CHAPTER 4

AGRICULTURAL CHANGE AND ITS DRIVERS: A REGIONAL OUTLOOK

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Key Messages

How can we reduce hunger and poverty, improve rural livelihoods and facilitate equitable, socially, environmentally and economically sustainable development through the generation, access to and use of agricultural knowledge, science and technology?

These messages derive from a range of drivers that have been studied extensively and are used here to help inform baseline projections for the future.

1. Demographic changes will have a significant impact on agriculture and AKST. Together, the combined populations of China and India currently constitute around 50 per cent of global population. The demography of the ESAP region is changing rapidly,. Population in India will exceed that in China within a few decades. In India and some other ESAP countries, the younger generation will continue to dominate the labor force. But in China, Japan and the Republic of Korea, family planning policies and improvements in health care will contribute to an ageing of the population. Economic development and rural-urban wage differentials will encourage rural to urban migration. An educated younger generation will be less interested in agriculture and the trend of rural depopulation will continue into the future. Therefore, 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.

2. Globalization and economic liberalization pose many challenges for agriculture and AKST. The contribution of agriculture to national economies is gradually declining for many reasons, including globalization and high economic growth in the services industry. However, the contribution of agriculture and allied sectors to the manufacturing sector is increasing. There is a much greater intensity of agricultural industry linkages. The existence of small and marginal farmers is challenged due to an inability to address scale issues and due to changing regulatory policies in the light of globalization. The integration of the Asian ESAP region with Western economies is increasing and this has improved investment and technology transfer to ESAP with beneficial outcomes for development. Despite increasing employment opportunities as a result of these investments, rural unemployment continues to be a major problem.

3. **Education, institutions, science and technology will play significant roles in shaping the future of agriculture.** Science and technology will play an increasingly important role in providing adaptive responses for agriculture to stressors such as climate change, increasing natural hazards, poverty and inequality, HIV/AIDS, avian flu, SARS and malaria. Increased investment in science and technology will be an imperative for the ESAP region to facilitate

adaptation. Despite the declining share of agricultural GDP in ESAP economies over the coming decades, investments in agricultural science and technology and education (private, public, international) will increase and the diversity of this investment will also increase. Agricultural labor is projected to be less attractive to younger generations, however the diversity of agricultural sector jobs is expected to increase and diversify in line with the increases in investment. The knowledge base of agriculture expands to multiple sources and interests. Local and traditional knowledge systems will become mainstream in parts (for example medicinal and aromatic plants), and continue to decline in other areas. Tribal and mountainous communities are likely to become more marginalized.

4. **Decline and degradation of natural resources and the environment will have significant implications.** 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. 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. 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.

5. **Increased natural hazards and climate change 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.** In the 20th century, average temperatures in the ESAP region have increased in line with the global average**.** Changes in precipitation are less discernible**.** The rate of sea level rise in the region, especially in the Pacific Island nations has been found to be higher than the global average. Extreme events such as floods, droughts and cyclones/typhoons are now more intense than before. Natural climatic events have caused significant damage to agriculture and livelihoods, resulting in micro-level food insecurity and deteriorating poverty among rural communities. According to IPCC projections, occurrences of natural hazards are likely to increase globally. The frequency of these events in regions that are already vulnerable to these hazards, particularly developing countries dependent on agriculture, is of particular concern in the ESAP region. Increases in average temperature and changes in precipitation patterns may lead to lower agricultural yields in many parts of ESAP. Sea level rise and resulting inundation in the coastal areas and increases in soil and water salinity, may have negative effects for agriculture in many parts of the region. Increases in temperature and humidity may also create a more favorable environment for increased pest and diseases. However, climatic changes 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 services. Biofuels and renewable energy sources will create additional energy supply opportunities.** Rapid economic growth has substantially increased energy demand in the ESAP region over the past two decades. The gap between energy demand and supply is growing and is likely to be met increasingly by biofuels and other renewable energy sources. Declining use of draught power, increasing rural industrialization, warehouse and storehouse energy demands, and rural transport will be met by expansion of alternative energy sources. Biofuels will play a major role in many parts of the region. The agriculture sector will continue to compete with other sectors for a range of inputs such as energy, services, infrastructure, and credit.

7. **Improvement of rural livelihoods in the ESAP region will arise from choices and decisions beyond the immediate agricultural sector.** Reduction of hunger and poverty in ESAP will result from agricultural sustainability (including fisheries, livestock and forestry) and emergence of non-farm employment opportunities. International climate change treaties, foreign direct investment, bilateral or multilateral investments, growth of health and education facilities and insurance etc, will bring a wide range of actors with diverse priorities and demands to the agricultural sector. The strength of democratic processes and decentralization will determine how these diverse actors will perform in technology generation and utilization – for example bio-pesticides, organic leather industry, GMOs, new livestock management practices, and coastal ecosystem management practices.

8. There are uncertainties around the potential evolution of drivers that influence the future of agriculture and AKST scenarios. However, the capacity of political, administrative and scientific systems to learn and adapt to these changes will influence the final outcome. This demands deliberate investment in learning and capacity building within organizations and at the international level. In the ESAP region, a collapse of trust in WTO, avian flu, climate change, cultural resurgence, political unrest – especially from marginal and poor populations, and global trade wars, are critical uncertainties that can shape decisions within the region, within countries in the region, or within communities in each country (especially China and India – constituting 73% of the ESAP population). The development impacts of AKST (especially on poverty) will depend on the decisions made in response to the ways in which these changes take place.

4.1 Introduction

Economic and social structures of South-and South East Asia and the Pacific islands, are unique. Economies of most of the countries are highly dependent on agriculture. Only few countries are industrialized and few others are in transition. In recent years, contribution of the agriculture sector is declining as a result of increasing contributions from manufacturing and services sectors. However, agriculture sector is still employing the highest number of people. For example, in India, this sector alone employs more than 60% of the total employed population. Agriculture sector employment in other South Asian countries is in the range of 43-52%. Overall employment in agriculture sector in South East Asia (except for Malaysia) is in the range of 37-58% slightly lower than of South Asia (ADB, 2006). The ESAP region, in more ways than one, is the last bastion of the peasantry (Hobsbawm, 2006).

Over the recent decades agriculture sector provided 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 agriculture sector has recently been facing a large number of problems in the ESAP region. **(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 area of dryland's occurring in two major Asian countries namely China and India are degraded (UNEP, 1997). **(2)** The gap between *water* demand and supply is increasing due to 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 millions of tons of food crop every year. Storm surge and tidal inundations cause crop loss in the coastal areas. Climate change is emerging as a new threat to crop agriculture in terms of excessive flood related inundation, shrinking cropping season, and temperature related yield loss. **(4)** globalization has multi-dimensional effects on agriculture. Subsidies are withdrawn which made agriculture products less competitive with highly subsidized developed country agriculture. **(5)** In spite of green revolution and per capita increase in income driven by globalization efforts, food insecurity remains a major problem in many ESAP countries. There are many causes which include: poorest of the poor are not yet targeted with education and healthcare; population growth rate exceeds the growth rate of food production; growing disparity among the poor and the rich; increased prices of food commodities that are going out of the reach of the poor because of limited income; and gender disparity.

In these contexts, the key question is: *what will be the future outlook of agriculture for the ESAP region and in particular the role of AKST in relation to meeting development and sustainability goals of reducing hunger and poverty; improving nutrition, health and rural livelihoods; and facilitating social and environmental sustainability?*

The key question was then defined through a series of more specific questions:

- How has the agriculture sector transformed/changed in the recent past?
- What were the key drivers behind such transformations/changes?
- 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 in the previous section can be addressed by either developing plausible futures based on socio-economic, technology and political assumptions that might take different shapes in the future or by extrapolating agricultural or related variables, based on assumptions made in/about the baseline period. 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 time-lines for the projections (**Table 4.1**).

[Insert Table 4.1: Approaches for scenario development and impact assessment]

4.1.2 Assessment approach for ESAP

This chapter does not develop any plausible scenarios. Instead it presents an assessment of agriculture 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. Modeling results from the Global Assessment Chapter have also been consulted.

This chapter is designed to assess the impacts of different drivers of change on AKST and *vis-à-vis*. A driver is defined as “any natural or human induced factor that directly or indirectly causes a change in AKST” (to quote the MEA, 2003, p. 85). This chapter is based on a list of key drivers of change of agriculture and AKST relevant to the ESAP region. Given the different histories of developments of, AKST itself as well as the extremely diverse nature of, intricate and complex relationships among drivers of change in the ESAP region, a classification of listing of direct and indirect drivers of change would be a superfluous exercise, academic at best but of little relevance to decision-making. What is important is to explore how these individual drivers will evolve in future; what is perhaps more important is to explore how these drivers of change relate

to each other and how their relationships and changing contexts will shape AKST in future. The IAASTD framework 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.

Plausible changes in the direct and indirect drivers and the nature of changes in their relationships are important for decision-makers to make the right decisions. A lacuna in current global decision-making and negotiations on globalization or climate change or poverty or any such international process/phenomenon, 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, p. 78). In this chapter we present some important trends in the major drivers of change that are important for plausible decision-making in the future. We refer to a large body of work on trends or projections of each driver of change which has been attempted for different purposes, by different authors/agencies, with different ideological orientations and values. It is important to note that wherever possible we refer to certain time points like 2015 (about a decade from now), 2020, 2030, and 2050 to allow for some comparability across different drivers discussed here. We also devote a sub-section to explore how these drivers of change relate to each other (the extent of heteroskedasticity in future development equations) and ask how they might then influence AKST and the ESAP agricultural sector in general.

4.2 Drivers of agricultural change (now and future)

4.2.1 Demographic change

4.2.1.1 Population growth

The population in Asia has reached 3.7 billion in 2000. It is projected that the population will increase continuously and reach 4.8 billion in 2025 and 5.0 billion in 2050, which will be 56% and 54% of the world's population respectively (United Nations, 2001). The ADB (2001a) shows that the People's Republic of China (PRC) has 39 percent of the region's population and its lowest population growth rate. South Asia has 40 percent of the region's population and one of the highest rates of population growth. 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 equally challenging implications for job creation, food security, and environmental stress.

Together, the combined populations of China and India currently constitute around 50 per cent of global population, and 73% of the ESAP population. The demography of the ESAP region is changing rapidly. Population in 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). The population trends of Asia are shown in **Figure 4.1**.

[Insert Figure 4.1: Asian population trends (Source: DESA, 2006)]

4.2.1.2 Demographic factors

Demographic factors have shaped agricultural expansion and growth over centuries. The Green Revolution in the ESAP region is the prime example of how population growth or the rhetoric of population growth and food shortages led to a planned and rapid increase in food production and productivity. In the next 20-25 years, South Asia will be the most populated part of the world and by 2025 will be home to half the population in the Asian region (United Nations, 2000) (**Table 4.2**).

[Insert Table 4.2: Regional population shares, 2004 and 2025 (%)]

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 capital income (Hussain et al, 2006).

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.

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 (MEA, 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.

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 lower. The marginal increase in fertility rates in EAP 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 that of the urban regions. Urbanisation, with almost 35 % of Indians living in urban areas, is likely to pose a major labour market concern as well as environmental concern (Dyson et al, 2004). Countries like 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).

4.2.1.3 Rural-urban migration

Rural to rural 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 percent in 1900 to 49 percent in 2005 and is expected to reach 60 percent, 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 percent 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. Past and projected population trends are illustrated in Figure1. From 2005 to 2030 the Asian urban population is expected to rise by 2.12 percent annually. At the same time, rural populations are anticipated to decline by 0.2 percent annually (DESA, 2006).

4.2.1.4 Age structure

The population structures show ageing in developed countries and young populations in most of the developing countries. In India and some other ESAP countries, the younger generation will continue to dominate the labor force. But in China, Japan and the Republic of Korea, family planning policies and improvements in health care will contribute to an ageing of the population. An ageing population is now one of the crucial social problems being addressed in China (Yuankai, 2007). In the countryside in particular, the Government is being forced to acknowledge the need to support millions of senior citizens, Jianhua, 2007). 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 (ibid).

Asia is one of the world's fastest ageing regions with the percent 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 percent of the population. Ageing presents challenges to agricultural sector productivity and innovation adoption and raises concerns over poverty among rural elderly and women. Asian developing

countries have a relatively large youth population that requires strategies to balance their aspirations with opportunities. A substantial young population in developing countries is the potential labor pool for regional developed countries and national urban development.

The outlook for the future in the Asian region is for the youth population to increase slowly to 685 million in 2040 when they would make up 14 percent of the total population. Moreover, while the growth and young adult population will continue to grow over the next two decades, in most OECD nations their numbers will decrease (Hugo, 2005).

4.2.1.5 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. Positive trends in declining fertility had led to reduction in family size while improvements in population sex ratio present a mixed picture with potential for increased matriarchal households and stress on family labor in farm sector (United Nations, 2001). The region demonstrates a decreasing trend in agricultural employment rates with increasing importance of non-farm work for income security; diversity marks agriculture and rural workers with a significant contribution by unpaid family workers (women and children).

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 age 15 to 64 were employed in all sectors, including agriculture, in nine Asian countries (ADB 2001). The status and future projection on percentage of women age 15-49 in some Asian Countries and regions are shown in **Table 4.3**.

[Insert Table 4.3: Status and future projection on percentage of women age 15-49 in some Asian Countries and regions]International trade stimulated female employment in East and South-east Asia in manufactured textiles, electronics and electrical products and other household items for export. Rapid industrial expansion also generated increased employment in the service sector for both men and women. Large increases in the percentage of women in the labour force in China, Hong Kong, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, Sri Lanka and Thailand. The expansion of female employment was particularly notable in Singapore. Fifty-five per cent of female population of Thailand was economically active in 1995, a level matched only in China. Total employment as a proportion of the population stagnated throughout South Asia, particularly because of population growth rates in that subregion (United Nations, 2002).

4.2.1.6 Inter-regional migration

Migration, both international and internal, is on the rise though there is marked difference among the educated and unskilled migrants in destination countries. Increasing people's movements in search of economic mobility brings mixed migration impacts as human resource flight through loss of skilled and semi skilled labor but with capital gain 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 show 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 regionalisation and reductions in the cost of transport imply a move toward a common labor market in the ESAP region.

The Asia Development Bank has estimated 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 general lower level of general well being (ADB,2001b). For the next few decades, livelihood gains and the quality of life in rural areas will determine the overall development gains of the Asia-Pacific region.

Since 1950 countries such as Australia, China, Fiji, Indonesia, Japan, Korea DPR, Republic of Korea and the Philippines have recorded negative population gain in rural area. Almost all the countries record relatively less gain in rural population. Yet many developing countries in the region still have a larger percentage of rural population compared to urban population. But it is also should be recognized that in most developing countries in the region urban population is represented by less 50% of the total population. Particularly countries that depend on agriculture as drivers of economy register less than 30 % as urban population –for example Bangladesh, Bhutan, Cambodia, India, Lao PDR, Nepal, PNG, Sri Lanka, Samoa, Solomon Islands, Vanuatu and Viet Nam. But for China the projection is that by 2030, the urban population at 60.5% will exceed rural population. (UNDP, 2003)

Likely ESAP regional implications will be a 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.

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 manufactures and services.

Economic growth is itself a function of many variables, including demographics, factor endowments, international trade, savings and investment, institutional capacity, and technical progress. These aspects were discussed in previous sections. The aim of this section is to examine economic growth as a driver of agricultural change in the context of scenario analysis.

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 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 scenarios: A1, A2, B1 and B2. Growth rates for Asia[1] were projected to span a range of 3.9 (A2) to 6.2 (A1) per cent 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 cent per annum.

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. These projections are reported in **Figure 4.2.**

Roland-Holst et. al. (2005) also analysed the potential for accelerated growth and higher living standards in the region under different scenarios about improved regional integration and trade liberalization. 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

[1] ASIA is defined as Centrally planned Asia and China, South Asia and Other Pacific Asia.

Asia, are removed. This scenario results in aggregate income differentials relative to the baseline in 2025 of between 8.1 per cent for Japan and 116.6 per cent 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 per cent for Asia for the period 2006-15. Oceania is projected to grow by 3.09 per cent per year on average over the same timeframe. This compares to projections undertaken in 2003 by FAO indicating a 2.2 per cent per annum growth rate for Oceania over the period 1999-2010, 5 per cent for South East Asia, and 3.3 per cent for South Asia (FAO 2003).

[Insert Figure 4.2: 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 cent per annum on an annual average basis for 2010-30 in the central scenario and 6.8 per cent in the high growth scenario. The corresponding figures for South Asia are around 3.4 per cent and 5.1 per cent 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, labour supply in developing ESAP countries is expected to continue to grow over the next two decades. However labour supply in some developed ESAP countries is expected to decline along with a marked aging in population. The case is particularly evident for Japan, whose population is not only aging but in decline.

ABARE (Matysek et al. 2006) provide estimates of labour supply growth over the period 2001 to 2050, including for some ESAP countries. While Japan's labour supply declines over the entire projection period, other developed ESAP countries' labour supply growth slows over time. China, South Korea and Chinese Taipei are all expected to have negative growth in labor supply by 2030-50.

However, significant improvements in education and literacy rates are expected to raise labour productivity, particularly in South and South-East Asia (**Table 4.4**). This may have beneficial or negative implications for agriculture, depending on the level of development of the country and its structure, *inter alia*.

Mechanization in agriculture has historically increased, most strongly in South and South-East Asia and China. The mechanization trend has been stagnant or in slight decline in some of the developed ESAP countries but is expected to continue to increase in most developing countries (FAO 2003).

Other factors that will influence the level of agricultural productivity into the future include 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. These variables are discussed in other sections of this chapter.

[Insert Table 4.4: Sources of economic growth]

In all Asian economies, the predominant source of growth over the coming decades will be chiefly attributable 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 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 expect 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 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 4.3**).

[Insert Figure 4.3: Yield growth rates by region, all cereals. Source: Rosegrant et. al. (2001)]

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).

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 (ADB 2006). High oil prices can also result in increased demand for biofuels, with implications for production of other agricultural crops (section 4.9.1).

Projected agricultural commodity prices are expected to fall by 2015, relative to 2001 levels. ADB (Park and Zhai, 2006) present 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. These issues are discussed in sections 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. This has led to an increase in the level of competition and to the closure of less profitable, primarily smaller farms (Tauer and Mishra, 2006). This is largely explained by increased competition from global markets where large farms are able to remain competitive because of economies of scale, preferential access to markets and technologies (Adrian et al. 2005; Mishra and Park 2005).

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 slaughterhouses, 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. Globalisation 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).

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). Hertel and Keeney (2006) report estimates of a 48 per cent increase in exports of agriculture and food from China, a 17 per cent increase from Indonesia, 13 per cent increase from the Philippines, 88 per cent increase from India, 24 per cent increase from Bangladesh, 35 per cent increase from other East Asia and a 10 per cent reduction from Vietnam.

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 4.5** presents projections from the World Bank (2007) based on its central growth scenario.

[Insert Table 4.5: Projections of poverty by region]

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

4.2.3.1 Food consumption and demand

Recent FAO projections suggest that as population growth rates decline and countries become richer, demand for food will continue to grow. Rapid population and income growth in East Asia have been key drivers behind the rising demand for world food commodities (ADB 2006). 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 2006).

Growing projected demand for agricultural commodities in the ESAP region suggests there will be significant challenges in achieving the Millennium Development goals. Agricultural productivity growth will be crucial to ensuring adequate food supply, however this will be challenged over the coming decades by resource depletion and environmental degradation. Agricultural research and development will be important in ensuring continued productivity gains. Trade liberalization will also be important 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 commodity demand and prices. Agricultural and light manufactures demand will increasingly give way to heavy industrial raw materials (ADB 2006). This process is expected to be repeated in India over the next few decades, with further 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).

Globalization, changes in prices, changes in climate, changing costs of water (irrigation) and access to different kinds of food has enabled major changes in food demands. It is expected that in North India, Northern and Southern China, the current demand for rice (a gradual shift in demand from wheat based diets) will continue well into the future (FAO, 2006). A gradual shift in demand from rice towards wheat is taking place in South East Asia – especially in Thailand, Philippines, Malaysia and Indonesia. Though this trend is just starting in Vietnam, 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 wheat-and-rice staple diets (FAO, 2006). However, a notable exception is Bangladesh, which, with its heavy dependence on rice, is projected to continue to derive 70-80 per cent of total food calories from cereals over the next few decades (FAO 2006). The Pacific countries like Samoa, Tuvalu, and Solomon Islands reveal increasing preference for these cereals in place of their conventional starchy roots/tubers. (*ibid*).

4.2.3.2 Changes in dietary habits

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. The World Bank (2007) projects wages income will rise at the fastest rate in East and South Asia of anywhere in the world. As disposable incomes increase, demand for starchy staples declines, while demand for livestock products, fruits, vegetables and processed food products increases (OECD-FAO 2006).

The implications of economic growth on food demands 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 (Rosegrant et al. 2001). With additional growth and improvements in per person wealth, food demand will shift again.

Another driver of changing import demand for cereals has been significant improvements in agricultural productivity as a consequence of the Green Revolution (Boestel 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 2006). 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 2006).

FAO (2006) provide projections for the commodity composition of food demand for a range of global regions including South Asia and East Asia (**Table 4.6**). Daily calorific intake increases through time in both regions, however the composition of that intake varies between South and East Asia. 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.

[Insert Table 4.6: Changes in the commodity composition of food demand (expressed in kcal/person/day)]

4.2.3.3 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 2006). A partial explanation lies in adoption

of capital to offset labor shortages, with the type of technology adopted at least 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 Socio-political drivers

4.2.4.1 Economic liberalization and regulation

Economic liberalization and increasing globalization has benefited those countries and populations within, who have capital, entrepreneurial ability and education, and skills (WCSDG, 2004). Whereas the poor, assetless, illiterate and unskilled populations of the world 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 (of people earning less than 1 $ a day), by half (1990-2015) (ADB, 2005, Table P1). Some countries like the PRC, Thailand, Sri Lanka have already halved or more than halved their population living in abject poverty (less than 1 $ a day), and will continue to have lower shares of their population under this condition.

What are the chances that economic liberalization in an era of globalization will bring more effective redistribution in unequal societies like in some of the ESAP countries like India, the Philippines, Bangladesh, etc.? One argument is that within these countries, the demand for redistribution will depend on the design of the redistributive policies- "specifically that demand for income insurance declines as inequality decreases" (Przeworski and Meseguer Yebra, 2006, quoting the Moene and Wallerstein (2001) study). But 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 the "provincials" who are less mobile, with lower labour market skills (Bowles and Pagano, 2006).

Economic liberalization and new labour and knowledge market regulations may enhance private investment – but to what extent these drivers will change investment in R&D is not known.[2] In a region where fundamental labour 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/other technologies.

4.2.4.2 Political stability

A political fall out that will play up significantly in ESAP's future, stems from peoples disillusionment with economic liberalization, their own 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, all developed countries (except the USA and UK) have enhanced and expanded the size of their government sector (ratio of government expenditures to GDP), the ESAP region will also respond with an increasing size of the government sector – with the 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. But 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 (ibid)

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, anti-democratic legislations, etc. in countries ranging from Sri Lanka, India, Nepal, Thailand, Bangladesh, Myanmar, East Timor, Vietnam, Indonesia, Papua New Guinea, and some more Pacific countries). While political instability caused by such forces do reduce and even disable trade in agricultural goods and discourage learning and technology

[2] 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).

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 agro-ecological terrains (for the case of soft borders and people negotiating these borders in India's North Eastern states, see Baruah, 2005; Hazarika, 2002; Kurian, 2006). 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 increasing India-ASEAN relationship may add to political stability in the region in a wider sense. But this depends on India's capacity to generate economic growth within, 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, relationships of the ESAP region with global powers (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 of the PRC is keen on improve 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, Xinhua News Agency, 27-2-07). An important commitment for the future will be that the country will adhere to peace and peaceful processes for development in the region (ibid). Indian political parties – irrespective of their ideological differences are all committed to (a) peace and friendly neighbourhood relationships (b) industrialization as the mainstay of economic growth in future, (c) rural regeneration, and (d) infrastructure, energy investments. However, political strategy towards regional co-operation (especially in trade and labour 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 to safe its own/its allies interests in the region (Christiansen, 2007).

4.2.4.3 De-regulation

Deregulation has been attempted in many ESAP countries, with India, China, Thailand, Indonesia and several developed ESAP countries like Australia, New Zealand and Japan taking 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 SriLanka – and India will be the most closed (relatively) for some time to come (World Development Report, 2006). This is however, to be expected till the employment growth rates match with 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 spells doom for the manufacturing sector and agriculture sector (Patnaik, 2005; Sen, 2005). 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 (Veeramani, 2007, Mani, 2005) 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, 2005).

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 to 0.85% per annum to economic growth in China (2005-2014 period), 0.80% in Indonesia, 1.32% in India, and 0.45% in Bangladesh (Ianchovichina 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 Vietnam seem to be investing at these rates. Countries like India, Indonesia and Philippines have

fallen behind their own 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 upgradation or export oriented units (in industrial investments), etc. 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, 2006). 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 broader MDGs. (Farrington, 2006).

Much of the infrastructural investments, however, continue to take place in urban or peri-urban areas and areas like coastal China, metropolitan areas in Thailand, Indonesia, Vietnam and India, leaving rural infrastructure relatively unattended (World Bank, 2006). 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, **Box 4.1**). 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, WatSan, 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 (ibid). The South Asian countries are likely to invest more in infrastructure provision – especially in energy and energy trade across the border (Jones, 2006).

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 programmes in many countries, including some small countries like Nepal, Sri Lanka, etc., seems to playing an important role in

strengthening local democracy, by bringing peoples 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, ASEAN, etc. 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[3]. 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 the emerging scenario options (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 co-operation is wanting in several key areas of co-operation 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 coopertation, addressing poverty and injustice growing inequality and social disparity in the region. (Sobhan, 2004). However, recent developments in ASEAN points towards a move to deepening of regional integration over the coming decade (ibid). It is important to recall here that monetary cooperation among Asian countries increased substantially after the Asian financial crisis of 1997/98.[4]

The tension between the two developed economies (Japan and Australia) in the ESAP region and their differing views on and expectations from the Chinese economic growth is likely to

[3] 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).

[4] Growth during the early 1990s largely fuelled by increasing input use and increasing borrowings did not sustain Asian economies for long – the Asian crisis of the 1997-99 period was waiting to happen (Krugman, 1994; World Bank, 1996).

increase in future.[5] On one side there is Japan's mistrust of the Chinese growth and on the other side there are Australian expectations of access to Chinese markets and mobilizing investments from China, both of which will continue to increase (Terada, 2006). This is likely to influence and shape the regional cooperation among the Asia-Pacific countries (ibid).

It is also likely that trade and economic cooperation among countries of these 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)[6] 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, 2007).

4.2.4.6 Agricultural trade

Trade in agriculture and allied products has grown significantly in the region during the period 1991-2004 (FAO, 2006). The ESAP region will continue to be a net importer of agricultural products (including forestry and fisheries) (ibid). Current trends like the sub-regions SE Asia and the Pacific islands being net surplus producers and exporters, while South Asia and the developed Asian economies – Japan, Singapore, Australia and New Zealand continuing to be net importers of agricultural products may continue till the 2010s.[7] 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

[5] Cooperation in monitoring the 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).

[6] 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, -----www. ---------, 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 (National Intelligence Council, 2004; Tammen, et al. 2000 – quoted in Tammen 2006). 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 Carribean region and the Asia-Pacific region (Nayyar, 200 -----).

[7] What is striking about the ESAP countries is that today (2002-2004) food/agricultural imports especially cereal imports account for less than 10% of foreign exchange reserves (compared to the period 1969-71, when cereal imports was to the tune of 40% to 120% of foreign exchange reserve in some countries) (FAO, 2006).

domestic policies to maintain economic growth and social justice will be tested in the context of agricultural trade in the ESAP region during the 2010s.

The current trend however is towards PTAs. Besides the overall economic growth, both India and China have increased their share in global trade and in various bilateral and preferential trade agreements 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 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) compared to India's (accounting for 2% of increase in global exports and imports during the period). (World Bank, 2006; FAO, 2006). 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).[8] One of the greatest fears in most ESAP economies is that farmers distress will increase with increase in imports of critical crops and with removing the tariff barriers. But 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 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. This is crucial in the Pacific region - besides the major trade and economic cooperation agreements, environmental, bio-diversity and ethnic factors legitimize the need for sub-regional cooperation in ensuring sustainable development – especially for the poor in these small island Pacific countries (UNESCAP, 2005). The Pacific countries may also face the greatest threat from global warming and climate change, with disastrous consequences to natural and human life.

[8] 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.

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)[9]. They have taken on different organizational formats. The Asia Pacific Research Network (APRN) for instance is a collective 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 programmes, 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, insurance, etc. 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 (Yamamoto and Ashizawa, 1999; and Korten, 1997). 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, 2007). 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 (Sulaiman and Hall, 2005; Christoplos, 1996).

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

[9] The organizational format of these organizations range from simple trusts or registered societies to private not-for-profit organizations. They may be locally based within a group of villages or international in membership, and work may be entirely voluntary, contributory, or salaried often at internationally competitive pay-scales.

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 hardly ever acknowledged by formal public sector agricultural science. 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.

4.2.5 Education, culture, ethics and health

Patterns of demographic change and prospects of economic growth discussed in sections 4.2.1 and 4.2.2 above have major implications for social development. 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 is mainly by 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, that 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 labour force.

A significant impact of the demographic profile of each country is evident in the estimates available for growth in labour force in the region. Asia's labour force will increase by 14% or by 245 million in 2015 compared to 2005. Though China will contribute to this labour force increase, the share of China in the increase is rather limited – because of its internal fertility rate and population growth rate. By 2015 China will add a 7% additional labour to its current labour force. The corresponding figures for Bangladesh (25%) and Philippines (24%) are far higher.(ADB, 2005). Labour 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 labour 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-ordinating and monitoring industry.

Increasing economic liberalization and reduction in tariff rates in future (beginning with 2010) does cause concern about demise of 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 labour (Rural World 3) (Pimbert et al, 2001). There will be increasing demand for labour/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 change 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 labour 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 labour force participation in the world.

Gender and urban biases in education (see IFAD, 2001; ADB, 2004; UNESCO, 2006) will continue to be the 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. (Fennel, 2006; IFAD, 2001). Agricultural education investments are likely to decline in the formal University/Agricultural University set up (Byerlee and Echverria, 2002). But investments in private and public sector higher education and research as well as investments in the form of Farmer Field Schools, training programmes 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 (UNESCO, 2006; IFPRI, 1995; Ooi, 1998)

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 labour 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.

[Insert Box 4.1: Points for future investment in human resources in Asia-Pacific region]

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 trend to understand local knowledge systems and their role in shaping or utilizing the outputs of AKST will be strengthened in the ESAP region. But 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 are 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 2006; Biggs and Matsaert, 2000; Hall et al, 2004). 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, will continue well into the 2020s in the ESAP region unless challenged by dynamic developments which the social sciences are compelled to study (Cernea, 2001; Raina, 2005).

4.2.5.3 Local and traditional 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. Given rapid urbanization, corporatisation of agriculture, this is a trend that will prevail in the region for at least 10-15 years. Note that indigenous knowledge, agro-ecological approaches to understanding and scientifically validating indigenous knowledge have been much analyzed and discussed topics for over twenty years now. [10] 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,

[10] See Chapter 2 for a detailed discussion on the evolution of indigenous knowledge as a platform that challenged the mainstream view of agricultural science and technology.

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 (bio-prospecting, IPM, health care, fisheries, etc.) and thereby pose challenges to IPR and knowledge piracy often indulged by Western pharmaceuticals (Pushpangadan, 2000; Gakuru, 2006). Investments in NFE, traditional health care, organic agriculture, IPM etc. bring opportunities to acknowledge, revive and provide opportunities for economic growth to repositories/practitioners of traditional knowledge.

4.2.5.4 Human and ecosystem health

By 2020, the ESAP region will be home to a massive section 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 (World Bank, 2005, and Rosegrant, 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 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). 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.[11] 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). 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

[11] It is worth noting that japan with its 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, Chapter 7).

populations, with unique bio-geographical 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 (Rangarajan, 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 centres like IRRI and CIMMYT through their Rice-Wheat Consortium across the five countries in the Indo-Gangetic Plains), water management (in all ESAP countries), agro-forestry (in India, China, Thailand, and some East Asian and Pacific countries), favourable 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 overfishing. 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; quoting World Bank, 2005). In terms of agriculture, air pollution is likely to pose severe constraints to production and productivity gains (Marshall et al, 1997). 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 air pollution,

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 convincing and attractive rates of return to investments in agricultural research and several impact assessment studies, there is little available on possible trends/estimates of agricultural research investment. (see CGIAR, SPIA studies, conferences). 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, p. 151).

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. 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).[12] While internationally, and in the developed countries, this decline has been more than compensated by increasing private funding of agricultural research, the developing countries of the ESAP region have made little gains in private funding of agricultural research[13].

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, 2000; Tabor, Janssen and Bruneau, 1998), there is currently increasing emphasis on the role of the government in research and other enabling investments in the agriculture sector (ARD, 2006; Hall et al, 2002; Byerlee and Echeverria, 2002). Much of private investment in agriculture –is in the industrialization and capitalization of the sector. Given the trends of increasing urbanization and expected growth of value-addition and

[12] Agricultural research intensity ratios are found to be relatively low for developing countries in the Asian-Pacific especially when compared to the target suggested by Pardey and Alston (1995) and Pinstrup-Anderson, Lundberg and Garrett (1995), which is 2 percentage of GDP.

[13] 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). Now private investment in agricultural R&D is less than 10% of total agricultural R&D in the ESAP countries (Pray, 2002).

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 and Berdegue, 2000). Increasingly, the argument for pro-poor agricultural/rural innovation is to look for complementary investments in other actors (organizations) which play a major role in enabling generation and utilization of knowledge (besides technology) (Hall et al, 2004; Biggs, 2006; ARD, 2006).

4.2.6.2 Research organizations and institutions

The expansion of research organizations in the agriculture and allied sectors being 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, 2003). 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 AVRDC 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.

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, village artisan based, and public 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). 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 (Hall, 2005; Raina, 2003; Chathaway, 2004; Sahai, 2004; 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, 2002). The Asia Pacific Association of Plant Tissue Culture and Agro-Biotechnology have reasons for approving the release and utilization of GM crops in the region (Sahai, 2004)

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 Bio-Vision 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 gain seventh place in the world of biotechnology.

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 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. 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 IPM, 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 and China 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 system.

4.2.6.5 Innovation or generation and utilization of knowledge

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). This reflects two major concerns that plague Asian agricultural research organizations: (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.

4.2.7 Natural resources - land use and land cover change

Millennium Ecosystem Assessment (ME) recently concluded that 60% of the ecosystem 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. The ecosystem services could degrade significantly until 2050 and 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 natural environment, overexploitation of inland and marine fisheries, land degradation, competition between urban and agriculture water supplies and degradation of water bodies/wetlands, water pollution and loss of biodiversity. Combination of natural resources degradation process will impact agriculture productivity and livelihoods especially in the marginal and vulnerable areas.

Over the recent decades agriculture sector provided 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 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.

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 area of dryland's occurring in two major Asian countries namely China and India are degraded (UNEP, 1997). 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.

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 percent less than that of 1950 (ADB, 2001c) (**Figure 4.4**).

[Insert Figure 4.4: Decline in Water Resource Per Capita (1950-2025). Source: Asian Development Bank, 2001c, "Water for All: The Water Policy of the Asian Development Bank"]

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 percent (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. The PRC, 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 requires 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 to 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.

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 (Jha et al., 2005; Niroula et al., 2005; Nguyen et al., 1996).

4.2.8 Climate change and natural hazards

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. Interseasonal, interannual and spatial variability in rainfall trends have been observed in the last few decades. A decreasing trend in annual mean 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 southeastern coast of China, Bangladesh and along the western coasts of the Philippines (IPCC, 2007).

Climate models' projection results documented in the 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 modelling 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 modelling experiments project extreme heatwaves 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 cause significant damage to infrastructure and coastal agriculture in the ESAP. As generation of cyclones and typhoons are highly related to sea surface temperature, Knutson *et al.* (2004) suggested that with a 2 to 4^{o}C rise in sea surface temperature, cyclone/typhoon intensities in East Asia, Southeast Asia and South Asia could increase by 10-20%.

4.2.8.1 Climate change and agriculture

According to the IPCC (McCarthy et al., 2001), agricultural production in ESAP will be threatened by climatic variability and increased frequency of extreme weather events in coming decades. Increasing temperatures, especially the night-time temperature, could be detrimental to the growth of crops. From field level experiments conducted at IRRI in the Philippines, for each degree increase in minimum temperature in the growing season, rice yield could be reduced by 10% (Peng *et al.*, 2004). As such, reductions in the duration or changes in timing of the onset of seasonal floods will affect the scheduling and extent of the cropping and growing seasons, which may in turn have as large an impact on livelihoods and production systems. Mirza (2002) estimated 1.6 to 1.77 million tons of rice damage in Bangladesh by a 20-year flood for a 2 degree C rise in global mean temperature [the previous sentence is not clear – needs rewriting]. The range of damage could increase to 1.78 to 2.3 million tons for a 6^{o}C temperature rise, which is the upper bound of the global mean temperate rise expected by the end of this century (IPCC, 2007). Potential increases in droughts especially in South Asia could reduce crop yield and may be harmful to livestock populations.

Should sea water intrusion occur this would cause a reduction in agricultural productivity in the affected coastal areas. However, brackish water fisheries may be enhanced as a result of sea level rise. Some areas of ESAP where agriculture is now constrained by cold climate and inadequate precipitation could be benefited, for example, in northern China.

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 (McCarthy et al., 2001). 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.

4.2.8.2 Floods

Flooding occurs annually in many parts of EASP, and brings about both positive and negative impacts in the region. Damage to crops by floods 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 (**Figure 4.5**). 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). Table ? shows loss of major crops due to floods in different years in Bangladesh.

[Insert Figure 4.5: Various seasons crop calendar of Bangladesh (Source: Ahmed, 2004)]

4.2.8.3 Droughts

Droughts are very common in many countries in ESAP. In South Asia, Bangladesh is also highly vulnerable to droughts. The droughts occurring in the monsoon period severely affect rice crop production. Between 1950 and 2000, Bangladesh was severely affected by nine droughts. Past droughts have typically affected about 47 per cent of the country and 53 per cent of the population (Task Force, 1991). North Korea is another country in ESAP which is highly vulnerable to drought. The famine of 1997 and 1998 caused by acute floods and droughts killed between 600000 to two million people as result of 50 percent reduction in corn production (Watts, 2005).

It is anticipated that future climate changes could influence variations in 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 95% of water supplies in the region are used for agriculture, crop productivity will be severely impacted if access to water is diminished (FAO, 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 pose significant pressure on water availability in the dry summer months and instigate the gradual transformation of already water stricken areas in into arid deserts (Barnett and others 2005; McCarthy et al., 2001).

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). Thus, AKST initiatives to develop pest and disease resistant crops could greatly improve adaptation capacities throughout the ESAP region.

4.2.8.5 Adaptation

Farmers may also have to adapt to changing hydrological regimes by changing crops (McCarthy et al., 2001; Manuta and Lebel, 2005). Schemes are being developed in many flood vulnerable

areas to adapt to rather than protect against flooding. For instance, in order to reduce the damage of flooding along the Mekong River, the Government of Viet Nam advocated and promoted a shift in the cropping calendar within the river basin to sow the winter-spring crop in November instead of February and harvest in March instead of June; and to sow the summer-autumn crop in April instead of July and harvest in August instead of November. According to the new cropping schedule, the harvesting of summer-autumn crop will be completed before the floods (Tinh and Hang, 2003). The role of AKST in *developing new varieties* to adapt to different growing seasons and climatic conditions is therefore significant.

Scientists at IRRI in the Philippines have identified a gene that enables rice to survive complete submergence. The discovery would help 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. A rice variety has already been developed and is under trial in Bangladesh and India. In the face of increasing drought frequencies, AKST initiatives can improve *water conservation techniques* used for irrigated and rainfed agriculture. Adaptation strategies should also promote a shift from conventional crops to more water efficient crops (Safriel, 1995). The IPCC (2007) recommended some adaptation measures for the agriculture sector in Asia. Implementation of most of these recommended measures need substantial input of technical, financial and human resources (**Table 4.7**).

[Insert Table 4.7: Climate change and adaptation measures in agriculture]

4.2.8.6 Food security, human adjustment/migration and trade implications

Food security, hunger and famine-all these not directly related to climate related crop loss; but natural hazards accelerate them. Climate change and possible increased natural hazards could increase hunger and malnutrition in many nations in ESAP which include Bangladesh, China, India, North Korea, Viet Nam and the Philippines. A sizeable proportion of the population (urban and rural) suffers 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. Parry *et al.* (2004) projected a three-fold increase in global cereal prices by 2080 as a consequence of decline in net productivity due to climate change. IPCC (2007) noted that subsistence producers who grow crops like sorghum, millets in dry conditions could be at greatest risk of a potential drop in productivity and from the danger of losing crop genetic diversity. In the near term, Parry *et al.* (2004) projected an additional 49 million people would be at risk of hunger if the world follows the SRES A2 emissions scenario without any

carbon fertilization. By 2050 (mid-term) and 2080 (long-term), the additional people at the 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. Food trading with northern countries would be expected to increase to meet any shortfalls. 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.

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. But, 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, labour 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 of farming and irrigation equipment. The anticipated declining trend in rural populations, and thus agricultural labour, could pose a threat to urban food security, especially in the face of significant urbanization. (*ibid*).

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 km^3 of water, mostly for irrigation (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 pattern is to move from traditional bioenergy 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 electricity generation. Improving the efficiency and reducing harm of traditional bio-energy remains a challenge and needs to be addressed.

Bioenergy can take the form of solid biomass or liquid biofuels – and have the significant advantage that theoretically does not 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). However, increasing food prices, potential deforestation and depletion of water resources could emerge as byproduct environmental problems.

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 percent, of which 0.7 percent is attributed to traditional biomass (IEA, 2004). **Table 4.8** lists recent biofuel policy initiatives in six ESAP countries that are anticipated to support this increase.

[Insert Table 4.8: 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 has 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).

4.2.9.3 Bioelectricity or electricity from biomass

A common inquiry is the potential of biomass to produce electricity, especially with respect to mounting global energy demands. Coombs et al., (1992) conclude that a sustainable, economically competitive global bioenergy supply is around 270 EJ per year, which is approximately 70 per cent of the total world energy consumption in 1990. Since the actual amount of bioenergy that is used was merely 12 per cent 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).

Rice husks in Southeast Asia have significant potential for electricity generation. It was estimated that 3255 tonnes of rice husk are produced in Southeast Asia every hour. 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. 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 millions of acres would be needed to meet the countries gasoline demands for a business-as-usual scenario in 2050. This figure decreases to 114 millions of acres is sprawling land development is curbed, biofuel conversion efficiency is improved and feedstock yield is increased (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 may be necessary to meet projected energy demands. 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, leaves and other forest litter, overexploitation of this resource will result in damage to forest ecosystems and a subsequent loss in biodiversity. This is especially a concern 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 demands for biofuel. Energy security is also linked with food production since a predominant use of biofuels is for cooking. Therefore, the adequate supply of biofuels has an important bearing on the nutritional security, especially in rural areas and for low income households (Mahapatra and Mitchell, 1999; Kampman et al., 2005). However, prices of food would likely to increase due to use of more agricultural land and labor for biomass production.

A study in Eastern India investigated the increased pressure on regional forests to provide fuelwood, which is the major 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 capita 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, absence of labour 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 labour hours

normally dedicated to fuelwood collection (Mahapatra and Mitchell, 1999). Thus, the promotion of tree planting on farm and community land to meet the fuelwood 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, which ultimately transfer power to the communities to secure their future (Contreras-Hermosilla and Fay, 2005).

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 capita agricultural land between 1960 and 2025 due to urbanization, degradation, biofuel plantation etc. (Lal, 2000). A study by Engelman and LeRoy (1995) shows that the per capita arable land area will be <0.1 ha by 2025 in some densely populated countries of Asia under scenarios of medium population growth rate. Competition is heightened when soils are degraded due to poor agricultural practices or natural processes (Swift and Sanchez 1984; FAO, 1999). Competition may increase the price of food and fodder crops if the cultivation of biofuel feedstock becomes more profitable (Kampman et al., 2005). This could have significant socio-economic effects for ESAP where food security is already a significant 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 feedstocks 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). Initiatives to bring areas of degraded and low quality lands under biodiesel plantations should be developed and focus should be on the cultivation of crops rich in non edible oils (Lal, 2006; Yuit and Wall, 2006). Jatropha, a crop cultivated in almost all tropical and subtropical countries, is an important feedstock for biodiesel as the plant grows in poor soil and withstands long periods of drought. Plus, the seeds contain about 35 % of non-edible oil. Thus, it will not compete directly with food crops. 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 Prices of fossil fuels and implications for agriculture

Increasing energy demands and rising global oil prices are putting financial strain on ESAP countries especially since all countries are net imports of petroleum fuels, which accounts for 34 percent of South Asia's energy mix. This also has implications for agriculture and thus food security since the costs of agricultural inputs, processing, and transportation become more and more expensive. This could result in an increase in food price. Thus, many governments are looking elsewhere for energy sources. Long term developments in fossil fuel prices, such as decreasing reserves, political instability, and future investment in production, may make biofuels more economically attractive (Slingerland and van Geuns, 2005; Kampman et al., 2005). Energy tax directives that seek to favour biofuels also make them more competitive with fossil fuels. While biofuels are presently more expensive, new technologies are predicted to be cheaper than conventional fossil fuel and diesel. However, new biofuel production systems are still in the research and development phase and significant investments and government incentives are still required to market them on a large scale. In addition, farmers may only capture a small share of the total added value from biofuel production since large biofuel producers and the gasoline industry often benefit disproportionately from broad incentives (Kampman et al., 2005; Henniges and Zeddies, 2006; Rosegrant et al., 2006).

In addition, industrialized nations are looking to ESAP to increase production of biofuels to meet their environmental targets 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 lowest cost (Slingerland and van Geuns, 2005; Kampman et al., 2005; Henniges and Zeddies, 2005). This trend is illustrated in Figure 3. 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 (Bird Life International, 2005; 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

originates 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 biofuels to air pollution. A study by Venkataraman, *et al.* (2005) concluded that biofuel black carbon emissions in India have essentially remained unchanged during the 1985–1995 period despite an increase in biofuel consumption due to the gradual introduction of clean technologies. Furthermore, the use of modern biofuels, such as biodiesel and ethanol, is expected to reduce harmful pollutants from vehicle exhaust compared to petroleum-based fuels.

4.3 Future food systems, agricultural products and services

4.3.1 Past assessments and relevance to ESAP (e.g. FAO, IFPRI, GEO, IPCC, MA)

4.3.1.1 FAO (2002)

In the report 'World Agriculture: Towards 2030/2050', the FAO concludes that future food consumption patterns are determined by growth in population and in incomes, and by changes in dietary preferences. Projections show a continuing slowdown in the growth of the world's population. Since the peak population growth rate of 2.04 percent a year in the late 1960s, the growth rate has fallen to 1.35 percent and is expected to fall further to 1.1 percent in the period 2010 to 2015 and to 0.8 percent in 2025 to 2030. Absolute population will also fall from a peak of 86 million a year in the late 1980s to current annual additions of around 77 million and. These increments will fall to 67 million a year in 2025 to 2030 and 43 million per year in 2045 to 2050. While future economic growth is projected to rise 1.9 percent a year in per capita incomes between 2000 and 2015, it is unlikely that the absolute impoverished population can also be halved, declining from 1.27 billion in 1990 to merely 0.75 billion in 2015.

Corresponding to a declining population growth and slowed economic progress is a projected decrease in the growth of demand for food despite rising global demands for agricultural products. The annual rate is expected to fall from 2 percent for the period 1989 to 1997-99 to 1.6 percent for 1997-99 to 2015 and to 1.4 percent for 2015 to 2030. The decline is even more pronounced in developing countries with a drop from 3.7 percent for the past 30 years to an average 2 percent for the next 30. This is attributed to the fact that daily food consumption in many large developing countries, such as China, is approaching that of industrial countries. Once this level is reached, further growth in demand is thereby slowed. For instance, growth in wheat yields is projected to slow to 1.1 percent and in rice yields to only 0.9 percent per year in developing countries. However, this trend is not expected in India because cultural traditions

favor vegetarianism, which will hold back the country's demand for meat and animal feeds at rates well below those seen in China.

In order to satisfy food requirements to be created by increased population, an extra billion tonnes of cereals will be needed each year by 2030. This means that developing countries could be required to import 265 million tonnes of cereals annually. 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. 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 percent of production growth with the remaining 80 percent resulting from intensification practices such as higher yields, increased multiple cropping and shorter fallow periods. In South Asia, almost 98 percent of suitable land is already in use. Thus, there is little capacity for expansion in area and it is projected that more than 80 percent 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 percent of their irrigable area and South Asia (excluding India) is expected to exploit almost 90 percent. This will result in a 14 percent increase in water withdrawals for irrigation in developing countries by 2030. Consequently, 20 percent of developing countries are expected to face water shortages.

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 percent, from 2680 kcal in 1997-99 to 2850 kcal in 2015. The proportion of undernourished people is anticipated to fall from 20 percent in 1990-92 to 11 percent by 2015 and 6 percent by 2030. However, the 2015 target of halving total absolute number of undernourished people will probably only be reached in 2030 when the numbers are expected to fall to 440 million. This 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. The proportion of global population living in countries with per capita food consumption under 2200 kcal per day will fall to only 2.4 percent in 2030. However, in South Asia, the fraction could fall by 40 percent from 1997-99 to 2030 and in East Asia the number could halve.

The 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 the 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.

4.3.1.2 IFPRI (2001)

In the report, Global Food Projections to 2020 (IFPRI, 2001), the International Food Policy Research Institute (IFPRI) explores prospects for the global food markets in terms of long-term food supply, demand, trade, and prices under various future scenarios. The projections to 2020 begin from a base year of 1997 and are generated using a global food projections model called the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). The first stage of the assessment was to determine and investigate a baseline scenario that reflects the best estimate of the future given specific policy, technological, and behavioral assumptions. In the baseline scenario, total cereal demand is expected to increase by 1.3 percent per year between 1997 and 2020. However, this is a decrease from historic rates, primarily because population growth rates are slowing. Developing Asia will account for 52 percent of the global increase in cereal demand. As incomes and urbanization rise, the mix of aggregate cereal demand will change from rice and wheat being the major cereal crops in developing countries in 1997 to maize becoming the mainstay. In Asia, the aggregate demand for rice will decline by 4 percent of total cereal demand between 1997 and 2020 while the demand for maize rises 6 percent. However, per capita demand for maize will decline by 16 percent from 1997 levels. This is due to rapidly growing incomes and urbanization driving a 9 percent increased in wheat consumption between 1997 and 2020.

Global cereal production, which is projected to grow at a rate of 1.26 percent per year during 1997–2020, is slightly lower than the increase in demand. On a regional level, the gap between supply and demand varies. For instance, while East Asian demand will exceed production, a surplus of 73 million tons between 1997 and 2020 will be produced in the developed world. Area under cereal production is projected to expand 27 percent, accounting for 32 percent of total production growth. Area expansion will only increase 9 percent between 1997 and 2020 in the developing world as a whole, providing for only 15 percent of cereal production growth during this period. Asia will face limited development since approximately 80 percent of the potentially arable land in Asia is already under cultivation. Plus, rapid urbanization is expected to consume 14 million hectares of arable land between 1990 and 2020. Yield growth rates for all cereals and all regions are expected to slow from 1.6 percent annually in 1982–97 to 0.9 percent annually in 1997–2020. This is a result of policy changes, economic reforms, increased intensity of land use,

increasing input requirements and decreasing investment in crop research and irrigation infrastructure. Water will also be major constraint to the achievement of food security in many developing countries. As of 1997, cereal harvested irrigated area was approximately 176 million hectares in developing countries but is only expected to rise by 29 million hectares by 2020.

Other crops markets will face similar futures. Aggregate roots and tubers demand in the developing world will increase by 55 percent between 1997 and 2020 but the supply is expected to increase only by 51 percent. This results in a decline of 10 million tons in roots and tubers exports out of Southeast Asia and influences a 3 million tons decline in worldwide roots and tubers trade between 1997 and 2020. International soybean trade is expected to rise from 32 million tons in 1997 to 52 million tons in 2020. China and Brazil will be the top soybean-consuming developing nations, the United States and Latin America will be the major suppliers and Europe and China will be the main importers of 19 million and 12 million tons, respectively, in 2020. Southeast Asia will increase the regional surplus of edible oils, with production growth exceeding demand growth by 7 million tons between 1997 and 2020. East Asia will increase its edible oil imports from 4 million tons in 1997 to 10 million tons in 2020.

Per capita calorie availability will increase in all developing regions, from an average of 2,667 calories per capita in 1997 to 3,015 calories per capita in 2020. The number of malnourished children under the age of five in the developing world is projected to decline by 21 percent between 1997 and 2020. Although child malnutrition is expected to decline by 31 percent in South Asia, India will still be home to 44 million malnourished children in 2020, representing 34 percent of the total in the developing world. China will have the largest decline, at 54 percent.

In addition to the baseline, alternative scenarios were investigated to assess sources of variability, including slower population growth rates, varying rates of yield growth and the extent of trade liberalization. At the global level, worldwide cereal production will increase 29 percent under a pessimistic scenario compared with 38 percent increase under an optimistic scenario. Similarly, worldwide cereal consumption will be 28 kilograms per capita lower than the baseline under a pessimistic scenario and 30 kilograms higher under an optimistic scenario. The most significant deviation is a 46 million increase from the baseline in the number of malnourished children in the developing world under a pessimistic scenario. Conversely, the number of malnourished children falls by 94 million children from the baseline for an optimistic scenario.

Alternative scenarios were also employed to examine various growth scenarios for Asia, especially those that influence more severe impediments to the expansion of agricultural production. Under a pessimistic scenario, Indian and Chinese cereal production declines 15

percent from the baseline scenario, resulting in significant trade deficits for both countries. However, the results indicate that world markets are capable of absorbing these large increases in imports without huge price consequences. In terms of consumption, Indian kilocalorie consumption in 2020 declines by 171 per capita from the baseline scenario and Chinese kilocalorie consumption declines by 264 per capita. Furthermore, the number of malnourished children increases by 2 million children over the baseline for both countries.

4.3.1.3 GEO (2002)

The GEO report (2002) does not discuss food systems (i.e, food production, distribution, transformation, access, consumption and outputs-food and waste), agricultural products and services directly. Land and water-the resources required for food production have been discussed. These resources and their degradation are particularly important for agriculture and AKST in the ESAP as at least one-quarter of the GDP of many is supported by this sector. Land degradation problems are directly related to land-use practices, particularly agricultural expansion and intensification. The report identified physical responses to land degradation problems that have originated from the competing influences of fiscal and market incentive programs led to many of the failures. The GEO report indicated increases in water consumption in future to be driven by population increase. Although in the past, policies were only concerned with increasing supply, recently focus has increasingly shifted to integrated water resources management. There is no direct reference of future of land and water resources in the four scenarios of the GEO which looked at 2032 timeline, however, 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 would be fallen 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 environment and development paradigm to be supported by new, more equitable values and institutions.

It is not known how the future will unfold; therefore, under any of the four scenarios, implications for food systems agricultural products could be significant.

4.3.1.4 IPCC (AR4-2007)

Food systems and agricultural products are discussed in Chapter 10: Asia in two sections entitled "Key future impacts and vulnerabilities' and 'Adaptation: Sector specific practices, options and constraints'. Climate and socio-economics are key drivers in food production. Effects of climate on agriculture with regard to crop calendar and yield are discussed in Section 4.2. Future climate change scenarios are also discussed in the same section. Here future food systems and agricultural products are summarized in relation to climate change, land and water and socio-economic scenarios.

The SRES storylines for the Asia region constructed a range of socio-economic scenarios for different time-lines. The population projections for Asia range between 1.54 billion people in 2050 and 4.5 billion people in 2100. The economic growth is projected to be 4.2-fold and 3.6-fold of the current GDP by 2050 and 2100, respectively. This demonstrates a decline in economic growth after 2050. The IPCC AR4 concluded that agriculture, food security and water resource is likely to be impacted by future climate change. Under A1FI emission scenarios, modeling results (without fertilization effect of CO_2) show that in the short-term (2020), crop yield could be reduced by 2.5 to 10% from the 1990 baseline in parts of Asia. However, as with more warming and precipitation changes, the yield reduction could be increased to 5-30%. On the other hand, when CO_2 fertilization effect is taken into account, crop yields could be increased by 20% in East and Southeast Asia. On contrary, in South Asia, yield could be declined by 30% even if the direct positive physiological effects of CO_2 are considered.

Modeling analysis reveal substantial adverse changes for rain-fed agriculture, especially for wheat in the ESAP. For example, 0.5^{o}C rise in winter temperature could result in wheat yield by 0.45 tonnes per hectare in India. For rain-fed rice, yield reduction could in the range of 5-12% in China for a 2^{o}C rise in temperature. In South Asia, farm level (non-irrigated wheat and rice) net revenue loss projected to be in the range of 9-25% for a 2.5^{o}C temperature rise.

Climate change can introduce changes in cropping area. In Mongolia, a northward shift of agricultural zones is projected. By 2050, in northern China, tri-planting boundary will likely to be shifted by 500 km from Changjiang valley to Yellow River basin and double planting regions will shift towards the existing single planting areas; resulting a shrink of its area by 23%. In East Asia, suitable land and production potentials for cereals could marginally increase.

Irrigation water demand will increase due to increases in temperature. An estimated 28 million ha in South and East Asia would require substantial increase in irrigation. For each degree increase in temperature, irrigation water demand could be increased by 10% in the arid and semi-arid regions of Asia. In rain-fed crops in the north and northeast China, water related challenges could be multiplied driven water demands and soil-moisture deficit resulted by increase in temperature and decrease in precipitation.

4.3.1.5 MA (2005)

The Millennium Ecosystems Assessment (MA) discusses the food systems in Chapter 9: 'Changes in Ecosystem Services and Their Drivers across the Scenarios'. Food systems divided into food production and food supply and demand. Food is divided into cereal, meat and fish. In the upfront, the chapter discusses about major economic and environmental drivers. The MA concluded that in future expansion of agriculture in the low income countries would lead to tremendous changes in land use. It projected that 10-20% of current grassland and forestland might be lost until 2050. Following are the projected future of food systems.

Order from Strength: The greatest implications from land use changes would be felt due to large increases in both crop and grazing areas. In this scenario, society invests relatively less resources in crop technology and supporting other infrastructure such as irrigation. As a result expansion in area will be needed to meet growing demand of food. Reduced investments in yield improvement would be insufficient to maintain pace with the demand levels, resulting significant increases in international food prices. Crop area expansion is also related to remaining trade protection levels. Cereal production and consumption in Asia is projected to be the lowest among the four scenarios (**Figure 4.6**). Meat production is also the lowest.

[Insert Figure 4.6: Cereal Production in Asia under four MA Scenarios in 2050. Scenario Names: GO: Global Orchestration; OS: Order from Strength: AM: Adapting Mosaic; TG: TechnoGarden (IMPACT)]

TechnoGarden Scenario: Under this scenario, a drive for innovations occurs in the food production system facilitated by growing income, medium-level population growth, increasing trade liberalization. Under technogarden, cereal production in Asia would be slightly lower than the global orchestration scenario. This scenario projects reduced pressure on expansion of crop area as it put less preference on meaty diets as well as improvements in crop yileds through technological innovations. South Asia would experience the largest increases in per capita fod demand (23 Kilograms) compared to 6 kilograms global average. Per capita demand for meat

could also be largest in Asia (12 kilograms) against global average of 6 kilograms. This is due mainly to increases in per capita in come and dietary changes.

Global Orchestration: This scenario projects the highest increase in food demand due to rapid income growth, increasing trade liberalization and urbanization. Demand for creal and meat demand grow fastest among the four scenarios, with cereals being used increasingly as livestock feed. In Asia, the highest growth in grain production is projected by 2050 facilitated by agriculture research and supporting infrastructure. Rapid growth in food demand would also met from global trading. Consumption of cereal would increase in Asia due to less diversification in diet. Large increases in meat demand in Asia are also projected.

Adapting Mosaic: This scenario focuses on the adaptation of local approaches to the improvement of ecosystem services. Income is projected to grow slowly; however, populations will grow continuously until 2050. Food production is achieved through the methods similar to order from strength, i.e, through expansion of agricultural lands with little attention to yield growth. Food demand will see a slower rate of growth due to higher prices. Average per capita food demand decreases sharply Asia (15 kilograms).

Under all scenarios many people would suffer from food insecurity, and child malnutrition cannot be eradicated by 2050 (with low to medium certainty) while with substantial increases in food supply (medium to high certainty). Diets in poorer countries become more diversified (low to medium certainty).

4.4 Major Uncertainties of the Drivers and Projections

The picture of plausible futures of each one of the drivers of change of agriculture and AKST, presented in 4.2 above, is subject to major uncertainties. These uncertainties affect individual drivers as well as the interaction between different drivers.

The definition of risk as a quantifiable change in or likely future of some variable (life of an individual, catch of fish, agricultural production, etc.) makes it evident that there are certain assumptions or questions that decision-makers have about these variables. There are certain issues or variables about which there are no assumptions that can be made – even with a fair or medium certainty. These are variables whose future trends or changes may bring in questions that decision-makers may not be asking now. In some cases crucial data is missing; in some the capacity to understand or project non-linear changes is lacking. 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 understanding/analysis. Yet, it is important to keep decision-makers informed about the existence of uncertainties.

4.4.1 Key uncertainties summarized

Table 4.9 summarizes the key uncertainties that have been suggested or imagined to affect the ESAP region. Many more were suggested in various interviews and in the literature that was reviewed. The four uncertainties presented here in **Table 4.9** are however, the most frequently suggested. In column 2, the key drivers of change that are likely to be affected are listed; and in columns 3 and 4, the implications of these uncertainties for agriculture and for overall development and sustainability goals in the ESAP region are listed (with an assumed chronological order to the extent that is possible).

[Insert Table 4.9: Major uncertainties and likely impacts in the ESAP region]

The implications of these uncertainties for AKST are many. Climate change and consequent variations in crop/animal production and productivity may increase investments in AKST but have increasingly little impact on the problems it addresses. Increasing resource constraints and deteriorating law and order situations will impose restrictions on access to, participation in and utilization of technology and knowledge for millions of poor 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, fisheries, etc. will lead to migration, consequent displacement and strife and may carry an entire generation of location specific knowledge to urban or other centres. 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.

4.5 Relevance and implications for AKST in the future

With reference to our concern about the agricultural sector in Asia–Pacific countries and the shape and impact of AKST, it does look like globalization will not constrain redistributive policies that increase efficiency. The poor, and rural people who are more dependent on non-mobile factors of production (such as land and other physical resources) stand to gain from the fact that greater economic integration will bring a global rate of return to all mobile factors of production. The prospects for economic growth in the region over the period to 2030 on poverty reduction will also be significant.

The impact of liberalization on AKST in the ESAP region has been mainly two fold; (i) increasing investments in a diverse range of crops/commodities/ways of production (as in organic)

compared to the erstwhile engagement with cereal crops, and (ii) increasing access to international knowledge and technology markets, especially investments in commercially appropriable technologies and services, and a realization that the public sector NARS that generated technologies for the green revolution of the 1960s and 1970s needed reform. Overall, the trend in the ESAP region has been an increase in food/agricultural commodity prices in the post-liberalization era when commodity prices that were thus far protected at levels well below international price levels rose after domestic markets were opened up.

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 (Joshi et al., 2003). The change in diets and declining terms of trade for cereals in Asia will lead to diversification of farm production into higher value products (Ivory, 2001). 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.

References

Acharya, S.2003. Labour migration in the transitional economies of South-East Asia. Economic and Social Commission for Asia and the Pacific, Working paper on Migration and Urbanisation, December.

ADB (2005) Key indicators of developing Asian and Pacific countries, ADB: Manila.

ADB (Asian Development Bank). 2001a. Growth and change in Asia and the Pacific: Key indicators 2001. New York: Oxford University Press.

ADB (Asian Development Bank). 2001b. Asian environment outlook 2001. Manila.

ADB 2001c, "Water for All: The Water Policy of the Asian Development Bank". Department of Economics and Social Affairs.

ADB, 2006 a. "Regional Cooperation for Sustainable Development in Asia Pacific Asian Development Bank's Perspective and Experience," Speech delivered by Rajat M Nag, Special Advisor to the President on Regional Cooperation, ADB. (www.adb.org/Documents/Speeches/2006/sp2006003.asp)

Adrian, A. M., S.H.Norwood and P.L.Mask. 2005. 'Producers' perceptions and attitudes toward precision agriculture technologies'. Comp. and Electronics in Agr. 48:256-271.

Anderson, K. and Martin, W., 2006. 'Agriculture, Trade reform and the Doha Agenda', in Agriculture, Trade Reform and the Doha Development Agenda, Anderson and Martin (eds), World Bank.

Asian Development Bank (ADB), 2006. Asian Development Outlook 2006: routes for Asia's trade, Hong Kong.

Barnett, T.P., J.C. Adam, and D.P. Lettenmaier,., 2005. Potential impacts of a warming climate on water availability in snow-dominated regions. Nature, 438, 303-309.

Batra, Amita (2006) Asian Economic Integration: ASEAN +3+1 or ASEAN +1s? Working Paper No. 186, ICRIER, New Delhi, India.

Bird Life International, 2005. Bioenergy fuel for the future? A BirdLife International position paper on Bioenergy use in the EU. http://www.birdlife.org/eu/pdfs/2006/2005_bioenergy_position.pdf. Last visited January 20, 2007.

Byerlee, Derek and Echeverria, Ruben G. (Eds.) (2002) Agricultural Research Policy in an Era of Privatization, CABI Publishing: Wallingford, U.K.

Chang, Hui-Shung. and Zepeda, Lydia. (2000) "Agricultural Productivity for Sustainale Food Security in Asia and the Pacific: the Role of Investment," in ---- Ed). Agricultural Investment and Productivity in Developing Countries

Contreras-Hermosilla, A. and C. Fay, 2005. Strengthening Forest Management in Indonesia through Land Tenure Reform: Issues and Framework for Action. A collaborative paper for Forest Trends and the World Agroforestry Center.

DESA, 2006, World Urbanization Prospects: The 2005 Revision, United Nations, New York.

Dutkiewicz, R. [ed.], 1999. The Challenge of Rural Energy Poverty in Developing Countries. World Energy Council, London, pp. 30 – 46.

Dyson, T., Cassen, R., and Visaria, L. (2004) Twenty-first century India: Population, Economy, Human Development and the Environment, Oxford University Press: Oxford.

Emori, S., T. Nozawa, A. Numaguchi and I. Uno. 2000. A regional climate change projection over East Asia. Preprint Volume of the 11th Symposium on Global Change Studies, 9-14 January 2000, Long Beach, California:15-18.

FAO, 1998. Proceedings of the Regional Expert Consultation on Modern Applications of Biomass Energy. Kuala Lumpur, Malaysia 6–10 January 1997.

FAO, 1999. Poverty Alleviation and Food Security in Asia - Land Resources. Regional Office for Asia and the Pacif (RAP) Publication 1999/2, Bangkok, pp.161.

FAO, 2006. Water at a glance. Food and Agriculture Organization, Rome. http://www.fao.org/ag/agl/aglw/WaterTour/index-l_en.htm.

FAO, 2006. World agriculture: towards 2030/50: prospects for food, nutrition, agriculture and major commodity groups, interim report, Global Perspective Study Unit.

Fennel, Shailaja (2006) “Future Policy Choices for the Education Sector in Asia,” paper in Session 3, Asia 2015 – promoting growth, ending poverty. London: March 2006.

Food and Agriculture Organisation (FAO), 2003. FAO Agricultural Commodity Projections to 2010: Medium term prospects, Rome.

Gao, X.J., D.L. Li, Z. C. Zhao and F. Giorgi. 2003. Climate change due to greenhouse effects in Qinghai-Xizang Plateau and along Qianghai-Tibet Railway. Plateau Meteorology. 22(5): 458-463 (In Chienese with English abstract).

Gerard, Francoise and Ruf, Francois (Ed.) (2001) Agriculture in Crisis: People, Commodities and Natural Resources in Indonesia, 1996-2000. CIRAD, Montpellier; Curzon Press, Richmond.

GM, 2002. GM well-to-wheel analysis of energy use and greenhouse gas emissions of

Gratzl, B. and M. Fawer-Wasser, 2006. New report from Bank Sarasin on the sustainability of biofuels. Bank Sarasin & Co. Ltd Media Release, Basel, 25 July 2006.

Greene, N., 2004. Growing Energy: How Biofuels Can Help End America’s Oil Dependence. National Resources Defense Council (NRDC), New York, pp.86.

Hasumi, H. and S. Emori (eds.). 2004. K-1 coupled model (MIROC) description, K-1 technical report 1. Center for Climate System Research, University of Tokyo. 34pp.

Henniges, O., and J. Zeddies, 2006. Bioenergy in Europe: Experiences and Prospects.

Henning, R. K., 2004. Integrated Rural Development by Utilization of Jatropha curcas L. (JCL) as Raw Material and as Renewable Energy - Economy & Dissemination Strategy. The Jatropha Website, http://www.jatropha.de/, Last visited: Jan. 23, 2007.

Hertel, T. and Keeney, R. 2006. 'What is at stake: the relative importance of import barriers, export subsidies and domestic support', in Agriculture, Trade Reform and the Doha Development Agenda, Anderson and Martin (eds), World Bank.

Himpe, F. 1997, Technical and Economic Feasibility of Cogeneration Projects from Rice Husk in Proceedings of the Regional Expert Consultation on Modern Applications of Biomass Energy, Kuala Lumpur, Malaysia, 6-10 January 1997. Regional Wood Energy Development Program in Asia (RWEDP) Report No.36, pp. 16-18.

Hoogwijk, M., 2004, On the global and regional potential of renewable energy sources, Ph.D. thesis, University of Utrecht, pp. 256.

(http://www.birdlife.org/eu/pdfs/2006/2005_bioenergy_position.pdf. Last visited January 20, 2007).

Hugo, Graeme. 2005. Migration in the Asia-Pacific region. Global Commission on International Migration.

Hussain, Athar; Cassen, Robert; Dyson, Tim, 2006, Demographic Transition in Asia and its Consequences, IDS Bulletin, Volume 37, Number 3, May 2006, pp. 79-87(9)

International Energy Agency, 2004. World Energy Outlook 2004. IEA, Paris, pp. 570.

International Trade Strategies Pty Ltd. (2004) Background Paper for the Strategic Plan of Action on ASEAN Cooperation in Food and Agriculture 2005-2010.

IPCC 2000, Special Report on Emission Scenarios, Nakićenović et al., Cambridge University Press.

IPCC. 2007. Chapter 10: Asia. In: Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Working Group II Contribution to Intergovernmental Panel on Climate Change Fourth Assessment Report. Cambridge University Press, Cambridge, U.K (in press).

Jha, R., H.K. Nagarajan and S.Prasanna. 2005. Land fragmentation and its implications for productivity: Evidence from Southern India-ASARC Working Paper. Australia South Asia Research Centre, Australian National University, Canberra, Australia.

Joshi, P. K., A. Gulati A., P.S. Birthal and L. Tewari. 2003. Agriculture Diversification in South Asia: Patterns, Determinants, and Policy implications. Markets and Structural Studies Division, International Food Policy Research Institute, February, Washington, D.C.

Kampman, B. E., L.C. den Boer and H.J. Croezen, 2005. Biofuels under development An analysis of currently available and future biofuels, and a comparison with biomass application in other sectors. CE, Delft, pp. 112.

Kaneda, Toshiko. 2006. A critical window for policymaking on population ageing in developing countries. Population Reference Bureau. January 2006.

Knutson, T. R. and R. E. Tuleya. 2004.Impacts of CO2 induced warming on simulated hurricane intensities and precipitation: sensitivity to the choice of climate model and convective parameterization. J.Climate. 17: 3477-3495.

Krugman, P. (1994) The Myth of the Asian Miracle, (http://www.mit.edu/krugman)

Kuncoro, Ari, (2006) Manufacturing Growth in a Country Undergoing Political Transition: How Firms Cope with Changing Business Environment in Indonesia , Paper presented at the GDN, Beijing Conference (Medal winner in the Industrial Development and Long Term Growth category).

Lal, M.2003.Global Climate Change: India's monsoon and its variability. J. Environmental Studies and Policy. 6 (1): 1-34.

Lal, R., 2006. Perspective Managing soils for feeding a global population of 10 billion. J Sci Food Agric, 86, pp. 2273–2284

MA (Millennium Ecosystem Assessment), 2005, Ecosystems and Human Well-being: Synthesis, Island Press, Washington, DC.

Mahapatra, A.K. and C.P. Mitchell. Biofuel consumption, deforestation, and farm level tree growing in rural India. Biomass and Bioenergy, 17(1999), pp. 291-303

Mahmoud,C. and Shively, G. 2004. 'Agricultural diversification and integrated pest management in Bangladesh', Agricultural Economics 30(3) pp187-94.

Manuta, J, and L. Lebel. 2005. Climate change and the risks of flood disasters in Asia: crafting adaptive and just institutions. Unit for Social and Environmental Research (USER), Chiang Mai University, Thailand. 15pp.

Matysek, A., Ford, M., Jakeman, G., Gurney, A. and Fisher, B.S., 2006. Technology and climate change, ABARE Research Report 06.6, Canberra.

McCarthy, J. J., O. F. Canziani, N. A. Leary, D. J. Dokken, K. S. White, 2001. Climate Change 2001: Working Group II: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge, UK, pp. 1005.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J.Dokken and K.S.White. 2001. Climate Change 2001. Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge, U.K.

Millennium Ecosystem Assessment (2003) Ecosystems and Human Well-Being, Island Press: Washington, USA.

Mirza, M.M.Q.2002. Global warming and changes in the probability of occurrence of floods in Bangladesh and implications. Global Environmental Change. 12(2):127-138.

Mishra, A. K., T.A. Park. 2005. 'An empirical analysis of internet use by U.S farmers'. Agr. and Resource Econ. Rev.34(2): 253-265.

Nguyen, T., E. Cheng and C. Findlay. 1996. Land fragmentation and farm productivity in China in the 1990s. China Econ. Rev.7(2): 169.-180.

Niroula, G. S. and G.B.Thapa.2005.Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land Use Policy. 22:358-372.

OECD-FAO 2006. Agricultural Outlook 2006-2015, Rome.

Park, C.Y. and Zhai, F. 2006. Asia's imprint on global commodity markets, ERD working paper series no. 90, Asian Development Bank.

Parry, M.L., C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fischer. 2004.Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change.14:53-67.

Peng, S., J.Huang, J.E. Sheehy, R.C. Laza, R.M. Visperas, X.Zhong' G.S. Centeno, G.S., Khush, and K.G., Cassman. 2004. Rice yields decline with higher night temperature from global warming.PNAS. 101(27): 9971-9975.

Pingali, P.2004. Agricultural Diversification: Opportunities and Constraints. Agricultural and Development Economics Division, FAO, Rome, Italy.

Pingali, P.L., and Heisey, P.W., 1999. Cereal Crop Productivity in Developing Countries, CIMMYT Economics Paper 99-03, Mexico.

Prebisch, Raúl. 1950. The Economic Development of Latin America and its Principal Problems.

Rajasekaran, B. (1993) "A framework for incorporating indigenous knowledge systems into agricultural research, extension, and NGOs for sustainable agricultural development", Studies in Technology and Social Change No. 21. Ames, IA: Technology and Social Change Program, Iowa State University.

Rajasekaran, B., D.M. Warren and S.C. Babu. 1991. "Indigenous Natural-Resource Management Systems for Sustainable Agricultural Development - A Global Perspective." Journal of International Development 3 (4): 387-402.

Raju, K. V., 2006. Biofuels in South Asia: and Overview - Editorial Introduction. Asian Biotechnology and Editorial Review, 8(2), pp/ 1-9.

Roland-Holst, D., Verbiest, J.P., and Zhai, F. 2005, 'Growth and Trade Horizons for Asia: Long term forecasts for regional integration', ERD working paper series no. 74, Asian Development Bank.

Rosegrant, M. and S. Malik (Eds.) (1995) "A 2020 Vision for Food, Agriculture, and the Environment in South Asia: A Synthesis," Vision 2020 – vision synthesis. IFPRI: Washington, D.C.

Rosegrant, M., Paisner, M.S., Meijer, S. and Witcover, J. 2001. Global Food Projections to 2020: emerging trends and alternative futures, IFPRI, August.

Ross, S. (2006) “Demographic change in the Asia-Pacific: The Effect on Average Living Standards,” Journal of the Asia-Pacific Economy, Vol. 11(3): 229-248.

Living Standards,” Journal of the Asia-Pacific Economy, Vol. 11(3): 229-248.

SaciWATERs (2002) Higher Education on Water Resources in South Asia: Towards Capacity Building for IWRM, South Asia Consortium on Interdisciplinary Water Resources Studies, Hyderabad, India.

Safriel, U.N., 1995. The role of ecology in desert development. Journal of Arid Land Studies, 55, pp. 351-354.

Salayo, N.D., M. Ahmed, L. Garces, and K. Viswanathan (2006) “An overview of Fisheries Conflicts inSouth and Southeast Asia: Recommendations, Challenges and Directions,” NAGA WorldFish Center Quarterly, Vol. 29, No.1 &2.

Scheeren H. A., J. Lelieveld, G. J. Roelofs, J. Williams, H. Fischer, M. de Reus, J. A. de Gouw, C.Warneke, R. Holzinger, H. Schlager, T. Klupfel, M. Bolder, C. van der Veen, and M. Lawrence, 2003. Impact of monsoon outflow from India and Southeast Asia. Atmos. Chem. Phys.,3, pp. 1589–1608.

Scherr, Sara J. and Satya Yadav (1997) “Land degradation in the Developing World – Issues and Policy Options for 2020,” IFPRI Vision 2020, Brief No. 44. IFPRI: Washington D.C.

Schneider, K., Graham, B., Millsteed, C., Saunders, M. and Stuart, R. 2000. Trade and Investment Liberalisation in APEC, ABARE Research Report 2000.2, Canberra.

Shah, T., C. Scott, A. Kishore and A. Sharma, 2003. Energy-Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability. International Water Management Institute (IWMI), Colombo, Sri Lanka, pp. 37.

Singer, Hans. 1950. The distribution of gains between investing and borrowing countries. American Economic Review 40 (2): pp473-85.

Slingerland, S. and L. van Geuns, 2005. Drivers for an International Biofuels Market. Discussion Paper, CIEP Future Fuel Seminar, Clingendael Institute, December 9, 2005.

Sustainable Development Policy Institute (2005) Sustainable Development- Bridging the Research/Policy Gaps in Southern Contexts, Volume I: Environment, SDPI, Islamabad, and Oxford University Press, Karachi, Pakistan.

Sustainable Development Policy Institute (2005) Sustainable Development- Bridging the Research/Policy Gaps in Southern Contexts, Volume II: Social Policy, SDPI, Islamabad, and Oxford University Press, Karachi, Pakistan.

Tabor, Steven R., Willem Janssen and Hilarion Bruneau (1998) Financing Agricultural Research: A Sourcebook, ISNAR: The Hague, the Netherlands.

Tammen, Ronald L. (2006) “The impact of Asia on world politics: The China and the India options for the US,” International Studies Review, Vol. 8(4):

Tandon, R. (2000) Voluntary action, civil society and State. Mosaic Books: New Delhi.

Tauer, L. W. and A.K. Mishra. 2006. 'Can the small dairy farm remain competitive in US agriculture?' Food Pol. 31(5): 458-468.

Terada, Takashi (2006) "Thirty years of the Australia-Japan partnership in Asian regionalism: evolution and future directions," in Australian Journal of International Affairs, Vol.60 (4) December 2006, pages 536 - 551

Tinh, Q. D. and P. T. Hang, 2003. Living with Floods in the Mekong River Delta of Vietnam. Paper for 3 World Water Forum: Poverty and Flood Theme. 18 March 2003.

Tustin, J. [ed.], 2006. Annual Report 2005. IEA Bioenergy, Rotorua, New Zealand, pp. 120.

UNDP (2003) Human development report: 2003. United Nations Development Programme, Oxford University Press, New York

UNEP, 2006. GEO Yearbook 2006. EarthPrint, Hertfordshire, UK. pp. 100.

United Nations Economic and Social Council. 2004. Commission on Population and Development. World demographic trends. Thirty-Eighth Session. E/CN.9/2005/8. New York.

United Nations Environment Programme (UNEP). 1997. World Atlas of Desertification, 2nd edn. Arnold: London

United Nations, 2001, World population 2000, New York: United Nations Population Division

United Nations, 2001, World population prospects: The 2000 revision. New York: Population Division, Department of Economic and Social Affairs.

United Nations, 2002, Sustainable social development in a period of Rapid Globalization: Challenges, Opportunities and Policy Options, Economic and Social Commission for Asia and the Pacific, United Nations, New York

United Nations. 2000. World population 1950–2050: The 2000 revision. New York:

Venkataraman, C., G. Habib, A. Eiguren-Fernandez, A. H. Miguel, and S. K. Friedlander, 2005. Residential Biofuels in South Asia: Carbonaceous Aerosol Emissions and Climate Impacts. Science, 307, pp. 1454 – 1456.

von Braun, J., 2005. The World Food Situation – An Overview. Prepared for CGIAR Annual General Meeting, Marrakech, Morocco, December 6, 2005. International Food Policy Research Institute, Washington, DC, pp. 8.

Wang, G., 2005. Agricultural drought in a future climate: results from 15 global climate models participating in the IPCC 4th Assessment. Climate Dynamics, 25(7-8), 739-753

WEC, 2005. The World Energy Book. Issue 1: Autumn 2005. The Petroleum Econmist Ltd, London, pp. 32.

World Bank (2006) Dancing with the Giants: India, China and the Global Economy, Briefing paper

World Bank (1996) Indonesia: Dimensions of Growth, Washington, D.C. World Bank.

World Bank (2005) Agricultural growth for the poor – an agenda for development. World Bank: Washington, D.C.

World Bank (2006b) – the scenario planning – Annexure –

World Bank (2007), Global Economic Prospects: Managing the next wave of globalization, Washington D.C.

World Bank (2007, 2006) World Development Indicators (www.worldbank.org)

World Bank. World development indicators. 2006. World Bank, Washington, D.C.

World Commission on the Social Dimension of Globalization (2004) A Fair Globalization – Creating Opportunities for all WCSDG, ILO: Geneva.

Yamamoto, T. and Ashizawa Kim, G. (-----) Corporate NGO partnership in Asia Pacific. JCIE publications: Tokyo

Yamamoto, T. et al., (1995) Emerging civil society in the Asia pacific community: Integrative Survey Report and Conference Report of the Osaka Symposium, JCIE publications: Tokyo.

Yatsuka Kataoka, 2002, Overview Paper on Water for Sustainable Development in Asia and the Pacific, ASIA-PACIFIC FORUM FOR ENVIRONMENT AND DEVELOPMENT FIRST SUBSTANTIVE MEETING, January 12-13, 2002, Bangkok, Thailand

Yuit, G. C. H. and J. Wall, 2006. Alternative energy: beware the hidden costs. The Straits Times (Review), 22 July 2006.