity of the sector to pollution. Even less is known to enable better linkages between agriculture and other sectors of the economy, where environment-friendly production practices and waste reduction or utilization become built in synergies within the system.

Overall, the commitment in ESAP to invest in local capacities for development demands a convergence of policies and programs in education and employment. ESAP will need skills and competencies as well as a diversified basket of employment strategies, designed to meet the needs of globally competitive producers and small peasants and landless laborers. The region will also need knowledge and investment inputs to ensure that its tribal and indigenous knowledge systems are developed and utilized for environment-friendly development. Most of all, education in general and AKST in particular, has to consciously acquire the disciplinary and social competencies that are necessary to understand the tradeoffs between economic growth and the environment.

4.2.6 Science and technology

4.2.6.1 Research investment

There is little information or projections available for future investments in agricultural research in the ESAP region. Despite estimates of attractive rates of return to investments in agricultural research and several impact assessment studies, there is little available on possible trends/estimates of potential agricultural research investment in future. The determinants of agricultural research investment – especially in the public sector – seem not to respond to any of these conventional economic arguments/findings, and are influenced by a myriad of complex factors (World Bank, 2005; Tabor, et al., 1998). Rather, investments in agricultural R&D in the ESAP region seem to be arbitrary and entirely politically driven or to follow a precedent approach at best, like any other public bureaucracy. “The sheer complexity of agricultural development, especially the lack of obvious and standard approaches for investing in agriculture, has led to rather fickle support from international and national policy makers” (World Bank, 2005). Despite a recent resurgence in national/international policy realms and donor commitment to invest in agriculture, there is little attention being given to increasing investment in agricultural research.

It was argued that as part of a wider global phenomenon, the ESAP region faces and will continue to face a relative decline in the amount of public funding available for agricultural research and extension (Anderson and Purcell, 1996). However, within the ESAP region, the recent resurgence of public investment in agricultural research (accounting for 32.7% of global public agricultural research expenditures in 2000, compared to just 20% in 1981) is likely to continue. China and India together account for 31% of the public agricultural R&D investment (in 2000) in developing countries. They will also contribute hugely to future public agricultural R&D investment, the growth rates of public agricultural R&D investment having gained momentum from the late 1990s (Pardey et al, 2006). This revitalization of public R&D in investment in India and China is largely a result of government policies to revitalize public sector research and enable commercialization of agricultural technologies – especially increasing linkages with the private sector. In ESAP, Japan following severe cuts in public agricultural R&D, and Thailand will be the next largest investors in their domestic agricultural science. The decline in Japan's public sector commitment to agricultural R&D is more than compensated by its massive increase (in the 1990s) in private agricultural R&D investments, a trend that is likely to continue.

The developing countries will continue to expand their share in global public sector agricultural R&D investments. The ESAP region, mainly because of China and India, will have an increasing share of this developing country investment in formal public sector AKST (Pardey et al, 2006). But the increasing share of the developing countries (from 45.4% in 1981 to 55.7% in 2000), may mean that in future the developing countries cannot rely on technological spill-over from the rich countries or international research communities. It is argued that the S&T linkages between the rich and poor countries will get more attenuated as the funding in developed countries gets re-oriented from agricultural productivity to environmental impacts of agriculture, food quality, medical, energy and industrial applications of agriculture (Pardey et al, 2006). It is also argued that the productivity obsession to the neglect of other aspects of agricultural-environmental-social systems has been the bane of formal agricultural R&D in the developing countries (Roling and Wagemaker, 1998). Given the past record of Western science determined research in much of public sector R&D in developing countries, especially Asia, changing priorities in the West might be a positive turn in the funding patterns, bringing spillovers of knowledge that can enable better livelihoods for the rural poor and their environments in developing countries. Almost all formal AKST in ESAP is organized based on some Western – especially US model of agricultural research. Given the overview of social and political drivers and increasing opportunities for education in the ESAP region (though rural areas will still lag behind) there will be new private and NGO sector actors involved in AKST. Then, with a committed program of institutional reform, this shift in research interests and allocations between rich and poor countries can push Asian economies to invest more heavily, on environmental impact, food quality, gender sensitive technologies, and integrate more with research for non-farm rural employment, and such needs that are currently under-researched.

Internationally, and in the developed countries, the slow down in public spending has been more than compensated by increasing private funding of agricultural research. But the developing countries of the ESAP region have made little gains in private funding of agricultural research, though their share in total private sector R&D investment continues to be highest among the developing countries. Some estimates reveal that not much has changed since the finding that private sources fund less than 7% of total agricultural research spending in India, Bangladesh, Pakistan and Indonesia (Umali, 1992). Private investment in agricultural R&D is less than 10% of total agricultural R&D in the ESAP countries (Pray, 2002). More accurately, private investment in the region is only 8% of total investment in agricultural R&D (Pradey et al, 2006; CGIAR Science Council, 2005).

Private R&D in biotechnology has grown significantly in Asia (La Vina and Caleda, 2006; see Biospectrum various issues, APBioNet, Chaturvedi and Rao, 2004). In Asia, the magnitude of private sector presence in R&D will continue to be significantly different in different sectors, with health-biotech R&D (pharmaceuticals, vaccines and diagnostics research) being located largely in the private sector (both domestic and FDI led investments in R&D in MNC units in Asia). Private R&D in agricultural biotechnology in the near future, will be located largely within these MNCs (with strong product lines), with the strategy of buying up of all market-end firms/facilities showing up much stronger in ESAP countries where the MNCs have not yet bought up all the near market firms and near strategic research facilities. Much of the non-MNC private biotech R&D is funded by domestic public or international donor funds, fuelled by the promise of profits (La Vina and Caleda, 2006).

Contrary to conventional wisdom that private investment in agricultural research and extension will increase in Asia-Pacific countries and that the role of the Government is to focus investment on basic research, human capital and infrastructure and to provide an environment conducive to private research (Chang and Zepeda, 2001; Tabor et al., 1998), there is an increasing emphasis on the role of the government in research and other enabling investments in the agriculture sector (Byerlee and Echeverria, 2002; Hall et al., 2002; World Bank, 2006d). Much of private investment in agriculture –is currently in the industrialization and capitalization of the sector. Given the trends of increasing urbanization and expected growth of value-addition and food retailing in the ESAP region, private investments will continue to be made in the off-farm parts of the agricultural production and marketing chain, in seed, fertilizers, herbicides, machinery, processing, retail marketing, etc. where the private industry can deal with the knowledge outputs and the commercialization of these technologies or knowledge outputs.(Reardon et al, 2003). Increasingly, the argument for pro-poor agricultural/rural innovation is to look for complementary investments in other organizations besides public sector, national agricultural research systems (NARS), which can play a major role in enabling generation and utilization of knowledge (including technology) (Hall et al., 2004; Biggs, 2006; World Bank, 2006d).

This also reaffirms an interest in the NGOs or non-profit research entities investing in the agricultural sciences, with the current figure of 1% of the ESAP agricultural research investment being made by them likely to increase in future, as partnerships with public and private R&D increases. In India, for instance, there are organizations like MSSRF, MANAGE, MYRADA, CISED, Mitraniketan, BASIX, and several of the NGOs who host ICAR –KVKs (the extension units under the ICAR – called Krishi Vigyan Kendra). These NGOs are at the forefront of not-for-profit research in agricultural, horticultural and livestock systems. The demand for reform in the public sector agricultural research organizations is one of the factors that promote the role of NGOs or not-for-profit firms in agricultural research (Raina, 2003a).

Changes in dietary profiles in response to rapid urbanization, growth of incomes, and expansion of value-chains and food retail in ESAP, show that in 2020 the demand for livestock and dairy products, will be more than double the current level. While integrated crop-livestock systems and access to common property resources for herders and pastoralists may become crucial for poverty alleviation, there may be increasing investments in high-tech animal production systems. Much of this investment is expected to come from private sector, especially from MNCs in food processing and retail.

Overall, investments in agricultural R&D have proven that predictions of a decline in investment (as given in Anderson and Purcell 1996) have in fact been reversed in the ESAP countries. Agricultural R&D investments have grown since the mid-1990s, a trend that may continue into the future, focused on non-conventional but increasingly crucial issues for ESAP, such as green production systems, reduced environmental pollution, farmer friendly markets, open source software/genetic material/protocols, gender relationships etc. Increasing market opportunities will also bring increasing investments from private R&D.

4.2.6.2 Research organizations and institutions

The expansion of research organizations in agriculture and allied sectors was a phenomenon of the 1970s and 1980s in most of the ESAP countries. The current interest in these countries is on changing or reforming institutions or the rules/norms that govern these research organizations (Byerlee and Echeverria, 2002; Hall et al., 2002; Huang et al., 2002; Raina, 2003a). It is expected that this resurgence of interest in funding agricultural R&D and in institutional reform in agricultural R&D will lead to greater effectiveness of knowledge to achieve the MDGs. The lessons from experiments on new models or approaches to funding research organizations and corresponding changes in their institutions/rules will be applied increasingly in the ESAP region (World Bank, 2006c).

It is only in the late 1990s that the distinction between the agricultural research organizations themselves and the institutions or rules/norms that govern these organizations, was made in the social science literature on agricultural research in the ESAP region (Biggs and Smith, 1998; Raina, 1999, 2003a, 2003b; Biggs and Matsaert, 2004; Hall et al., 2004). In the ESAP countries, the linear compartmentalized (into research, extension and adoption) organization of knowledge in AKST will continue for some time, because it is deeply entrenched in existing formal agricultural research organizations and policy making organizations (Hall et al., 2004; World Bank, 2006d; Biggs, 2007; Raina and Sulaiman, 2007b). But recent trends show increasing donor interest in non-linear systems of knowledge generation and utilization, as well as the institutions or rules/norms that will promote new non-linear ways of working in R&D organizations and extension organizations (IDRC, 2006; World Bank, 2006d). These will increasingly be applied to the agricultural sciences and existing formal R&D organizations.

The CGIAR organizations in the ESAP region are experimenting with institutional reforms; partly in response to the pressure from international evaluations to prove their efficacy in reducing poverty and rapidly declining rate of donor support to the CGIAR system (Lele, 2004; CGIAR Science Council, 2005). Recent experiments which will give important insights and incentives to initiate institutional reform include, increasing pressure for agricultural diversification, the private-plant breeders consortium in ICRISAT, regionally differentiated research strategies in AVRDC, the natural-resource based no-tillage technology systems in the CIMMYT-IRRI sponsored Rice-Wheat Consortium in South Asia, the internal processes to set research priorities that suit the spatial dimensions of poverty in CIMMYT, innovation systems research to enable pro-poor livestock and fodder innovation systems in ILRI (Joshi et al., 2003; Hall et al., 2004; Erenstein et al., 2006; Raina and Sulaiman, 2007a). Different theoretical frameworks and approaches like the Sustainable Livelihoods Framework, the Innovation Systems approach, the Network models etc. will increasingly be tried by different CGIAR organizations in the ESAP region, to enable changes in ways of working in science and among its partners, to achieve goals of sustainable development. The AVRDC, for instance, has a regionally differentiated strategy for vegetable research and development, which emphasizes research on more nutritious vegetables in the East Asia region through a network approach (the AVRDC-ASEAN Regional Network on Vegetable Research and Development), and enhancement of vegetable cultivation area (by over 9 million hectares) in the Indo-Gangetic Plains of South Asia by 2010 (See AVRDC, 2002). The organizations involved in these emerging networks and new research strategies may continue to be governed by linear knowledge flows and will not be in a position to influence or change policy decisions and practices to enable innovation, unless pro-active investments are made to enable learning and change within these organizations.

Pressure for institutional reform and reorganization is now increasing within the University system in Asia – especially India, Thailand, China (much experimentation and change is on in China), Sri Lanka. The Universities are being forced to re-consider their traditional roles (as sources of ideas, basic scientific knowledge, and teaching resources) and embrace new ones like making contributions to regional development through innovation. They are being asked to transform themselves from ‘knowledge containers’ to ‘entrepreneurial universities’ (EDB, 1995; Government of Japan, 2002; NKC, 2006). But these new functions of the University evolve as they interact and learn from/with several key development partners. What is evident through the ages is the capacity of the University to evolve with the demands that society places on them (David, 2004). If the agricultural growth drivers and social and economic drivers of change place sufficient pressure on the University system, the decline of University research in Asia (Byerlee and Echeverria, 2002) can be avoided. It is unlikely that the Universities will invest in research that is less visible and pro-poor – they are more likely to address areas like IT, textiles, architecture, biopharmaceuticals and other visible more areas with an articulate demand.

In ESAP, the response to new institutions and policies like the Trade Related Intellectual Property Rights (TRIPS) under the WTO regime, and the relative reluctance of countries to buy into the intellectual property rights (IPR) regimes, will be conditioned by the major fear of negative impacts (of these institutions as curbs on technology/knowledge) on millions of lives and livelihoods. Many address the issue of IPRs, as a knowledge generation incentive. Little is asked about how future institutional reform must address issues of knowledge utilization in the field, given that public agricultural research has generated vast amounts of technologies that find no application at all. Notwithstanding the overstated generalization that patent regimes and intellectual property rights will enhance commercialization of technology and knowledge in agriculture, the ESAP region will face continuing opposition to IPRs in agriculture, or any form of private appropriation of biological material, technology or knowledge for commercialization (Shiva, 2000). There is also some questioning of how the TRIPS agreement may or may not detract R&D from addressing relevant knowledge generation and use questions in the Third World – especially the ESAP region (Connett-Porceddu, 2006; Musunga, 2006).

ESAP is also home to the “open source biological information sources” that are available (over a million life science patents and appropriate soft ware to make it transparent and accessible to users) and is growing rapidly to meet the needs of ESAP’s scientific community and industry (Herrera, (interview with Jefferson), 2005). The problem here is that even in the medium term, say about a decade from now, there will only be a few groups (limited often, to closely networked actors) that have the capacity to share or utilize this open source data base (Connett-Porceddu, 2006; Herrera (interview with Jefferson), 2005 – see BioForge website). The developed countries have led the evolution of a policy framework for exclusionary patent rights; the evolution of norms/institutional arrangements for sharing an open and inclusionary source is on now, and will be taken up by several networks and technical cooperation programs in the ESAP region. In terms of ideal institutional arrangements ESAP will soon have to decide whether IPRs or Open Source Biological Software or a flexible combination of the two, will help more effective knowledge utilization among its peasants. Given the argument that open source soft ware can be effective in incremental innovations and may not be useful for radical innovations (Bonardi and Warin, 2007), it may be ideal for developing countries with large peasant populations and rural non-farm employment demands, to invest in open source soft-ware. The question that will be asked increasingly will be about their potential for generating local ownership and appropriate institutional reform in public and private R&D in individual countries (Connett-Porceddu, 2006).

The institutions or rules/norms that govern the public sector agricultural research organizations and their ways of generating and evaluation technologies is increasingly receiving attention in the ESAP region (Raina, 2003b; Hall, 2005; World Bank, 2006d; Raina and Sulaiman, 2007). It is expected that formal AKST organizations in the region will be increasingly called upon by Governments and the public, to prove their efficacy in improved livelihoods and incomes for the rural poor, poverty reduction, overall quantity and quality of food systems, and sustainable environment with significant reduction in agricultural pollution. Increasingly emerging challenges will also demand institutional reform within the agricultural R&D organizations; these challenges may be pest or disease outbreak (avian flu, anthrax, etc.), impacts of climate change, water scarcity, trade or other market standards, energy or fuel crisis in rural areas, food processing and retail demands. New or modified ways of working, or institutional changes, will be necessary to achieve these goals.

4.2.6.3 Biotechnology, transgenic crops and pesticides

It is predicted that much as the chemical and mechanical inputs into agriculture have moved from household level and village artisan based sources to public and private funded sources of knowledge and artifacts, the biological components will also move to industrial/manufactured goods markets, and private sources of knowledge and product generation (Rieuvenkamp, 2003). Asian biotechnology investments are predominantly in public sector organizations, despite the fact that private research in the biosciences and biotechnology has grown rapidly over the past two decades. Most Asian bioscience capacities are therefore in a ‘public-sector bind’ with

- (i) a precedence and affiliation towards conducting research, almost as an end in itself without worrying about application, commercialization or utilization,
- (ii) significant compartmentalization of R&D into different sectors (Ministries) and
- (iii) little capacity for biotechnology commercialization and the partnerships necessary for commercialization (Chaturvedi, 2002; Peczon and Manalo, 2004; Hidayat, 2006; Wong et al, 2004; La Vina and Caleda, 2006).

A common feature that marks the public sector R&D in the biosciences is a strong historical continuity- an inertia and resistance to change. This inertia has more to do with internal institutional rigidities than with lack of technological capabilities or due to an increase in concern about environmental safety; this is proven by the fact that public research organizations in Asia have a line-up of several biotechnology results that can have potential applications in society. Though there are only a few notable public sector enterprises in biotechnology, it is likely that increasing institutional reform will enable venture capital led biotechnology enterprises to emerge from public R&D, and there will be increasing collaboration between public-private R&D and private industry.

Some countries like Japan, Singapore, China, India, and Malaysia are home to fast growing and thriving biotechnology enterprises – national biotechnology strategies in each of these countries reveals ways to continue on this expanding biotechnology enterprise mode. In the ESAP region, some countries like South Korea have taken a pro-active approach to development of biotechnology and transgenics for application in various sectors. The Korea BioVision 2010 is a plan put forth by the Ministry of Commerce Industry and Energy (MOCIE), where the role of transgenics in several fields and the national strategy to utilize are highlighted (Feddema, 2003). It is projected that following this strategy the country will place seventh in the world of biotechnology.

While China has an edge in commercializing agricultural biotechnology, and some specialized areas like stem cell research, India has established its advantages in industrial biotechnology, animal/veterinary health products and diagnostics. The growth of these specific sectors has also been conditioned by the domestic policies enabling their growth – the Indian pharmaceutical industry for instance. Increasingly, there is pressure on these enterprises to shift their attention from catering to the global MNCs/global market, so as to focus on the domestic development needs (Frew et al, 2007).

Asia will continue to be the “new promised land” for the large diversified MNCs in the pharmaceutical sector (Ekchart, et al, 2005). Besides cost savings due to availability of cheap labor, industry now sees the availability of quality manpower to work in the biotechnology sector. In the enterprise domain, the most globally integrated and tantalizing bio-innovation success in Asia is that of Singapore. The Government of Singapore through its Economic Development Board (a statutory board under the Ministry of Finance) spearheaded the development of biotech enterprises in the country (Tsui-Auch, 1999; Pownall, 2000; Ekchart et al, 2005; La Vina and Caleda, 2006). The strategic research and health biotechnology spearheaded by this Board provide a model and potential applications of this model of biotechnology development may emerge in other Asian countries.

Increasing applications of biotechnology in agriculture and health promise pro-poor benefits in the ESAP region. But these are contingent upon new and modified ways of working, involving new directions in science, new partners, finding and sustaining non-research partners and other complementary skills, participation of the poor in identification and selection of problems that need answers from biotechnology, pro-active policy and institutional arrangements in each country (Raina, 2003; Sahai, 2003; Hall, 2005; Chathaway, et al 2006; IDRC, 2006).

Transgenic crops continue to receive substantial funding from public and private sector research as well as several quasi-public –private organizations in the ESAP countries. Several multinational firms as well as international research institutes and universities have been investing heavily in biotechnology and transgenic research in Asian countries. (Pray and Naseem, 2005). The Asia Pacific Association of Plant Tissue Culture and AgroBiotechnology have reasons for approving the release and utilization of GM crops in the region (Sahai, 2003). The ESAP region, with the exception of China is wary of release of transgenic crops and livestock into the production environment. Japan still has and perhaps will continue to hold its ban on all transgenic agricultural crops and commodities though it is a leader in biotechnology applications in the health and environment sectors. Overall, the ESAP region is weak in evaluation and risk analysis required for the release of genetically modified organisms, and research policy in ESAP countries will continue to ignore the alternatives proposed to assess risk and estimate the costs and benefits of/from GMOs using non-monetary and pluralistic approaches (Jasanoff, 2000). Pro-active and democratic decision making processes in S&T, especially concerning choice of technology, may take time to emerge in ESAP, despite conscious demand for discursive processes, ecological and democratic values in S&T in the region (see Dryzek, 1998).

There is a need to address gaps in communication and articulation capacities that arise from a variety of discontent with or mistrust about technological changes that have evolved over time. These are often called the ‘violence of science.’ (see Shiva, 2000; PAN, 2002). This distrust is of two kinds – (i) a blue, nostalgic mode that craves for the old world uncorrupted by modern allopathic medicine, chemical fertilizers, and polluted water, and (ii) a green, forward looking mode that demands a clean-up of the current mess of lifestyles, disrupted ecosystems, social tensions and pollution (Bauer and Gaskell, 2002). Asia will now increasingly invest in media research to assess these nuances of discontent with biotechnology and to see how it is articulated (as blue or green objections to modern technology, as wider political economy arguments, as governance or institutional reform processes).

4.2.6.4 Pesticide and herbicide use

Use of pesticide and herbicide use in the ESAP region is not as intensive as it is in much of North America or Europe. Yet, the damage to water bodies and ecosystems at large is rated as rather severe (UNESCAP, 2005). There are some tracts that use a heavy dose (of over 80% of recommended dose) of pesticides and herbicides (Huang, et al, 2002). The pesticide industry expects that world demand for pesticides will soar till 2009, once many of the current pesticides become cheaper because patents have expired (http://freedonia.ecnext.com/coms2/summary_0285-284519_ITM). The trend of soaring demand for biopesticides may be sustained in the developed regions, and in Asia mainly fungicides will gain use by their effectiveness to recover the Asian soyabean crop from rust (see 4.2.7)

The alternatives to heavy pesticide and herbicide use seem to come from at least three different scientific and social perspectives, all receiving acclaim, policy attention and NGO-led mobilization or campaigns, in the ESAP region.

- The first is the emergence of genetically modified crops with in-bred resistance to specific pests and diseases – the best examples being cotton engineered for resistance to the American boll worm, brinjal/egg-plant engineered to resist the fruit borer, and rice engineered to resist the tungro virus and blight. Developments in this area – of using herbicide tolerant genetically engineered varieties or using crop varieties modified to control pests (like the Bt cotton), are likely to continue, in Asia.
- The second, becoming an increasingly popular alternative is integrated pest management (IPM or a more stringent version called non-pesticide management, NPM) using a combination of physical, chemical, biological agents and modern weather based or traditional knowledge inputs.
- The third, and found increasingly responding to consumer demands in Western markets, is organic agriculture, where no chemical inputs (including fertilizers) are used, the soil and water systems are completely de-toxified and cultivation processes and processing of produce are certified by some EU-based or American certification process.

While agricultural research systems have and will continue to invest heavily in pesticide research and in biotechnology and even on different versions of IPM (ranging from no pesticides to biopesticides only to some chemical pesticides, in combination with other pest management practices), there is very little resource allocation for, capacity building within, and conviction in the public sector NARS to work on organic agriculture - the science of and scientific certification for organic agriculture. In India organic agriculture is largely funded by international donor agencies and conducted largely by university departments and NGOs, and with little information or scientific support from or even acknowledgement from public sector agricultural R&D

organizations, especially the ICAR and its SAUs (See www.csa-india.org). While public agricultural research also held similar attitudes to organic agriculture in China and the Philippines, there have been significant changes in the recent past which can make organic agriculture a major alternative to pesticide+chemical based agriculture, and consequent environmental degradation. While organic agriculture is big business with private investment and research in Australia, in countries like China, Indonesia, Thailand, and Philippines, organic agriculture receives significant public sector R&D attention. They have established their organic standards and certification systems, and have come up with policies for organic agriculture and action plans for its promotion, not only for export but for domestic markets. Several sources like the Thailand Department of Agriculture, China Organic Certification Agency, Department of Agriculture-Bureau of Agricultural and Fisheries Products Standards, Philippines, and several conferences (for example, the Seminar on Organic Agriculture: Trade and Certification in APEC economies, sponsored by CNCA, Beijing 2006, Biofach China Conference, Shanghai, December 2006, BioFach China Shanghai 2007) are now evident as Government-led or Government-private sector collaboration in organic agriculture.

Japan is and will continue to be the largest consumer of organic products in Asia; with a growth rate of 21% projected till 2020. Several countries, including China, Thailand and Bhutan have declared their own national strategies for organic agriculture (FAO, 2004). The growth of organic agriculture and markets and other facilitation services like certification agencies, in Asia, must be viewed in conjunction with the overall growth expected in the Asian retail market. Food retail in Asia is expected to grow in leaps and bounds, accounting for 41% of the global food retail trade in 2020 (Partos, 2007).

4.2.6.5 Innovation or generation and utilization of knowledge

A recent development in the Philippines, the emergence of a 5-year development plan by the Benguet State University (BSU) to develop an ‘organic agricultural college’ is an innovation intended to produce human capacities for learning about, researching, and extending technical support and market services for organic agriculture in the country. Another example, the Thai PM’s concern about the need to study and be prepared to face the agricultural production implications and consequences of their FTA with China which will be effective from 2010 onwards, is revealed in his request to experts to ensure that Thai farmers produce the finest and best quality produce. (www.bilaterals.org, 1 Nov, 2006). These examples reflect two major concerns that Asian agricultural research organizations are being asked to address: (i) the capacity to utilize in the field, the knowledge that is generated, (ii) the capacity to learn about and respond to emerging challenges in the agriculture sector/other sectors that may affect agriculture. It is this, the capacity of a system of inter-related organizations and individuals to be enable the generation and utilization of knowledge, and be prepared for the changes the may take place, that the ESAP region now plans to build.

The ESAP region now witnesses a renewed interest and scholarship in agricultural innovation – the questions being asked are (i) why is there a widening gap between research and utilization of knowledge, and (ii) why is there so little that policy makers learn about the field conditions (SDPI, 2005ab; Tyler, 2006). This cannot be answered by research results or policies that prescribe increased investment in research or more research organizations. Social science researchers in Asia are increasingly realizing that these questions are not about research but about innovation. Conceptually innovation signifies the processes of change when knowledge (including technology) is generated and used in economically productive ways in agricultural or rural societies (Douthwaite, 2002; Biggs and Matsaert, 2004; Hall et al, 2004; Raina, 2004). In order to enable innovation systems to emerge many Asian countries are emphasizing the need for institutional change within the formal agricultural research organizations – especially, their capacity work effectively in partnership with other organizations.

Despite well-intentioned recommendations (based on agricultural innovation systems analysis in four developing countries) to facilitate or strengthen the relationship of agricultural R&D with a range of relevant partner organizations (IDRC, 2006; World Bank, 2006d), the ESAP region, especially the developing countries are not likely to follow, the recommendations made. Future trends in innovation are likely to be bolstered by some of the recent decisions for future- such as increasing investments in rural infrastructure, attention to increasing access to rural credit and other services that are now beyond the reach of the rural poor, investments in and forging of new networks and relationships across ESAP to address specific development concerns such as AIDS, pollution, biotechnology, markets for rural value added products etc. But active institutional reform within public sector AKST organizations for innovation and development in ESAP, looks remote, given the institutional inertia and the overwhelming euphoria of the green revolution that refuses to wear off despite evidence of rural poverty. There is also the deeply entrenched technological determinism that drives public sector funding of R&D worldwide, and the relative reluctance of R&D policy makers to learn lessons from past experiences (Raina and Sulaiman, 2007b).

The diversity of the ESAP region demands that innovation strategies will have different goals in the developed countries, niche geo-political and ecological systems within developed countries, and different domestic concerns in developing countries (ranging from poverty reduction to reclamation of degraded land or controlling arsenic pollution in water or increasing phytosanitary innovation capacity to meet international trade regulations). There is empirical evidence that even in the largely globalized food systems today, agricultural and food systems adapted to local cultures and ecosystem carrying capacities can be developed and function fruitfully (Hendrickson and Heffernan, 2002). It is likely that with increasing donor interest (World Bank, IDRC, GTZ, AKF, Japanese Government, among the major ones) the ESAP agricultural R&D, extension, industry, farmers, rural banks, rural service providers, input suppliers, environmentalists, and other local markets actors will pay more attention to building locally relevant innovation capacity.

4.2.7 Natural resources - land use and water use, land cover change

The Millennium Ecosystem Assessment (MA, 2005) recently concluded that 60% of ecosystems are degraded or used unsustainably including fresh water (very vital for agriculture), capture fisheries, soil, the regulation of regional and local climate, natural hazards and pests. Ecosystem services could degrade significantly until 2050 and this is projected to be a barrier to achieve the Millennium Development Goals (MA, 2005). There are a number of natural resources management concerns that are likely to aggravate the ESAP region in future. They include: conversion of forest and coastal lands for agriculture and aquaculture, flood control and loss of natural fish habitat, increased use of fertilizers and pesticides and their impacts on the natural environment, overexploitation of inland and marine fisheries, land degradation, competition between urban and agricultural water supplies, and degradation of water bodies/wetlands, water pollution and loss of biodiversity. The combination of natural resource degradation processes will impact agricultural productivity and livelihoods especially in the marginal and vulnerable areas.

Fragmentation as a result of inheritance, population pressures or land scarcity creates efficiency problems during large scale outlays including irrigation and agricultural management. Evidence from China and South Asia indicates that land fragmentation is detrimental to land conservation and economic gain, thereby discouraging farmers from adopting agricultural innovations (Niroula et al., 2005). Large scale investment such as irrigation requires large up front costs to purchase fixed capital such as control units and water pumps. Extending irrigation networks is considerably cheaper since extensions use existing fixed capital. However, land and ownership fragmentation poses a problem since irregular farm shapes and diverse ownership structures make it difficult to approve and implement large scale technologies such as irrigation. The detailed problems associated with fragmentation are well documented and evidence presented by various researchers indicates the negative impacts of fragmentation on land productivity (Nguyen et al., 1996; Jha et al., 2005; Niroula et al., 2005). In the future expansion of agriculture in the low income countries could lead to tremendous changes in land use (MA, 2005) with 10-20% of current grassland and forestland lost by 2050.

Over the recent decades the agriculture sector provided services to reduce hunger and poverty in many parts of the ESAP region, especially in South and South East Asia. Despite successes in food grain production, the agriculture sector has recently been facing a large number of problems in the ESAP region. Natural resources availability is under serious pressure from competing sectors. Rapid urbanization and industrial expansion are creating huge and increasing demands for land and water.

Detailed analysis shows that, globally, there is enough land, soil and water, and enough potential for further growth in yields, to make the necessary production feasible. At present some 1.5 billion ha of land is used for arable and permanent crops and a further 2.8 billion ha are to some degree suitable for rainfed production. A significant fraction of potential land is either locked up in other valuable uses or unsuitable for cultivation due to low soil fertility, high soil toxicity, high incidence of human and animal diseases, poor infrastructure, and difficult terrain. Accordingly, land expansion is expected to account for 20% of production growth with the remaining 80% resulting from intensification practices such as higher yields, increased multiple cropping and shorter fallow periods. In South Asia, almost 98% of suitable land is already in use. Thus, there is little capacity for expansion in area and it is projected that more than 80% of the increase in production will have to come from yield increases. Furthermore, about a third of the harvested area in developing countries in 2030 is expected to be irrigated land. However, by 2030, East Asia is expected to use 75% of their irrigable area and South Asia (excluding India) is expected to exploit almost 90%. This will result in a 14% increase in water withdrawals for irrigation in developing countries by 2030. Consequently, 20% of developing countries are expected to face water shortages (FAO, 2002).

The FAO study suggests that a future policy environment should be created in order to promote sustainable farming methods that reduce environmental damage while maintaining or even increasing production and associated costs. These methods include no-till and conservation agriculture, integrated pest management and plant nutrient systems and organic agriculture. To reduce the population of undernourished, the study recommends giving more priority to agriculture, increasing national food production, and reducing inequality of access to food until the root causes of food insecurity have been removed (FAO, 2002).

Land degradation has become a serious threat to agriculture. Over 57% of the total area of dryland occurring in China and India is degraded (UNEP, 1997). China has initiated new guidelines in response to increased pressure on resources (see Box 4-3). Intensive agriculture and overuse of fertilizers have led to degradation of soil quality and fertility in many parts of

ESAP. In addition to this, intensive agriculture has contributed to fewer areas available for fisheries and livestock production.

Box 4-3. Chinese national development program compendium of science and technology for mid-long term (2006-2020).

Physical responses to land degradation problems have originated from the competing influences of fiscal and market incentive programs (GEO, 2002). In the past, policies were only concerned with increasing supply, however recently focus has increasingly shifted to integrated water resources management. No direct reference to the future of land and water resources is made in the four scenarios of the GEO which looked at a 2032 timeline; however, the following conclusions could be drawn:

Market First: Advances in technology and structural changes in economies might slow the trend in land degradation and water scarcity management.

Policy First: Rate of land degradation could fall due to implementation of more stringent land conservation measures in response to changing tax and subsidy structures. Water conservation, uses and management would improve in future.

Security First: Pressure on land and water resources would increase due to rapid environmental changes, wider inequality in economic and social developments and erosion of traditional livelihoods and communities.

Sustainability First: Land and water resources would be managed in a better way due to emergence of new environmental and development paradigms and be supported by new, more equitable values and institutions.

While water availability is decreasing, water demand for agriculture, industry and households is increasing in the region as a result of population growth and economic development. In 2025, water availability per capita in the region will be between 15 and 35% less than that in 1950 (ADB, 2001c) (Figure 4-5).

Figure 4-5. Decline in water resource per capita (1950-2025).

The amount of water used to meet domestic and industrial demands in Asia is increasing rapidly, with rates of increase between the years 1995 and 2025 projected to range from 70 to 345%

(ADB, 2001c). As economies grow, people's lifestyles typically begin to include an overuse of water, and people's attitudes accelerate the increase of domestic water demand. Production processes of industries consume a lot of water unless water saving and recycling technologies are introduced. China, India, Indonesia, Malaysia, the Philippines, and Viet Nam are typical countries in that water consumption needs have been increasing as they move rapidly through the industrialization chain (ADB, 2001c). It is easily projected that economic growth in the region in the near future will require more water for industry and the people. In urban areas, which by 2030 will be home to about half of Asia's population, water stress will become more severe. The increase in water demand in all sectors even as water resources are limited is expected to create conflicts among sectors and within each sector over water allocation. In Asia, many countries share international river basins as sources of water. Increases in domestic water stress would also bring more potential for conflicts among countries. On the other hand, such competition for water also provides opportunities for cooperation on allocation and sharing of water resources (Kataoka, 2002).

The gap between water demand and supply is increasing due mainly to increased demand from agriculture, rapid urbanization and industrialization. Water transfers to intensive irrigation based agriculture and urban areas are placing substantial ecological and political pressure on water resources and this trend will become more severe in the future. Industrial and agricultural effluents are affecting water quality across the region and threaten public and aquatic health.

Water will also be major constraint to the achievement of food security in many developing countries. As of 1997, the cereal harvested irrigated area was approximately 176 million ha in developing countries but is only expected to rise by 29 million ha by 2020 (IFPRI, 2001).

Increasingly in the ESAP region, there is concern that conservation practices and environmental movements in general pose a development cost, mainly due to the tradeoff between a development option that can lead to economic growth and an environmental option which can reduce or mitigate the degradation.

4.2.8 Climate change, natural hazards and adaptation

The ESAP region is highly vulnerable to climate variability and change. Climate change and natural hazards, such as floods, droughts, pest attacks and diseases are important drivers of change for agriculture and AKST. The Southwest monsoon weather system which endures from June to October dominates agricultural production, employment and human-well being. Increasing trends in temperature have already been observed in various regions of ESAP with some spatial variability. Inter-seasonal, inter-annual and spatial variability in rainfall trends have been observed in the last few decades. A decreasing trend in annual rainfall was observed in Northeast and North China, parts of northeast India, Indonesia, the Philippines and some areas in Japan. Annual rainfall shows increasing trends in western China, Changjiang Valley and along the south-eastern coast of China, Bangladesh and along the western coasts of the Philippines (IPCC, 2007).

Climate models' projection results documented in the latest IPCC WGI report (IPCC, 2007) show a significant acceleration of warming over that observed in the 20th century in the ESAP region (delineated from the Asia region). Warming similar to the global mean is expected over Southeast Asia. However, more significant warming is projected for South Asia and East Asia.

Results of recent climate modeling experiments show likely significant warming in future over the Himalayan Highland including the Tibetan Plateau and arid regions of Asia (Gao et al., 2003). A large number of modeling experiments project extreme heat waves and intense precipitation for South Asia, East Asia and South East Asia (Emori et al., 2000; Lal, 2003, Hasumi et al., 2004). Tropical cyclones/typhoons already cause significant damage to infrastructure and coastal agriculture in the ESAP region. As generation of cyclones and typhoons are highly related to sea surface temperature, a 2 to 4°C rise in sea surface temperature, cyclone/typhoon intensities in East Asia, Southeast Asia and South Asia could increase by 10-20% (Knutson et al., 2004).

4.2.8.1 Climate change and agriculture

Agricultural production in ESAP will be threatened by climatic variability and increased frequency of extreme weather events in coming decades (IPCC, 2007). Impacts to agricultural systems as a result of climate change could include degradation of land, destruction of existing crops, loss of biodiversity, changes in crop and livestock production and increased health problems due to nutritional impacts and vector distribution. However, advancements in AKST could drive new initiatives that promote adaptation to climate change. A discussion of how specific natural hazards are changing with climate in ESAP and examples of adaptation measures to overcome vulnerability to these hazards follows.

Climate change and variability may affect the agriculture sector in ESAP in many ways. First, a large area in ESAP is under rainfed agriculture. For example, in India, 60% of the land area under cultivation is rainfed. Any change in temperature, humidity and climate will have impacts on crop production. Modeling analyses suggest substantial decreases in cereal production in Asia by the end of this century. Rainfed wheat production may substantially decrease (Fischer et al., 2002). Second, there will be significant regional differences in wheat, maize and rice yields. Using climate scenarios from the HadCM2 model, Murdiyarso (2000) found that in East and South East

Asia, crop yield could increase by 20% while South Asia may experience a 30% decline in crop yield even taking into account the beneficial CO_2 fertilization effect. Third, temperature alone could be detrimental to crop yield. Using field level data collected at IRRI experimental stations in the Philippines from 1979-2003, Peng et al. (2004) concluded that rice grain yield declined by 10% for each 1°C increase in growing-season minimum temperature in the dry season, whereas the effect of maximum temperature on crop yield was insignificant. Fourth, sea level rise and resulting intrusion of saline water could cause significant damage to rice crops in many coastal areas especially in the mega-delta region of ESAP. Currently available rice and other crop varieties are highly vulnerable to salinity. A small change in salinity can cause significant damage to crops. Fifth, crop damage due to possible increases in extreme weather events such as floods, droughts and cyclone/typhoon and related storm surges may occur. Sixth, climate change may introduce positive benefits for rice crops in some areas in ESAP especially in Northeast China (Wang et al., 2005).

4.2.8.2 Floods

Flooding occurs annually in many parts of ESAP, and brings about both positive and negative impacts in the region. Bangladesh is one of the most highly flood vulnerable countries in the world - 21% of the land area gets flooded annually. India is also highly vulnerable to flooding where 40 million ha (or 12% of land) is flood prone. Recent episodes of flooding in Indonesia, Malaysia and Viet Nam demonstrate the vulnerability of these countries to this hazard.

Future climate change will likely alter flood patterns in the ESAP region. Most of the climate models are in agreement about increasing precipitation in eastern India and Bangladesh. This may trigger more flood episodes in future. A 2°C rise in global mean temperature, the mean flooded area in Bangladesh could increase by 23 to 29% (Mirza, 2005). The maximum monthly flow of the Mekong is estimated to increase by 35–41% in the basin and by 16–19% in the delta with lower values estimated for the years 2010–38 and higher values for years 2070–99, as compared with 1961-90 levels. The thawing volume and speed of snow cover in spring is projected to accelerate in Northwest China and the western part of Mongolia while the thawing time could advance, increasing water sources and potentially leading to floods in spring (IPCC, 2007).

Flooding occurs annually in many parts of ESAP, and brings about both positive and negative impacts in the region. Damage to crops by flooding is highly dependent on three related factors: timing, magnitude and frequency. For example in Bangladesh, the crop calendar has evolved around the onset and retreat of the monsoon. If floods (flash floods) occur too early for example in April and May, it can cause substantial damage to standing crops. In early July and August (as happened in 2004), floods can damage growing aman rice. However, if floods occur very late (e.g. in early to mid-September), farmers cannot re-plant the crop as the growing period would be severely limited by incoming winter (November/December).

In Asia, climate change may affect existing complicated food chains in the surrounding oceans. This may eventually impact the fisheries sector (IPCC, 2007). Rising air temperature would lower availability of oxygen for fish species at higher elevations. In the plains, the timing and amount of precipitation could also affect the migration of fish species from river to floodplain for spawning, dispersal, and growth (FAO, 2003). Future changes in ocean currents, sea level, sea water temperature, salinity, wind speed and direction, strength of upwelling, the mixing layer thickness and predator response to climate change have the potential to substantially alter fish breeding habitats and food supply for fish and ultimately the abundance of fish populations in Asian waters (IPCC, 2007).

4.2.8.3 Droughts

Droughts are very common in many countries in the ESAP region. India is one of the most vulnerable countries to drought, particularly the states of Gujarat, Haryana, Rajasthan and Punjab. Bangladesh is also highly vulnerable to drought, especially those occuring in the monsoon period that severely affect rice crop production. In China, the areas affected by drought have exceeded 6.7 M ha since 2000 in Beijing, Hebei Province, Shanxi Province, inner Mongolia and North China (Zhou, 2003; Yoshino, M., 2000). North Korea and Australia are other countries in ESAP which are vulnerable to drought.

It is anticipated that future climate change could influence variations in temperature, precipitation and/or evapotranspiration, which could in turn exacerbate water shortages and drought frequency in the ESAP region (McCarthy et al., 2001). Since up to 81.3% (as of 2000) of water supplies in the region are used for agriculture, crop productivity will be severely affected if access to water is diminished (García et al., 2006). Decreased precipitation and increases in evapotranspiration can lead to deficiencies in soil moisture as well as stream flows that provide for irrigation (Wang, 2005). Furthermore, the retreat of glaciers and decline in snow melt in much of South Asia, could place significant pressure on water availability in the dry summer months in the long-run and instigate the gradual transformation of already water stricken areas into arid deserts (McCarthy et al., 2001; Barnett et al., 2005).

4.2.8.4 Pest attack and diseases

The predicted warming trends linked to climate change are expected to influence pest and disease frequency and damage extent. This is attributed to the fact that extreme heat weakens host plants while providing favorable growth conditions for crop pests and pathogens over wider geographic ranges. For example, a decline in frost events in New Zealand has led to an increase in the tropical grass webworm, and caused severe damage in northern agricultural regions of the country (McCarthy et al., 2001; UNEP, 2006). Climate change together with changing pest and disease patterns, will likely affect how food production systems perform in the future in Asia. This will have a direct influence on food security and poverty levels, particularly in countries with a high dependency on agriculture (IPCC, 2007).

4.2.8.5 Adaptation

In the face of climate change, the agricultural sector could minimize damage and take advantage of changing environments by implementing adaptation measures and coping mechanisms. There are many technological options available to adapt to meet future challenges. First, development and introduction of high temperature tolerant crop varieties. Currently available crop varieties are not capable of tolerating high temperatures, especially increased night time temperatures. Yield responses from current rice varieties are high in response to increases in night time temperature (Peng et al., 2004). Second, development of salt tolerant crop varieties can reduce shortfalls of crops under sea level rise scenarios. One rice variety has been found to be tolerant to high temperatures (Agarwal et al., 2003). Third, development and introduction of crop varieties that can endure long inundation periods as a result of extreme flooding. Current rice varieties and especially the HYVs have two major limitations: their stems are short in length and they cannot sustain long inundation periods during flooding resulting in severe losses of crops. Scientists at IRRI in the Philippines have identified a gene that enables rice to survive complete submergence. The discovery will help in developing new rice varieties that could withstand flooding (IRRI, 2007). The development could benefit millions of farmers whose rice crops are constantly vulnerable to flooding especially in the low lying mega-deltas of ESAP. One such rice variety has already been developed and is under trial in Bangladesh and India. Fourth, as water resources availability will be highly variable over time and space, technological development and diffusion are necessary for water conservation and increasing irrigation water application efficiency (IWAE). Current IWAE is roughly 40% in India and in Bangladesh. The introduction of low cost drip irrigation can increase IWAE and eventually will reduce water requirements. The additional water to be saved through higher IWAE could be utilized for bringing additional lands under irrigation. Fifth, useful climate information through advance warning on floods, droughts, pest attacks, etc. can help farmers to get better prepared for extremes. Sixth, livestock and other animal heath is a poorly studied subject in ESAP. Climate change can introduce new pathogens and expand the territory of animal diseases. Technological development is necessary to understand the mechanisms that spread pathogens, their hosts and the potential damage to animal health. Some adaptation measures (IPCC, 2007) for the agriculture sector in Asia will need substantial inputs of technical, financial and human resources (Table 4-5).

Table 4-5. Climate change and adaptation measures in agriculture

4.2.8.6 Food security and human migration

Food security, hunger and famine are not exclusively related to climate affected crop losses; but natural hazards do exacerbate these issues. Climate change and possible increases in natural hazards could increase hunger and malnutrition in many nations in ESAP including Bangladesh, China, India, North Korea, Viet Nam and the Philippines. A sizeable proportion of these populations (urban and rural) suffer from food insecurity, especially the rural marginal farmers. Although as a result of globalization, per capita income has increased, inequality is on the rise. Prices of essentials especially food are on the rise. A three-fold increase in global cereal prices by 2080 as a consequence of decline in net productivity due to climate change is projected (Parry et al., 2004) projected. Subsistence producers who grow crops like sorghum and millets in dry conditions could be at greatest risk of a potential drop in productivity and from the danger of losing crop genetic diversity (IPCC, 2007). In the near term, an additional 49 million people would be at risk of hunger if the world follows the SRES A2 emissions scenario without any carbon fertilization (Parry et al., 2004). By 2050 (mid-term) and 2080 (long-term), the additional people at risk of hunger could increase to 132 and 266 million, respectively.

Rural to urban migration may increase if sufficient income sources are not available in rural areas. Countries of the ESAP region could face substantial food shortages unless they succeed in adapting to environmental changes. The situation does not look optimistic given the recent stagnancy in agricultural productivity. Higher temperatures, increased rainfall, drier summer months and saline water intrusion will decrease agriculture productivity in the short to mid-term. In the long-term, technological breakthroughs may alter the situation. However, this will be highly dependent on the development, deployment, and diffusion of new technologies. The commitment of individual countries to reduce emissions and enable mitigation and adaptation to climate change will be crucial.

4.2.9 Energy

4.2.9.1 Energy crisis in agriculture

Efficiency of agricultural production and the quality and quantity of energy used to power it are correlated. However, access to adequate, reliable and affordable supplies of modern energy sources, such as hydrocarbons or electricity, is minimal and traditional energy sources for food production, such as fuelwood, biomass and human and animal power, are also diminishing. It has been recognized and acknowledged that global energy use is unsustainable in the long term. Thus, the energy sector is undergoing a rapid shift toward energy efficiency and conservation in addition to the development of renewable and recyclable energy sources. Rural areas have the advantage of transitioning to more sustainable energy systems by employing techniques such as organic farming, improved water and soil management, integrated pest management, mechanization and biotechnology. The technological and institutional challenges remain in building the capacity of rural areas to adopt more sustainable measures, which often involve high initial investments in capital, labor and training. If rural populations are excluded from the shift to sustainability there is a risk of massive emigration to urban centers (Dutkiewicz, 1999).

Agricultural activities consume from 2 to 8% of the total rural household energy requirements, depending on levels of mechanization in farming and irrigation equipment. The anticipated declining trend in rural populations, and thus agricultural labor, could pose a threat to urban food security, especially in the face of significant urbanization.

Regional groundwater exploitation has escalated at the expense of the energy economy. South Asia as a whole spends 5 to 6 billion USD per year to pump approximately 210 km3 of water, mostly for irrigation (with 27-35% of the power being subsidized). Economic losses in the electricity sector due to agricultural power subsidies are estimated at 5.4 billion USD in India (Shah et al., 2003). While farmers will soon be faced with water availability issues, such as declining water levels, high rate of well-failure, salinity and reduced well-yields, irrigation itself will face high energy costs and unreliable electricity supply. Furthermore, energy demands for agriculture activities can be influenced by climate change, in the form of increased electricity requirements for irrigation pumping during warmer weather to maintain soil moisture (McCarthy et al, 2001).

4.2.9.2 Bioenergy

The general emerging pattern is to move from traditional bioenergy (wood fuels, charcoals, etc.) to modern fuels as household income rises (Barnes and Floor, 1996). However, with rising oil prices and falling oil supplies, concerns over greenhouse gas emissions and political instability in many oil rich countries, there is a renewed interest in bioenergy, mostly liquid biofuels but also for electricity generation. Improving the efficiency and reducing the harm of traditional bioenergy remains a challenge and needs to be addressed.

Bioenergy can take the form of solid biomass or liquid biofuels – and has the significant advantage that it theoretically can be produced so as not to yield net carbon dioxide emissions (Bird Life International, 2005; Tustin, 2006). As energy crops are cultivated they sequester an equal amount of carbon dioxide that was released when combusted. Another advantage is that the intensification of biofuel production is expected to engage existing national agricultural industries. In ESAP, the main energy crops include sugar, coconut, cassava, castor kernel and oil palm. Since supporting local farmers is good politics for national leaders, policymakers are directing resources towards the biofuel cause (Yuit and Wall, 2006). It can benefit commercial plantations and similar agriculture in the rural areas. The rural dwellers can also benefit from the use of by-products from bioenergy production. However, increasing food prices, potential deforestation and depletion of water resources could emerge as byproduct environmental problems. In addition, a variety of energy inputs used during the cultivation of feed stocks and production of biofuels can produce greenhouse gases that contribute to global warming.

World primary energy demand projections suggest that the supply of non-hydro renewables as a percentage of global electricity supply/electricity generation will triple from 2% in 2002 to 6% in 2030. While wind power will see the biggest increase from 0.3% in 2002 to 3% in 2030 and is expected to succeed biomass as the largest source of non-hydro renewable electricity generation, it is anticipated that electricity generation from biomass will triple between now and 2030. Furthermore, the demand for biomass and waste fuels will rise by 1.3%, of which 0.7% is attributed to traditional biomass (IEA, 2004) (Table 4-6).

Table 4-6. Biofuel policy initiatives in ESAP (Source: Raju, 2006).

Both Thailand and India have launched national policies to promote gasohol, which is a blend of 10% ethyl alcohol and 90% gasoline. The Thai gasohol program started in 1985. As of December 2005 the country had more than 4,000 stations serving alternative fuels and an import ban on methyl tertiary-butyl ether (MTBE), which is the petrol-based fuel additive that ethanol replaces, will be mandated in 2007. The government has pledged a renewable energy target of 8% of total energy consumption with 24% of the target as liquid biofuel. Initiatives are also under way in the Philippines and Indonesia to implement similar gasohol policies (Bhandhubanyong, 2005; Yuit and Wall, 2006). In addition, the promotion of biodiesel produced from coconut oil is under way in the Philippines, with Thailand, Malaysia and Singapore expected to follow suit. The Indonesian government is focusing on biodiesel production from palm oil. An anticipated 5.6 billion of the 22 billion USD pledged for biofuel production and distribution initiatives will be spent on palm oil production. Similarly, the Malaysian biodiesel policy is expected to produce up to 500,000 tonnes of a biodiesel blend of 5% palm-oil-derived and 95% petroleum-derived diesel (Yuit and Wall, 2006). Note that these are technical potential (TP) estimates and utilization of full TP is dependent on economic viability.

4.2.9.3 Bioelectricity or electricity from biomass

Given growing global energy demands, a question of interest relates to the potential for biomass to produce electricity. A sustainable, economically competitive global bioenergy supply is around 270 EJ per year, which is approximately 70% of the total world energy consumption in 1990 (Coombs et al., 1992). Since the actual amount of bioenergy that is used was merely 12% of world primary energy consumption in 1993, significant potential to expand bioenergy initiatives remains (WEC, 1994). ESAP is no exception. Renewable energy as percentage of TPES in 1992 was only 24.6% for SE Asia and Pacific countries and 52.5% for South Asia (WEC, 1994). These estimates rely on the physical potential for biofuels however and do not consider technical questions relating to base and peak loading capacity factors.

Rice husks in Southeast Asia have significant potential for electricity generation. It was estimated that 28.5 million tonnes of rice husk are produced in Southeast Asia per year. Assuming energy content of 3,000 kcal per kg of rice husk and accounting for typical boiler and steam turbine efficiencies, a steam turbine consuming 5.4 kg/kW will potentially produce 2778 MWe or 24.35 x 106 MWh (at 100% load factor). Since the total average energy consumption per hour for the Southeast Asian countries is 16,628 MWe, rice husk could theoretically supply 13.6% of the total electricity consumption. However, this figure depends on capacity of husking mills and associated costs (Himpe, 1997).

A recent study analyzed the global bioenergy potential for the period 2050-2100 based on forecasted future development paths and land-use patterns using four storylines of the IPCC SRES Emission Scenarios. The resulting potential for abandoned land ranges from about 130 to 410 EJ/y in 2050 up to 240 to 850 EJ/y in 2100. While the potential at low-productive land is negligible, “at rest” land could potentially provide approximately 35 to 245 EJ/y in 2050 and from about 35 to 265 EJ/y in 2100. At a regional level, South Asia has an average of approximately 3% of world potential for abandoned agricultural land and 5% of world potential for “at rest” land for the year 2050 (Hoogwijk, 2004). A contrasting study of bioenergy potential in the USA concluded that 1753 million acres would be needed to meet the country’s gasoline demands for a business-as-usual scenario in 2050. This figure decreases to 114 million acres through improvement of biofuel conversion efficiency and increases in feedstock yield (Greene, 2004).

4.2.9.4 Competing land uses and implications for food security

While the intent of biofuels projects would be to make use of existing agricultural land or abandoned and/or low quality farmlands, the clearing of virgin forest as well as agriculture and forest lands may be necessary to meet projected energy demands if biofuels are to be relied upon to the extent projected in some of the estimates reported above. As a result, any emission reductions provided by the use of biofuels will be lessened due to the significant loss of carbon sequestration capacity when virgin forest is cut down (Yuit and Wall, 2006).

Furthermore, while forests themselves provide a source of biomass (in the form of timber harvest waste, unmarketable lumber, trees removed during land clearing operations, wood residues produced by sawmills, forest thinning material, and leaves and other forest litter), overexploitation of this resource will result in damage to forest ecosystems and a subsequent loss in biodiversity. This is a concern especially for biodiversity rich continents such as Asia (Bird Life International, 2005; Kampman et al., 2005). Unless alternative sources of energy are developed, forest policy must incorporate energy needs into afforestation and forest preservation strategies in order to meet projected demands for biofuel.

Energy security is also linked with food production since a predominant use of traditional biofuels is cooking. Therefore, the adequate supply of traditional biofuels has an important bearing on nutritional security, especially in rural areas and low income households (Mahapatra and Mitchell, 1999; Kampman et al., 2005).

A study in Eastern India investigated the increased pressure on regional forests to provide fuelwood, which is the major traditional biofuel in rural eastern India. Dwindling supplies are influencing the use of crop residues, leaf litter, dung, and kerosene to meet energy needs. The mean per person consumption of fuelwood, dung, leaf fuel and crop residues by farm households is 0.46, 0.08, 0.12 and 0.04 tones respectively. Other reasons for using dung include higher livestock numbers, insufficient labor to gather fuelwood, and accessibility of biogas plants. Leaf fuel is gaining recognition since it is essentially free from the legal, social and political constraints associated with forest biomass. However, intensive use of dung, agricultural wastes and leaf litter may deprive the soils of much need organic nutrients. The study also evaluated the hypothesis that dwindling forest biomass supplies will motivate tree planting. The analyses concluded that on-farm production of fuelwood was not influenced by scarcity of forests. However, agroforestry has the potential to limit deforestation and improve agricultural productivity by freeing up labor hours normally dedicated to fuelwood collection (Mahapatra and Mitchell, 1999). Thus, the promotion of tree planting on-farm and provision of community land to meet fuelwood demand should be deliberated (FAO, 1998; FAO, 1999; Slingerland and van Geuns, 2005). However, the influence of community agroforestry on conservation depends on secure land tenure and associated land ownership rights (Contreras-Hermosilla and Fay, 2005).

Competing uses of land for biofuel feedstock production could have impacts on food security. A major constraint of the biofuel industry is land availability and the competition between biofuel feedstock and food crops for this land (Gratzl and Fawer-Wasser, 2006). Studies predict an exponential decrease in global per person agricultural land in future (2025) due to urbanization, degradation, and biofuel plantation, among other things. (Lal, 2000). A study by Engelman and LeRoy (1995) shows that the per person arable land area will be <0.1 ha by 2025 in some densely populated countries of Asia under a scenario of medium population growth. Competition is heightened when soils are degraded due to poor agricultural practices or natural processes (Swift and Sanchez 1984; FAO, 1999). The prices of food and fodder crops would increase even if large-scale cultivation of biofuel feedstocks is promoted irrespective of economic value of food crops and biofuel feedstocks (Kampman et al., 2005). This could have significant socioeconomic effects for ESAP where food security is already an issue (Yuit and Wall, 2006). Furthermore, monocultures and block cropping, which could arise from increasing biofuel demands, are associated with declines in biodiversity (Bird Life International, 2005). Ecosystems may also be harmed by more intensive forms of biomass farming as a result of changes in the water table, increased pesticide use and encroachment on wildlife habitats (Kampman et al., 2005).

Countries should concentrate on region specific biofuel feedstocks (e.g., *Jatropha curcas*, sugarcane, palm oil, sun flower, etc.) depending on soil and climate conditions, as well as energy crops that can be grown with minimal chemical inputs and with high water efficiency (Bird Life International, 2005; Raju, 2006; Yuit and Wall, 2006). However, in order to avoid pressure on lands suitable for food crop agriculture, initiatives are required to bring degraded and low quality lands under crops rich in non edible oils (Lal, 2006; Yuit and Wall, 2006). For example, Jatropha is such a crop that is cultivated in almost all tropical and subtropical countries, and is an important feedstock for biodiesel as the plant grows in poor soil and withstands long periods of drought. The Jatropha system promotes the planting of Jatropha hedges to protect gardens and fields against roaming animals and reduce erosion. The oil from the seeds can then be used as a bioenergy source. The Jatropha system and/or plantations are currently employed or are under consideration in Cambodia, India, Indonesia, Laos, Nepal, Papua New Guinea, Sri Lanka and Thailand (Henning, 2004; Yuit and Wall, 2006).

4.2.9.5 Outsourcing of biofuel feedstock production

Industrialized nations are looking to ESAP to increase production of biofuels to meet their environmental targets in terms of emissions of greenhouse gases and reduce dependency on fossil fuels (Yuit and Wall, 2006). There is a potential imbalance between countries with a high and rising demand for biofuel use and countries where biofuels can be produced at lower cost (Kampman et al., 2005; Slingerland and van Geuns, 2005; Henniges and Zeddies, 2006). Many developing countries are currently considering or already expanding biofuel production and processing capacities. This may create challenges as it becomes increasingly efficient to produce bioenergy, since competition for land and other resources will arise between food and fuel production (von Braun, 2005). Bioenergy should be seen as a positive step forward only if it is conducted in a sustainable fashion with equal emphasis placed on conservation efforts, energy efficiency and climate change policy (Yuit and Wall, 2006).

4.2.9.6 Pollution and health impacts

Traditional bioenergy derived from the combustion of wood and agricultural residues for heating and cooking may impart negative health impacts from indoor air pollution (De La Torre Ugarte, 2006). On a more global scale, the burning of biofuels is linked to large pollution plumes. The Mediterranean Intensive Oxidant Study (MINOS) investigated long-range transport of pollutants and concluded that air pollution over the eastern Mediterranean between 1 and 12 August originated in ESAP. During the Asian Summer Monsoon, convection carries polluted air into the upper tropospheric anti-cyclonic circulation and is then transported in the upper troposphere over the Mediterranean. This plume is characterized by enhanced concentrations of biofuel combustion tracers, such as methonal (Scheeren et al., 2003). However, the introduction of cleaner cooking technologies can reduce the contribution of traditional biofuels to air pollution. Traditional biofuel black carbon emissions in India have essentially remained unchanged from 1985 to 1995 due to the gradual introduction of clean technologies (Venkataraman, et al., 2005). This is despite an increase in traditional biofuel consumption. The use of modern biofuels, such as biodiesel and ethanol, is expected to reduce harmful pollutants from vehicle exhaust compared to petroleum-based fuels. An extensive survey of emissions from a range of biodiesels suggests that burning this fuel reduces health risks associated with petroleum diesel. Biodiesel emissions show decreased levels of polycyclic aromatic hydrocarbons (PAH) and nitrated polycyclic aromatic hydrocarbons (nPAH), which have been identified as potential cancer causing compounds (US EPA, 2002). If wastes from modern biofuel plants are not processed as per environmental requirements, they could be sources of pollution. Biofuels will play a major role in the energy management issues that ESAP countries will confront in the near future, involving wider policy regimes, institutional and technological choices.

4.3 Major Uncertainties of the Drivers and Projections

Major uncertainties affect individual drivers as well as the interaction between different drivers. It Is important to note the difference between risk and uncertainty. The definition of risk refers to a quantifiable change in or likely future of some variable (life of an individual, catch of fish, agricultural production, etc.). Therefore, risks are associated with certain assumptions that decision-makers can make about these variables. Unlike risk which is amenable to a certain (limited) extent of quantification, uncertainties are beyond quantification because there are gaps in assumptions (including those about number and nature of relevant determinants), missing information, and poor systems of analysis. These are variables whose future trends or changes may bring with them questions that decision-makers may not be asking at present. In some cases, crucial data may be missing; in others the capacity to understand or project non-linear changes may be lacking. Yet, it is important to keep decision-makers informed about the existence of uncertainties (Table 4-7).

Table 4-7. Major uncertainties and likely impacts in the ESAP region

The implications of these uncertainties for AKST are many and varied. Climate change and consequent variations in crop/animal production and productivity may increase investments in AKST but have a diminishing success rate over time if climate change continues to worsen. Increasing resource constraints and deteriorating law and order situations could impose restrictions on access to, participation in, and utilization of, technology and knowledge for millions of people.

Several other changes in the relationships among the drivers of change will also shape the nature and intensity of AKST in the region. For instance, increasing production problems in dryland agriculture and fisheries could lead to migration, consequent displacement and strife and may carry an entire generation of location specific knowledge to urban or other centers. Displacement will in turn affect the access to education and S&T training, thus reducing further the availability of technically qualified and trained human resources for AKST.

4.4 Relevance and Implications for Agriculture and AKST

4.4.1 Drivers of change and implications for agriculture

This chapter has discussed the available evidence from the literature on a range of variables that are key drivers of change of agriculture and AKST.

Given the pattern of evolution of the key drivers of change, the future of agriculture and food systems in ESAP reflects the continuing social, economic and environmental importance of agriculture. Agriculture in ESAP will be influenced by the economic and political choices made by individual Governments, developing and developed, and will in turn play a crucial role in shaping some of these macro-economic decisions in the region. The latter may include options for domestic social security nets, regional and global trade choices, impacts on and investments to mitigate global climate change processes, and may also lead to internal negotiations and alignments within the region, among countries willing to adopt different paths to address social and environmental sustainability. The overall sociopolitical power play in the region is an important dimension that underpins this discussion.

Overall, the trends or projections of the key drivers of change draw upon on a diverse set of policies and institutional arrangements prevalent in the ESAP region – and they reflect some of the inconsistencies and the diversity that exists in these policies and regional contexts. It must be noted that this chapter does not prescribe or attempt to smooth out the differences or inconsistencies among these projections the drivers of change – say, different predictions about demographic change or the impacts of climate change. The chapter highlights how these various predictions, despite differences in assumptions and policy contexts, have important messages for the future of agriculture in ESAP, that demand attention from decision-makers in the region.

The major implications of the key drivers of change for agriculture and food systems in ESAP are the following:

1. Given the decreasing share of agriculture in the economy of the region, and its overriding importance in providing employment, food, nutrition and health, social and environmental well-being, it is clear that **agriculture can provide solutions only if appropriate macro-economic policies are in place**.

Despite impressive overall economic growth and a declining share in the overall economy (GDP), agriculture will continue to play a major role in the economy of ESAP countries, mainly because it will continue to be the mainstay for a large proportion of the rural population in almost all the developing ESAP countries, and will be a major contributor to environmental degradation as well as focus of environmental remediation in both developing and developed ESAP countries; South Asia will be home to half the Asian population in the next 20-25 years, with an increasingly younger work force and larger proportion of women engaged in cultivation and agricultural labour. Rural women will play greater roles not only as unpaid family workers but more importantly as de facto farm managers. Thus, in the future, AKST will have to empower rural women by enhancing their skills and knowledge on all aspects of production and processing which will raise agricultural productivity and lead to economic development;

- Despite projected increases in food production and a marginal improvement in per capita food consumption, South Asia will account for almost half of the world's malnourished children (with India hosting one in every three undernourished children in the world, and China recording the highest reduction in child malnutrition by 2020), and will continue to have low access to education, health and basic environmental services like drinking water and sanitation;
- While the diversity of agricultural production and market access will increase, the role of small and marginal farmers in production systems will continue well into the future, until overall rural out-migration due to education and more urban jobs will allow these populations dependent on small unviable holdings to move to higher paid jobs and more predictable

incomes. This has implications for investments and subsidies in the region, to protect small producers, to provide some social security, or to enable through investments, more opportunities for employment in a liberalized Asian/global context;

- Globalization and increasing market liberalization will lead to increasing regional preferential trade agreements, especially for agriculture, with all ESAP countries gradually withdrawing production (input and price) subsidies and other trade distorting practices; some studies point to a trend of increasing inequality and of a need for redistributive policies that may reduce widening income gaps in ESAP.

2. Agriculture will gain from and contribute to economic growth in the region**, but the economic gains will be far less than the contributions of the sector to factors of growth and growth processes.**

- The ESAP region is expected to be the fastest growing region in the world over the next two decades (national and per capita income growth rates in East Asia and Pacific countries will be higher than those of South Asian countries). There will be increasing trade in agriculture which will be accompanied by a steady fall in prices of agricultural commodities and an overall increase in prices of inputs (especially rising energy prices), with increasing total factor productivity and substitution of labor for capital in agriculture;
- Demand for agricultural commodities will not only increase dramatically over time, but the composition of that demand will change significantly as per person wealth increases. The ESAP region is gradually diversifying its farm production in favor of higher valued commodities including fruits, vegetables and meats. The change in diets and declining terms of trade for cereals in Asia will lead to diversification of farm production into higher value products. The decline in the terms of trade and falling prices will also mean that for countries in the ESAP region to maintain a comparative advantage in agricultural commodities, they must offset through higher productivity by increasing farm sizes and increasing the mechanization of farming processes. Further, agricultural development in ESAP must exploit comparative advantages in a more globalized economy. This will mean further industrialization and product diversification, leading to the creation of larger, more technologically advanced farming industries.
- The demand for rural employment, improved livelihoods and political stability, along with increasing agricultural diversity, post-harvest and value-addition processes, specialization (organic agriculture for instance) and urbanization of food markets, will pose macro-economic challenges as well as opportunities to move people out of direct dependence on agriculture to other non-farm or urban employment. Agriculture will be integrated into industrial, environmental and health sector growth in a wider, more diverse form.

- Agriculture will be at the receiving end of most of the negative consequences of globalization and trade liberalization with elimination of tariffs in the ESAP region, marking a wider rural-urban disparity, increasing concentration of food markets/retail and grain trade in the hands of a few global players, varying levels of investment (public and private), improved transport and communication facilities, along with increasing restrictions on economic activity due to IPRs or other trade policies, increasing disillusionment, political instability, intra and inter-regional tensions (over water, trade, subsidies, environmental compliance, oceans and fishing rights, etc.), and increasing marginalization of indigenous and tribal people within these countries. Concerted action by Governments will be necessary to ensure that social safety nets and adequate investments and benefits flow to the agriculture sector and into poorer regions and communities within ESAP.

3. Environmental and social costs of agricultural growth and overall economic growth will pose additional challenges. With increasing evidence of impending climate change and marginalization of significant proportions of rural Asians from mainstream development processes, there is a requirement in ESAP for an increasingly diverse portfolio of policies, institutions and organizations to address these diverse complex problems.

- Agriculture in ESAP will be increasingly constrained by worsening environmental degradation (land, water and air pollution) caused by population pressures, agricultural production practices, urban and industrial wastes, and perceptible climate change impacts. The lack of legal and institutional mechanisms as well as lack of compliance to arrest environmental degradation and improve mitigation investments and practices will continue in most developing ESAP countries;
- Increasing land degradation, decreasing access to sufficient quality irrigation, increasing incidence of pests and diseases (with added problems epidemics like the avian flu and other livestock diseases), and varying impacts of global warming, will most likely result in increasing rural distress and migration in many ESAP countries. This will add to environmental degradation and urbanization pressures;
- The role of non-conventional actors will become increasingly important in ESAP agriculture (the socially responsible among the corporate sector and the CSOs); especially in enabling environmental sustainability through efforts to invest in organic agriculture, and indigenous knowledge systems, and to improve livelihoods in marginalized and remote parts of the region, and through their capacity to mobilize community-wide compliance to environmental legislation (at the local, national and global levels);
- Many ESAP countries – both developed and developing – will become increasingly conscious of the tradeoffs between resource depleting subsidies given to farmers, polluting industries, and trade. There is evidence of increasing efforts at the national and regional/global levels

from Governments and international bodies to address the options for reducing waste and inefficiencies, and for environmental remediation and conservation policies.

- The region is also experimenting with and rapidly adopting several conventional resource conserving technologies (watershed management, water harvesting, zero-tillage, IPM,) as well as new technologies and institutional arrangements that promote these technologies, like biotechnology, bioenergy/biofuels, biopharmaceuticals, bioplastics (environmental/green chemistry).This is despite a lack of consensus among the major actors (the State, private industry and CSOs) about the national and local processes and choices available for technology adoption and the associated effects on environmental, economic and social well-being.

Thus, the key drivers and their evolution convey the following messages for the future of the agricultural sector and food systems in ESAP:

- Agriculture and food systems need well-informed and more integrated support in the form of several direct and enabling policies;
- While existing and future terms of trade will ensure that the ESAP economy will draw benefits from agriculture, specific policies or increased investments to reduce the losses to rural and agricultural populations may be necessary;
- The environmental costs of agricultural production and the tradeoffs between environment and development will have to be addressed.

4.4.2 Relevance and implications for AKST to achieve development goals

Given the evolution of the drivers of change and their relevance to agriculture, we now explore the nature of AKST needed to address the development and sustainability goals of reducing hunger and poverty, improving nutrition, health and rural livelihoods, to facilitate social and environmental sustainability.

The ESAP region shifted fairly rapidly from a combination of subsistence agriculture and commercial cultivation (catering to colonial industries and trade), to an overwhelmingly food security driven commercial production of staple cereals. There was also a significant increase in production of milk, fruits, vegetables, poultry and fish. These were accompanied by the establishment and development of formal organizations and research programs for agricultural technology generation and diffusion, aided initially by global NGOs (e.g., Rockefeller, Ford), and later by international development organizations and national governments. Overall, AKST in the ESAP region has been crop/commodity focused (i.e. cereal crops, livestock, apiculture, aquaculture) and has paid some attention to natural resources as factors of production that contribute to agricultural growth (Chapter 2). Formal organized AKST has focused mostly on irrigated cereal producing tracts and less on arid ecosystems or drylands, coastal or mountain ecosystems, and other marginal production systems. AKST in the ESAP region has generated and enabled the utilization of several environment-friendly production technologies, such as land and water conserving technologies and IPM. Public sector R&D continues to grow in ESAP countries, along with emergence of new technologies such as biotechnology and concerns about institutional reform to enable increasing access to and utilization of technology and knowledge.

Given this context it is likely that in future, AKST in the ESAP region will be characterized as follows:

- Public sector R&D dominated AKST systems will continue in many developing ESAP countries, along with some CGIAR centers;
- Private investment in AKST and commercially appropriable technologies will continue to increase in the developed ESAP countries and in East Asia;
- Given the young age of much of the population, and opportunities for education and information technology in Asia, there will be an increasingly important role for a university education system that caters to formal AKST, with associated private and public goods;
- ESAP is also likely to witness increasing collaboration between the corporate sector and NGOs, both in technology dissemination and in new farming arrangements such as contract farming or cooperative farming that gives scale advantages to small farmers;
- Institutional reform in public sector NARS to enable effective AKST systems that can enable innovation and development will continue to be a hurdle in many ESAP countries.
- AKST will engage pro-actively with many marginal agricultural production systems and indigenous knowledge systems.
- Allocations in AKST on environmental problems will increase – and so will corresponding investments in appropriate production systems, and resource conserving technologies.

Based on the projections for the drivers of change and messages about increasing hunger, poverty and environmental degradation in parts of ESAP, the AKST requirements for achievement of the development and sustainability goals include:

- Reducing hunger and poverty:
    a) Increasing public sector investment in formal AKST organizations to address declining productivity growth rates in staple cereals in Asia.
    b) Greater exchange of and participation in international knowledge and technology networks and markets, in response to increasing globalization.
    c) Increasing attempts to understand, analyze and improve agricultural production and livelihoods in dryland, pastoral, coastal and mountain ecosystems, and other marginal agricultural production systems.

d) Open debate about subsidies to protect small holders versus investments along with AKST to enhance their production and market capacities.
e) Facilitation of other employment options for rural landless labor in areas where capital substitution for labor occurs.
f) Increasing recognition of the role of complementary investments in rural and meso- or macro- variables like rural infrastructure, rural banks, post-harvest systems, and transport, that enable more effective generation and utilization of agricultural knowledge and technologies, and more non-farm rural employment.
g) Application of agricultural knowledge and technologies to complement social security systems or targeted food distribution systems in areas of abject poverty.
h) Increasing partnerships between public AKST organizations and CSOs – for innovation and for specific monitoring of local agroecological systems.
i) More attention from national and international policy circles to institutional arrangements that restrict poor people's (especially women's) access to knowledge and technologies, and appropriate corrective measures from local AKST to enable utilization of knowledge that can enhance the income and well-being of the poor.

- Improving nutrition, health and rural livelihoods:
  a) Increasing investments in AKST for a diverse range of crops/commodities/ livestock, forestry and aquaculture systems.
  b) Increasing food safety and standards, and adoption of sanitary and phyto-sanitary systems that enable rather than distort trade in agricultural/food products.
  c) Formal AKST investments in alternative methods of production (eg organic) that are more environmentally friendly.
  d) Increasing interactions and partnerships in formal AKST, with a wide range of organizations involved in research, development, finance, transport, storage, packaging and other products or services, in public, private or civil society sectors.
  e) Substitution of all resource degrading and resource depleting inputs/chemicals/ pesticides, with new technologies or production practices such as biotechnology or IPM, wherever all required safety regulations are in place and adequate monitoring mechanisms are available.
  f) Integration of AKST with specific programs that address child malnutrition or other targeted nutrition programs – biofortified rice, vegetables, organic grain, high-protein local foods, preserved or processed foods, for example.
- Environmental sustainability:
  a) Improved AKST assessment methods and systems of monitoring and evaluation that can forewarn of environmental consequences.

b) Increased domestic and global investments in AKST organizations for research on the implications of climate change for agriculture, and for technologies for adaptation and mitigation.

c) Increased investments in cost sharing schemes for environmental services provision - enabled by resource-conserving technologies in developing countries – especially in parts of the Pacific islands and South Asia.

d) Promotion of industrial and environmental biotechnology, including biofuels and bioplastics that can enable both remediation of the environment and increase rural non-farm employment.

e) Greater development of partnerships and international agreements in AKST that can promote regional and global networks for specific ecosystems and recognize ways to minimize tradeoffs between the environmental and production imperatives of each agroecological system.

Current trends in many developing ESAP countries reveal that the capacities to make such investments or partnerships in AKST and the political willingness to make the choices (subsidies vs. investments, IPR vs. open source knowledge systems,) to enable better utilization of AKST by the poor, are limited. The capacity of the agriculture sector and AKST to improve hunger and poverty and environmental sustainability depends significantly on reforms within the sector, as well as on several other macro-economic variables and political processes. AKST in ESAP needs significant capacity development to learn from and work with a wide range of organizations and processes, in order to enable innovation for development.