CWANA CHAPTER 3
AGRICULTURAL CHANGE AND PLAUSIBLE FUTURES

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Key Messages

1. **The trend in population growth will continue, leading to strong increase in demand for food and intensified pressure on natural resources, high rates of unemployment, and increased urbanization and migration.** The anticipated increase in urbanization and labor migration will speed up the shift of labor from agriculture to other sectors.

2. **Hunger and malnutrition, especially child malnutrition, will continue to worsen, leading to a weakened workforce.** The incidence of malaria, HIV and AIDS, tuberculosis, maternal mortality, and water-borne diseases will be on the rise in the region because of a shortage of proper health care.

3. **With the increased pace of trade liberalization, agricultural producers will face problems of access to the market and competition in it vis-à-vis industrial countries.** New barriers in terms of quality, social standards and intellectual property rights will further limit market access. Countries in the CWANA region have been denied market access for their agricultural output; labor and environmental standards in the multilateral trading system are also an obstacle for the region.

4. **Although investment and improved management of AKST will proceed at a slow pace, it will have a greater role in agricultural development because of expanded research programs and better relations of research with extension agents and farmers.** CWANA will need to improve and develop proper educational systems in agriculture and related sciences and reverse the trend of downgrading agriculture as an engine of development.

5. **Indigenous knowledge will continue to lose ground to new technologies.** Transgenics will continue to be a source of controversy because of cultural and traditional beliefs.

6. **Good governance, democratization, decentralization and other sociopolitical reforms can remove stumbling blocks and speed up development.** Pressures from globalization can contribute to adoption of democratic thinking in some countries, consequently reducing corruption in developing economies.

7. **There is room for improvement in coordination at all levels—public, private and civil society—to facilitate development.** Better coordination and collaboration will enhance development objectives, especially poverty alleviation and amelioration of hunger.

8. **Despite the substantial role of women in agriculture, they will continue to have limited authority and ownership of resources such as land, labor, credit or capital.** Nevertheless, through higher education for women and change in attitude, society will develop institutions of governance, legal systems and policies that are socially aware and gender sensitive, which will decrease the disparities between women and men.

9. **Natural resources will face severe degradation and unsustainable productivity as a result of intensified exploitation.** Increasing land degradation will limit the ability of agricultural systems to provide food security for the region. However, alternative scenarios show that there will be other options for improving the positive role of agriculture by minimizing its negative environmental effects.

10. **Agrobiodiversity will continue to be endangered and many plant and animal species will be lost for various reasons.** This will adversely affect food production and food security.

11. **Use of agrochemicals will increase because of an expansion of intensive agriculture, which will lead to increased risk of pollution and adverse effects on human health.** Nonetheless, increased awareness and modern AKST options for pest control, i.e. IPM, will strengthen the regulatory control of pesticide application at the regional level.

12. **Water will continue to be the most limiting factor for agriculture because of competition from other sectors and more frequent droughts in the region.** Water quality will also be at risk because ground water has been overdrawn and surface sources have been polluted.

13. **Agriculture will be severely and adversely affected by climate change, especially in low-income regions**. Developments in AKST will determine the ability of agricultural systems to respond to the consequent results of climate change.

14. **Higher energy prices could encourage the use of more energy-efficient technologies in agricultural production.**

15. **Indicators show that agriculture may become an important producer of bioenergy. However, in the CWANA region, the issue of bioenergy is controversial and unpredictable because of its link to food production and biodiversity.**

3.1 Introduction and Scope

This chapter builds on the major issues and challenges identified in chapter 2 and projects the corresponding future status. In other words, it explores a plausible future of the CWANA region, perceived for the next 50 years, in the short, medium and long term, and in this context takes the *reference world* scenario (i.e. business-as-usual) outlining plausible futures as a benchmark and adds value while prospecting the situation 50 years ahead. With this backdrop, the present scenario has a logical plot and narrative storyline—the manner in which events unfold over the next five decades. To this end, the scenario draws heavily upon the existing body of knowledge and learns from the historical analysis of trends, in qualitative terms. Although the scenario is not prescriptive in nature, it suggests the most likely outcomes for CWANA and agricultural knowledge, science and technology (AKST) in the region (World Bank, 2006b).

Apart from the business-as-usual scenario, we may perceive other plausible scenarios, such as

- sunset agriculture, interfacing authoritative governance and weaker AKST institutions
- sunrise agriculture, interfacing democratic governance and strong AKST institutions
- people-centered and development-oriented agriculture, interfacing globalization

Since the role of agriculture is likely to further decline as key employer in the long term, its contribution to national output may concomitantly decrease, as has happened in industrial countries (Fresco, 2002; Inter-Academy Council, 2004b). However, given the political will to change, agriculture can potentially reemerge as a promising sector with value-added contributions toward economic growth and development in the region through AKST. In this context, it has a future as a sunrise sector (Fresco, 2002; Lipton, 2005). The world in general, and CWANA in particular, has witnessed the ills brought on by authoritative regimes and the models of development that have been implemented. Hence the focus is likely to shift on the learning curve toward more people-centered development. Historical evidence suggests that development models drawn in consultation with the people for whom those interventions are made hold promise of yielding more sustainable solutions in terms of development objectives, since they place people at the center of the development paradigm (Hardi and Zdan, 1997).

This chapter is based on a pragmatic and rational understanding of direct and indirect drivers, and how these are likely to behave in future, learning from historical trends and analyzing them in qualitative terms. Thus the chapter sets a future scene with a logical plot describing how things are likely to unfold under different socioeconomic and political conditions and an AKST environment in the short, through the medium, to the long term.

3.2 Method

The approach uses the business-as-usual scenario as its benchmark and adds value while prospecting the situation 50 years ahead. Scenario development and analysis provide a logical way of thinking through a range of plausible futures. Scenarios are “plausible and often simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces and relationships” (MA, 2005). Scenarios can be developed for various purposes: to explore a range of plausible futures, to analyze possible response strategies, or to provoke creative thinking (Alcamo, 2001).

A number of recent international environmental assessments have made use of scenario development and analysis, and the scenarios introduced by international environmental and agricultural assessments have influenced both scientific and public debate. Prominent examples of global scenario-based assessments include the Intergovernmental Panel on Climate Change (IPCC, 2007), the Global Environmental Outlook of the United Nations Environment Programme (UNEP, 2002) and the Millennium Ecosystem Assessment (MA, 2005).

3.3 Key Drivers of Agricultural Change

The factors that drive the change—that regard the future of agriculture in the CWANA region—need to be looked at in more detail. We must understand these drivers to assess the plausibility of the scenarios.

A driver is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver unequivocally influences ecosystem processes. An indirect driver operates more diffusely, by altering one or more direct drivers.

For the purpose of this assessment, a driver is a factor that can to a certain degree potentially change the development landscape in a given sector or subsector of economy with regard to agricultural research and development (R&D). A direct driver influences agricultural production and services and can therefore be identified and measured to a degree of accuracy. The influence of an indirect driver is established by understanding the nature of its effect on a direct driver. Drivers can be influenced by policy choices. However, the distinction between indirect and direct drivers may at times not be clear. Many implicit links exist between and across the different drivers and the discussion in this chapter needs to be viewed in that context.

A host of direct and indirect drivers is relevant to agricultural systems and AKST (Conway, 1997; Dixon et. al. 2001; FAO, 2004; Das and Laub, 2005; DFID, 2005). Following is a prioritized set of direct drivers.

Economic drivers: Economic growth and development, national and per capita income, macroeconomic policies, international trade, trade policies, trade liberalization and capital flow, marketing chains, market access opportunities, market distortions and support, food security, competition between different crops.

Food demand and consumption patterns: Population dynamics, consumption levels, dietary preferences, food quality, nutritional values and standards.

Agricultural and natural resource management: Land tenure, agricultural inputs, pest and disease management, use of agrochemicals, cropping patterns, role of livestock, agricultural biodiversity, transgenic crops (GMOs), impact of agriculture on natural resources, constraints of management, indigenous knowledge.

Land and water resource management: Land use, land cover change, land degradation, land availability and productivity, water allocation, water quality, transfer and transboundary water management, surface and groundwater management and protection.

Climate change: Effect of climate change (global warming, change in precipitation) on agriculture, drought, floods and famine, other climate-driven changes.

Energy and biofuels: Relationship between energy (cost, production, distribution, access) and agriculture; hydroelectric energy, bioenergy.

Human resources: Education, training, role of women, rural labor migration, social capital, cultural and religious factors.

Investment in AKST: Scientific and technological developments, private vs. public investments in R&D, rate of adoption of new technologies (biotechnology, information technology), training of agricultural scientists, interregional research cooperation.

Following are the main indirect drivers of change.

Demographics: Demographic dynamics of population size and growth, age and gender structure, spatial distribution.

Sociopolitical: Sociopolitical developments, governance and democratization, corruption, enforcement of legislation, traditional norms, civil society and the private sector, conflicts, international politics.

CWANA countries with inward-looking development policies will not be able to fulfill their international development commitments, like those reflected in the Millennium Development Goals (Global Monitoring Report, 2006; World Bank and IFPRI, 2006).

Where this is the case, AKST will not effectively play its role in attaining the cherished objectives of development goals. However, the national policies may be influenced by international economic and geopolitical conditions (Table 3.1).

INSERT Table 3-1. Key drivers affecting agricultural production in the CWANA region and assessment of their role in the future

3.3.1 Direct drivers

3.3.1.1 Economic drivers

Under the reference world scenario, the capacity and capability of countries may readjust to change in the global arena in a dynamic way. Democratic institutions will gradually evolve and national policies will get more focused in the long term. Economic growth and development in CWANA will help the region attain its development goals, albeit somewhat more slowly than the rest of the world. Present-day economic paradigms like trade investment and innovation will be enhanced by an enabling environment under the globalization and technological boom, consequently facilitating achievement of economic and development objectives (World Bank, 2006a, 2006c, 2006d).

Foreign direct investment can potentially play a key role as an enabling driver (Black, 2003). However, it may be rather difficult in the future to attract such investment because of competition among the countries, although investment policies of national governments will tend to change and adjust to the situation. Proper investment policies provide a springboard to the development agenda since trade, investment, economic growth and development are closely linked. Poverty in the CWANA region will be alleviated to some extent with these changes in policies, especially with an increase in AKST investment, and thus will help realize development goals in the medium to long term.

With the forceful trend of globalization, national economies are bound to integrate with the international economy, sooner than later (FAO, 2006). This can lead, in the short term, to

adjustment pains, before actual gains are realized in the long term. For example, agriculture will undergo structural reforms, including a shift from a self-sufficiency paradigm to export-led agriculture or a shift from subsistence crops to cash crops and from low-tech to high-tech practices. This, on the one hand, may provide better market opportunities for the production surplus that farmers generate. But at the same time, food security may be compromised and joblessness created among farmers, especially if compensatory policies and social safety nets are not in place (World Bank, 1997; WRI, 2005).

The need to establish social safety nets to cope with this situation will increase in these countries. If governments do not act swiftly in the short term, small-scale farmers will leave their farms and thus may become victims of the onslaught of globalization. Emerging democratic thinking and awareness of human rights will, however, compel governments to address social safety issues in the medium to the long term. While trying to adjust to the global policy framework, national governments will have relatively less policy space in which to maneuver, through price or other domestic support mechanisms such as subsidy. Thus they will have to focus on efficiency and higher productivity, for which they will need a strong AKST base to realize IAASTD goals.

A lot, therefore, will depend on government capacity to adjust to the changing environment and deal with the complex issues outlined above. AKST will certainly have a central role in developing the required capacity and in making agriculture efficient and sustainable. Today ventures in the trade–investment–growth paradigm in many developing countries will continue, and the more progressive ventures will capitalize on this paradigm.

For the near future, the fate of World Trade Organization (WTO) negotiations is uncertain, especially the Doha Development Agenda with its built-in development dimension that makes trade liberalization development friendly. Regional protectionism and support such as through the Organisation for Economic Co-operation and Development (OECD) continues to be a hurdle to overcome in free trade. Although WTO negotiations suspended in July 2006 were recently resumed, the risk of protectionism remains. However, mushrooming free trade agreements and preferential treatment agreements will hopefully be a starting point for integration, initially at regional and then at international levels.

Accordingly, proactive engagement of developing countries in multilateral negotiations will be important for securing their trade interests. If the issues of tariff peaks, tariff escalation and subsidies are objectively addressed, countries of the region will take advantage of emerging market opportunities in agriculture, including export of high-value, processed products. AKST will then be instrumental in developing the required capacity to make the region competitive,

especially in agricultural processing (Johnson, 2005; Juma and Yee-Cheong, 2005). Future growth in trade-to-GDP ratio will depend to a great extent on both negotiation outcome and management ability of national governments. Integration of science and technology with national economic development will help solve such problems. Knitting agricultural research institutions into a coherent national agricultural research system (NARS) and integrating national agricultural research plans with the development agenda will be realized in the region with time (Kemmis, 2001; Adato and Meinzen-Dick, 2002; Thirtle et al., 2003; Ryan, 2004).

Agriculture and food markets in the CWANA region will hopefully be reorganized so as to provide access to both domestic and international markets. It will take some time for countries to solve such problems as poor market infrastructure and means of communication, lack of a cold chain and adequate storage facilities, inadequate transportation infrastructure, and not enough vertical linking of producers, industry and consumers (USAID, 2004). As a result, countries will continue to produce primary commodities and incur high postharvest losses, which will have deleterious consequences on trying to deal with food security, poverty alleviation and amelioration of hunger.

According to the current trend in investment in farm sectors and infrastructure, it will not be possible for CWANA countries to penetrate markets across borders in the near future. Integration of local markets with regional or international markets will be delayed. Limitations such as high tariffs will hamper the realization of the potential benefits of globalization, but these limitations may be overcome to a great extent by developing AKST (Foster and Welch, 2002).

Rehabilitation of sea, air and dry port infrastructure—basic for transporting goods and services—will continue to be a weak link in most CWANA countries in the near future. Legislation related to markets, especially for border control like quarantine facilities and the movement of goods and services within the country and across borders, will follow the same trend.

Collective regional efforts and multilateral initiatives will be helpful in evolving the required market system in CWANA. Success stories of the region in terms of market structure, like the one in the United Arab Emirates (UAE), a regional trade hub, will be replicated elsewhere, given political will and investment opportunities. Growth in trade will help countries attain development goals, alleviate poverty, and ameliorate hunger in the CWANA region.

In some countries of the region, nontransparent market practices hinder the development of competitive marketing systems, because of hoarding practices, and strong lobby groups with political support and monopoly. Effective policy regulations related to competition will help fight such monopolies.

Linking farmers with industry and consumers through contract farming will help evolve a better marketing system and cope with problems related to value-chain management, including post-harvest losses. Cooperative settings can also evolve by mobilizing and organizing farming communities. This will help overcome problems associated with the cyclical nature of agricultural markets, such as in poultry and horticulture. Another challenge will be the potential risk of exotic and transboundary diseases like avian flu and mad cow disease, which are likely to emerge movement of goods and services increases under globalization.

Some of these problems will be managed by applying standard management practices, especially those related to sanitary and phytosanitary (SPS) issues, and by adopting good agricultural practices. These practices will build confidence and certainty in the global marketplace that will help sell regional produce. AKST will play an important role in SPS management, in terms of both standardization and quality infrastructure development. Countries of the region therefore need to participate proactively in the international standardization process, through international standard-setting bodies like the International Plant Protection Council (IPPC), the World Health Organization (WHO), and the Codex Alimentarius Commission (CAC).

3.3.1.2 Food demand and consumption patterns

In the past two decades, average per capita incomes have increased around the world, more than doubling in many countries. In addition, the world population is expected to grow by more than one billion people in the next decade, most of whom will reside in low- and middle-income countries. This growth, combined with rising income levels in developing countries, is expected to increase and change the composition of global food demand over the next couple of decades (World Food Conference, 1974; UVIN, 1995).

Direct per capita food consumption of maize and coarse grains will decline as consumers shift from wheat and rice to foods such as meat, fruit, vegetables and dairy products, as their incomes increase. Growth in income in developing countries will drive strong growth in per capita and total meat consumption, which in turn will induce strong growth in consumption of cereals for feed, particularly maize (Pretty and Hine, 2001, 2003). These commodities will be procured from supermarket chains and fast food establishments, controlled by multinational and transnational corporations (MNCs, TNCs) (Jordan, 2000). These trends will lead to an extraordinary increase in the importance of developing countries in global food markets (Rosegrant et al., 2001).

Many developing countries are currently undergoing a rapid nutrition transition. Falling real prices for food enable a growing number of consumers to move swiftly toward greater calorie intake and

allow them to embark on consumption patterns that had hitherto been reserved for consumers in industrial countries with, at least nominally, much higher income. FAO's long-term outlook suggests that the shift toward a greater supply of energy will accelerate and that it will encompass a growing number of countries.

In addition to falling real prices of food, rapid urbanization has and will continue to affect consumption patterns. Essentially the entire population growth over the next 30 years will be urban. Urbanization creates a new, improved marketing and distribution infrastructure, attracts supermarkets and their sophisticated food handling systems (cold chains, etc.), and brings about better roads and ports. It thus improves access for foreign suppliers, imports become important in the overall supply of food, and all in all urbanization globalizes dietary patterns.

Most importantly from a nutrition perspective, these changes include not only a shift toward higher food-energy supplies but also a shift toward more fats and oils and more animal-based foodstuffs, and thus higher intakes of saturated fat and cholesterol.

As discussed above, growing population and declining agricultural productivity are likely to create more demand for foods that most CWANA countries may not be able to meet locally, at least in the short to medium term (Boserup, 1965). However with AKST, more efficient practices will evolve, in both planning for parenthood and agriculture production that may in the long term help satisfy food demand locally (Santaniello, 2003).

3.3.1.3 Natural and agricultural resource management

Responsible management of natural resources is the key to attaining sustainable agricultural and rural development. Seeds of various plant varieties are basic to agricultural development, especially for crop-breeding programs. Access to high-yielding varieties and a more diversified seed base will potentially increase production efficiency. However, local seed production in CWANA region is insignificant, and there is extensive reliance on exogenous sources, which are mainly controlled by MNCs and TNCs in this field (CDE, 2002; Buck et al., 2003; Shyamsundar et al., 2005). This will continue at least for the short to the medium term. Moreover, indigenous crop varieties will be dislodged. Some may even eventually become extinct, with adverse implications for agrobiodiversity in the region, implying weaker social and food safety nets for generations to come (Warren and Rajasekaran, 1993; FAO, 1996; Thrupp, 1998; Huang et al., 2002; Howard, 2003).

Productivity will be constrained as a result of the reduced access to indigenous sources of seed caused by scarcity of seed preservation measures, that is, gene banks. In the same vein, the lack

of AKST and R&D capacity will limit the plant breeding needed to develop better seed varieties. Furthermore, promoting AKST will help preserve indigenous seeds through gene banks and local knowledge and practices (Ellen et al., 2000; Ellis, 2000; Evenson and Gollin, 2003; UN Millennium Project, 2005).

Commercial fertilizers have made it possible in the twentieth century to dramatically increase the quantity and quality of food produced on agricultural land. The ability of agriculture to produce far greater quantities of food than in previous centuries can be attributed to four factors: advanced plant breeding techniques, intensive irrigation, availability of fertilizers on a commercial scale and development of plant protection products. With mounting pressure to increase production, more fertilizer will be needed to replenish the organic base of the land resource being depleted. However, no rehabilitation plans are in place to help restore soil fertility in the CWANA region (Scherr, 1999). Most countries of the region produce little fertilizer, and most of the requirements are met through imports, which will ultimately lead to monopoly. Under globalization, falling trade barriers will increase access to fertilizers, and through fair competition fertilizer prices will become cost effective in the long term.

Biodiversity provides not only food and income but also raw materials for clothing, shelter, medicines and breeding of new varieties; it also performs other services such as maintaining soil fertility and biota, and conserving soil and water, all of which are essential for human survival. The importance of agrobiodiversity encompasses sociocultural, economic and environmental elements. All domesticated crops and animals result from human management of biological diversity, which is constantly responding to new challenges to maintain and increase productivity.

The state of biodiversity in agriculture will change as a result of the effect of pesticides on wild species; farmers, the agrofood industry and government will all need to conserve biodiversity. Steps will include adopting integrated pest management (IPM) and making changes in government policies on crop and pesticide inputs and regulations to reduce risk from pesticides. A major challenge for CWANA countries will be to reconcile the desire to expand agricultural production with the obligation to meet national and international objectives and commitments to conserve biodiversity. CWANA countries also need to take into account what agricultural practices cause change in biodiversity in both negative (e.g. excessive farm chemical use) and positive (e.g. creating field margins as wildlife corridors) ways, in particular the effects of different farming practices and management systems (UN, 1992; OECD, 1998, 2005, 2006; Laird, 2004; CBD, 2006).

Deforestation, mostly occurring in developing countries, coupled with overgrazing has led to land erosion, and ultimately to desertification in some areas of the region. It is also a major source of global emissions of greenhouse gases contributing to climate change. Lack of land rehabilitation plans together with meager investment in this area further accentuate the scenario. Efforts need to be made for integrated rangeland management, which AKST can potentially underpin.

Livestock will continue to be the mainstay of the farming community and will employ a sizeable agricultural workforce in many of the CWANA countries. Poor genetic makeup, limited feed resources and lack of effective animal health cover will continue to be the main constraints for livestock development in the region. Under globalization, and especially through transfer of technology, increased access to quality animal health services and upgrading of genetic livestock material will be possible. However, lack of capacity in CWANA countries will continue to be a limiting factor in the short and medium term (Inter-Academy Council, 2004b; International Council for Science, 2006).

Agrochemicals are some of the most important products used in agricultural production. They play an important role in increasing agricultural production and incomes. Being high-tech products, agrochemicals set certain requirements for the user. Pesticide research has provided compounds of progressively increased activity, and recently discovered insecticides, fungicides and herbicides are outstandingly potent. Consideration of the practical use of such chemical agents suggests that greater attention should now be given to methods of application and to the physiochemical properties that determine redistribution and biological availability following release.

The use of agrochemicals will increase as intensive agriculture expands. Runoff from intensively exploited areas will carry heavy loads of pesticides and herbicides as well as fertilizers. The chemicals will pollute water sources and overload them with nutrients. Such high chemical loads will lower water quality for such uses as drinking and irrigation or fish culture—compounding the water scarcity in the region. In particular, in countries where most of the population lives in villages that depend on ground or surface water for their own consumption, polluting this source can lead to extensive health problems in rural communities. Also, continuous and improper use of herbicides and pesticides will promote resistance to these chemicals in weeds, microorganisms and insects.

There is growing social awareness about pesticide-intensive pest control programs. This concern will be a driving force behind the adoption of modern AKST methods of pest control such as IPM, already popular in some countries (FAO, 2000).

3.3.1.4 Land and water resource management

Land resource management is the actual practice of how the local human population uses the land. Its use should be sustainable (FAO/Netherlands, 1991). In a broader sense management includes land-use planning, as agreed among stakeholders; legal, administrative and institutional execution; demarcation on the ground; inspection and control of adherence to decisions; solving of land tenure issues; settling of water rights; issuance of concessions for plant and animal extraction (timber, fuelwood, charcoal and peat, nonwood products, hunting); promotion of the role of women and other disadvantaged groups in agriculture and rural development in the area; and the safeguarding of traditional rights of indigenous peoples (FAO, 1995).

Improved land management that ensures better resource use and promotes long-term sustainability is basic to future food production and to the economic welfare of rural communities. Because of the dynamic aspects of land management, a flexible and adaptive "process" approach for monitoring the quality and quantity of the world's land resources (such as soil, water, plant nutrients) and for determining how human activities affect these resources is essential. However, systematic assessment of sustainability of current or planned land uses can be hampered by too much detailed data that are difficult to interpret, lack of baseline information from which to compare change, or data that are inconsistent over time or geographic area (USDA, 1994).

From the land management point of view, the major concerns are

- decline in quality of the soil as a rooting environment
- erosion and loss of topsoil by wind and water
- loss of vegetative cover, including woody perennials
- acidification, decline in soil fertility and depletion of plant nutrients
- salinity and salinization, particularly in irrigated systems

Increased control over land resources by the powerful, especially large-scale farmers with political constituencies, leads to a monopolistic attitude, where land is a symbol of power and not productivity (Basu, 1986; Bonfiglioli, 2004).

In the long term, national governments will address issues of food security and rural development (Chambers and Conway, 1991). This may lead to better investment in AKST. As a result, an enabling environment will be provided for better management of land resources, e.g. through efficient soil conservation, water management, and salinity and waterlogging technologies and practices.

In most CWANA countries, traditional inheritance laws will continue to intensify fragmentation of landholdings and production systems. This too negatively influences the realization of economies of scale in agriculture in affected countries. The possibility of land consolidation and integration of the production system is the most promising scenario for overcoming the prevailing problems.

Water resource management is the integrating concept for a number of water subsectors such as hydropower, water supply and sanitation, irrigation and drainage, and environment. An integrated water resource perspective ensures that social, economic, environmental and technical dimensions are taken into account in managing and developing these resources.

Water is the most important natural input in agricultural development (UNWWAP, 2003; CA, 2006; IWMI, 2006). In some areas, ground water is used for irrigation, but because of factors such as drought and overdrawing of groundwater reserves, this important resource has a negative annual balance, with dropping water tables. Besides climatic changes and drought, the scarcity of water resources will be intensified because of pollution from industrial, agricultural and urban sources (WMO, 1997; Pearce, 2006).

Better investment in water resource schemes and better management of water resources will lead to sustainable increases in the productivity of water—and better livelihoods for poor people in rural areas. As a result of these smarter investments, over a 20-year time horizon, we expect less environmental degradation and less poverty.

Integrated water management will achieve positive results by using a three-pronged approach:

- Significantly influence how investments in irrigation development, improvement and management are made, by feeding results of relevant research into the global debate on water for food and environmental security.
- Develop and disseminate research tools to enhance the understanding of the most critical issues in managing irrigation water.
- Provide tools, processes and knowledge that allow water resource managers to adapt and respond to new and changing needs and expectations.

Water-use efficiency in CWANA countries is poor, because of several factors including poor on-farm water management, land slope, inadequate land grading and hydraulic structures. Rational use of water will not be practiced in the short to medium term, so water-use efficiency will deteriorate. A different technology mix will be required to optimize the efficiency, which will be possible by developing AKST (Penning de Vries et al., 2003; IWMI, 2006).

3.3.1.5 Climate change

Climate change in the past century has already had a measurable effect on ecosystems. The earth's climate system has changed since the pre-industrial era, in part because of human activity, and it is projected to continue to change throughout the twenty-first century.

The many challenges global climate change poses, from increased temperatures and extreme weather events to rises in sea level, are now widely recognized in both scientific and policy circles (Smit, 1993; McCarthy et al., 2001). The global mean surface air temperature is projected to increase from 1990 to 2100 by 1.4–6.4 °C, accompanied by more heat waves (IPCC,2007). Precipitation patterns are projected to change, with most arid and semiarid areas becoming drier but with an increase in heavy precipitation events, leading to increased incidence of floods and droughts. The Millennium Ecosystem Assessment scenarios project a sea level rise of 9–88 cm.

In this respect, the fourth report of the Intergovernmental Panel on Climate Change (IPCC) estimates that a global temperature rise during the century of between 2 ^{o}C and 4.5 ^{o}C is almost inevitable. Ominously, however, it also says that much higher increases, of 6 ^{o}C or more, cannot be ruled out. IPCC's latest report makes it clear that climate change may be far worse than previously thought because of potentially disastrous positive feedbacks, which could accelerate rising temperatures (IPCC, 2007).

Furthermore, a recent report from Britain's Sir Nicholas Stern warned of the devastating economic effect global warming could have on the world in coming years. Stern, former chief economist at the World Bank, cautioned that if greenhouse gas emissions were not significantly reduced, by 2050 the global economy would shrink by up to 20%, millions of people would be permanently displaced and droughts would plague the earth.

So far, the main response both nationally and internationally has been to focus on initiatives aimed at reducing the potential size of these effects. Most industrial countries have sought to do this by committing themselves through signing the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, to stabilize or reduce greenhouse gas emissions and enhance carbon sinks (Klaey, 2000; Baumert et al., 2005).

Climate change will potentially lead to such eventualities as drought and famine, which some of the CWANA countries have already experienced. .The capacity of national governments and communities to mitigate disasters will be limited in the short to medium term, rendering them still vulnerable to the adversities of climate change. Climate change is a global issue with regional

implications. Many multilateral environmental agreements address these issues, and some countries of the region have ratified some such agreements (WCED, 1987; UNEP, 2002).

Too much or too little rain can be a matter of life or death in some countries in the CWANA region (UNEP, 2002; WRI, 2005). At different times and in different places across the region, climate change poses the threat of both. Prolonged and severe climatic desiccation, coupled with intensive exploitation of soil, pasture, forest and other natural resources, as well as the huge increase in human and livestock populations will lead to extensive degradation and result in an inherently fragile environment in some parts of the region to the extent that conflicts caused or catalyzed by these compounding ecological factors are bound to take place (De Wall, 1989).

In fact, ecological degradation, caused mainly by climate change, has been so severe that traditional means for preventing and managing interethnic disputes have been rendered virtually unworkable. Indeed, many of the current disputes are being fought not along traditional political borders but along ecological borders that divide richer and poorer ecozones (Bachler and Spillmann, 1992).

To continue to treat the conflict in Darfur and many other parts of Africa as purely ethnic, tribal, political or religious, and to ignore the growing impact of ecological degradation and depletion of the resource base will ultimately lead to a distorted understanding of the real situation. This will consequently limit the possibility for genuine conflict resolution (El-Nour, 1992; Suliman, 1993, 1996, 2000). Therefore, a new model of development is called for, in which strategies to increase human resilience in the face of climate change and the stability of ecosystems are central. Above all, the challenge calls for new flexibility and not a one-size-fits-all approach to development (De Wall, 1989; Suliman, 2000).

The aforementioned issues and other environmental factors precipitating climate change, like industrial pollution, can only be addressed through efficient technologies. Yet the available technology mix (AKST) can have both positive and negative effects on the climate, and at times may not be efficient or environmentally friendly. National governments will remain complacent with what already exists, at least in the short term. But this will compromise their attaining their environmental health agenda in that time frame.

Regionally, countries sharing borders or that are members of regional cooperation or custom unions could address cross-border environmental issues. The coping strategies proposed could at times be costly, and countries of the region might not be able to handle the issues on their own. At present, as issues of environmental goods and services are being negotiated in WTO,

national governments and communities may not be able to engage in them proactively. Finally, considering the current weak AKST infrastructure and scarcity of human resources, countries will not be able to give the support needed to mitigate climate change.

In the absence of effective mitigation efforts, climate changes will potentially lead to major crises, which will encourage stronger alliances between selected countries to attempt to reduce the incidence and damage of further natural disasters. Development of AKST will counteract the adverse fallouts on the region (Röling and Engel, 1991; Pardey and Beintema, 2001; Pingali and Traxaler, 2002; Byerlee and Alex, 2003; Byerlee et al., 2005; NEPAD, 2005).

A key component of all the strategies is to link early warning and risk management systems to regional and local practitioners such as health-care providers and farmers (WGCCD, 2006). Government departments and the media will also play an important role, particularly in getting information to rural areas. Present media gaps in communicating meteorological information make uninformed farmers more vulnerable to climate change.

3.3.1.6 Energy

Perhaps the greatest challenge in realizing a sustainable future is energy consumption. Energy is ultimately the basis for a large part of the global economy, and more of it will be required to raise living standards in the developing world. Today, we are mostly dependent on nonrenewable fossil fuels that have been and will continue to be a major cause of pollution and climate change. Because of these problems and our dwindling supply of petroleum, finding sustainable alternatives is becoming increasingly urgent (Starss, 2006).

Scientists are warning that the end of oil is coming sooner than governments and oil companies are prepared to admit. The London-based Oil Depletion Analysis Centre says that global production of oil is set to peak in the next four years before entering a steepening decline that will have massive consequences for the world economy and the way that we live our lives.

Under globalization, prices of oil will further increase. The present situation in the Middle East supports this scenario. Access to energy will be further hindered by the increased monopoly of associations such as OPEC. This state of affairs will have implications on evolving efficient technologies for agricultural development in the short to medium term.

Development of alternative means of energy such as solar, wind and biofuels needs strong underpinnings, from both a strong natural resource base and AKST capacity. With development of AKST capacity in the region, coupled with soaring petrol prices, alternative means of energy

will become available in the long term. In oil rich economies, agricultural development is being accomplished by income-generated oil resources without integration with AKST. This will lead to unsustainable development in the long term. Tapping renewable energy resources such as solar energy, biomass and alcohol from plant residues is a more efficient way to achieve sustainable development. However, developing countries will find it difficult to produce biofuels without sacrificing food availability, as subsidized production for biofuel will compete with food production.

Biofuel production will increase demand for agricultural land at the expense of natural ecosystems. Perhaps more critically, it will also require large quantities of water—already a major constraint to agriculture in many parts of CWANA. Pursuing biofuel production in water-short countries will put pressure on an already stretched resource and will turn green energy into a major threat to resources.

3.3.1.7 Human resources and feminization of agriculture

Building human resource capacity directly implies agricultural education. By definition the term capacity building (and the process) has education, both formal and nonformal, at its core. In its broadest interpretation, capacity building encompasses human resource development (HRD) as an essential part of development. It is based on the concept that education and training lie at the heart of development efforts and that without HRD most development interventions will be ineffective. It focuses on a series of actions directed at helping participants in the development process to increase their knowledge, skills and understanding and to develop the attitudes needed to bring about the desired developmental change.

Human resources and capital along with natural resources are essential for development. Many dimensions of human resource development are end objectives of development, e.g. literacy, better health and nutrition, economic well-being. It is generally recognized that a country's human resource capacity for productivity is a prerequisite for social and economic development. However, the problems of development, and in particular food security and poverty, are complex, and improved HRD is only one of several necessary conditions for social and economic progress.

Sustainable development, with its management, technological and institutional aspects, clearly encompasses human resource development, and in particular HRD in agriculture. Unfortunately, the term HRD has been applied to such a wide array of activities that its meaning is often ambiguous. To be meaningful, HRD needs to be carefully defined.

Competitiveness in agriculture and food systems demands improvement and development of the human resource through investment in education, training, health, and information and

communication technology (ICT) (Jaffé and Rojas, 1994; Rice et al., 2000; WHO, 2005; Stern et al., 2006). The establishment of agricultural schools and colleges will continue to present additional, sometimes alternative, knowledge systems for agriculture and related sciences. There is a threat of vacuum of experienced and knowledgeable experts and professors in national educational and research institutions because of retirement regulations and an increased number of university graduates seeking job opportunities in NARS.

Capacity-building efforts should focus on institutional strengthening, including the design of new organizational structures to improve the "goodness of fit" between the policy context for sustainable development and enacting institutions in both public and private sectors. These institutions include agricultural education and training institutions as well as extension agencies, research institutions, NGOs and community organizations. A multiplier effect can be achieved if strong links among agricultural education institutions, NGOs, research organizations, public and private extension services and others are fostered. This approach recognizes that there are multiple sources of technology development and dissemination and that integrated institutional networking to build capacity.

Building human resource and institutional capacity through agricultural education and training means enhanced investment, expanded international cooperation, improved quality and relevance of education, and broadened access to and participation in educational activities, especially by women. A wider financial base will be needed, including increased support from the private sector. This does not mean, however, that governments can detach themselves from the responsibilities of building human capacity. If there is not strong national commitment to sustained human resource development, the goal of sustained agricultural and rural development will not be realized.

In many parts of the world today the trend is increasing toward what is termed the feminization of agriculture. As men's participation in agriculture declines, the role of women in agricultural production becomes ever more dominant. War, and sickness and death from HIV and AIDS, have reduced rural male populations. Another major cause of this phenomenon is the migration of men from rural areas to towns and cities, in their own countries or abroad, in search of paid employment.

This will be in line with the present trend regarding the gradual increase of women’s work over time in some countries of the region. Between the years 1960 and 1985, the percentage of women’s participation in agriculture increased considerably in all countries (Narayan, 2002).

This trend is resulting in an increase in the proportion of households headed by women. Approximately one-third of all rural households in sub-Saharan Africa are now headed by women. Studies have shown that women heads of household tend to be younger and less educated than their male counterparts. They also generally have less land to work and even less capital and extra farm labor for working it.

With a shortage of labor and capital, women heads of household will often be forced to make adjustments to cropping patterns and farming systems. These adjustments will result in decreases in production and, in some cases, shifts toward less nutritious crops. Not surprisingly, these households will often suffer from increased malnutrition and food insecurity.

Nor has the fact that the participation of women will increase translate into their ownership of resources such as land, labor, credit and capital. As an example, traditional inheritance laws may be cited whereby the rights of the male heirs are twice those of the female.

Nevertheless, through higher education for women and change in attitude, society will develop institutions of governance, legal systems and social or gender-sensitive policies that will decrease disparities between women and men (UNDP, 2005).

3.3.1.8 AKST investment, indigenous knowledge and transgenics

The visible signs of science and technology are most evident in food production. Much of the increase in agricultural output over the past 40 years has come from an increase in yields per hectare rather than an expansion of area under cultivation.

Investment in agricultural research has a net payoff; in many developing countries, the share of agriculture in the GDP ranges from 25 to 70 percent (Hurni et al., 2001; FAO, 2003). However, the share of investment in agriculture and agricultural research will continue to be low, compared with that internationally recommended (FAO, 2004). This is one of the reasons that new technologies and better agricultural practices have not taken root in CWANA countries, and traditional agricultural practices, which are relatively less efficient, continue to dominate. Adoption of the new and more efficient agricultural technologies will require urgent and increased investment in AKST (Inter-Academy Council, 2004a; CGIAR Science Council, 2005).

Agricultural technologies and knowledge have, until recently, largely been created and disseminated by public institutions. But over the past two decades, biotechnology for agricultural production has developed rapidly, and the world economy has become more globalized and liberalized. This has boosted private investment in agricultural research and technology, exposing

agriculture in developing countries to international markets and the influence of multinational corporations. But the public sector still has a role to play, particularly in managing the new knowledge, supporting research to fill any remaining gaps, promoting and regulating private companies, and ensuring their effects on the environment are adequately assessed.

However, the relatively weak institutional and human capital base in the region has negatively affected agricultural development. With the establishment of globalization, CWANA countries will have opportunity to interact across borders with nations and communities that have advanced production systems and practices. Exchange of knowledge and experience across regional and international boundaries will let scientific information flow in, to the advantage of agricultural development in CWANA. The role of internationally recognized scientific and research organizations and institutions in the region will be of great benefit in this respect.

Countries of the region will get involved in investment treaties with transfer of technology. Considering that 90 percent of the genetic resources of the world are in the South, of which CWANA is a part, these countries will expand claim for intellectual property rights for providing access to genetic resources and indigenous knowledge. With good management and development, these resources will accrue monetary gains to the advantage of their custodians. But in the immediate future, organizational fragmentation of agricultural research will continue to prevail in most CWANA countries.

Indigenous knowledge is local knowledge, unique to a given culture or society. Indigenous agricultural and environmental knowledge gained global recognition through the United Nations Conference on Environment and Development (UNCED) in 1992. However, indigenous knowledge systems have never been systematically recorded in written form and therefore are not readily accessible to agricultural researchers, development practitioners or policy makers.

There is no standard definition of indigenous knowledge; however, there is general understanding as to what constitutes it. It is variously regarded as ethnoscience, folk knowledge, traditional knowledge, local knowledge and people's knowledge. The role of indigenous knowledge in preserving agrobiodiversity is essential to human development.

Small-scale, resource-poor farmers have good reasons for sticking to their local knowledge and the farming practices they have always used. Modern technologies can be successful and sustainable only if the local knowledge interplay of cultural, social and ecological systems are taken into consideration. In so stating, we suggest that, given the pervasive scenario of rapid population growth and the attendant domestic food demand deficits, the need has emerged to

balance sustaining the indigenous knowledge production system with modern technology, through a systematic hybridization strategy (Titilola, 1990, 1994).

Indigenous knowledge of plant genetic resources is an invaluable tool in the search for new ways to conserve and use these resources to benefit local communities. Agenda 21, one of three nonbinding environmental agreements signed at UNCED, emphasizes that local governments and intergovernmental organizations should respect, record and work toward incorporating indigenous knowledge systems into research and development programs to conserve biodiversity and sustain agricultural and natural resource management systems.

It is impossible to predict exactly which new modern biotechnology derived from plants or animals will be ready for the marketplace over the next decade. Some possibilities:

- genetically engineered plant varieties that provide improved human nutrition (e.g. soybeans enriched in omega-3 fatty acids)
- products designed for use in improved animal feeds, providing better nutritional balance by increasing the concentration of essential amino acids often deficient in feed components, increased nutrient density, or more efficient use of nutrients such as phosphate that could provide environmental benefits
- crops resistant to drought and other environmental stresses such as salinity
- crops resistant to pests and diseases (e.g. *Fusarium*-resistant wheat; chestnut-blight resistant chestnut; plum-pox resistant stone fruit; various insect-resistant crops)
- additional crops containing a number of transgenic traits incorporated in the same plant (stacked traits)
- crops engineered to produce pharmaceuticals, such as vaccines and antibodies
- crops engineered for particular industrial uses (e.g. crops with improved processing attributes such as increased starch content, producing useful enzymes that can be extracted for industrial processes, or modified to have higher content of an energy-rich starting material such as oil for improved use as biofuel)
- transgenic animals for food, or for production of pharmaceuticals or industrial products (e.g. transgenic salmon engineered for increased growth rate to maturity, transgenic goats producing human serum factors in their milk, and pigs producing the enzyme phytase in their saliva for improved nutrient use and manure with reduced phosphorus content)

TNCs and MNCs have an aggressive trade interest in biotech products and GMPs (Atanassov, 2004). GMPs will lead to monocrop culture with adverse implications for bio- and agrodiversity (Benbrook, 2004; Brookfield et al., 2003). But given the low level of AKST in the CWANA region, coupled with religious and other social factors, the trend for not accepting GNPs and seed crops

will continue at least in the near future (Cohen et al., 1999; World Bank, 2002; Tollens et al., 2004)

Nevertheless, better science and tougher regulations are needed to police the future growing of genetically modified crops in the CWANA region. Current genetically modified foods appear safe to eat but there are doubts about future products and the environmental effect of transgenic crops. For reasons of expense, concerns for safety, and inadequate understanding of basic biology, the use of transgenics in livestock production is likely to be minimal for many years to come. Substantial gaps in scientific knowledge remain that must be addressed. The prospect for genetically modified and organic farming coexisting in future is full of uncertainty and poses difficulties.

3.3.2 Indirect drivers

3.3.2.1 Demographics and human health

The population dynamics of CWANA region are witnessing high rates of growth compared with other regions. These high rates coupled with problems like poor social safety nets, education, immunization, and child and mother care negatively affect human productivity and longevity. Children and women, the worst victims of the skewed demography, will continue to be marginalized in the absence of social safety nets (Ratner, 2004).

In the densely populated regions of CWANA, agriculture will remain a key source of livelihood, although over the past few years, its capacity to employ people as a dependable livelihood has declined. Migration will continue as people seek off-farm jobs not available in villages. This will lead to mounting pressure on urban satellites. The United Nations Millennium Project found strong links between rapid population growth, high fertility and ill-timed pregnancies—which add up to a demographically related poverty trap. Demographic trends affect both development prospects and security.

The interaction between health and agriculture operates in two directions—agriculture affects health, health affects agriculture. Agricultural production and its outputs can contribute to poor health, depending on the system of production and consumption. Agricultural policies clearly affect the quantity, quality and price of food, all of which play important roles in diet change in developing countries.

The greatest challenge now is the burden of nutritionally related diseases. Agricultural policy should take into consideration the whole spectrum of these diseases, to help strengthen the "one agenda" that will gradually break the cycles of both poverty and hunger in a sustainable way.

Under globalization, because of expanding tourism, cross-cultural contacts, and trade liberalization, diseases such as avian flu and HIV and AIDS are expected to rise in the region. Some countries in the region are hard hit by both of these disease problems. HIV and AIDS also have long-term implications for the nutritional health of affected communities and families, which further compound the risk of food insecurity under the business-as-usual scenario discussed earlier. This in turn adversely affects the rehabilitation of those infected with HIV (ILO, 2005; UN, 2005).

It is expected that population growth over the next several decades will be concentrated in the poorest urban communities in sub-Saharan Africa, South Asia and the Middle East. Populations in all parts of the world are expected to age substantially during the next century. While industrial countries will have the oldest populations, the rate of aging may be extremely fast in some developing countries in CWANA region.

3.3.2.2 Sociopolitical drivers

Sociopolitical drivers encompass the forces influencing decision making and include the amount of public participation in decision making, the makeup of participants in public decision making, the mechanisms of dispute resolution, the role of the state relative to the private sector, and levels of education and knowledge.

Over the past 50 years, there have been significant changes in sociopolitical drivers. There is a declining trend in centralized authoritarian governments and a rise in elected democracies.

Good governance is a general term for the way in which a government acts and functions for the benefit of a society. Good governance should therefore not be seen as a sector in itself. If there is good governance in a country, we expect the government of that country to be transparent (clear and complete financial accountability, accountability concerning its policies); to play a facilitating and encouraging role toward civil society on economic, political and social grounds; to be a neutral arbiter in society; to be accountable for its rules and laws and to be cost effective and service-oriented toward its citizens.

All these elements tell us something about the way a country and government operates and the type of processes and dynamics that are going on within a country. The success of these elements often depends on political, cultural, social and economic aspects that can be found within the context of a country.

To promote good governance, specific attention is paid to democratization and decentralization, gender, human rights, strengthening of the rule of law, promotion of independent media, institutional strengthening, public finance management and civil service reform.

Citizens in many developing countries are demanding better performance on the part of their governments, including increased transparency and accountability. Institutional development activities focus on strengthening the ability and capacity of countries to design and implement development policies on their own and in a sustainable way. It is a multidimensional concept not limited to training activities and organizational capacity development; it also includes the overall environment of institutional performance: budgeting procedures, formal and informal patterns within organizations, organizational culture, social structures, etc.

The trend toward democratic institutions has helped empower local communities, women and resource-poor households. The need for good governance, democratization, decentralization and other sociopolitical reforms will remove the stumbling blocks and will speed up development. Pressures from globalization can contribute to adoption of democratic thinking in some countries, consequently reducing corruption in developing economies.

There is room for improvement in coordination at all levels, public, private and civil society, to facilitate development process. Better coordination and collaboration will enhance development objectives, especially poverty alleviation and amelioration of hunger (Hemmati et al., 2002).