CWANA CHAPTER 5

LOOKING FORWARD: ROLE OF AKST IN MEETING DEVELOPMENT AND SUSTAINABILITY GOALS

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Key Messages

5.4.2 Implications for development pathways

5.4.3 Implications for the environment: assessing how TIPOS will affect natural resources

5.4.4 Implications for food safety and security

5.5 Mitigation of Measures Related to Negative Aspects of TIPOS

5.5.1 Determining measures to balance any negative impacts on natural resources

5.5.2 Determination of measures to overcome any negative aspects of TIPOS on food safety

Key Messages

A. AKST has an important and essential role in meeting Sustainable development goals of: reducing hunger, improving human health, reducing poverty, improving livelihoods, and attaining environmental, social and economic sustainability.

B. Enabling drives which drive the different development pathways of AKST.

C. Available and required Technological, Institutional and Policy Options (TIPOs) to respond to major deficits regarding sustainable development goals in CWANA include:

a. Increasing agricultural productivity

b. Market orientation, diversification and risk management in agricultural production

c. Rational management of natural resources including water resources, land and wildlife

d. Human capacity development through integrating and improving education, research and extension

D. Since water is the most restricting factor for agricultural development, more emphasis should be placed on optimal utilization of water in agriculture and water demand management options.

E. Regional cooperation is essential in managing water resources, improving water use in agriculture, attaining integrated water resources management, and resolving conflicts over water resources in the region.

F. TIPOs to overcome constraints include:

a. Mitigation options for global climate change

b. Options to conserve biodiversity

c. Increasing food supply and food security utilizing nutrient cycling methods, GMOS, organic farming and other available options to produce more nutritious food and high yielding crops with minimum impacts of the environment.

d. Increasing participation of women to attain gender equity and cooperation between countries and international organizations to attain social sustainability and reducing conflict

e. Expansion of woodland and rangelands to reduce desertification

f. Enhancing and sustaining human capacity

g. Use of biotechnology in coping with biotic stress.

G. Implications of TIPOs include:

a. Utilizing of local knowledge has positive impacts on biodiversity, ensuring food security, adoption of new technologies and developing human resources.

b. TIPOs will have positive and negative impacts on the environment and the natural resources including land, water and biodiversity.

H. Mitigation of measures related to negative aspects of TIPOS include:

a. Using measures to balance impacts on natural resources include: public education, public awareness and sufficient regulation.

b. Measures to protect biodiversity include: research and training, institutional building, investing in information acquisition and exchange

c. Measures to reduce negative impacts on food safety include: Partnerships at local, national and international levels, improving food testing and monitoring of quality, harmonization of national standards and guidelines

d. Measures to improve food security include: Institutional building and improving linkage between agricultural research and agricultural extension services.

5.1 The Role of AKST in Meeting Sustainable Development Goals

5.1.1. Scope

The IAASTD sub-global and global assessments all aim to achieve a reduction of hunger and poverty, improve rural livelihoods, and facilitate equitable, environmentally, socially and economically sustainable development through the generation, access to, and use of agricultural knowledge, science and technology (AKST).

Chapter One of the CWANA sub-global assessment sets the scene of the CWANA in terms of context, agricultural production systems, tackles the key issues in the context of agricultural development and development-related problems such as hunger, poverty, livelihoods and environment in the CWANA region and identifies the current status of AKST in the CWANA. The historical and current perspectives of AKST and gaps thereof are discussed in Chapter Two. Chapter Three depicts an analysis of plausible future scenario with focus on the different ways AKST is developed and applied, and the relevant impacts on the situation of hunger, nutrition, poverty, social equity and environment. The historical and current capability and appropriateness of different AKST systems to deal with the needs and interests of different stakeholders (rural/urban, farmer/consumer, farm/laborer/processor, men/women) in the context of addressing the development and sustainability goals are assessed in Chapter Four. Finally, Chapter Five discusses AKST options and roles in dealing with uncertainties and to meet the development and sustainability goals in the future in the CWANA region building on the proceeding chapters.

5.1.2. Most pressing/urgent areas where AKST can play a role in meeting sustainable development goals

5.1.2.1 Hunger, nutrition and human health

Increased agricultural production/productivity is a direct driver for reducing hunger and improving nutrition and human health in that sufficient and more nutritious and diverse food results in a healthier constitution and improved body defenses/immunity (Rosegrant et al., 2005; relates to MDGs 1, 4, 5, 6). Increased agricultural production/productivity also directly helps increasing income, thereby reducing poverty and securing/fostering livelihoods of farming populations. Higher productivity may further allow for more diverse food production and thus diversified nutrition. More diverse and higher-quality diets not only provide sufficient protein and vitamins, but also help combating micronutrient deficiencies.

However, increasing productivity has to be approached cautiously; too often a narrow focus on productivity gains results in an unsustainable exploitation (overuse and pollution) of natural resources (environmental degradation), in problems related to food quality and safety (with negative effects on nutrition, health, or marketability), or in neglecting social aspects in trade-off with profitability (including abuse and social dumping). Therefore, AKST-related initiatives need to be guided towards sustainable agricultural productivity which will help achieve development goals.

5.1.2.2 Poverty and livelihoods

Nearly a third of the population of developing countries live below the poverty line. Three-quarters of the poor live in rural areas depend upon agricultural for their survival, and about two-thirds of them (an estimated 678 million people) keep livestock. This large proportion indicates the importance of animals to their livelihoods. The number of poor keeping livestock in urban or peri-urban environments is growing, but remains less than the number in mixed rural systems.

Livestock is for many poor families an important asset. Income is generated by selling products like milk or meat. But livestock plays in many cases also another role in the livelihood of farmers. Animals are often kept as a “living bank” and are sold if there is an urgent need for money. They are also part of the culture and are seen as a symbol of wealth. AKST therefore, faces challenges how crop and livestock resources could be developed on sustainable basis, with enhanced output per unit and at the same time increasing productivity of areas.

5.1.2.3 Environmental sustainability

Crop production (use of pesticide, fungicide, agro-biodiversity). AKST can and will have to provide approaches, strategies and technologies that allow for more sustainable use and management of limited water resources. These will, on one side, have to focus on quantitative aspects, i.e. on increasing water supply and decreasing water demand. On the other hand, conservation of water quality will have to receive more attention in the future: AKST in this regard will not only have to concentrate on the protection of water resources against pollution - from agricultural activities as well as from other sources, AKST will also have to explore ways for using water of lower quality in agriculture, and to matching the quality of water supplied to its specific use, considering the reallocation of water of different quality among sectors. Progress in AKST is especially important, because agriculture is by far the biggest consumer of freshwater resources in the region, and progress in AKST will allow freeing up water for other sectors (including the environment) which will progressively need more (good-quality) water.

Effect of weather and climate

- As a consequence of climate change, CWANA is projected to become warmer and drier with reduced crop productivity (Thomas et al., 2003). Short-term variations caused by weather affects crop yields even in the modern era of technology-based agriculture:

- The CWANA region is already one of the most water scarce areas in the world, and this is predicted to worsen markedly over the next 25 years. As a result the food security situation will also likely worsen.
- Temperature stress occurs commonly when the temperature is either too low or too high for optimal growth. A short period of stress can severely depress growth later. Sudden cold snaps injure plants because they do not have enough time to become acclimatized to the cold weather. Moisture stress often accompanies high-temperature stress.
- Natural disasters cause severe damage by physically harming crops and the soil that supports them.

Therefore AKST has to play a role on one hand towards mitigating climate related adversaries and on the other help develop more environment friendly practices and technologies.

Food safety and agricultural production (chemical residues – medicines - in food of animal origin)

Most farming in CWANA is based on livestock – crop integrated production systems. At the farm/community level, the following are some of acceptable farming practices:

- Manure application to fields to recycle nutrient, improve fertility and increase organic matter content
- Use of crop residues for livestock feeding to improve nutrition and reduce biomass burning.
- Use of urea-molasses blocks for ruminants feeding, to enhancing microbial fermentation, increase digestive efficiency and reduce methane production.
- Policy guidelines to regulate strategic planning are therefore important elements for managing livestock – environment interactions. Most important are policies on:
    - Mixed farming systems, with integration of arable and livestock production
    - Reduced-grazing, cut-and-carry systems in areas of high human population density (e.g., peri-urban), with safeguards for animal welfare; and
    - Community-based land use and environmental management planning.

The challenge, therefore, is the design and operation of organized multi-level systems for detecting and assessing the environmental hazards and monitoring environmental quality. Possible technological approaches for consideration involve the following:

- evolving some mechanisms to recognize and detect new hazards via their effects upon animals;
- developing protocols for animal testing of potential hazardous substances and
- monitoring of the environment, using some health indicators.

Therefore AKST has to help promote good agricultural practices and food safety and quality standards.

5.1.2.4 Economic sustainability

The *economic sustainability* of a farm is subject to the viability of, and markets for, an enterprise or product. The economic sustainability of an agricultural sector is subject to the whole economy on local, national and international level.

Sustainable development considers the following potentials:

- stability or growth of potential of the basic production funds and usage of this potential;
- stability and preservation of renewable and non-renewable natural resources (existing and used);
- stability and growth of human (intellectual) potential (labor potential);
- stability and growth of financial abilities..

The interrelation and interdependence of all these potentials have been underlined: financial ability can feed and strengthen production, as well as natural and labor potentials. At the same time, each of those potentials can strengthen the financial potential: by mining, by reuse of resources by selling their results abroad, *etc.*

Most important for each country is to evaluate its current situation from the point of view of all four above-mentioned potentials in their interrelation, and to develop as accurately as possible forecasts of changes in short-term (5 years), medium-term (15-20 years) and long-term (35-50 years) perspectives, for which agricultural and water strategies should be developed, and AKST can help evolve suitable strategies.

The condition of these main potentials determines the degree of sustainability of the- dynamics of county development and it generates two very important outputs for water management strategies:

- the strategic requirements for the quantity and quality of water and related hind resources, from the position of the perspective of country's sustainable development;
- the economic and financial ability of the country to strengthen water-environmental potential and to solve problems related to the development of the productive arid labor; potentials of water sector.

5.1.2.5 Social sustainability

AKST plays an important role in attaining social sustainability through sustainable development of the population and the demography of the region. Social sustainability is related to economic development. Economic development creates more job opportunities for both men and women in the region. This results in reducing population growth rates and thus attaining sustainable demography. It also reduces difference between rich and poor and between genders. Economic development of the rural areas results in reducing migration and thus reaching social sustainability of these areas. Reduction of migration rates from rural areas to urban areas will result in reducing population growth and expansion of urban centers and thus attaining social sustainability there too. *AKST* can therefore helping agricultural and rural development with long term positive impacts on social sustainability.

5.2 Future AKST Options

5.2.1 Development pathways for AKST

Chapter 3 outlines how business as usual interfaces forceful global trends like globalization and trade liberalization, based on a pragmatic and rational understanding of direct and indirect drivers, and how these behave under different set of conditions, learning from the historical trends and analyzing these in qualitative/quantitative terms. These scenarios are affected by two sets of drivers (forces) which are categorized into direct key drivers and indirect key drivers. The later are in fact enabling drivers, which help direct drivers of the change. The enabling drivers are: science and technology policy and research and development infrastructure, human resource capital, investment, knowledge and innovation driven economy, intellectual property management capacity and innovation driven trade. The enabling drivers are basically the following development pathways:

- **Innovation-driven economic growth paradigm**

The underpinnings for innovation are to come from National Agricultural Research System (NARS) which needs to be geared for this change, including *inter alia* its restructuring to cater to innovation-driven economy. Such a paradigm shall rely heavily on AKST capacity of the regional countries in gender and NARS in particular to help deliver the development goals.

INSERT BOX 5.1

- **Public –private partnership**

Private partnership in research is vital especially in innovation driven economies, and countries that followed this pathway such as the Singaporean and Korean private sectors can contribute towards participatory research policy formulation aiming towards solving farm/industrial problems including *inter* alia a shift towards value-added agriculture. By investing in these areas private sector capacity to undertake independent research needs to be developed through appropriate policy mix. Innovation-driven growth investment in research is a prerequisite that in turn will require policy focus from national governments.

- **Investment in agricultural research**

The governments have to address these issues through investment-friendly policies and by assigning due priority to agricultural research. Investment in research shall help *inter alia* develop research infrastructure, which in turn will help improve research efficiency in the region. At present, investment in research is too low to contribute effectively towards development goals.

- **Development of research infrastructure**

A well-knit infrastructure on research, commodity/discipline basis, orchestrated at NARS level is required. A close linkage with CGIAR and other international and regional agencies would be rewarding. Private sector and academia too need to be integrated at least at a functional level in the NARS.

- **University-industry linkages:**

Universities have a central role to play in promoting AKST. Apart from the development of core human resource varsities can be instrumental in solving farm/industry problems by undertaking problem-solving research. In this context, University-Industry linkage could help improve research efficiency and will also help develop broader ownership for investment in research and promote cause of AKST.

- **Gearing towards export-led growth**

Development of agriculture and to that end investment in research and AKST would be geared if countries are able to produce production surplus, sell it on global market place and generate some revenue. This will help realize the shift from subsistence to export-led growth. If this shift is not realized then countries can become vulnerable to imports, which will have long-term implications in terms of food security, livelihood security, environmental health, and sustainability.

- **Women folk** in the CWANA are among key actors. Not only their role needs to be acknowledged but also through better education and incentives like micro credits their role could be strengthened, and streamlined for overall development, thus helping integration of gender in development.
- **Human capital**

There is a need to develop core human resources to underpin AKST-led growth. Universities need to be geared towards this end and curricula and syllabi need to be retailored. Special focus needs to be on development capacity to innovate through appropriate mix of human resources and institutions.

5.2.2 Technological institutional and policy options

A wide variety of technological, institutional and policy options can contribute to meeting development and sustainability goals in the CWANA, and to facilitate coping with uncertainties in/of the future.

5.2.2.1 Increasing agricultural productivity

Crop production. Apart from the general management strategies and practices commonly applied to increase crop productivity, management strategies and practices to use water efficiently and productively are of outmost importance in the dry areas of CWANA. Adequate soil fertility and fertilization, crop protection against pests and diseases (reduced productivity and increased water use), and weed control (competition for water, nutrients, and light) not only increase crop production but also increase the efficiency of water use – which is of major importance in dry areas of the CWANA.

Similarly, high-yielding species and varieties (possibly developed through hybridization, apomyxis, and/or possibly genetic engineering) adapted to the specific conditions of a certain location (through participatory decentralized crop breeding programs) may use water more productively if managed adequately than varieties and/or landraces with inferior yield potential.

The choice of optimal planting date can (in combination with e.g. short-duration varieties) increase water productivity substantially by making best possible use of limited precipitation and by placing/moving the cropping season into a period of low evaporative demand ("seasonal shifting"; see e.g. van Duivenbooden et al., 2000); supplemental irrigation (and possibly mechanization) may greatly facilitate moving the cropping season for better water-use efficiency.

Appropriate crop rotations or relay/intercropping practices, e.g. including (food) legumes that fix atmospheric nitrogen, also facilitate making better use of limited precipitation; e.g. growing a legume crop instead of fallowing every second year has proven to increase water productivity substantially in the WANA cereal production (van Duivenbooden et al. 2000). In addition, crop rotations may reduce weed, pest and disease pressure and positively influence soil fertility (including soil structure).

Mulches (management of crop residues combined with appropriate soil management) may not only reduce unproductive evaporative water loss from the soil surface, but also enhance infiltration of scarce precipitation; mulches may thus contribute to improved water productivity if their effect on soil temperature does not prolong the crop growing period into a dry season (in addition to reducing wind erosion, soil temperature, or surface sealing). A large soil volume that can be explored by crop roots is crucial for storing water that can be used by crops. Therefore, management factors increasing soil depth and the soil volume accessible by roots (such as breaking impermeable layers, anti-erosion measures like terraces, fertilization for vigorous root growth, or soil amelioration for increased water holding capacity) are important for making optimal use of scarce water. Particularly in windy areas windbreaks may reduce evapotranspiration through an ameliorated microclimate and thus improve water-use efficiency if competition of the windbreak species (usually trees) is not limiting crop production.

In many cases (as e.g. for mulching or adequate soil management) some degree of mechanization may greatly support management practices fostering a more efficient use of limited water resources and precipitation.

Rainfed cropping. In addition to the above listed general strategies and practices to increase crop and water productivity, certain management aspects are of particular importance in rainfed cropping. To store as much water as possible in the soil, maximizing infiltration of precipitation and reducing runoff is a major priority to improve water supply to crops in environments where water is a limiting factor for plant growth.

Water harvesting technologies (collection, storage and/or concentration of precipitation) at micro-, meso- and macro-scale may not only increase crop productivity in dry areas, but allow producing crops in environments where cropping is not possible without such technologies (by minimizing the risk of crop failure); additionally, water harvesting may protect land from degradation and desertification. The development and utilization of drought tolerant and/or resistant plant material with high yield potential is prerequisite in the drought-prone areas of CWANA if irrigation is not available/ possible.

Irrigated agriculture. In addition to the management factors discussed above, irrigation-specific options may be considered to render irrigated cropping more water efficient and productive: Irrigation and conveyance systems should be planned and/or improved to minimize water loss. Piping, lining, regular maintenance of conveyance systems are ways to reduces water losses through evaporation, percolation underneath the canals, seepage, overtopping, bund breaks, leakage through rat holes etc. and runoff. Optimizing water distribution in the field is a key for efficient water use in irrigation. Field application efficiency may be increased through improved irrigation systems (methods) and efficient irrigation scheduling. Particular attention should be paid to exploit the potential of supplemental and deficit irrigation, which may increase water productivity tremendously and greatly reduce the threat of crop failure (risk reduction, stability) (see e.g. Oweis et al., 1999).

Salinity represents a major threat to irrigated agriculture in most areas of CWANA because evapotranspiration generally exceeds precipitation to a great extent (already in the third millennium BC, the Sumerian cities of Mesopotamia crumbled, partly because salinization due to poorly managed irrigation). Proper irrigation management and availability and maintenance of suitable drainage systems are keys to avoid land degradation due to salinity. Particularly in cases where non-conventional water sources (such as drainage of brackish water) are used for irrigation, management practices have to consider the considerable threat of salinity.

Livestock. Three major types of farming systems may be distinguished: grazing systems, mixed systems and industrial systems. These systems can be characterized by the different stocking rates with the grazing systems having the lowest and the industrial one the highest level. In mixed systems livestock farming is combined with crop farming, where (part of) the crop (by-) products are used as feed resources (Chapagain and Hoekstra, 2003).

Traditional pastoralism (mainly based on sheep and goats) and, to a limited extent, mixed farming still exists. However, in the grazing and small mixed-farming sectors in CWANA, little technological change has occurred (Delgado et al*.,* 1999). Pastoralists are being driven into ever more marginal areas through the gradual expansion of arable terrain. But these marginal lands are increasingly coming into focus as reserves of biodiversity, and thus pastoralism is likely to disappear in many regions where it competes with agriculture (Extensive pastoral livestock systems). In more ecologically favorable environments, notably the Nile valley in Egypt, competitive dairy systems have emerged that use a mixture of domestic and imported feed resources and intermediate labor -intensive technology (Delgado et al. 1999).

Given that many countries in the region cannot expand crop area, two possibilities remain to increase feed-grain availability: intensification of production on existing land resources and importation of feed. Because much of the gain from intensification will probably go toward meeting the increasing demand for food crops, substantially more feed grains will have to be imported by developing countries in the future (Delgado et al. 1999).

In the grazing and mixed farming systems in CWANA, productivity gains still seem possible. Animal nutrition can be improved through different technical interventions like e.g. dry-season supplementation, non-conventional feeds or increased use of silvo-pastoral systems. Making better use of manure produced by livestock may not only be interesting for mixed systems, but ameliorate also fodder production and land conservation in grazing systems (e.g. by fertilizing fodder shrub plantings). Another way of increasing productivity is through animal breeding. This can be achieved through the improvement of local breeds or/and introduction of high-yielding breeds for crossbreeding schemes. However the later bear the threat of rare livestock breeds being progressively eliminated by genetic introgression, representing a corresponding loss of valuable genetic traits and biodiversity. With regard to animal health, the control of serious diseases is becoming increasingly effective, and treatment more easily accessible. As farmers gain confidence that diseases may be controlled, they are prepared to invest more in animal production (Morton and Matthewman, 1996). This important fact will considerably increase livestock productivity both in grazing and mixed systems. Aspects of hygiene are not only important with regard to animal health, but increasingly also for marketing of livestock products and will thus receive more attention.

Technical options for improved rangeland management (*i.e.* preventing degradation and rehabilitating marginal and degraded land) are available e.g. rotational grazing, corralling to rehabilitate degraded spots, seeding/planting possibly supported by fertilization and/or water harvesting, agro-forestry (fodder shrubs such as atriplex), maintaining livestock biodiversity, reducing the number of artificial water points, etc. However, these practices have often developed in completely different eco-social regions (e.g. in more stable environments of high potential areas), and thus the introduction of such technical packages was often unsuccessful (Alawuc, 2002; Sidahmed, 1996).

Mixed farming systems should still play an important role in the future, since integrating livestock and crop operations is still the main avenue for sustainable intensification of agriculture in many -particularly dryer- regions of the developing world (Delgado et al. 1999). Crop-livestock integration has manifold advantages and benefits: Livestock uses land which is not suitable for crop production, and provide manure for the crop production. The integration of -particularly leguminous- fodder crops in crop rotations may further improve crop productivity. Additionally, the use of rotations (including e.g. green manures) and the integration of livestock into farming systems widen the range of products, thus reducing the impact of failure or market collapse of any one individual crop.

Increased livestock production in CWANA to meet the rapidly growing demand for meat and milk products will probably have to be based on intensified mixed systems since land degradation due to excessive stocking rates on rangelands (grazing systems) is already widespread in the region. However, the potential threats of pollution as well as of animal and human health and welfare will have to be watched cautiously. Removing policy distortions that promote artificial economies of scale in livestock production, developing approaches to let poor producers capitalize from the benefits of increased livestock production, and the regulation of environmental and public health concerns will represent important challenges for the CWANA decision-makers.

Fisheries. A large quantity of harvested fish is discarded due to improper post harvest methods. Proper preservation methods can lead to an increase in the sustainable production from fisheries. More research is needed to improve fishing methods to increase their efficiency and to reduce the by-catch. Some important fish stocks are under threat due to over-fishing. Therefore, more research should be done on the biological and economical aspects of these stocks to determine the optimum yields of these stocks to ensure its suitability of the production from these fish species.

Aquaculture. It is expected that aquaculture will grow significantly in some CWANA countries. This growth will differ from one sector to anther in aquaculture including marine aquaculture, integrated agriculture-aquaculture, and the culture of non-food fishes. Increasing the demand for fish, increasing the domestic food supply and increasing export revenue are the main forces which will direct the expected growth of aquaculture industry in the future.

Challenges facing aquaculture differ from one country to another in CWANA region, but in general they include limited availability of suitable sites for new aquaculture activities, providing a continuous supply of fingerlings, the availability of local species for aquaculture, dealing with diseases and locating markets. In some cases, the sites are available, but the access to these sites is difficult due to several interests from different group of users. Another reason for limited sites availability is the absence of suitable technologies for particular sites as some sites requires special technology to be utilized. It is very important to determine suitable sites and allocate them for aquaculture projects to reduce the conflicts with other users such as tourism, agriculture and many other human coastal uses. This can be done by establishing a system for joint works between different governmental authorities responsible for aquaculture. It is also important to develop new technologies that can be applicable for local sites.

Using local fish species is important for sustainable aquaculture as there are many problems associated with using exotic species of which transmission of diseases is the main problem. Therefore, research should be increased towards determine the suitable local species of marine organisms for aquaculture. This species should have a high growth rates, be resistant to environmental changes and diseases, and be in demand in the markets. If an exotic species is to be used for any reasons, special procedures should be followed such as detailed risk assessment of effects of introducing this species on the local environment and species, strong quarantine procedures at the entrance of this species. Some countries do not allow the importation of fingerlings of exotic species, but they allow the importation of brooders. This will give the country a more surveillance over the brooders and the fingerlings which result from the breeding process.

It is essential to address environmental issues in order to develop sustainable aquaculture in CWANA. Therefore, Environmental Impact Assessments (EIA) should be done for every commercial project. These commercial projects should promote friendly and environmentally sound technologies for production and management of the culture process. Monitoring of these projects is very important to study the effects of the projects and the best methods to reduce them. Likewise, Codes of Conducts for best practices and methods in aquaculture projects should be prepared to ensure the sustainability of aquaculture. These codes can be written jointly between the government and private sector in any country.

Forestry. Forests are essential in increasing water infiltration and reducing runoff rates, thus improving water availability. Forests are essential elements of the hydrological ecosystem function (ecosystem services); soil conservation (on marginal lands); and for wood production. Expansion of forests and increasing there productivity could be done through utilizing appropriate species, protection of forests from grazing, zoning practices, water harvesting practices and the use of non-conventional water resources such as brackish water and treated wastewater for supplementary irrigation of forests in dry areas.

Agro-forestry. Innovation, adaptation, and participation will have to receive high priority in AKST with regard to agro-forestry in CWANA. Improving the availability of information on underutilized crops is one of the most important areas that demand immediate attention. New technologies such as molecular genetics and GIS will certainly play their part in the process of developing conservation and use strategies. Participatory research should be therefore actively pursued among stakeholders. Participatory plant breeding approaches may not only be an important element of the work on these crops; it may be the only feasible approach to obtaining improved materials. Similarly, participatory approaches may be essential to resolving other production and marketing constraints.

Role of mechanization and labor organization in agricultural production. SDGs targeted: productivity, but also social sustainability, i.e. gender equality and education. This requires more labor which is constrained by schooling, reducing workload for women; wages and salaries. The option to overcome labor shortages in agriculture is through mechanization. Conservation agriculture (such as conservation tillage) often requires some degree of mechanization. Larger land holdings (which are more common in certain CWANA countries than in many other regions) require mechanization to increase productivity. In addition, increasing labor constraints (particularly due to increasing opportunity costs of labor and insufficient remuneration of agricultural work) is a further drive for the need for mechanization.

Conventional and organic farming, biotechnology. Organic farming is an option to conserve resources and improve the quality of the product and reduce pollution. In addition to organic farming biotechnology methods are essential in producing high yield varieties and varieties tolerant to salinity and drought and thus improving yield per unit area. These are technical options as opposed to conventional methods used in agriculture.

Adaptation to global climate change (GCC). Adaptation to climate change can take many forms, including actions taken by people to lessen the impacts of climate change. The range of options include reactive adaptation that includes actions taken concurrent with changed conditions and without prior preparation and planned adaptations that are taken with prior preparation either concurrently or in anticipation to changed conditions. However, adaptation should be implemented in combination with mitigation to reduce the impacts of climate change and help to achieve the sustainable development.

Water: the adaptation options related to water resources include increasing water-use efficiency with demand-side management (pricing incentives, regulations and technology standards), increase reliability of water supply with supply-side management (construct new water storage and diversion infrastructure), change institutional and legal framework to facilitate transfer water among users (establish water markets), reform flood management plans to reduce downstream flood peaks, reduce paved surfaces and use vegetation to reduce storm runoff and increase water infiltration and reevaluate design criteria of dams and other infrastructure for flood protection.

Food and fiber: adaptation options include changing the timing of planting, harvesting and other management activities; using minimum tillage and other practices to improve nutrient and moisture retention in soils and to prevent soil erosion; altering minimum stoking rates on rangelands; switching to crops or crop cultivars that are less water-demanding and more tolerant of heat, drought, and pests; conducting research to develop new cultivars; promoting agro-forestry in dryland areas, including the establishment of village woodlots and use of shrubs and trees for fodder; replant with a mix of tree species to increase the diversity and flexibility: promoting re-vegetation and reforestation activities; assisting the natural migration of tree species with connected protected areas and transplanting; improving the training and education of rural work forces; establishing or expanding programs to provide secure food supplies as an insurance against local supply disruptions; reforming policies that encourage inefficient, non-sustainable, or risky farming, grazing and forestry practices (e,g. subsidies for crops, crop insurance, water).

Coastal areas and marine fisheries: adaptation options in this aspect include preventing development in coastal areas vulnerable to erosion, inundation and storm-surge flooding. Use "hard" (dikes, levees, seawalls) or "soft" (beach nourishment, dune and wetland restoration, afforestation) structures to protect coasts. Implement storm warning systems and evacuation plans, protect and restore wetlands, estuaries and flooding plains to preserve essential habitat for fisheries. Modify and strengthen fisheries management institutions and policies to promote conservation of fisheries. Conduct research and monitoring to better support integrated management of fisheries.

Human health: human beings should adapt climate change to preserve their health by rebuilding and improving public health infrastructures. Improve epidemic preparedness and develop capacities for epidemic forecasting and early warning. Monitor environmental, biological and health status. Improve housing, sanitation and water quality. Integrate urban designs to produce heat island effect (e.g. use of vegetation and light colored surfaces). Conduct public education to promote behaviors that reduce health risks.

5.2.2.2 Market orientation diversification and risk management in agricultural production

SDGs targeted poverty, livelihoods and economic sustainability. It has to include food safety considering incentives/steering mechanisms. There are different risks involved requiring risk management strategies and prerequisites to implement them. Therefore, diversification as one strategy to reduce risks (at various scales from seed mixtures up to crop-livestock integration), but also to achieve a better market orientation for improved income and livelihood. This requires information availability such as market studies and market conditions, market access. Improving market conditions encourage farmers to increase production and invest in technologies such as water harvesting to minimize the risk of crop failure in drought-prone areas or using supplemental irrigation. Risk avoiding in dry years could be done through diversification especially in a risky climatic environment determine investments in these techniques.

5.2.2.3 Rational management of natural resources (conservation of NR quality)

Water. Water management in and for agriculture has to be set in a broader perspective of Integrated Water Resources Management (IWRM; see e.g. GWP TAC, 2000; for links and resources regarding IWRM see InfoResources, 2003). IWRM aims at the coordinated development and management of water, land and related resources in order to maximize the resultant benefits in an equitable manner for all sectors and members of society without compromising the sustainability of ecosystems. Thus, IWRM pursues three major objectives: i) Efficiency (maximizing economic and social welfare derived from water resources and investments in water services provision); ii) Equity (in allocating water resources and services across different economic and social groups); and iii) Environmental sustainability (not putting at risk the water system that we depend on for our survival).

Efficiency of water use in agricultural production. Improving water use efficiency in agriculture should include technical, economical, institutional and social options. Technical options include the improvement of water conveyance and water distribution systems (infrastructure and organizational aspects), and water application at farm level (irrigation systems, scheduling, practices, etc.). Management options include efficient water pricing alternatives and organizing users through efficient institutions.

Water harvesting. Runoff farming and the use of stored water for irrigation may be used at micro-, meso- and macro-scale, and numerous technologies have been developed according to specific environmental and socio-cultural conditions (Oweis et al., 2004). Other water harvesting techniques include floodwater harvesting, fog and dew harvesting, and groundwater harvesting by quanats, underground dams or special wells.

The application of remote sensing data and hydrological models at watershed level may not only facilitate the identification of suited water harvesting sites and technologies, but also help preventing problems between upstream and downstream water users and allow for considering sufficient quantities of water for natural flora and fauna.

Use of non-conventional water resources. Reclaimed water, gray water, fog collection, recycled water, brackish water, salt water, or desalinated water may all be considered usable for some needs, and in fact, may have environmental, economic, or political advantages. Reclaimed water such as treated wastewater, e.g., can be used to recharge groundwater aquifers, supply industrial processes, irrigate certain crops, or augment potable supplies (Gleick, 2000).

However, the use of non-conventional water resources may be associated with certain problems. The use of treated wastewater in agriculture, e.g., might entail health hazards and water quality problems that will have to be addressed. Regulations regarding wastewater treatment and reuse will have to be developed and adopted, addressing alternatives to eliminate health hazards to communities, users of water and consumers of crops. Such regulations will particularly have to cover the responsibility of water polluters in treating their wastewater to a way acceptable for safe utilization (e.g. in agriculture) or disposal in the environment. More training to farmers, water users and crop consumers will be required to address issues related to health and water quality aspects.

Groundwater recharge. Maintaining and increasing aquifer recharge may counterbalance increased exploitation to a certain extent. First and foremost it is important to enhance natural recharge by adequate land management, i.e. by reducing runoff of precipitation. Besides enhancing natural recharge, artificial recharge of groundwater aquifers represents a viable option. Artificial recharge could be achieved through preventing runoff and surface spreading and/or direct well injection into the groundwater. Recharge water can originate from different sources: effective recharge from (possibly trapped) precipitation, over-irrigation, leakages in water supply systems, or runoff coming from various sources such as cultivated and uncultivated lands or from urban areas, which may be first stored at surface for infiltration (Morris et al. 2003). Artificial recharge might require temporary storage structures and water treatment (sedimentation tanks) to improve water quality. Treated wastewater could be also used as a source for artificial recharge of groundwater. However, quality issues should be evaluated when treated wastewater is utilized.

Water demand management. Technical options for demand management include improving water infrastructure, rehabilitation of existing water conveyance and distribution systems, lining of earth ditches with concrete and other methods of lining, replacing irrigation ditches with pipelines where affordable, rehabilitation of old irrigation wells, rehabilitation of hydraulic structure and irrigation networks, or installing water meters and water measuring devices. Knowledge and understanding of farmers with regard to water-efficient technologies and practices will therefore have to be strengthened and increased.

Virtual water trade. "Virtual water" is the water used in the production process of an agricultural product. Trade of agricultural products is thus also trade in virtual water. Trade of virtual water at national and particularly at international level may reduce the pressure on scarce water resources and improve water use efficiency at global level (see e.g. World Water Council 2004): By importing products requiring large amounts of water for production from areas with abundant water resources, water-scarce countries/areas may reduce the pressure on their own water resources and thus make water available for other purposes (principle of comparative advantage).

Soil. Approaches to avoid and reverse soil and land degradation should consider:

- Following a participatory, multi-disciplinary systems approach (sector-wide thinking;

- Following the principle of subsidiarity in decision-making (decision should be delegated to the lowest possible level)
- Fitting/targeting the specific environment (regarding e.g. development pathways, farming systems, soil types, degree of degradation, etc.); and
- Combining indigenous traditional wisdom with modern knowledge and technologies (such as remote sensing, GIS, and simulation modeling).

Interventions to avoid, reduce and reverse soil and land degradation are required at different levels, and have to be coordinated and synchronized. Most obvious are **interventions at plot/field level**: Numerous practices and technological options fostering sustainable land management are available from traditional and/or modern knowledge. However, such options (such as cover cropping, terracing, green manuring, conservation tillage, rotations with leguminous crops, etc.) have to be adapted to the specific agroecological and socio-economic conditions of the farm enterprises.

For many interventions focusing soil and land management a **community or watershed** approach will be necessary. Land use planning (possibly coupled with changes in land tenure), zoning rules (particularly important in peri-urban areas), and the control on agricultural land conversion are issues, which are typically dealt with at this level. Also management of common lands (e.g. by leasing, rotational grazing, etc.), which are often heavily degraded, has to be tackled at community or watershed level. Particularly in marginal lands, spatial concentration and intensification of production should be encouraged (possibly with perennial crops) to achieve more profitable production and simultaneously protect fragile land from degradation. Improvements in present land use and/or identification of alternatives to inappropriate land use have to be negotiated in a multi-level stakeholder approach in view of sustainable land management, whereby it is important to integrate local authorities and national administrations in all actions.

Land tenure legislation must guarantee long-term land use rights (to owners and lease-holders) if land users are expected to invest in long-term soil conservation measures. However, often such rules need to be tailored to local conditions (e.g. traditional land rights and the interests of different stakeholders) and nationwide legislation is inappropriate. It is important that regulations are enforced which is rather possible if local (decentralized) than national institutions are entrusted with this responsibility.

Biodiversity. Losses of biodiversity are undoubtedly occurring in many parts of the globe, often at a rapid pace. These losses require countermeasures such as an increased effort towards conservation by many different means. Conservation may be *in situ* or *ex situ*, either in the natural or semi-natural habitat, or in some purpose-built environment. The choice of one or the other technique, or a combination of both, will depend on the particular case. *In situ* conservation will involve the maintenance and protection of natural habitats, while botanical gardens and seed banks are used for the *ex situ* conservation. Both of the latter require precise knowledge of taxonomy. Today, conservation also embraces various components of agro-biodiversity like crop varieties, land races, semi-domesticates and crop relatives. The methods of biotechnology can be applied to the study of virtually any biological phenomenon and will in some cases have practical applications for maintaining biodiversity. Conversely, threats to biodiversity by biotechnology also need to be considered.

Intervention	**Description**
Moves towards sustainable Agriculture	Develop means to support sustainable agricultural production, negative impacts on natural biodiversity are minimized
Bioregional perspective	Adoption of a broader perspective of agriculture to capitalize on shared regional opportunities offered
Inventory/information sharing	Survey, inventory and disseminating information for enhancing agricultural Development
Genetic resource conservation	Develop national *ex-situ* storage facilities
On-farm management of Plant Genetic Resources	Enhance on-farm management of genetic diversity (land races and traditional breeds of livestock) and ways to manage these in a more efficient and durable way.
Broadening the genetic basis of crops and livestock	Efforts are needed to widen the genetic base of modern cultivars, usually very narrow
Conserve biodiversity in natural Ecosystems	Natural and semi-natural ecosystems contain wild species, races and populations of great importance for food and agriculture, develop efforts to strengthen maintenance of these ecosystems across the region
Broaden cultivated crop portfolio	Efforts to be direct efforts widen diversity of farm crops/breeds to promote agricultural sustainability

(Street K. and Z. Khalikulov, 2004).

Recent use of modern information technologies, such as (GIS) Geographic Information Systems, used to characterization of geographical distribution of wild plants, and use of the technology to conserve the environmental and biodiversity such, as new electronic technology for monitoring the environment, Integrated pest management (IPM), Planetor a computer program for analyzing environmental problems, beside new strategies and policies to conserve the biodiversity and improve research on biodiversity.

5.2.3 Capacity development options to overcome the challenges in CWANA

5.2.3.1 Education, research and extension

CWANA countries have an opportunity to use co-operational linkages independently, and create special regional association of agricultural education, research and extension institutions and to interconnect them with a unified network. Education and training should be based on new scientific achievements, innovations. A full, comprehensive training cycle, integrated with science, ensuring that outputs are adopted by the production systems. The following options are available to develop education institutions:

Option1: Specialization of certain higher education institutions, especially those in the area of agriculture, remains a widely employed practice. In the Central Asia leading federal-level specialized institutions were the Tashkent Agricultural Institute (now Tashkent State Agrarian University), Tashkent Institute of Irrigation and Mechanization of agriculture (now Tashkent Institute of Irrigation and Land reclamation) of Uzbekistan, with similar institutions existing in Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan.

Option2: New methods of delivering services and new schemes of organization of training that result from the revolutionary changes in information and telecommunication areas (distance and correspondence learning) will be able to cover all levels of rural society.

Option3: Using a complex approach in education as a unified system which takes into account the inputs at all levels in education hierarchy, including higher (universities and institutes) and secondary vocational education (colleges and academic lyceums) that contribute to agricultural education and human capacity development as well as formation of humanitarian and social capacity, and its role in the process of renovation and reorganization of agricultural production.

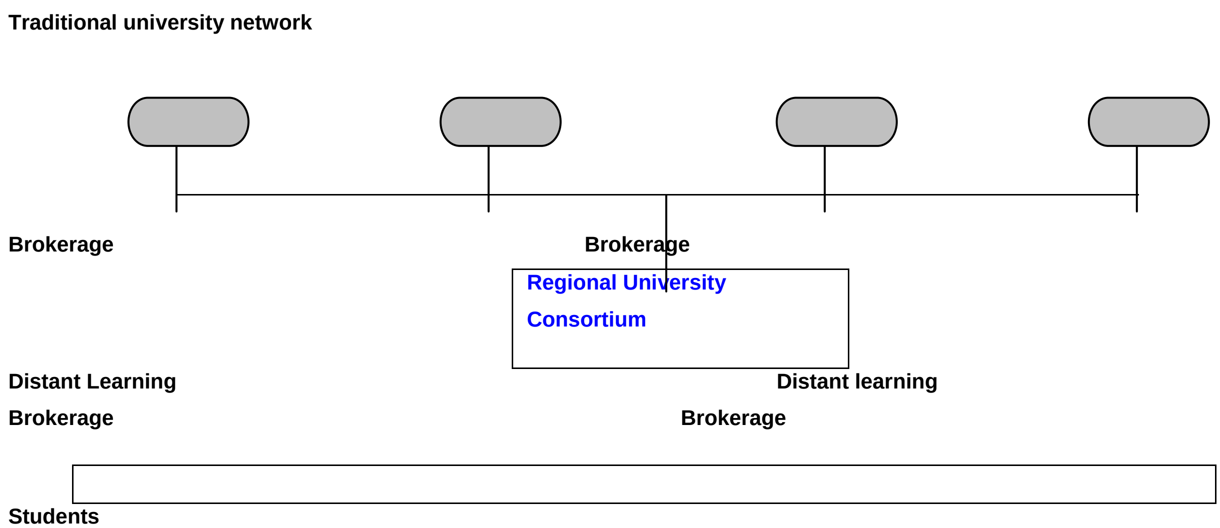
Option4: Countries could switch to more progressive forms of admission of students that are drastically different from the former which mostly employed command and distribution method. Training of specialists should consider the actual demand for human resources in a specific field of agricultural production.

Option5: Technical renovation of lab and experimental equipment, facilities and materials could be achieved through the creation of conditions suitable for research and experiments in-door and in the field. This could be achieved through providing specialized machinery, equipment and tools necessary for experimental activities.

Option6: Using private investment and funding affected the focus of the education and resulted in the new subjects and specializations added to the curriculum. Therefore, retraining of higher education institutions' staff to teach these subjects and integration of education and the science in areas such as "international trade" or "agricultural products marketing", require availability of the necessary qualifications, knowledge and skills.

Option7: Higher education institutions must have their own training production farms and research sites to deliver practical training to students. Creation of this kind of training centers that are linked to higher education and simultaneous re-training of specialists is extremely important to strengthening and development of farmers' movement. That is training a farmer who would be able to work in new conditions of high competition, deterioration of climatic and natural conditions and who would be familiar with peculiarities of land cultivation, agribusiness marketing, insurance and law, a minimum knowledge to deliver agricultural technology and animal health care services in rural areas. Consortium of universities and tele-universities, virtual university are new models of delivering higher education.

General operation layout of the proposed model of university consortium for agrotechnology training.



One more new institutional form of university-based education is tele-university, also based on the consolidation of the resources of traditional universities, however, this consolidation is much closer than in case of university consortium. Tele-university itself undertakes development and delivery of training courses, awards degrees and issues diplomas and certificates while employing teaching staff, auditoriums and other resources of traditional universities.

Option8: AKST systems of different countries have their own development priorities and programs. There are collaborative scientific programs which stipulate the national system to act jointly on a specific crop or an aspect of scientific research which has an impact on the agricultural education system with regard to the requirements and the actual development process.

Option9: Methodology could be created in country-wide centers such as those in Moscow and Leningrad (now St.Petersburg). Scientific activities to be conducted under one union and higher education institutions are subordinate to the central offices for industrial management under relevant Ministries of Agriculture. Programs to be approved and funds to be distributed on a centralized basis.

Creation of scientific and education and innovation centers would integrate activities on:

- Education

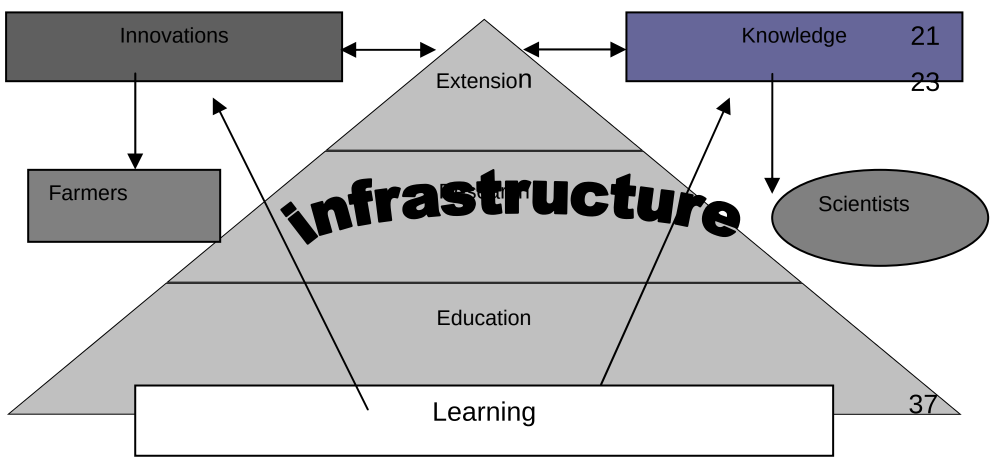
- Research
- Innovation
- Introduction
- Extension (information and consultancy)

The following conditions favored the development of Agricultural Extension:

- Use of information to educate professional agriculturists (including farmers) who may further enlarge or refine this body of knowledge or become active disseminators of the same.
- Existence of an appropriate administrative structure to promote dissemination of the new information.
- There is official mandate to carry out extension work.
- Agricultural universities and institutes need to adopt and reoriented curricula’s for new requirements with special training programs on extension development, including extension education.

Integration of education, Research and Extension is the main challenge for the CWANA to achieving SDG. Box 5.2 shows an integration of education, research and extension.

Box 5.2. Integration of education, research and extension



5.2.3.2 Knowledge management

In order to manage knowledge properly, information and communication technology (ICT) is needed. The following table summarizes different kinds of AKST knowledge and ICT methodologies.

Different kinds of AKST Knowledge and ICT methodologies:

Knowledge Type	Accessing S&T Knowledge
	KM about ecosystem and Environment
	Indigenous K.
	K. about economic and social processes
ICT Methodology	Data Analysis and Statistical Packages
	Data Base Management Systems & GIS
	Web Based Systems Tools
	Expert Systems Shells

ICT methodologies. Data, information, and knowledge are found in various forms such as text, images, video, and audio or in the head of experienced people (tacit knowledge). The role of information and communication technology is to invent, and devise tools to store, edit, update, transfer and retrieve data, information, and knowledge. These tools can be classified into:

- Data Analysis and statistics packages
- Data Base Management Systems and GIS
- Web-Based Systems Tools
- Expert Systems Shells

Agricultural knowledge. Agricultural knowledge include the information and knowledge that is mostly needed by growers who are the backbone of agricultural production and by extension workers, researchers, and decision makers who are supporting them. In effect, there are no specific ICT methods that are specific to a certain region. What is really needed in CWANA is to coordinate existing efforts in collecting these knowledge sources, identified here after, and avail it through the appropriate ICT to the end users either directly or through intermediaries, like extension services.

Science and technology knowledge. There are many extension documents in CWANA which are produced by National Research and Extension Systems (NARES) in order to inform the growers about the latest recommendations concerning different agricultural practices such as irrigation, nutrition, pest control, and others. These practices include agricultural production inputs like what variety to cultivate, the amount of water needed to irrigate, the amount of fertilizers, pesticides needed if the plant is infected, and others. They also describe different technologies for agricultural practices, Books related to the production process are also a very useful information source. Applied research papers and research results are good sources for aggressive well-educated growers. The ICT methods needed are to store, and retrieve information efficiently to transfer this knowledge to researchers, extension workers, students and growers. Therefore, there is a need for developing more intelligent search engines and to avail this information globally using modern communication technology (the Internet and Web Technology). Automatic acquisition of knowledge from these sources using knowledge discovery and data mining techniques may also be needed to develop more robust, efficient, and easy to use knowledge base systems. For example, there are a lot of images describing disorder symptoms. Detailed images for all symptoms, and unique images that confirm the occurrence of disorders at different stages, are also available within the extension administration and specialized institutes. Developing an image base of these images and retrieving them efficiently is also needed. Videotapes describing how to perform an agricultural operation by professionals are very useful. Some of these tapes for some crops are available within the extension administration and specialized institutes.

Ecosystems and environmental knowledge. Knowledge on conserving the environment and natural resources is available in different forms. This knowledge is developing in the regions and more efforts are needed to get it circulated around the region.

Traditional and local knowledge. This knowledge is available through experienced growers, and specialists in different commodities. Some inherited agricultural practices are not included in any information storage media. Expert System technology may be appropriate to keep this type of knowledge (Rafea, 1995), (Rafea, 1998), and (Rafea, 2000)

Knowledge of economic and social processes. Knowledge on global trade, markets, prices, commodities exchange, land usage, crop production, population, consumptions, and others economic and social factors are very important for developing policies for the agricultural sector.

INSERT FIGURE 5.1 HERE

5.2.4 Policy options to overcome the challenges

Policy recommendations for land use/tenure rights. Specific actions and policy recommendations for land use/tenure rights include:

- Terminate local government interference in land privatization and land use.
- Review and amend land legislation to ensure that it unambiguously defines suitable land ownership, use and inheritance rights, and the conditions under which land can be expropriated.
- Strengthen the judicial agencies responsible for land ownership use, to ensure that they are independent, transparent and accessible; and that they provide adequate protection for land users.
- Develop a legal and institutional framework which ensures that land users and owners have clear, secure rights to own, use and transfer property; and which defines and supports the state's role as ultimate land custodian. Future procedures and administrative structures should be low-cost, accessible by all, transparent and conducive to the efficient operation of land markets and secured credit transactions.

- Develop a system of land ownership, land use and land transfer rights which ensures that producers have full incentives to raise agricultural production and to use their land in a sustainable manner.
- Ensure that these rights are fully transferred to all producers through the issue of land use titles; and that producers have the right to choose whether they operate as individual farmers' or as collectives, formed according to their preferred means of association (family, village etc).
- Develop an active market for selling and leasing land and/or land use rights.

Policy recommendations for input and product pricing. There are many activities that public institutions can and should engage in, however, to improve competition, including the following:

- Develop a public market information service to provide regular (daily or weekly) information by newsletter, radio or television on product prices in major regional markets;
- Reduce the costs and delays associated with border transit procedures;
- Intensify current efforts to create a low-cost, green corridor which gives improved access to neighboring markets; and trade agreements with regional trading partners;
- Modernize the regulations and procedures associated with seed testing and certification, and relax restrictions on the import and use of high-performing seed varieties from other countries; and
- Revise and modernize product standards to be consistent with international standards, and phase in these new standards in a manner which the private sector can afford.

Integrated water resource management. The basic principles of IWRM could be applied through following:

- Promoting transparent decision making, decentralized governance and participatory approach in water operations under the principle of subsidiary;
- Promoting managerial, financial and institutional innovations at all levels including new models of cooperation between the various stakeholders and the introduction of water pricing and water rights to encourage rational and efficient allocation of water, discourage waste, enhance water quality and ensure adequate water services.
- The reconciling the competing objectives of countries and sectors (power operation, flood control, irrigation, industrial and domestic supply, environment), decrease conflicts in water use, support regional cooperation and information exchange.
- The fostering of demand – responsive versus supply oriented approaches. This requires that water users and consumers be engaged in the process of selecting, financing, implementing and managing water services that meet their demands and willingness to pay.

Policy recommendations for subsidies and direct payment. As the markets in which agricultural products compete are changing rapidly, measures to increase output must be accompanied by measures that improve the ability to compete on these markets. The objective should be to increase value-added rather than production, by re-orienting and raising production and processing, based on the following initiatives:

- Identify and introduce the varieties of agricultural products that correspond to consumer demand in major domestic and export markets;
- Introduce modern, low-cost farm management systems to improve yields and product quality.

Probably the most desirable outcome for CWANA countries would be to push partners to agree to relatively low and uniform import tariffs. With these bound rates setting the de-facto standard for other members of the customs union, any country could make similar commitments itself and would ultimately benefit from tariff-free access to important regional markets through the customs union without being burdened by a structure of protection that would render its imports unnecessarily expensive.

Policy recommendations for institutional reform and role of government. In CWANA countries, where private sector institutions are weak and reform still has far to go, the state retains major responsibilities. The government should focus its resources and activities on policy formulation, guidance on legislation and regulation, and the provision of essential public services in the areas of seed and plant protection, animal health, border control, food safety and product standards and certification. Policy formulation should be based on the preparation of a coherent medium-term sector strategy, which should then form the basis for Ministry input into budget preparation, public investment planning, and specific policies and legislation relating to land use and land reform, trade, taxation, market activity and competition, rural finance, research and extension.

Production targets should be discontinued as a policy instrument, and replaced with growth in value added, household income and export revenue. The efficiency with which essential public services are provided should also be improved, together with a comprehensive modernization of current regulatory practices (including product standards). Activities such as seed and livestock breeding should be transferred to the private sector, and more resources should be allocated to providing information and support to producers and agri-business on land privatization and market activity.

The ability of public institutions to re-orient their activities is currently constrained by limited awareness of what is appropriate in a market economy, a reluctance to change old approaches, and a limited allocation of human and financial resources for policy formulation. Weak budgetary resources and a significant need to re-train staff and boost output are further constraints.

5.3 Technological, Institutional and Policy Options (TIPOs)

5.3.1 Mitigation of global climate change

Agriculture can help in mitigating the emission of green house gases and increasing the quantity of carbon it sequesters (captures) by doing the following:

- conservation tillage can be increased, and the management of other crop residue practices to lower emissions from equipment and increase soil organic-matter content can be adopted;
- low-greenhouse gas fuels, such as diesel and alcohol-based fuels from biomass (woody and herbaceous plant tissue and animal wastes that can be converted to energy) can be utilized;
- better management of cattle waste and, if possible, the trapping or processing of methane, or both, for its energy and nutrient content can be adopted; and
- nitrogen fertilizers only when and in quantities and forms needed by crops to reduce the emission of the oxide can be applied

5.3.2 Actions to conserve biodiversity and promote sustainable use

Conservation of species diversity (e.g. threatened species, wild species). Efforts have been done by different international fisheries organization such as FAO to change the criteria for adding new marine species to the list of endangered species. Fisheries authorities in the countries were encouraged also to participate in the convention in related subjects.

Marine protected areas are good tool for conservation of fisheries biodiversity as they are also good tool for protection of critical habitats. Convention on Biological Diversity (CBD), was ratified in 1995 with the main objectives of conservation of biological diversity and the sustainable use of its component**.** This convention plays an important role on the conservation of aquatic biodiversity. FAO Code of Conduct for Responsible Fisheries (CCRF) which is also ratified in 1995 is an important tool for conservation of aquatic biodiversity. For introduction of alien species, both CBD and CCRF have similar articles. Both treaties encourage the countries to notify its neighbors about the introduction, and encourage the countries to establish database or information system for the introduction of aquatic organisms. They both also encourage the countries to monitor the aquatic environment and conserve the genetic diversity. Countries should develop code of best practices for responsible introduction of alien species.

Conservation of genetic diversity (e.g. crop, livestock, trees, fish, wild life). West Asia and Mediterranean North Africa are endowed with considerable genetic diversity with regard to small ruminants. This consists of various breeds of sheep and goats which are adapted to a range of arid and semi-arid environmental conditions. Local breeds might be endangered through intensification of production systems and un-controlled crossbreeding with exotic breeds. Therefore it is important to think of possible ways of conservation the genetic diversity of these local breeds which might be valuable in the future.

One way of preservation of genetic diversity is through storage of frozen semen in gene banks. This is called ex-situ conservation. Another way is the in-situ conservation of these breeds. The best way forward would be a combination of both conservation approaches, but the costs of ex-situ conservation might be high. Storage facilities could be shared by different countries and therefore reduce costs for each single country.

In aquaculture, broodstock is obtained either from the wild or domesticated in the hatchery. Depending on wild is not enough for optimum aquaculture production. In the hatchery, broodstock must be managed to ensure conservation of genetic resources, to maintain the desirable characters of the farmed species and to avoid problems of inbreeding.
Genetics process is used in aquaculture to improve breeds. There are deferent processes that can be used for improvement such as Hybridization; chromosome set manipulation, and sex reversal. Genetic technologies can be used also to reduce the environmental risks of escaping the exotic species from the aquaculture facilities. In order to reduce the effects of changing genetics resources of produced organisms in the hatcheries, several protocols were prepared which demonstrate the best methods for choice of origin and number of parents from specific fish species.

Promotion of sustainable use and consumption (e.g. biodiversity-based products). Renewable resources are the living, ecological resources that continually grow and can be harvested and converted into goods and services to meet human needs. The quantities of renewable resources are finite, and some are currently not economically viable. The quantities of renewable resources will remain stable so long as they are not over-harvested or damaged. Wastes from extraction, harvesting, production and consumption are often improperly handled and may damage these renewable resources. If allowed to continue, the damage will limit the quantities of renewable resources available. Worse, it may reduce these resources to such a degree as to exceed the ability to renew itself in the face of continuous harvesting and damage to the ecosystem in which it resides.

Maintenance of biodiversity to adapt to climate change. Reduction of soil plant cover in dry lands due to the desertification process causes further reduction of sinks, i.e., global warming, which in turn exacerbates desertification. Loss of surface moisture due to desertification releases solar energy, otherwise expended on evaporation, to warming of the lower atmosphere. This increases warming and reduces rainfall. Thus, desertification and climate change are interlinked by positive feedback relations. Desertification and climate change are therefore a manifestation of non-sustainable development. Desertification can result from non- sustainable water resource development and use, and climate change may further reduce water supplies. The prospective loss of biodiversity due to global warming may still be mitigated by an exploitation of the genetic diversity of species living in the semiarid ecosystems.

Reduction of pollution and its impacts on biodiversity. The effects of pollution may work at quite different levels: the nutrient pollution reduces mainly the species level diversity, whereas the organochlorides work also on the genetic level. The loss of genetic variation is more difficult to notice than that of species variation, and hence it is very important to understand the effects that different pollutants have on the ecosystems, species, and their genes.

5.3.3 Actions for food supply, security and nutrient cycling

Livestock. Actions required would include the followings:

- In depth understanding of the epidemiology of the most economically important diseases of livestock in the region. Key information on epidemiology of identified diseases would be prevalence and risk factors, including transmission mechanism, which perpetuate their occurrence.
- Design easy to use control technologies, such as application of products, which do not require refrigeration (e.g, thermostable vaccines) and drenching techniques the farmers can use on farm. Most importantly, institutional issues facing the delivery of required animal health services in CWANA need to be evaluated in terms of, (1) making a balance between public and private roles and (2) finding mutually acceptable balance between regulatory standards to be maintained and the benefits accruing to those who keep livestock.

Capture fisheries. Actions required would include the followings:

- Provide more information about fish stocks is important in the management process. This information may include, but not restricted to size, structure and other biological parameters of the fish stocks.
- Develop plan for sustainable management of fish stocks which allow responsible use of the stocks and allow rebuilding the depleted stocks.
- Developing infrastructure in the fisheries communities.
- Improving fishing techniques and reducing the by-catch.
- Education of local people on new techniques on fishing and quality assurance.
- Increase the participation of women in post harvest activities.
- Increase the cooperation between countries and international organizations.

Aquaculture. Actions required would include the followings:

- Reducing the use of fish as source for fish meal.
- More research towards selective breeding.
- Developing the rearing techniques.
- Better health management.
- Develop the small scale aquaculture and integrated aquaculture.
- Development and transfer of technology between countries.

- Increase the use of biotechnology in aquaculture.

GMOs (genetically modified organisms). CWANA should be supported in increasing research and development related to socially useful and environment-friendly biotechnologies, including - as appropriate - the possible development of certain GMOs. Consideration must be given to the potential benefits for food and nutrition security, and thereby for human health and well-being, on the one hand, and to the need to avoid risks to human health, social justice and the environment, on the other hand. Adequate safeguards must be put in place to ensure that all concerns are protected, including environmental concerns, while leaving options open for future generations. The most urgent ethical task is to assess activities relating to food and agriculture in the light of their actual and potential impact on the reduction of poverty, hunger and malnutrition.

Promotion of technologies that increase crop yields without any harmful impacts related to water, nutrient and pesticide use. Options include optimal use of fertilizers, pesticides, and other off-farm purchases with pest management practice to operations that actively seek to minimize farmer's off-farm purchases, and emphasize crop production, apart from the new techniques (Hess, 1999). Sustainable agriculture techniques are being advocated to improve long term sustainability of production method, and environmental sustainability in agriculture and natural resources management would incorporate conservation methods into activities for food production, one of the new technology (IPM) Integrated Pest Management is a way of addressing the problem of making agriculture more sustainable and more productive. There are many indigenous institutions concerned with resource management, but the development of local institution is increasingly recognized as essential for the sustainability of agriculture and natural resources management, without any harmful impacts related to water and any natural resources. The difficulty in the promotion of environmental sustainability lies in the fact that this issue tends to be considered at the global level, whilst the success of policies affecting agriculture and natural resources management depend to more extension implementation at local level.

New opportunities and technologies for more nutritious food, higher yields. Integrated pest management (IPM) is just one of many technologies that help to realize the promise of sustainable agriculture, combine natural method of pest control (such as physical removal, natural predators), with minimal and targeted pesticide use. Others include:

- New electronic technology already used for monitoring the environment includes snow monitoring for water supply, airborne video for immediate assessment, regional water consumption, lasers to measure soil erosion, microwaves to help monitor soil water. These technologies do not require sunlight for illumination.

- Computer models for pesticide and fertilizers used research information on pesticides chemistry, soil properties and estimates of soil water movement to predict what happens to the pesticides and their concentration (DeCoursey, 1991).
- Weather prediction over days or weeks help the farmer to the timing of operations planting, harvesting and type of production (irrigation, dry land) and management activities (Smit, 2002).
- Organic production is one of several approaches to sustainable agriculture, but organic farming demands many techniques such as, inter-cropping, mulching, integrating of crops, livestock and various agricultural systems and practices.
- Greenhouses use is increasing now, the major reason is for increasing the area of protected cultivation by improving water use efficiency.
- Utilize High yielding new varieties for high quality foods, which contain greater protein than regular varieties, beside post harvest to reduce losses of food and quality, in other hand, fruits and vegetable contain vitamins A, B, C, minerals, deity fiber, and antioxidant, health authorities recommend regular consumption of variety of fruits and vegetables to enhance human nutrition and health.

5.3.4 Actions required for reducing desertified land

Expansion of woodlands and rangelands results in *reducing desertified land. It could be done through the use of proper stocking rates; proper land use planning; the use of soil water conservation practices*

5.3.5 Actions for enhancing and sustaining of human

Human capacity development would be accomplished through education, improving wages, training of farmers and field personnel. This results in social equity and gender equality.

5.3.6 New opportunities and technologies for abiotic and biotic stresses

Drought and salinity are major problems in the CWANA. These hazards would be faced through using and developing plants varieties which are drought tolerant, salinity tolerant, pest and disease resistance. Development and selection of such varieties could be done through biotechnology.

5.3.7 Actions for enhancing economic development and sustainability

There are certain priorities that have to be followed for policies on sustainability: These include:

- Agriculture must be more profitable in the long run in order for farmers to invest in improved agricultural technologies and conservation, but profitability of agriculture alone will not solve the problems of environmental degradation.
- Strategies to promote agricultural growth and sustainability should simultaneously alleviate poverty and encourage the use of technologies that increase productivity while conserving soil and water.

- Population pressure is a major source of stress on natural resources, particularly in CWANA countries, where the carrying capacity of the land may have already been exceeded.

5.4 Implications (positive and negative) of Various TIPOs on the Utilization of Local Knowledge, Development Pathways, Environmental Impact and Food Safety

5.4.1 Implications for the utilization of local knowledge

Implications of utilizing local knowledge on biodiversity. Efforts on biodiversity conservation can learn from the context-specific local knowledge and institutional mechanisms such as cooperation and collective action; intergenerational transmission of knowledge, skills and strategies; concern for well-being of future generations; reliance on local resources; restraint in resource exploitation; an attitude of gratitude and respect for nature; management, conservation and sustainable use of biodiversity outside formal protected areas; and, transfer of useful species among the households, villages and larger landscape. These are some of the useful attribute of local knowledge systems.

The traditions are reflected in a variety of practices regarding the use and management of trees, forests and water. These include:

- Collection and management of wood and non-wood forest products
- Traditional ethics, norms and practices for restraint use of forests, water and other natural resources
- Traditional practices on protection, production and regeneration of forests.
- Cultivation of useful trees in cultural landscapes and agroforestry systems.
- Creation and maintenance of traditional water harvesting systems such as tanks along with plantation of the tree groves in the proximity.

These systems support biodiversity, which is although less than natural ecosystems but it helps reduce the harvest pressure (Pandey, 2002). Biodiversity is the sum of organisms that include plants, animals, microorganisms and the ecosystems they live in (CBD 1998).

Efficient management of water resources is especially important in the dry areas of CWANA where water scarcity is severe. The use of traditional water-harvesting systems could substantially increase the agricultural outputs of the dry areas.

As for the dry areas of WANA (which constitute quite a number of the CWANA countries) they are rich in traditional and ancient water-harvesting systems, indicating a wealth of indigenous knowledge that could be used to develop new practices and improve the efficiency of some of the systems still in use today. The systems can be very efficient as evident from the fact that farmers have practiced agriculture since ancient times in areas with an annual rainfall as low as 100 mm. The growing scarcity of water calls for more efficient rainwater use. Even though water-harvesting techniques offer more environmental, social and national benefits, many farmers and communities are failing to adopt water-harvesting techniques because:

- Land-tenure systems in many areas do not encourage the development of water-harvesting systems. Farmers are not willing to invest in land that they do not own, or do not have the right to use for a long period of time.
- Government policies are often not conducive to the development of such practices. Environmental protection measures are mainly passive, such as prohibiting the plowing of *badia* land in order to prevent desertification and land degradation.
- Water harvesting, though a low-external-input technology, requires inputs of resources for construction and maintenance.

Ensuring food security. Local knowledge has an essential role to play in maintaining food security through the promotion of many practices in rainfed crop, weather, rainfall, drought forecasts, pest, and control pest, animal diseases and control animal diseases, storage for traditional and post-harvest, many practices to maintain the soil and water, soil conservation, water harvesting and methods, safety in waters, crop and lives tock management. Furthermore, food security depends on having genetic stock available. Farmers – and the world in general depend on agrobiodiversity variety and variability for food and agriculture. Through selective breeding and seed saving, farmers have been able to adapt crops to different climates and growing conditions, and breed for resistance to pests and diseases.

Local knowledge and traditional adapting farming methods were also lost during indoctrination about modern farming, and the death of great granddad for many reasons such as age, disease. The world's plant species are disappearing just as threats such as climate change, food borne illness, and bioterrorism are emerging. Already, about 75 percent of the genes diversity of agricultural crop has been lost. Thousands of breeding plants are being lost annually due to pests diseases, climate change, urbanization, the loss of local knowledge, and the global marketing of exotic breeding material.

We need to improve security, change starts in the community by using local knowledge especially the living walking libraries that are people -and we need the memory of our people to secure the future. On other hand, some types of foods are changing because the loss of local knowledge, such as barley consumption has decreased considerably in the last 40 years with the increase of urban population and the introduction of national policies supporting wheat consumption (Macpherson *et al*., 2005).

Adoption of new technologies including biotechnology. The threat of extinction for many species, both known and as yet undiscovered, grows ever greater as whole ecosystems vanish, human populations proliferate, and human-mediated interference increases. A laudable effort is being made to organize seed-banks for plants, but for many species of both vertebrate and invertebrate animals, there are no organized attempts to store genetic material. There are world wide attempt to coordinate to store, for every endangered animal species, samples of DNA, DNA libraries, or frozen cells or tissues that could readily yield DNA for captive breeding programs. In other words, DNA banks for endangered species.

Captive breeding provides an insurance policy against extinction and for some species may be the only hope of survival. It requires input from population genetics to preserve high levels of genetic diversity, and from reproductive physiologists to promote the establishment of pregnancies, for example by artificial insemination. Cryopreservation of gametes and embryos has a role to play, while in the future, nuclear replacement cloning from established cell lines might prove of value. Such strategies may succeed in saving a small fraction of endangered species, at least for a time. These tools will be particularly powerful when used in conjunction with efforts to conserve the habitats in which populations restored by DNA techniques can live.

Need for developing and sustaining human resources to adopt the new technologies. Insofar as scientific and technical progress in the region is concerned, a number of trends and opportunities have occurred, namely, the adoption of new technologies, particularly biotechnology and information and communication technology (ICT), privatization of state-owned enterprises and trade liberalization, a greater role of development agencies in agricultural and rural economies, and an increased international collaboration through the eco-regional approach and South-to-South programs (IPGRI in CWANA, 1999-2000).

Advances in scientific knowledge across a broad range of disciplines will be required in order to develop more and better food and fiber products with improved nutritional quality, to reduce food and commodity yield losses due to pests and diseases, to ensure healthy livestock, sustainable fisheries, aquaculture and forestry sectors, to manage water more efficiently, to prevent and reverse land degradation and to conserve and manage genetic diversity.

A focused and appropriate research agenda is required to meet these challenges that are supported by public investment. Unfortunately public investment in agricultural research and development is declining, while private sector investment is increasing in the OECD. Private sector investments tend to focus on commodities produced for OECD markets and often neglect the needs of the poor. Thus, increased investment by the private sector will not meet the demand for diversified agricultural products and improved rural livelihoods via the required multi-sectoral approach that covers the economic, environmental, ethical and social considerations.

5.4.2 Implications for development pathways

Impact on environment. Innovative solutions will be sought to address issues *inter alia* related to the environment. For example, cost-effective and efficient technologies will be developed to combat issues like pollution and other environmental hazards. Similarly, NRM practices will be strengthened through for example, improved methods of soil conservation, water management and for combating desertification. Biodiversity could be potentially threatened both by introduction of GMOs and thereby promotion of mono crop culture. Yet, better genetic resource conservation through gene banks *etc* can help conserve crop diversity.

Food security & safety. Under this paradigm global food security is likely to improve because of introduction of more efficient food production and preservation technologies and improved communication means. Regional and national food security however would be subject to the capacity of the region and country concerned to absorb, develop and employ new technologies. Efficient countries can displace other countries comparative advantage, and as a result some countries of the region may succumb to food insecurity. Food safety is likely to improve in all regions because of enhanced knowledge and improved hygiene methods.

Economic development and sustainability. Under this paradigm technology drives economy, and innovation gives monopoly rent to countries with efficient and responsive AKST settings. As such innovation will generate more economic returns, and give countries necessary resilience to sustain development. One of the limiting factors today in the region has been public sector dependent development policies. The 3P (public private partnership) paradigm helps overcome this constrain, and fuels development by providing investment, R&D support and also informs policy. This strength of 3P would also help address environmental protection & sustainability issues because of growing stake of private/commercial sectors in environmental integrity. Private sector would come forward to join governments in conserving land, water and biodiversity.

5.4.3 Implications for the environment: assessing how TIPOS will affect natural resources

Land. Although increasing agricultural productivity will reduce hunger and will improve the socio-economic conditions of CWANA, the options to increase agricultural productivity will have severe environmental impacts on land and water in the region.

As water is the most restricting factor in agricultural development in the dry CWANA region, emphasis will be placed on using water more efficiently and to increase production per unit of water applied. This will result in more intensive agriculture and more use of agricultural fertilizers and pesticides. As water resources are limited in the region, the use of marginal water such as brackish and treated wastewater will increase. Therefore, negative impacts on soil will include increasing problems of salinization, land degradation and soil erosion.

Extending the use of chemical fertilizers will result in increasing concentrations of different ions and cations in the soil. This might result in increasing soil salinity because of insufficient leaching which is becoming a common problem in soils used under greenhouses in the Middle East.
Extensive use of mechanization results in losing soil organic matter and soil fertility. It also results in reducing macro-pore spaces in soils and thus reducing soil aeration. Mechanization will result in the forming of tillage hard pans, which will reduce permeability of sub-soils for water and roots.
The extensive use of pesticides and insecticides result in increasing the contents of such substances and the contents of non-biodegradable substances in soils. The long-term effects of such increase are soil pollution and degradation. Intensive agriculture and the extensive use of agricultural inputs result in soil erosion and soil degradation.

The use of marginal sources of water such as brackish water and treated wastewater will result in increasing soil salinity, soil pollution by heavy metals and other substances and into soil contamination. The ecological balance between producers and consumers in the soil might be impacted and soil fertility might be reduced. Possibilities of increasing soil contents of nematodes and pathogens increase with using treated wastewater. As a result of such possibilities, the use of chemicals with soils might increase and thus soil pollution becomes more extensive.

Water. As a result of increasing water demands for agriculture, depletion of water sources and conflicts over water resources are expected to increase. These conflicts will be both among sectors of water use and among different user groups. Regional conflicts between countries over shared water resources will increase. Conflicts over surface and ground water sources might accelerate and add to the existing tensions and conflicts in the region. Possible water conflict areas might include The Tigris, The Euphrates, The Jordan, The Indus and The Nile Rivers basins. Conflicts over groundwater sources might include countries of North Africa and The Middle East.

Nearly most water resources are being utilized in the region. Therefore, water shortages are expected to result in more pressure on the agricultural sector to divert water from agriculture to other uses such as industrial and domestic sectors. This will result in conflict among sectors and internal socio-economic and political tensions. Each country of the region would need to address these conflicts.
Water user groups are presented in improving the management of water in the agricultural sector. Such groups will be essential in improving the efficiency of water use in agriculture and improving the distribution and management of water resources. However, such user groups will increase the

political powers of the water users and that might increase internal conflicts over water distribution and water allocation.

Improving on farm water management and improving the efficiency of water distribution will result in reducing return flows and possibly reducing recharge of some groundwater aquifers. Since existing resources are fully utilized in most countries of the region, reducing return flows and improving the efficiency of water use at the upstream end of any river basin might result in reducing water availability for downstream users, therefore, increasing conflicts over water resources. For example, when surface water systems are replaced by pressurized irrigation systems or if surface irrigation efficiency is improved (using surge irrigation for example), tail water runoff will reduce. The upstream users will increase their irrigated areas as a result of water savings. Therefore, downstream users might be negatively affected when irrigation systems are improved due to the reduction in return flows to them.

Another case will be when surface irrigation is replaced by pressurized irrigation over alluvial soils of wadis, the seepage to alluvial unconfined aquifers will reduce. Therefore, safe yield of such aquifers will reduce and therefore water availability for users of these aquifers will reduce. Such water conflicts will increase and would require improving the water rights structures and regulations in the CWANA region.

Increasing agricultural and domestic demands of water will deplete renewable and non-renewable water sources. Many countries in the region such as Saudi Arabia, Jordan and Libya have been using non-renewable water sources. These sources are expected to be depleted in the future, which will require fining new water sources. In other areas, the renewable water sources have been depleted beyond their safe yield capacities and thus their quality has been deteriorating. An example of that is Gaza Strip where ground water resources have been used beyond their natural recharge capacity. As a result, seawater intrusion and intrusion from brackish groundwater aquifers have deteriorated these groundwater resources.

The use of non-conventional water sources especially marginal water sources will be a common practice in the CWANA region in the near future. As a result of using marginal water resources in agriculture, leaching of salts and other elements from irrigation water might reach existing ground and surface water resources. This might result in degrading existing water resources.

Biodiversity. When the transformation of rangeland to irrigated cropland results in desertification, the effect on biodiversity is in the loss of natural ecosystems. When the overexploitation of rangeland results in desertification, the effects on biodiversity are first expressed in the direct loss of plant species and the animals associated with them, and later in the loss of topsoil and the potential for rehabilitating biodiversity. These biodiversity losses, both in goods and services, further exacerbate desertification in the affected areas. They also affect adjacent and other areas that used to enjoy some of the services, such as aquifer recharge for example.

Desertification is caused by reduction of biodiversity and causes further reduction of biodiversity. Reduction of biodiversity reduces carbon sinks hence increasing climate change. Thus, it is the loss of biodiversity that initiates the vicious circle of desertification-global warming-further loss of biodiversity. There is one difference, though, between desertification, climate change and loss of biodiversity: if emissions are reduced, the climate system can be restored; if rehabilitation measures are taken, desertified land may be reclaimed. But a species lost, or even a component of its genetic diversity lost, cannot be reconstructed or resurrected. Thus, the predicted warming may result in loss of drought-sensitive species and with them the impairment of ecosystem services. Conservation of biodiversity and sustainable use of its components are technologically linked in various ways and it is therefore generally difficult to make a clear distinction between them.

The role of institutions in facilitating the development and transfer of conservation and sustainable use of technologies cannot be doubted. Institutions are the main loci of technological development as well as the accumulation of technological capabilities. They are also the organs that undertake conservation and deploy technologies in using various components of biodiversity. Institutions, in the form of industrial firms, accumulate capabilities to engage in the application of biotechnology and other technologies to transform genetic resources into drugs and other products. Recent evidence on the history of technological transformation, especially in newly industrialized countries, shows clearly how important this role is.

In most developing countries the institutional basis for effective conservation of biological and sustainable use of genetic resources is distorted and weak. Institutional synergy is missing because most of the existing institutions operate in isolation and often compete for limited financial resources. There is a need for CWANA countries to create policy and legal measures that favor the formation of technology partnerships between their institutions and private firms on the one hand and private sector firms and R & D institutions of some of the industrialized countries on the other.

5.4.4 Implications for food safety and security

Assessing how the TIPOS will affect food safety. There is no doubt, uncontrolled use of fertilizers, feed/food additives and others used in routine farming and agricultural practices, making foods of animal origin unsafe for human consumption. Chemical residues in milk or meat are hazardous to human health. For instance, lead can cause a wide range of disorders, including anaemia and hepatic and neurological disorders; cadmium can cause kidney damage after long exposure; aflatoxins cause liver cancer and both dioxins and dioxin-like polychlorinated biphenyls (PCBs) are highly toxic and carcinogenic. Therefore, while the use of these substances and others may be necessary for increased agricultural productivity (food security), the negative aspect in the way of human health risks should be borne in mind and efforts made to minimize such risks.

Food security. Increases in crop production have been accomplished through fertilizer application, seed, chemicals, irrigation, and also extension services to transfer the technology to the farmer. However, as result of these many other problems - especially for environment and health – have arisen. The use of new technology, such as integrated pest management (IPM), integrated crop management (ICM), and techniques such as computer models for pesticides and fertilizer, planetor a computer program for analyzing environmental, GIS geographic information systems, all of these aim to reduce the residue and effects on the environment, and to try to make sustainable agriculture.

5.5 Mitigation of Measures Related to Negative Aspects of TIPOS:

5.5.1 Determining measures to balance any negative impacts on natural resources

Measures to balance the impacts of TIPOS on natural resources will include public awareness, public education and sufficient regulation. Public awareness and education should include teaching farmers integrated pest management practices to reduce the use of chemical pesticides and insecticides. It should include education and improving the knowledge about fertilizers and nutrient requirements of different crops. Education and awareness should include extending the use of organic farming to reduce negative impacts of agricultural chemicals on land. Regulations should be introduced to protect public health and conserve natural resources including soils and water resources from degradation.

The systems of water rights and water allocation should be improved in all countries of the region. These systems should address water allocation among the sectors and should respect historical water rights of the different users. They could also emphasize the equitable use of water and that water utilization should not cause harm to other users.

Regional conflicts about water resources should be resolved and addressed through negations among countries concerned. Helsinki rules and guidelines should be respected and implemented to avoid conflicts. Regional parties need to cooperate to formulate regional solutions for water shortages.

In order to balance negative impact on biodiversity, countries of CWANA region need to invest in:

- Research and training in the conservation of biodiversity and use of genetic resources should be emphasized. Countries have to invest in research on *in situ* and *ex situ* conservation.
- Institution building
- New forms of technology partnerships
- Investing in information acquisition exchange and management
- Biodiversity prospecting through the search for biological resources and accompanying indigenous knowledge—primarily for the purpose of commercial exploitation.

5.5.2 Determination of measures to overcome any negative aspects of TIPOS on food safety

To determine measures to overcome any negative aspects of technology, policy options on food safety include:

- Need for leadership and partnership, at all levels, at international and national and any level on health and environment.
- Need to determine at what stage, time, place, and type of food need testing for pesticide residues and others
- Need for sufficient pesticide residue and microbiological management.
- Need for a harmonization in national standards with the guidelines through international consensus, and mutual recognition and agreement of food safety issues.
- Need to improve the linkage between agricultural research centers and agricultural extension services.

There is a need for leadership and partnership, at all levels, at international and national and any level down to serve of health and environment. Furthermore there is a need for

- Sufficient rural policy to reduce food insecurity and poverty.
- Support to institutes to increase activities to increase production.
- Change to start in the community, beginning by using local knowledge through the living walking libraries embodied in people (granddad) and by using tradition to forest change.
- Improving the linkage between agricultural research centers and agricultural extension services

Different technological, institutional and policy options were discussed to attain sustainable development goals in the CWANA region. These options are valid for most countries in the region. However, these options will have different priorities among these countries. Each country will need to develop strategic plans to select the policies and prioritize their policies according to its local circumstances and needs. The TIPOS discussed will have positive implications on the sustainable development goals but might have negative implications on the environment and natural resources. These negative implications should be mitigated through balancing the use of natural resources, utilizing research, training and extension methods in addition to public awareness, public education and participation.

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