# CWANA CHAPTER TWO
# HISTORICAL AND CURRENT PERSPECTIVES OF AKST

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**Key Messages**

1. **In CWANA region, diversity in history and policies and natural resources has resulted in diversity in production, needs and trends.** Development of AKST is uneven and differs from one country to another. AKST has promoted the initiation of a green revolution in a few countries. However, AKST has been ineffective in avoiding overexploitation of natural resources (water, soil and biodiversity), providing enough food, reducing poverty and removing social inequity. More attention needs to be given to the multiple functions and sustainability of agriculture.

2. **The major factors that have negatively affected agriculture in the last 50 years are (1) the degradation of already limited natural resources (land, water, vegetation); (2) extreme climate variability—recurrent and severe drought episodes aggravated by the severe effects of climate change; and (3) recent and rapid changes in organizing input and output markets (privatization, trade liberalization).** In some countries conflicts, political instability and poor governance have hampered agricultural development.

3. **During the last 50 years and despite these constraints, agricultural production and yields increased, mainly in the irrigated systems. In the rainfed systems, yields remained below the world average.** High interannual climate variability and climatic hazards affect yields. Insufficient consideration of rainfed agriculture in AKST has been associated with major environmental and natural resource degradation in marginal lands. Despite important investment in AKST for irrigated areas, environmental problems expressed in overexploitation of water resources, soil degradation and pollution have occurred. Opportunities for organic farming are appearing, giving prospects for better incomes to farmers as well as protecting the environment. Organic farming is generally more environmentally friendly than conventional agriculture but may require well-planned policies and regulations to meet international standards.

4. **Most countries in CWANA became water scarce during the last 50 years. As this trend will intensify in the future, problems of water quality are expected also to increase.** Agriculture uses from 85 to 97% of water resources depending on the country (global average = 70%). It is also the primary reason for water pollution by pesticides and nutrients in groundwater, waterways, wetlands and coastal waters. In recent years these trends have begun to reverse through improved techniques, policies and strategies that encourage less exploitative water use, quality resilience, water protection, water harvesting, recharging and reuse, improved water use efficiency, water saving crops, drought-resistant varieties and better hydraulic infrastructure management.

**5. Arable land resources in CWANA have been pressured by expansion of cropped area, overgrazing, loss of soil organic matter and depletion of nutrients and by the salinization caused by irrigation.** Agricultural land is also being lost due to urbanization. This situation is aggravated by the lack of appropriate regulation aimed at protecting farmland. The following priorities for AKST are essential:

- improvement and reinforcement of land-use regulation and soil-protection policies;
- implementation of good practice guides for agriculture;
- rehabilitation and agricultural intensification by promoting local and regional associations to facilitate community-based soil management and restoration;
- restoration of the vegetal cover through agroforestry projects; and
- rehabilitation of salt-affected soils in irrigated areas.

**6. A high rate of deforestation has contributed to dust blows, atmospheric pollution and carbon loss and to climate change.** AKST is helping to promote new productive land-use systems that could reduce greenhouse gas emissions and act as sinks for $CO_2$, $CH_4$, NO and $N_2O$. Additionally, new approaches for producing clean energy are being encouraged. Research is greatly needed to determine cultural systems, species and varieties for biofuel production to satisfy the new needs for energy and to deal with their competition with food production.

7. **CWANA, cradle of the main cultivated crops in the world, is rich in unique agrobiodiversity in cultivated plants and their wild relatives, domestic animals and other species such as medicinal plants.** However, as a consequence of the extension of the agricultural area and of some agricultural practices, this agrobiodiversity is in danger. The development of monocropping systems has led to a reduced number of crops and species cultivated in the area and a significant loss of diversity, thus threatening the environmental and social sustainability of farming systems. According to the IUCN Red List, more than 1600 plant and animal species are threatened. In CWANA 27 countries are parties to the Convention on Biological Diversity (CBD) and 17 are parties of the Cartagena Protocol on Biosafety (CPB). Many actions have been taken to implement these agreements and joint projects were initiated to maintain biodiversity. However, some policy actions and technology transfer such as application of early warning systems and capacity building are still needed.

8. **Agriculture originated in CWANA and the region is rich in traditional knowledge on water harvesting, cultural practices and animal breeding.** In the last decade initiatives were developed to recognize, validate and maintain traditional knowledge. However, complete coverage is still lacking and there is danger that with increased urbanization this knowledge will be lost. AKST could benefit from projects that encourage its retention.

**9. The countries of CWANA have made significant progress in raising per capita food consumption.** They vary significantly in per capita income and living standards and hunger and malnutrition still prevail in some regions, including rural areas. This appears to be from insufficient attention given to food security at farm household levels.

**10. Agricultural risk management policies in CWANA have mainly consisted of emergency measures, especially to cope with drought consequences and epidemics and programs to improve farming techniques.** Most countries of the region need to design and implement a comprehensive and active risk policy. This would include the establishment of early warning systems, development of crop insurance and improvement in infrastructure, water management, agriculture and extension. Policies that protect human health, the environment and discourage cultivation of marginal land should be implemented. Marketing systems must be reinforced and farmer organizations promoted.

**11. Agricultural activities in CWANA are undergoing major changes; policies have been re-oriented to reduce public investment and support mechanisms favoring farm production.** These changes negatively affect small- and medium-size farms, which play a major role in agricultural production and rural employment, including female employment. They reduce urban drift. Agricultural development strategies in CWANA are faced with major challenges: reducing poverty and securing food self-sufficiency and a better position on international markets, while protecting the environment. The contribution of the private sector to agriculture research and development is still limited in CWANA compared to the large contributions in industrialized countries.

**12. In most countries of the region, rural migration and urbanization have been a major trend.** However, while the share of the rural population has declined, the rural population has dramatically increased. Persistent high demographic growth amplified the pressure on the labor market and on natural resources. Food insecurity, aggravated by drought and climate change and unemployment, could intensify migration pressure.

**13. Changes in farm structures in most CWANA countries have been characterized by two major trends: a movement toward the concentration of farmland within a minority of private and public farmers and a movement toward the fractioning of farmland, mostly through inheritance and demographic growth, which constrains consolidation and intensification of family farms.** This is in contrast to industrialized countries, where the intensification of farming systems has eliminated farms and enlarged the average farm size.

**14. In recent years, employment dynamics of the agricultural sector in most countries of CWANA has been characterized a significant decline in the share of the active agricultural population, which went in average from over two-thirds of the active population in the 1960s to less than one-third, with increasing participation of women in agricultural production.** Despite their major and increasing contribution to agricultural production and rural livelihoods, women's activities have remained unrecorded and undervalued, their role mainly restricted to unpaid family labor, as well as cheap and seasonal wage labor. While the illiteracy rate of rural women has remained very high in some countries (80% in Morocco), agricultural extension has continued to target mainly male heads of households. Agricultural development programs have frequently failed to integrate women's needs and priorities, gender equity objectives and, instead, frequently contributed to increasing women's workloads.

**15. With few exceptions, farmers associations have remained very weak because of insufficient public policies.** These weaknesses represent major constraints for consolidating the agriculture sector. Countries with strong farmer associations have a stronger agriculture sector and have successfully promoted more decentralized and participatory development as well as reinforced the professional organization of farm producers. Strong farmer associations will likely promote the participation of farmers in technology development, transfer and adoption.

## 2.1 Natural Resources, Agricultural Production and Infrastructure

### *2.1.1 Land use and land cover*

Land use and land cover characteristics are affected by a changing climate and increasing climate variability. Both land use and climate affect the biogeochemical cycles and properties of ecosystems, altering the supply of goods and services to society, including carbon sequestration. A slight increase in agricultural land has been observed over the last 50 years, but has reached a plateau in most countries and decreased in others. At present, agricultural land covers between 3 to 80% of a country. The highest proportion of use of agricultural land is observed in Central Asia and Caucasus (CAC) countries.

Agricultural land is mainly devoted to permanent pasture and rangeland. For the whole CWANA region the proportion is 83%, the lowest proportion in Southwest Asia (55%) and the highest proportion in the Arabian Peninsula (98%). In the Arabian Peninsula, an almost twofold increase in permanent pasture was observed in the last 50 years; permanent pastures increased from $86 x 10^6$ ha to about $171 x 10^6$ ha. In the other subregions, permanent pastures increased only slightly.

Arable land area in CWANA increased the last 50 years, but differences were observed among the subregions. In some, arable land increased significantly and is still increasing. (Nile Valley and Red Sea: from $15.5 x 10^6$ ha in 1961 to $22.5 x 10^6$ ha in 2002; Arabian Peninsula: from 1.1 to $3.7 x 10^6$ ha for the same period). In North Africa and in Southwest Asia, arable land increased in the 1970s, but is now stable (Skouri and Latiri, 2001). In the Central Asian countries, arable land area decreased in the beginning of the 1990s but is now increasing again.

During the last 50 years, irrigated land area increased in all the subregions except in the CAC countries. This increase and its proportion in irrigated land worldwide varied only slightly, except in the Arabian Peninsula. There irrigated land almost doubled due to considerable investment that supported dynamic development in the Arabian Peninsula. The share of irrigated cropland increased from about 30% in the early 1960s to more than 50% in 2000. The increase in irrigated land in the other CWANA subregions was much lower. At present, the proportion of irrigated land varies. The largest concentration of irrigated land is in Southwest Asia, around 23% of the agricultural area, corresponding to 14% of the world irrigated area. In the other regions, irrigated land varies between 2 and 5%.

Forests and woodlands are only around $136 x 10^6$ ha, 3.3% of the world area in forest. This proportion has not changed significantly in the last 50 years.

### *2.1.2 Agricultural production, cropping patterns and productivity*

While West Asian and North African countries have important advantages in agriculture due to natural endowments, countries in the Nile Valley, Arabian Peninsula and near the Red Sea have natural constraints to overcome to satisfy their food needs. Since the mid-1950s this has driven them to import food.

Crops grown are a function of climate and soil, country priorities and needs, irrigation water and profitability. Cropping patterns changed distinctly from 1961 to 2005. CWANA depends increasingly on expanding yields of rainfed crops and cash crops in irrigated areas.

#### 2.1.2.1 Grains

Among the agricultural products produced in the CWANA region, cereals continue to be important. Grains are the essential resource for human nutrition. Wheat is the most important grain in the Mediterranean, rice in Pakistan. Cereals represent over 35% in crop rotation systems with wheat as the most widespread crop (27%), followed by barley. In dry areas, sorghum and millet are important as well.

In the last 50 years, cereal production increased from $51 \times 10^6$ tonnes in 1961 (without CAC countries) to about $173 \times 10^6$ tonnes in 2005. Yet production is not stable and yearly variations are high partly due to variation in the timing and amount of rainfall. Because of high demographic pressure, only South and West Asian countries had stable per capita production in the four decades. The Nile Valley, Red Sea and North African countries saw per capita production fall quite sharply, requiring significant grain imports. Compared to world averages, grain production in the CWANA region is lagging behind.

The increase in production is associated with an increase in yield during the last 50 years (1960–1965: 1 tonnes $ha^{-1}$ to 2000–2005: 1.9 tonnes $ha^{-1}$). Overall yields are still low, compared to the world average, even when annual rainfall is good. The world average increased from 1.4 tonnes grain $ha^{-1}$ in 1960–1965 to 3.2 tonnes $ha^{-1}$ in 2000–2005. Only in countries where cereals are irrigated is the yield high and stable (Figure 2.1).

**[INSERT Figure 2.1]**

Southwest Asia produces about 60% of the cereals grown in CWANA, about 4.6% of world production. The rapid production increase in Southwest Asia, $35 \times 10^6$ tonnes in the 1960s to more than $100 \times 10^6$ tonnes in 2005, can be attributed to both increased yield (1.0 to 2.2 tonnes $ha^{-1}$)

and area harvested (35 to $44x10^6$ ha). Some countries, e.g., Turkey had high yield increases, while others did not.

In North Africa, production increased mainly from yield increases since land under cultivation had reached its maximum ($9.4x10^6$ ha). Annual yield variations are high and yields are still extremely low during dry years. These countries have high annual variation in rainfall; and drought is considered a permanent risk and the main factor affecting yield. When rainfall is adequate, these countries still have low yields. Increases the last 50 years have been limited (1960–1965: 0.7 tonnes $ha^{-1}$ to 2000–2005: 1.2 tonnes $ha^{-1}$) (Latiri, 2005).

In some Mediterranean countries, irrigation allows a more stable yield and increases have been observed since the early 1970s. In the Nile Valley and Red Sea countries, cereal production increased due to area and yield increases from $8.9x10^6$ tonnes in 1960–1965 to $26.3x10^6$ tonnes in 2000–2005. In the Arabian Peninsula, the area under cereals increased, but is still minimal: $0.7x10^6$ ha. Yields are above the world average because of irrigation. In CAC countries yields are about 1.9 tonnes $ha^{-1}$, but some countries, like Uzbekistan, have experienced regular increases the last few years. Like animal products, grains production fluctuated greatly in Central Asia and the Caucasus. Economic liberalization had a destabilizing effect in the early 1990s but this situation has shown recovery since the early 2000s.

2.1.2.2 Maize, legumes and industrial crops

Maize and rice are the most important irrigated crops. Oil crops, such as groundnut, sunflower and sesame are significant. Cotton is an important irrigated crop in most of Central Asia, covering over $3.8x10^6$ ha.

The most important legumes in the region are chickpea, lentil and dry beans. West Asian countries have been known for their pulses for a long time. Most pulses originate from Mesopotamia. The total share of South Asia and West Asia in the average pulse production in CWANA was 73% in the 2000s, with Turkey, Pakistan and Iran standing out as the most important producers. Egypt and Sudan in the Nile Valley and Red Sea subregion and Morocco in the North African subregion are also important producers. International demand for pulses has had a positive effect on volume and productivity Their area increased by about 50% and yield increased from 0.62 to 0.87 tonnes $ha^{-1}$ during the last 50 years. This production increase was mainly in Southwest Asia.

Legumes could play a major role in rainfed systems. About 30 million ha of land is left fallow in CWANA every year. If 70% of this land could be sown with forage legumes, it could produce enough to feed 80 million sheep. Moreover, there would be 1.4x$10^6$ tonnes of nitrogen added from symbiotic nitrogen fixed each year.

Sugar beet and sugar cane are mainly produced in Southwest Asia, comprising 8.5% of world production. In the other subregions, production increased but is still low. North Africa increased from 0.1 to 1.5% and Nile Valley from 0.1 to 1.2% of world production from the 1980s to today.

Sugar beet is an industrial crop highly supported by government policies in CWANA and in other parts of the world. Subsidies, until the 1990s, increased volume and productivity. Facilities offered to producers for storing and transporting their crops had significant results on the production and marketing of the sugar beet in West Asian and North African countries. Since the mid-1990s production volumes fell because of agricultural policy changes. Most of the sugar refining units were public enterprises that have gone private. Tunisia gave up its sugar industry, judging it more expensive to produce its own sugar than to import it. Most of the sugar beet farms converted to raising livestock. In Turkey, the government continues to subsidize beet production, but the changes in transportation patterns, including the switch from rail to truck transportation, diminished the willingness of the farmers to cultivate sugar beet. Many switched to other crops. Nevertheless, Turkey stands out as the largest sugar beet producer in CWANA, followed by Iran, Morocco, Egypt and Syria. Production in CWANA has increased, while the overall world production of sugar beet has decreased since 2000.

#### 2.1.2.3 Horticultural and vegetable crops

Horticulture and vegetables also exist in the cropping systems in the region. Potatoes, tomatoes, grapes, almonds, apples, olives and oranges are the most important crops in CWANA countries. Permanent crops under irrigation (dates, citrus and olives) are in almost all the countries of North Africa, the Arabian Peninsula and Southwest Asia. These regions have very diverse fruit and vegetable species. The high demand for them in international markets pushes most of these countries to invest heavily in their horticultural sector to increase productivity.

Vegetable production has increased from about 20x$10^6$ tonnes in the 1960s to 96x$10^6$ tonnes in 2005 (representing 11% of world vegetable production). It is mainly concentrated in Southwest Asia (6% of world production) and the Nile Valley and Red Sea subregions. Due to increases in harvested area and in yields production rose from 10.6 tonnes ha$^{-1}$ in 1960–1965 to 19.5 tonnes ha$^{-1}$ in 2000–2005 (world average in 1960–1965: 9.7 tonnes ha$^{-1}$ and in 2000–2005: 16.8 tonnes ha$^{-1}$). While production in the Nile Valley and Red Sea regions continues to climb, production in South Asia and West Asia is stable and even slightly decreasing.

The same growth trends can be observed in overall fruit production, which took off in the early 1980s. Countries of the Arabian Peninsula have followed this trend in fruit production, while their horticultural production has lagged behind. The North African countries have fluctuating horticultural production. Fresh fruits and vegetables are becoming important export products for exporting countries and should be an important component of protected agriculture and crop diversification programs in CWANA countries.

CWANA produces about 11.4% of world fruit, with yields slightly below the world average. While yields in the 1960s were 5.1 tonnes $ha^{-1}$ (world average: 7.5 tonnes $ha^{-1}$), they reached 8.9 tonnes $ha^{-1}$ (world average in 2000–2005: 9.7 tonnes $ha^{-1}$). Yield did not increase evenly. In the Nile Valley and the Red Sea regions, fruit yields are the highest, with an average of about 13 tonnes $ha^{-1}$, while the world average yield is about 10 tonnes $ha^{-1}$. Southwest Asia demonstrated the highest increase in yield, from 4.3 tonnes $ha^{-1}$ in 1961 to near 10 tonnes $ha^{-1}$ in 2005. In North Africa, fruit yield slightly decreased during the last 50 years. Increased production in the region is related to an increase in the area harvested, which doubled the last 50 years. The main increase came from the Nile Valley and Red Sea regions.

#### 2.1.2.4 Oil crops

Important public investments in the agricultural sector in Turkey and Pakistan in West Asia and South Asia, in Egypt and Somalia in the Nile Valley and the Red Sea and in Morocco and Tunisia in North Africa caused important increases in oil crop production of the CWANA region. The production increased from about 700,000 tonnes in 1961–1965 to more than $2.3 \times 10^6$ tonnes in 2001–2005 in South Asia and West Asia, accounting for 56% of the total production in CWANA in the 2000s. Nile Valley, Red Sea and North Africa subregions also had important increases in oil crop production.

#### 2.1.2.5 Crop–livestock–range systems

Crop–livestock–range systems are the most widespread form of agricultural production in CWANA. They are the least intensive in land and water use. Their distinguishing features are the use of arable crops and natural rangeland to feed small ruminants, the principal economic output of the system. Although cropland and animals are generally associated with strong systems of private property and smallholders, the predominant production unit, property regimes associated with rangelands are less well defined. Open and uncontrolled access to rangeland often results in extreme overgrazing.

Crop–livestock–range systems are primarily on the margins of major rainfed and irrigated cropping zones and are often associated with seasonal movement of animals and households.

The integration of crops and livestock is promising for low-income small-scale farmers. A great advantage of crop and livestock integration is that it uses diverse resources, such as fodder legumes, crop residues and livestock manure in a system of nutrient recycling. Livestock provide high profit per unit of labor, plus valuable manure for a soil improver. Livestock also have the advantage of being relatively easy to market, compared with harvested crops. There is a steady demand for livestock products, with relatively high and stable prices.

Increasing population, urbanization and incomes in CWANA are leading to a growth in demand for animal products, which opens opportunities for resource-poor farmers in domestic and export markets. However, these farmers face the challenge of producing for a competitive market. The role of technology is to promote the adoption of improved animal health and nutrition practices, genetic enhancement and better handling to achieve higher productivity. Plant species adapted to these dry areas can increase feed supply. During dry years barley, vetches, oats or other forage crops can improve the supply and quality of feed and prevent soil erosion, especially on hillsides. Spineless cactus or shrubs (like *Atriplex halimus*) alone or intercropped with other forage crops can also improve the supply and quality of feed.

Multinutrient feed blocks made from agroindustrial by-products and other ingredients are a low-cost source of supplements that can increase animal productivity. In addition, addressing and preventing endemic diseases leads to improved livestock productivity. Early weaning of lambs is another way to increase milk production. Improved rams can be distributed to producers to improve flock performance. Lamb fattening and dairy processing into high-value commodities and targeting niche markets can help increase earnings from small ruminant enterprises (Aw-Hassan et al., 2005). A holistic program that includes production, management and health of both small and large ruminants would increase productivity and animal health.

Irrigated fodder crops are important in Egypt. Berseem (trifolium forage legume) represents over 20% of the cropped area. These fodder crops are present in each country of the Arabian Peninsula, from 12% in Saudi Arabia to 32% in Qatar. In Kyrgyzstan, fodder crops represent 37% of the irrigated cropped area.

#### 2.1.2.6 Use of inputs

There is a uneven trend in the use of modern agricultural inputs in different CWANA subregions. The countries in the Arabian Peninsula, Nile Valley and Red Sea regions and North Africa practice extensive agriculture, while South Asian and West Asian countries, Pakistan, Syria and particularly Turkey seem to have opted for intensive agriculture since the 1960s. Data obtained from the FAO time series show the total number of agricultural tractors increased more than 20-

fold between 1961 and 2002 in South Asia and West Asia. It increased fourfold in Northern Africa, Nile Valley and Red Sea countries.

During the last 50 years, fertilizer use has increased significantly across CWANA. Turkey invested in huge fertilizer plants in the 1960s and 1970s. In Egypt, Iran, Iraq, Morocco, Syria and Tunisia, governments also invested in fertilizer production, although these investments were less than those in Turkey. Fertilizer use is currently about 7.5% of world consumption ($10.46X10^6$ tonnes); before it was 1.7% ($0.53x10^6$ tonnes). This increase is still occurring in Southwest Asia, although in North Africa and the Arabian Peninsula fertilizer use has slowed significantly or fallen.

Profiting from important government subsidies, insecticides, pesticides and herbicides for pest and disease management were introduced. Their production and marketing stayed in the hands of large multinational firms that created local subsidiaries. Turkey, Morocco and Egypt host multinational affiliates, while other CWANA countries import inputs. The fall in government subsidies to agriculture, since the 1980s in Turkey and Egypt and since the 1990s in Morocco, has had a negative effect on the use of these products. Another reason for the decline in use are changes in international rules, e.g., banning the use of pesticides in fresh produce for general food safety and environmental concerns. North African countries, Egypt and Turkey limit use of these inputs on agricultural products for export, while Syria started to increase their use in the second half of the 1990s.

Use of agricultural chemicals is uneven among farmers. Small-scale landholders all over CWANA continue to practice traditional agriculture, while capital-intensive agriculture is practiced by only a small portion of wealthy landholders. However, there are no statistical data to show this and real field research is drastically lacking in this area.

The increased use of certified seeds and the development of variety protection in CWANA subregions are governmental concerns and have been included in international grant programs since the beginning of the 2000s. Most of the countries, like Afghanistan, Algeria, Iran and Syria, intensified state initiatives to create seed trade associations to improve relationships among breeders, producers and farmers. Afghanistan is profiting from a USAID financial grant that helped it establish 20 village enterprises in five target provinces to produce and distribute certified seeds to farmers. Syria received a grant from the Japanese government that helped the Syrian General Organization for Seed Multiplication found a culture laboratory. Turkey stands out because it started seed improvement programs in the 1980s. The Turkish seed industry has shown remarkable progress the last 25 years. In Turkey, nearly 150 private seed companies deal with hybrids, vegetables and forage crops; foreign investments, mainly from the Netherlands, Israel and the United States of America, count for approximately one-quarter of them. A new law enacted in 2005 gathers dominant seed companies under one roof to better coordinate efforts.

Since liberalization policies were put in place, state control is loosening in the agricultural inputs market. Marketing channels are controlled more and more by NGOs (national associations or international organizations) or private enterprises. Governments still undertake important infrastructure investment in irrigation systems, but agricultural chemicals are now marketed mainly by private enterprises. State subsidies have been greatly reduced, affecting the use of these chemicals by small landholders. The decreased use of agricultural chemicals is in line with new international measures to reduce or eradicate pesticide residues or nitrates in water. However, lack of integrated agriculture has significantly reduced agricultural yields.

#### 2.1.2.7 Animal products

The 1990s saw important structural changes in product markets, when many countries of West Asia, South Asia and some countries in North Africa invested in raising livestock and developed milk-processing industries. In Pakistan, Turkey, Egypt, Tunisia and Morocco, heavy public investment resulted in an increase in milk production between 1961 and 2005. Milk became a commodity with high value. In all CWANA milk production per capita increased considerably. For Nile Valley and Red Sea countries this sector really took off in the early 1980s and sharply increased from the mid-1980s to the present. Accordingly, there has been an increase in the number and capacity of milk-processing industries in these countries, creating an attraction for foreign investment.

Meat production did not show the same increase as milk production between 1961 and 2005. The South Asian and West Asian countries increased meat production from about 110,000 tonnes (1961–1966 average) to nearly 6,000,000 tonnes (2001–2005) the last 40 years. But their high population increase somewhat saps this positive trend, so the yearly meat production per capita stays relatively low, when compared with industrialized Western countries. In North African countries and in the Arabian Peninsula, yearly meat production per capita increased considerably between 1961 and 2005, while in Central Asian and Caucasus countries a fall occurred, from 34 kg per capita annually during 1986–1990 to 27 kg per capita annually from 2001–2005. The poultry sector showed the most important increase with the spread of intensive production.

#### 2.1.2.8 CWANA case studies

To understand how cropping patterns changed, five countries have been selected for detailed examination: Turkey, Pakistan, Iran, Morocco, Egypt.

*Turkey:* Turkey is self-sufficient in food and is also the largest exporter of agricultural products in CWANA. Turkey has the most arable land in CWANA, 11th in the world and its climate gives it the highest yield capacity. All field crops, including aromatic plants and different fruits and vegetables, can easily be produced.

During the last 50 years, arable land increased with only small modifications in the cropping systems. The main crop is wheat; it has had the highest value of all agricultural products for 50 years (FAO, 2007). Its area increased, but its percentage in the cropping system stayed stable, between 43 and 45%. Oats, rye and forage declined in importance and chickpea and lentils have replaced fallow areas. Grape decreased, but it is still among the top-valued crops. Cash crops, such as maize and hazelnuts, are grown in both rainfed and irrigated areas. The amount of irrigated land increased. Cow's milk is also important. Chicken meat production increased and this meat is now among the ten top products in value. Beef is also in the top ten, while mutton decreased in value.

*Pakistan:* Pakistan has the second most arable land, 22%, in the region. The climate is arid with low rainfall and humidity and high solar radiation over most of the country. Most areas receive less than 200 mm annual rainfall. The high-altitude northern mountains receive more than 500 mm. Similar cropping patterns have existed in Pakistan for the last 40 years, with some modification, showing a large increase in permanent crops (1961, $150 \times 10^6$ ha; 2005, $700 \times 10^6$ ha) and irrigated land (1961, $10 \times 10^6$ ha; 20005, $18 \times 10^6$ ha). Cereals yield showed regular increases, going from 0.8 tonnes $ha^{-1}$ to 2.5 tonnes $ha^{-1}$.

*Iran:* Iran is one of the largest countries in CWANA, half of which is unproductive land. The diversity of climate in Iran provides a good opportunity for varied agriculture and horticulture. Water shortages are compounded by unequal distribution of rainfall. Similar to Turkey, wheat and barley are to main crops. Chickpea and lentils are planted fallow areas. Dates and watermelon replaced pistachios. Irrigated area increased from 5 to $8 \times 10^6$ ha and permanent crops increased from 5 to $20 \times 10^6$ ha. During the same period, yields in cereals, fruits and vegetables showed regular increases, cereal yield from 1 to 2.5 tonnes $ha^{-1}$, fruits from 4 to 11.3 tonnes $ha^{-1}$ and vegetables 6.8 to 22.6 tonnes $ha^{-1}$.

*Morocco:* Morocco is extremely dependent on its agricultural sector. Over 90% of the country's agriculture is rainfed; output is unreliable and only 19% of the land is cultivated. Morocco produces wheat, barley, citrus, wine, vegetables and livestock. Agricultural land increased from 4.5 to $7.5 \times 10^6$ ha without major changes in the cropping systems. However, the land area devoted to permanent crops and olives has increased in recent years. Vegetable yield increased threefold. Irrigated areas almost doubled. Like other Mediterranean countries, yields in cereals show huge annual variability.

*Egypt:* The total agricultural land of Egypt is about $3.28 \times 10^6$ ha, of which about 92% is in the Nile Valley. Almost all agricultural lands are entirely dependent on irrigation. In the last century, the arable area increased by about $1 \times 10^6$ ha, while the country's population increased nearly sixfold, from 11.2 to 65 million. While cotton was the main crop (26% of arable land), its area has been reduced from 834,000 ha in the 1960s to 315,000 ha in 2005. Grains, maize, wheat and rice occupy about 50% in the cropping systems, with large increases in wheat and rice over the last 50 years. Wheat is most cultivated crop. Clover for animal feed– almost nonexistent in 1960s -- increased along with the rotation system and now represents between 20 to 25% of the cropping area. Tomato production currently occupies 195,000 ha and is the highest grossing crop in Egypt.

Excessive use of irrigated agriculture has had adverse effects on the environment. Around 840,000 ha in Egypt, mostly cultivated lands in the North Delta, are salt affected.

### *2.1.3 Water resource development and management*

#### 2.1.3.1 Trends in potential water resources in CWANA

Economic growth remains dependent on water. Most areas of CWANA have scarce water and pronounced variable climate. CWANA's exploitable water resources have undergone a considerable evolution since the 1970s, particularly in the 1990s. Countries mobilized more of their water resources. New infrastructures were built; for example, water that Tunisia can use increased from $2.6 \times 10^9$ $m^3$ in 1990, 57% of the resource, to $4.1 \times 10^9$ $m^3$ in 2004, 90% of the resource. New hydraulic structures will be completed during the next decade, including 11 large dams and 50 retention dams or lakes.

Despite this, CWANA water resources per capita have decreased (Figure 2.2). This decrease comes from the increase in population. About half the CWANA countries are below the threshold of 500 $m^3$ per person annually (Figure 2.3), This threshold was once considered a minimum for easy development for a country, but now it is thought the average needs are around 1000 $m^3$ (Falkenmark, 1997; Tropp et al., 2006).

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**[INSERT Figure 2.2]**

**[INSERT Figure 2.3]**

2.1.3.2 Evolution in water uses and water demand. Agriculture uses 98% of the water in Afghanistan and Turkmenistan and about 65% or less in Algeria, Lebanon, Armenia and Bahrain.

Agricultural water withdrawal has evolved rapidly the past few years. Agriculture seems to be the sector where water must be saved (Table 2-1). Just a few countries, for example, Tunisia and Uzbekistan, have decreased water consumption in agriculture through the introduction of water saving policies.

**Insert Table 2-1. Water withdrawal (ww) and gap in CWANA region (Source: AQUASTAT FAO database).**

For some countries, total water withdrawal is greater than the amount that can be renewed. Supplementary water comes from depletion of renewable groundwater, abstraction of fossil groundwater and nonconventional resources, desalinated water, treated wastewater and saline drainage water. Water withdrawal, expressed as a percentage of internal renewable water, indicates the capacity to rely on renewable water sources. Values above 100% indicate that water flows in from outside the subregion or country, or that fossil or nonconventional water sources are used. The CWANA region has the highest percentage of water withdrawal worldwide and it is expected to intensify (Table 2-1). The withdrawal rates are already above the 40% threshold for water scarcity, beyond which cost and groundwater depletion increase dramatically. For some countries these percentages are extremely high, for example, the Kingdom of Bahrain.

### 2.1.3.3 Trends in water strategies and policies

Water conservation remains the main component for water resource management. The loss between producing the water and its use was estimated to be more than 25% in most countries. If one adds the waste from poor or underutilization of water to the loss between producing and using it, the amount wasted may be 40 to 50% of the global volume. Several attempts to conserve water and to save it are done in irrigated agriculture and include modernization of irrigation networks, improvement of plot water management and irrigation techniques, introduction of new techniques to regulate irrigation and encouragement of farmer associations to share and manage water. In Tunisia, drip irrigation is partly subsidized.

In rainfed agriculture water-harvesting techniques help supply crops with water. In CWANA arid and semi-arid areas, more than one million hectares are managed to harvest water for agriculture, mainly in West Asia and North Africa (see 3.5.2).

Several countries in North Africa, the Arabian Peninsula and the Nile Valley and Red Sea regions that have few renewable water resources overlie important nonrenewable fossil groundwater basins. These basins are partly shared with neighboring countries. For Algeria, Tunisia, Libya, Egypt, Saudi Arabia and the United Arab Emirates fossil water is an important resource. Libya exploits $3.7x10^9$ $m^3$ per year of its fossil groundwater. Although groundwater reservoirs may allow storage of huge quantities of water accumulated during the pluvial periods of Quaternary, their development cannot be considered sustainable. The lack of recharge results in the slow depletion of the aquifers. Moreover, as the water level declines, it increases the cost of pumping and the water quality deteriorates in some areas. This may make the extraction of fossil water less attractive.

Urbanization, tourism and industry pushed authorities in some countries to undertake adequate measures to protect wastewater collection sites from likely medium- to long-term pollution. The creation of treatment plants and the adoption of policies to reuse treated wastewater has contributed to increases in wastewater produced and treated.

Desalinated water is important in the Arabian Peninsula and Egypt. Saudi Arabia, the United Arab Emirates and Kuwait are, by far, the largest users of desalinated water. They use 71% of the total for CWANA, with Saudi Arabia alone accounting for 42%.

Groundwater is a significant resource. Irrigated areas in CWANA are estimated at $30x10^6$ ha, which is 7% of the agricultural area, using nearly $130x10^9$ $m^3$ of irrigation water per year. Roughly $13x10^9$ $m^3$ of irrigation water could be recuperated, monitored for quality and used.

Many countries have sustained agricultural development in diverse regions and urbanization of neighboring zones has accelerated. Water transfers can be used to more equitably distribute water and reduce gap between demand and supply by according priority to potable water needs and getting the most benefit from each unit of water. Internationally, the debate about water diversion has become heated. Many water-transfer projects have already been made in many CWANA countries. Resistance is growing to further developments, such as diverting water from water-abundant to water-scarce regions, even when the projects promote economic development, poverty alleviation and environmental protection. Examples of huge water-transfer projects are the Southeastern Anatolia Project in Turkey, the Nile River initiative and water management in the Jordan River region. The technical issues of these different water-management strategies are not the main problem. Environmental and social issues have become the main constraints.

Taking turns among water users started about 1760 BCE in Palmyra with Hammurabi’s Code. Water pricing was used in 137 CE (Sartre, 2001).Today water pricing is increasingly accepted as public policy throughout CWANA. Heavy governmental investments have been made in water cost-recovery in the whole CWANA region and high crop yields have been recorded in North

Africa, West Asia and Central Asia. Reasonable and effective water pricing systems provide incentives for efficient water use and water quality protection (Easter and Liu, 2005). Water pricing should cover cost for infrastructures and their depreciation and operations and maintenance. Metering water consumption is necessary for efficient water-pricing policies. Water metering has three major approaches: area, volume and market equilibrium, which is related to the crop and its profit. The predominance of gravityfed irrigation means water consumption must be measured on irrigation time and pipe capacity. Meters are used for systems under pressure. In Jordan, Al Hadidi (2002) describes the widespread installation of meters at private wells; billing can discourage overexploitation of the aquifers. Weak cost recovery translates into financial resources inadequate to maintain minimum operations and maintenance, causing services to deteriorate (Baroudy et al., 2005).

Most CWANA countries have adopted water pricing for irrigation and drainage. Water tariffs are increasingly important to manage demand. In Morocco and Tunisia water bills cover operating costs but exclude infrastructure costs. Water pricing is moving from reimbursement of maintenance costs to protecting the natural resource. However, some disadvantaged areas still benefit from government support. Generally, governments continue to support investment and fill the gap left by payment arrears (Baroudy et al., 2005).

#### 2.1.3.4 Effect of global changes on water resources

Climate change will affect precipitation, evapotranspiration, runoff—and ultimately, water resources. Changes in the water cycle likely will affect the magnitude, frequency and cost of extreme weather and the water available to meet growing demand. Recent reports (IPCC, 2007) show that climate change is likely to increase the days of intense precipitation and the frequency of floods in northern latitudes and snowmelt basins. Severe droughts could also increase because of a decrease in rainfall, more frequent dry spells and greater evapotranspiration. In the arid and semiarid areas of CWANA modest changes in precipitation can have a large effect on water supply. In mountain watersheds, higher temperatures will increase the ratio of rain to snow, accelerate the spring snowmelt and shorten the snowfall season, leading to a faster, earlier and greater spring runoff.

Temperature projections of climate are less speculative than projections of precipitation. The scenario problem lies in the scale mismatch between global climate models, with monthly data over several tens of thousands of square kilometers and catchment hydrological models, which require daily data and at a resolution of a few square kilometers. In CWANA few studies on climatic change scenarios are available, CWANA is not in the GEWEX experiment (Global

Energy and Water Experiment) while the HYMEX (Hydrological Cycle in Mediterranean Experiment) will cover part of CWANA.

### *2.1.4 Water management infrastructure for agriculture*

The control of water always has been critically important in the development of civilizations (Job, 1992). Since ancient times, different hydraulic systems have been built to augment rain and collect, store and transport water (El Amami, 1983; Khouri et al., 1995; Prinz, 1996). From simple cisterns in the ground, vital for the survival of families in arid zones, to large dams that are part of national policies to guarantee water to the greatest possible number of people, water storage always has been a primary preoccupation of CWANA governments, which face recurring droughts and limited water (Hamdi and Lacirignola, 1994; Jaber, 1997; ESCWA, 1998a).

The earliest recorded dam was on the Nile River at Kosheish, where a masonry structure 15 m high was built about 2900 BCE to supply water to King Menes' capital at Memphis. Evidence exists of a masonry-faced earthen dam built about 2700 BCE at Sadd-el-Kafara, about 30 km south of Cairo; this dam failed shortly after completion when, in the absence of a spillway, it was overtopped by a flood. The oldest dam in use is a rock-fill structure about 6 m high, built around 1300 BCE, on the Orontes River in Syria. By 1950, governments were building more dams as populations increased and national economies grew. Today nearly half of the world's rivers have at least one large dam. However, the last 50 years have also highlighted the performance and the social and environmental effects of large dams. Dams have fragmented and transformed the world's rivers and perhaps 40–80 million people have been displaced by reservoirs.

#### 2.1.4.1 Large dams

Since the 1950s. CWANA has built many dams, some are among largest in the world. In November 2000, the World Commission on Dams published an overview of dams and development (Clarke, 2000). It is based on 150 case studies, 13 in CWANA: Iran, Morocco, Pakistan, Tunisia and Turkey. While the large dams vary greatly in performance, most dams in CWANA underperform in achieving the intended benefits and services. In some instances, though, benefits occurred for much longer than predicted and still continue. Adverse effects on ecosystems occur frequently and many were unanticipated.

Irrigation components fell well short of targets in the irrigation command area developed, irrigated area achieved and, to a lesser extent, cropping intensity. It is difficult to find data on predicted and actual crop values. A high variability is observed among projects, data on smaller dams suggested greater consistency in performing closer to targets than larger ones. In contrast to irrigation, hydropower performance of large dams was, on average, closer to the goal, although performance varied.

Larger than necessary reservoirs may reflect overestimates of water demand or high reserves for drought. Multipurpose projects had higher variability and lower average performance than single-purpose projects. When a new dam is planned, the number of families and people that will be displaced and involuntarily resettled is routinely underestimated. The lack of records reporting these aspects also remains contested and continues to fuel controversy in the large-dam debate. Many positive and negative ecosystem effects from large dams were unanticipated, even in the 1990s. Mitigation was the most practiced response to ecosystem effects, but it has mostly failed or worked only sporadically.

Participation and transparency in decision making were neither open nor inclusive through to the 1980s. Emphasis has grown on transparency and participation in decision making involving large dams, especially in the 1990s. Many dam projects still do not plan for public participation of affected people. Participation of NGOs has increased in the projects since the 1990s.

#### 2.1.4.2 Small dams

CWANA countries have had, over varying lengths of time, policies of constructing small dams designed to use surface water and control erosion. The dikes of these dams are between 5 m and 15 m high (lower limit for large dams established by the International Commission on Large Dams). They are constructed of rubble in small rural catchments in areas of moderate relief. They have rustically designed lateral spillways with a discharge capacity of tens of cubic meters per second or, in some cases, just over 100 $m^3$ per second. Some, but not all, have a sluice gate. The dams cost around 500,000 euros, sometimes far less. Their reservoirs are relatively small, a few hectares and have a holding capacity from a few tens of thousands to $10^6$ $m^3$ (Albergel and Rejeb, 1997). Their main objectives are to reduce losses in agricultural land (estimated at 10,000 ha per year) and dam siltation, to increase water table recharge and to provide water for irrigated cropping (Albergel and Nasri, 2001).

Small dams have been known in West Asia since ancient times. The dam on the Nahr El Asi, near Homs, in Syria, was built in the reign of Seti 1 (1319–1304 BCE). Many were built at the start of the Christian era, Badieh Dam on the road to Palmyra was one. Numerous ruins testify to their presence in the dry steppes. Some still exist, but are completely filled with sediment. The first small dams built using modern techniques were those constructed during the 1960s in the province of Swaida to supply drinking water to villages on a basalt plateau that has no underground water. These reservoirs are usually stocked with fish. The lakes are used for fishing and for leisure activities, as with the small dam at Al Corane, not far from Damascus, in a small high valley. In the Middle East, the idea of a hill reservoir is not as well defined as in the Maghreb, but numerous small reservoirs have been constructed to create water reserves for the cattle of the nomadic Bedouin tribes.

In North Africa, the drought in the early 1980s, considered to be the longest ever experienced, marked the start of a policy of labor-intensive, small dam and hill reservoir construction. Small dams were primarily designed for irrigation, livestock watering, flood protection or supplying drinking water to rural areas that had no readily exploitable underground water. North African countries built a large hydraulic infrastructure in the 1970s and 1980s. Almost all the large dams are affected by significant sediment. Numerous small dams have been built to slow down siltation. For example, the largest dam in Morocco, the Al Wahda Dam on the Ouergha River in the province of Sidi Kacem (88 m high, with a capacity of 3.4 $10^9$ $m^3$), is protected by many small dams in the upstream catchment designed to hold the erosion coming from the steep marly slopes of the Rif. Some have already been constructed, while others are planned. Erosion from the Ouergha catchment, estimated at 98 Tonnes $ha^{-1}$ annually over 6150 $km^2$, causes the dam to lose 60 $10^6$ $m^3$ volume each year (Anonymous, 2001).

#### 2.1.4.3 Infrastructures for water harvesting

Water harvesting is a way to increase water available for crops. Section 2.5.2 on traditional knowledge presents the history of water harvesting, describing modern or rehabilitated infrastructures for water harvesting. Water harvesting is a proven technology to increase food security in drough-prone areas. Erosion control and recharging groundwater are additional advantages. Water harvesting can also be considered for rudimentary irrigation or storage of drinking water for animals. The farmers and pastoralists have no control over timing. Runoff can be harvested only when it rains. Although it exists in extremely old cultures (Nasri et al., 2004) and has been observed in most countries, extension and irrigation staff often have quite limited knowledge about various water-harvesting techniques and the associated socioeconomic implications. A growing awareness of the potential of water harvesting for improved crop production arose in the 1970s and 1980s. The stimulus was the well-documented work on water harvesting in the Negev Desert of Israel (Evanari et al., 1971). ICARDA is helping disseminate information on water technologies, promoting adoption and providing training for field staff in CWANA (Oweis et al., 1998, 1999).

Three main kinds of infrastructure for water harvesting are distinguished (Prinz, 1996; Prinz and Prinz et al., 1998).

- *Rainwater harvesting:* These infrastructures induce, collect, store and conserve surface runoff in arid and semiarid regions (Boers and Ben-Asher, 1982). This type of harvesting covers water collected from rooftops, courtyards and treated surfaces. The water is used for domestic purposes or garden crops. Microcatchments collect runoff from a small catchment, to feed the root zone of a tree, bush or annual crops. Macrocatchments convey runoff from hill-slope catchments to a cropping area at the hill foot or to a tank or artificial pond for watering cattle.
- *Flood water harvesting,* also called "large catchment water harvesting" or "Spate Irrigation," is collecting and storing of flow from floods in intermittent wadis for irrigation. Floodwater harvesting has two forms:
- *Floodwater harvesting* within the stream bed: the water flow is dammed and stored in reservoirs or is allowed to inundate the flood plain; the wetted area can be used for agriculture or pasture improvement.
- *Floodwater diversion:* the wadi water is forced to leave its natural course to nearby cropping fields. Various technologies and different names exist for these two floodwater harvesting types (see section 2.5.2 on traditional knowledge). Pakistan has more than 1.5 $10^6$ ha under floodwater harvesting. The irrigated area under floodwater harvesting in North Africa and the Middle East is increasing.
- *Groundwater harvesting* covers different infrastructures that concentrate and extract groundwater using little energy or only gravity. Qanat systems, underground dams and special wells are a few examples of groundwater-harvesting infrastructures.
- *Qanats,* widely used in Iran, Pakistan, North Africa and Spain, consist of a horizontal tunnel that taps underground water in an alluvial fan and brings it to the surface due to gravitational effect. Qanat tunnels have an inclination of 1 to 2% and a length of up to 30 kilometers. Many are still maintained and steadily deliver water to fields for agriculture and villages for drinking water.
- *Groundwater dams* are subsurface dams built in the wadi beds. They obstruct the underground flow of ephemeral streams. The water is stored in the sediment below ground and can be used after floods. A more sophisticated infrastructure is the sand storage dam, which is a sand filled reservoir watered by the wadi flow.

#### 2.1.4.4 Irrigation infrastructures

Irrigation covers about 48 million hectares in CWANA. Central Asia represents 59% of this total, although it covers only 21% of the total area. Pakistan alone, covering a little over 4% of the region, accounts for 33% of the irrigated areas. By adding Egypt, Iran, Iraq and Turkey, 72% of the land under irrigation are controlled by five countries in CWANA. Surface irrigation is by far the most widely used technique, practiced on 88% of the area. Sprinkler irrigation is practiced on

11% and microirrigation on 1.4% of the total area. In Libya and Saudi Arabia, sprinkler irrigation is clearly predominant, while in Jordan, Oman and the United Arab Emirates, microirrigation is most widely used. It is practiced on over half of the full and partial control irrigation areas (AQUASTAT, 2002). In Kuwait and Lebanon, sprinkler irrigation is used on more than 37% and microirrigation 39% of their full and partial control irrigation areas. The arid countries without large rivers choose to develop more intensively microirrigation and sprinkler irrigation to save water (AQUASTAT, 2002).

CWANA is subject to salinization because the volume of rainwater dissolving the salts generated by the soil is low. The problem has long been recognized; however, national assessment of salinization is difficult and little information on it can be found. Furthermore, no commonly agreed upon methods exist to assess the degree of irrigation-induced salinization. More information on salinization will probably become available. Strategies to improve the situation, recognized as a priority by most CWANA countries, should be defined. All countries reported having salinization problems, varying from 3.5% in Jordan to over 85% in Kuwait.

A measure necessary to prevent irrigation-induced waterlogging and salinization in arid and semiarid regions is installing drainage facilities. Drainage, in combination with adequate irrigation scheduling, allows leaching of excess salts from the plant root zone. Figures on drained areas are available for 13 of the CWANA countries in the FAO AQUASTAT database (2002). About 34% of these irrigated areas have been provided with drainage facilities, varying from 0.6% in Iran to over 90% in Egypt.

#### *2.1.5 Land degradation and water quality deterioration*

The degradation of arable land resources is as old as the history of irrigation and human settlement. A well-documented case occurred between 4000 and 2000 BCE, within the boundaries of CWANA, where secondary salinity affected the land and water in the Tigris and Euphrates valleys in Mesopotamia. History has repeated itself in the last century in many other countries of the region.

Water-quality deterioration, recognized as a global problem, has been exacerbated in dry regions. Research on water-quality deterioration began later than research on land degradation in CWANA, where problems from water-quality deterioration are expected to intensify, due to anthropogenic interventions and the increasing possibility of extreme events of climate change (IPCC, 1998, 2007). In addition, saline water intrusion is expected to increase, from sea level rise and overexploitation of groundwater in coastal zones. Salt-prone water and land problems are expected to increase in arid and semiarid regions (Qadir, Wichelns et al., 2007). Declining water quality has also increased water supply problems, especially in drier climates. Pollutants have a greater opportunity to accumulate during dry periods. A heavy reliance on irrigation in some areas has compounded the problem (UNEP, 2002). Research long focused more on water quantity and use than on its quality. Since the 1980s, there has been increased attention on the productivity of irrigated agriculture and conservation of the environment.

#### 2.1.5.1 Land degradation

Processes and causes of land degradation have been studied since the beginning of the twentieth century. Land degradation remains important for the twenty-first century because it adversely affects agronomic productivity, the environment, food security and quality of life. Land quality declines. According to the Global Assessment of Soil Degradation (GLASOD) (Oldeman, 1988), land degradation is linked to both climate variation and unsustainable human activities, such as overgrazing, deforestation and poor agricultural practices (Bossio et al., 2007). Land degradation is also linked to population density (Roose, 1996); in an agrarian system, if the population passes a certain threshold, land starts to run short and soil restoration mechanisms seize up. In some dry zones, when the population reaches about 100 inhabitants per square kilometer, the zone is rated as a densely populated, degraded area. A rapidly growing population and limited land resources mean that combating desertification will be difficult for developing and poor countries.

The Global Assessment of Soil Degradation is the first baseline study using a consistent methodology to estimate global soil degradation (Oldeman, 1988). Its estimates of the extent of affected areas are rough and should not be used as precise data (Table 2-2). However, they provide a good overview of the situation. National authorities concerned with land degradation need to update and refine present estimates and mapping. Major soil constraints and vulnerability for CWANA countries are related to sodicity, shallowness and erosion risk. Erosion risk is major, affecting 5% of Central Asia and the Caucasus and 20% of South Asia and West Asia (Table 2-3) (Nasr, 1999). Mechanisms that start land degradation are numerous (Bossio et al., 2007). A decline in soil structure causes crusting and compaction, leading to decreased infiltration rates and increased erosion. Significant chemical processes include acidification, salinization, pollution and fertility depletion. These processes can operate individually, simultaneously or in combination and threaten the sustainability of natural resources.

**INSERT Table 2-2.** Land degradation: severity of human-induced degradation in CWANA. Source: Terrastat, FAO database, 2006.

**INSERT Table 2-3.** Major soil constraints in CWANA. Source: Terrastat, FAO database, 2006

The salinization of land in CWANA is the consequence of both naturally occurring phenomena and human activities. Anthropogenic activities contribute more to salinization of land and water resources than primary salinity. Excessive irrigation, accompanied by inefficient drainage (Qadir and Schubert, 2002) caused by either lack of information on crop water requirements or a need to apply leaching water, has resulted in rising groundwater and soil salinization. For instance, nearly half the irrigated lands in Central Asia are affected by salinity (Kijne, 2005). The largest part of salt-affected soils and saline waters exists in the lower reaches of Amu-Darya and Syr-Darya basins, where salinity threatens food production.

2.1.5.2 Water-quality deterioration

Wastewater from household, municipal and industrial activities; agricultural drainage containing residues of pesticides, fertilizers and soil and reaction products of amendments; and overexploitation of brackish groundwater are the major contributors to deteriorating water quality in CWANA (Qadir, Sharma et al., 2007). In addition, drought has a negative influence on aquatic and land ecosystems and on the quantity and salinization of surface water and groundwater. More than half the major rivers in CWANA are seriously depleted and polluted, degrading surrounding ecosystems and threatening the health and livelihoods of the people depending on these rivers.

*Wastewater and sludge:* Water diverted for household, municipal and industrial activities generates wastewater containing undesirable constituents, depending on the source of the wastewater and its treatment. In most countries of CWANA, domestic wastewater is not segregated from industrial wastewater and other activities (Qadir, Wichelns et al., 2007). The wastewater is often discharged, untreated, into open drains, sometimes getting mixed with storm or fresh water. It is then channeled into natural water bodies or used in agriculture. In some cases, wastewater undergoes treatment.

Most wastewater treatment plants are of simple design or not adequately functioning in the region. Wastewater is diverted to farmers' fields—treated, partly treated, diluted or untreated. It is used by urban and periurban agriculture to grow crops, with vegetables being the most common, across CWANA (Lazarova and Bahri, 2005). Grain, fodders and industrial crops are cultivated as a secondary preference. In addition, parks, sports grounds and road plantings are irrigated with wastewater. Examples of wastewater aquaculture are also found in countries such as Kazakhstan.

The use and disposal of partly treated or untreated wastewater has environmental and health implications, but despite some governmental restrictions in CWANA countries and potential health risks, farmers use it (Keraita and Drechsel, 2004). In Central Asia, wastewater is discharged into streams, rivers, lakes and natural depressions, significantly polluting the ecosystem and threatening human health through water-borne diseases such as typhoid fever and bacterial dysentery (Fayzieva et al., 2004). Except for a few national assessments, only scattered information exists on the volume of raw or diluted wastewater currently produced and used in agriculture in CWANA (Qadir, Wichelns et al., 2007). Although water-quality management is reported to be a high priority and a major concern of governments in the CWANA region, most countries do not have sufficient resources to avoid polluting water bodies. However, with increased investment and awareness, the safe use of recycled wastewater can be increased (Karajeh et al., 2004).

Much of the operating cost of wastewater treatment plants involves handling and disposing of the sludge. This sludge is rich in organic materials but may also contain heavy metals and pathogens. Sludge needs to be treated and its environmental effect reduced. Sludge may be treated using pasteurization, aerobic thermophilic treatment, thickening with lime and composting. In Morocco, sludge from drying beds was tested on Italian ray grass crops. Heavy metals in the soil or in the vegetation did not accumulate (Jamali and Kefati, 2002). In Jordan, anaerobic pond sludge of stabilized waste could be used as fertilizer in agriculture after drying for three months, when pathogens numbers were reduced enough to meet safety standards (Hindiyeh, 1995).

*Saline and sodic water:* Under irrigated agriculture, increases in cropping intensity, excessive use of agrochemicals, inappropriate irrigation methods and salt-affected soils for crops contribute to increased salt in drainage water (Skaggs and Van Schilfgaarde, 1999). This water is collected in artificial or natural drainage systems or penetrates through the soil to become groundwater. Water scarcity in several countries of CWANA has led to reusing drainage water and overexploiting groundwater to produce food, fodder and wood (Qadir, Sharma et al., 2007).

Changes in river runoff directly affect river water quality. In Central Asia, the rivers Amu-Darya and Syr-Darya are the major source of irrigation. Long-term monitoring of these rivers shows that, in the 1950s, the salinity varied around the year within the range of 0.33 to 0.72 g $L^{-1}$. Other river water-quality parameters, such as major cations and anions, organic compounds, pH and pesticide levels, were also within safe limits during 1950s. Since the 1970s, salts in river water have increased steadily as a result of a decrease in the flow of Amu-Darya and Syr-Darya and increased discharge of return water, particularly drainage water from irrigated schemes. Consequently, there has been a significant increase in river water salinity since the 1980s.

Although return flow of water to the rivers is an additional reserve for use, it has become a source of environmental pollution in Central Asia (Altiyev, 2005). About 95% of return water is drainage water, containing elevated salts and pesticides, herbicides, fertilizer and other agricultural chemical residues. It is estimated that annually about 140 $10^6$ Tonnes of salt are discharged into the drainage water, 75% brought in by irrigation water. About one-quarter of the salt in drainage water is from the subsoil by mineral dissolution while some estimates reveal the average of mobilized salts at 40% of the total salt discharged (Kijne, 2005). About 51% of the total return flow goes into rivers, about 33% into depressions and 16% is reused in irrigation. As a result of returning water to natural depressions, hundreds of water bodies have been formed. Since these water bodies do not have an outflow, their water quality has deteriorated every year because of massive evaporation.

The Aral Sea, which is fed by two main rivers, Amu-Darya and Syr-Darya, is in the center of the Central Asian deserts and functions as a gigantic evaporator. This sea, which was the fourth largest inland lake in the world before 1960, is now the largest inland salty reservoir. It has become synonymous with environmental catastrophe, representing one of the world's worst ecological disasters. In the Soviet era, massive quantities of water from Amu-Darya and Syr-Darya were diverted for irrigating cotton, which decreased river water inflow to the Aral Sea. This led the sea to shrink dramatically. This seemingly irreversible process has continued, as irrigated agriculture has expanded and hydropower generation increased..

The disposal of agricultural drainage water containing many salts and agrochemicals into freshwater canals and rivers disperses salts and potentially toxic substances on a large scale. For instance, in the Euphrates Basin within Syria, about 1 $10^9$ $m^3$ of saline drainage water are put back into the Euphrates River, doubling the salinity in the river water (from ~ 0.5 to 1.0 dS $m^{-1}$) when it enters Iraq downstream. Inappropriate water management in the lower Euphrates Basin affects land and water quality in Iraq. In Jordan, water quality in the Amman-Zarqa Basin and Jordan Valley has been affected over the past few decades, with consequences for the downstream irrigated agriculture (McCormick et al., 2003). Anticipated increases in the basin's population and economic growth are expected to further affect the situation. Understanding the past dynamics and developing scenarios for the future that affect water quality for downstream users have been facilitated. National agencies have gathered extensive datasets, including water-quality data, for several years from strategic locations.

### *2.1.6 Agriculture and carbon sequestration*

2.1.6.1 Assessing of soil organic stock and the potential of carbon sequestration

In CWANA, soil organic content is low, ranging from 0.2 to 0.8% in relation to aridity (Lal, 2002) for soils of Pakistan (Rashid, 2000), Iraq (Aziz et al., 1988) and elsewhere in the region (Ryan and Matar, 1988; ICARDA, 1991). However, when rainfall is high, soil humidification allows better nutrient status and some soils may have a higher organic content, around 1.5 to 2.0% (Yurtserver and Gedikoglu, 1988).

The organic pool of most soils has been and is being depleted by soil degradation, erosion and subsistence and exploitative farming (Albergel et al., 2005). The historic loss of a soil organic content pool for CWANA may be 6 to 12 Pg. Assuming that 60% of the historic loss can be resequestered, the total soil carbon sink capacity of the region may be 3 to 7 Pg over 50 years (Cole, 1996; Lal, 2002). This may be realized by adopting measures to control desertification, restore degraded soils and ecosystems and improve soil and crop management techniques to enhance the soil organic content pool and improve soil quality. The strategies of soil carbon sequestration include integrated nutrient management and recycling, controlled grazing and growing of improved fodder on rangeland (Lal, 2001, 2002, 2006). In Morocco, Bessam and Mrabet (2001) show that switching from normal tillage to no tillage practices could increase carbon sequestration by 13.6% after 11 years. In Central Asia, the carbon studies component of the Livestock Management and Rangeland Conservation Tools project is providing data on rangeland carbon flux. First estimates in northern Kazakhstan (Wylie et al., 2004) show rangelands had an average of 1.27 tonnes C $ha^{-1}$ sequestration of $CO_2$ during the 2000 growing season. According to Lal (2002), the potential of soil carbon sequestration in different WANA ecosystems through desertification control and restoration of degraded ecosystems is 2.0 to 5.1 Pg C over 50 years (Table 2-4).

**INSERT Table 2-4.** Potential of soil carbon sequestration through desertification and restoration of degraded soils in the CWANA region. Source: Adapted from Lal, 2002

Soils have the potential to reach an annual carbon sequestration rate of 0.2 to 0.4 Pg C, accounting for 24 to 30% of the potential of global dryland ecosystems (Table 2-5) This potential rate of carbon sequestration can be maintained over 25 to 50 years, provided coordinated efforts are made to adopt appropriate land use and recommended soil, water and crop management technology. However, agricultural intensification involves carbon-based inputs including tilling, pesticides, fertilizers and irrigation. Emission of carbon from all these inputs needs to be considered in evaluating the net soil organic content sequestration.

**INSERT Table 2-5.** Potential of the WANA region and global dryland ecosystems to sequester carbon. Source: Lal, 2001, 2002.

2.1.6.2 Incentives for land-use change

Promoting changes in land use that would increase the carbon sequestration rate will benefit the international community and the governments, international NGOs and private companies that now pay for these services. Opportunities for funding $CO_2$ sequestration through land-use change are limited to reforestation and afforestation under the Land Use, Land-Use Change and Forestry of the Clean Development Mechanisms. This might explain why it is not very popular in the dry areas of the world. Ninety% of the Clean Development Mechanism projects are in Latin America and Asia and the Pacific. Morocco has registered 21 clean development projects and Egypt 28. However these focus on clean energy, transport and waste management and only a fifth concern forestation and reforestation.

As the carbon market grows, new opportunities might rise through emerging carbon management programs or voluntary carbon markets (Taiyab, 2006). In addition, biodiversity, desertification control and improved water quality produced through sustainable land use are better valuated and should also be considered.

Biofuel crops and other nonfood crops grown for use in industry, chemicals (plastic, paint), industrial fibers (paper and textiles), pharmaceuticals, personal care products and biofuels can be an alternative to traditional food production. They cut across all development, with significant effects on the economy, society and the environment. They offer an opportunity for farmers to develop exports and industry with more diversified horticulture. Meanwhile, the world's ecosystem gains from a rich source of renewable materials that do not further deplete the earth's natural resources.

In CWANA, water scarcity is the main constraint for developing nonfood crops. Production of renewable biomass-suitable biofuel to be used as a substitute for fossil fuel need not compete with food production. The best opportunities are biomass resulting from agroindustry, biomass from wastelands and agroforestry based on oil trees not dedicated to food production: jatropha for example. It can reduce soil degradation and can be used for bioenergy (http://www.jatrophaworld.org/).

### *2.1.7 Agrobiodiversity*

#### 2.1.7.1 Changes in agrobiodiversity and agroecosystems

CWANA countries have about 10% of the world endangered species, mainly among animals and about one-third of birds, mammals, reptiles and fishes (Table 2-6) for number of endangered species by subregion). Some of the world hotspots, where unique biodiversity is threatened are in the Caucasus, Iran-Anatolia, Mediterranean Basin, mountains of Central Asia and part of the Horn of Africa. The development of key biodiversity areas, representing the most important sites for biodiversity conservation worldwide, is a new concept being tested in the area (http://www.iucn.org/themes/s sc/redlist2006/redlist2006.htm; http://www.biodiversityhotspots.org). With the exception of some countries in the region, like Turkey and Iran, most of the biodiversity areas are not yet well protected. National conservation programs have not been initiated properly and biodiversity legislation has not been implemented to promote protection (http://www.cbd.int/reports).

**INSERT Table 2-6. Red List category summary subregion totals of CWANA plants and animals (Source: IUCN summarized from http://www.iucnredlist.org/info/stats).**

The expansion of agricultural production and the intensive use of inputs over recent decades in CWANA countries are considered to be major contributors to the loss of biodiversity (FAO, 1996a). At the same time, certain agricultural ecosystems can serve to maintain biodiversity, which may create conditions favorable for many species that might be endangered by fallowing or changing to a different land use, such as forestry. Agricultural food and fiber production is also dependent on many biological services. This can include, for example, providing genes for developing improved crop varieties and livestock breeds, crop pollination and soil fertility provided by microorganisms.

The preservation and enhancement of biodiversity poses a major challenge for agricultural policy makers, as population and demand for food increase. Policy makers will need to find ways of minimizing the conflicts between expanding production and maintaining biodiversity, enhancing the many complements between agriculture and biodiversity and finding ways to prevent the loss of biodiversity on agricultural land (Pagiola and Kellenberg, 1997). For a growing number of CWANA countries, protecting and enhancing biodiversity is becoming important in their domestic and international agroenvironmental policy objectives and actions, in response to growing public concern. In practice, government policies towards biodiversity involve balancing the tradeoffs between socioeconomic values and biodiversity conservation. Typically, policies with low ambition can avoid short-term costs but may lead to more costs over the long term, such as risks to agricultural production from genetic erosion. More ambitious policies and targets towards biodiversity conservation will require scientific research, including developing biodiversity indicators. Indicators can help support decisions by providing information about the risks and degrees of sustainability associated with different options.

### 2.1.7.2 Introduction of modern varieties, case studies on wheat

For thousands of years, small-scale farmers have grown food for their own consumption—planting diverse crops, recycling organic matter and following nature's rainfall patterns. The trend of switching from traditional agriculture to cash crop agriculture and monoculture is leading to a decline in local crops and varieties and the loss of traditional knowledge, farming and old varieties and landraces. At present, some minor crops are maintained by farming households on a small scale to supply their traditional food cultures. Harlan (1951) noted that "crop germplasm in Vavilovian Centers are vulnerable to loss due to technological and economic changes."

Until the 1950s, farming in CWANA relied upon farmers' accumulated knowledge of the local physical and social environment. At the end of the 1960s, introduced improved wheat started to replace local varieties, causing the loss of old and traditional wheat cultivars, especially in areas suitable for extensive agriculture. This replacement is the major cause of genetic erosion, which frequently occurs because the genes and gene complexes found in the diverse local varieties are not all contained in the modern seed (FAO, 1996a). The lack of extension, no national planning and policies and no local training for maintaining unique, local varieties and a wide range of ecological problems associated with agricultural practices have caused environmental pollution and biodiversity lost. Having the first national program and storage facilities, Turkey carried out an intensive survey and collection program, in 1968 and 1969, at the coastal regions to maintain the local wheat cultivars, which were being replaced rapidly by improved Mexican wheat (Sencer, 1975).

### 2.1.7.3 Expansion of agriculture and crop and plant diversity change

CWANA has mainly dryland and mountain ecosystems. Both are fragile and open to a rapid decline of biodiversity. The expansion of agricultural production into formerly uncultivated mountain lands or forest reduces the habitat for other species and leads to a decline or deterioration of ecosystems, particularly where the lands are only marginally suitable for agriculture. The threat to traditional crops will increase as cropland available for each household is reduced (Tan, 2002).

Degradation of habitat and loss of related biodiversity are already leading to irreversible situations. They are responsible for migration of local communities, desertification and increasing mass poverty. It is difficult to separate those social factors causing habitat degradation from economic ones, since they are interrelated and have similar consequences. Important ones for Turkey are its location, agricultural activities, overexploitation of natural resources, population growth, large populations living close to natural resources, unregulated and overgrazing of pastures and high meadows, forest and stubble fires and incomplete cadastral works for determining ownership of land (Kaya, 2003). Overgrazing and extensive woodcutting, in addition to intensive agricultural practices, have caused a major threat to wildlife in Jordan by destroying natural habitat. Despite the economic importance of mining in Jordan, unplanned mining and quarrying can also destroy habitat (http://www.biodiv.org/reports/).

#### 2.1.7.4 Market prospects and consumer preferences

The change in consumer and market demand and the loss of interest in some by-products of local cultivars is contributory to agrobiodiversity loss. When farmers become integrated into the market economy, they change from landraces or local cultivars to crops and fruits with higher production. The market demand for uniform varieties suitable for industrial processing is another cause for decrease in farming local varieties. However, landraces are often better suited for organic farming. Therefore, there is an increased market for some landraces (Tan, 2002).

The market for medicinal, aromatic and ornamental, species and traditional edible wild plants for food is high, with attractive prospects for the national market and for export. This creates options for additional income for the low-income rural population. In Turkey, there is a long tradition of eating edible wild plants. A recent study on wild medicinal plants of Turkey identified 346 taxa of commercially traded wild native plants. For households, many medicinal, aromatic and ornamental species are underpriced and overexploited. Villagers generally sell products without processing; the added value is captured elsewhere. Where resources are undervalued, prices or policy corrections could have an immediate beneficial effect (Ozhatay et al., 1997). To avoid overexploitation, some countries have legislation especially related to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) or a related project. For example, Turkey has its Regulation on the Collection, Production and Export of Wild Flower Bulbs (http://rega.basbakanlik.gov.tr).

*Enhancing the multiple uses of underutilized species: case study 1:* Various projects in the region are ongoing. For example, a pilot project in Syria aims to assess socioeconomic aspects related to producing and marketing selected neglected and underutilized species and shed light on challenges and opportunities in the economic exploitation of these species. The study looks at the market channel and product development of neglected species to identify the causes limiting their full deployment, along with the needs for their sustainable use. This investigation concentrates attention on actions to promote production, processing and marketing. It focuses on the needs of rural communities, where these species can become valuable in enhancing income generation (www.bioversityinternational.org).

*Azraq Oasis, wetland reserve, Jordan: case study 2:* The Azraq Oasis is located in Jordan's eastern desert near the border with Iraq. It once supported a rich biodiversity and was a stopover for hundreds of thousands of migrating birds. But increasing demand for water in the greater Amman area led to large-scale pumping of the Azraq Basin in recent decades. By 1993, after more than 20 years of intensive extraction, the underground springs giving life to the oasis had dried completely. Today, the Azraq ("blue" in Arabic) wetlands are experiencing a remarkable recovery thanks to a multifaceted project cofinanced and managed by UNDP, in its capacity as an implementing agency for the Global Environment Fund (GEF). Other partners include various Jordanian government agencies and the Royal Society for the Conservation of Nature / Jordan (www.gefweb.org/Outreach/outreach-PUblications/ Project_factsheet/Jordan-cons-1-bd-undp-eng-ld.pdf).

Constructing dams and replacing dry farming with irrigated farming changes the cropping pattern and decreases the local varieties and weedy forms adapted to dry farming, as was the case for Turkey. But through planned and intensive collection missions the wild relatives and weedy forms of many species are collected and conserved as elsewhere (Tan, 1998). The on-site conservation of wild progenitors of legumes and cereals is also managed (Karagoz, 1998).

#### 2.1.7.5 Change in rangeland composition

Because livestock use most of the primary production in agrobiodiversity systems of arid and semiarid regions, degradation has always been attributed to it (Sidahmed and Yazman, 1994; Squires and Sidahmed, 1997). Grazing helps maintain the composition and the diversity of rangelands. Overgrazing is the main cause for the change in rangeland composition. Countries like Turkey and Syria set up policies for managing rangelands (http://www.ifad.org/photo/region/pn/tr.htm). The absence of grazing livestock has some negative effects on vegetation. Presently, government supported programs maintain the original forest landscape with the help of goats. Goat keepers are paid, per day and per head, for grazing their goats in the forests of some countries.

#### 2.1.7.6 Effects on animal breeds

Large numbers of indigenous livestock breeds are also threatened. Wildlife and livestock often symbiotically coexist. Plant biodiversity may decrease with the absence of grazing livestock. The replacement of the local breeds with exotic breeds is the main reason for breed extinction. Additionally, two main factors lead to the extinction of breeds: the expansion of crops and irrigation into marginal zones and the conversion of former pastures into protected areas. As a result, livestock keepers often lose first their traditional pastures, then their grazing livestock. Absence of market demand and inability to competitive with improved breeds in production is another factor. When communities become integrated into the market economy, animal keepers switch to breeds that produce more milk, meat or eggs. If there is no demand for a local breed, related knowledge can vanish within a generation. Habitat loss also affects wild animals. For example, wetland decline has resulted in the eviction of buffaloes and the disappearance of nesting habitats for some migratory birds. Unbalanced water use and unplanned surface and underground water extraction are affecting the habitats and microecosystems of both animals and plants. In Jordan, pollution of surface and underground water and aquifers from agrochemicals, sewage discharge and solid waste disposal has caused an increased threat to the reproduction of many animals.

Conflicts and disasters also affect both bred and wild animals. Wars and natural disasters can cause massive loss of livestock. Aid agencies often try to help by restocking and importing animals from industrialized countries. Possibly there will be some effects from the wars in Afghanistan and Iraq and the earthquake in Pakistan.

#### 2.1.7.7 Maintenance and conservation of agrobiodiversity in CWANA

The main focus of policy in biodiversity has been to protect and conserve endangered species and habitats. Some CWANA countries, such as Turkey, Pakistan, Morocco and Jordan, have introduced legislation for the protection of specific endangered species and habitats. They have also designated certain areas as biosphere reserves, nature parks and other protected sites. Most countries do not have legislation to protect agrobiodiversity. In some countries, the legislation has been prepared but not adopted or has not been enforced (http://www.biodiv.org/reports/). Turkey, for example, has various pieces of legislation to protect biodiversity, related to preserving agrobiodiversity and maintaining plant genetics. The most important direct legislation is the Regulation on the Collection, Conservation and Use of Plant Genetic Resources (http://rega.basbakanlik.gov.tr).

Given the importance of the region in both the richness and the uniqueness of its agrobiodiversity, in the 1950s and early 1960s FAO took the initiative to promote collecting and conserving genetic resources worldwide. The 1961 Technical Meeting on Plant Exploration and Introduction was the first multilateral initiative to recommend establishing exploration centers in the regions with the greatest genetic diversity. A pilot exploration center was established in 1964 at Izmir, Turkey, with an agreement between FAO and the Turkish government within a joint project of UNDP. The Crop Research and Introduction Centre with the inclusion of agricultural research, the Agricultural Research and Introduction Centre (ARIC) was the first regional center of Southwest Asia for collecting and conserving Southwest Asian plant genetics (FAO/UNDP, 1970; Kjellqvist, 1975, Frankel, 1985; Tan and Inal, 2003). This initiative was a good opportunity to preserve the unique agrobiodiversity in the first regional gene bank. ARIC (now known as the Aegean Agricultural Research Institute, AARI) did not remain a regional center but successfully began to work nationally in the mid-1970s and is still the Coordination Centre of National Plant Genetic Resources/Plant Diversity National Program of Turkey (Tan, 2000, 2001). In the other countries of this region plant genetic activities are not yet fully organized into a national program and strategy. Plant genetic conservation is mainly done through breeding and selection programs in research institutes and universities and also in the departments of forestry and livestock within the ministries of agriculture. Because of the lack of national policy and special budgets, plant resources are not receiving enough support. Moreover, there is often no coordination among different national institutions (www.bioversityinternational.org). In some countries, in addition to the national programs, many organizations are involved in conserving plant and animal resources. NGOs are active mainly in biodiversity conservation and do not take a key role in plant genetic resources in most countries.

Some CWANA countries have begun to develop national biodiversity plans, which usually incorporate agriculture in biodiversity conservation. These strategy plans set out the policy objectives and targets for managing and sustaining biodiversity. Most countries are addressing the threats to species loss and the need to address this issue through integrated local and distant conservation. They are highlighted in their National Biodiversity Strategy and Action Plans and National Reports prepared under the terms of Article 6 of the CBD (www.biodiv.org/reports). Almost all countries prepared reports for the preparation of the State of the World's Plant Genetic Resources for Food and Agriculture (FAO, 1996a) as an element of FAO. Turkey, as member of Organisation for Economic Co-operation and Development (OECD), has activity reports for both animal and plant diversity indicators, which are policy biodiversity indicators for measuring the performance of national policies and helping monitor progress in fulfilling international obligations (Tan, 2001).

Agricultural research and development institutions of the Arab League—ACSAD (Arab Center for Agricultural Research in the Dry Lands and Arid Zones) and AOAD (Arab Organization for Agricultural Development), COMSTECH-OIC (Scientific and Technical Committee of the Organization of Islamic Conference), the CIS (Commonwealth of Independent States among Central Asia and Caucasus countries) and the AU (African Union) are the principal intergovernmental bodies for international and regional collaboration in the region.

However, the way these conservation efforts are organized varies across countries, ranging from involvement of governmental and nongovernmental organizations to amateur collections and commercial companies. Some countries have national gene banks, others have several specialized agricultural research institutes responsible for maintaining agricultural genetic resources, while some countries work together in regional gene bank networks. The crop and regional networks are also related to agrobiodiversity protection. The Central Asia and Trans-Caucasus Network on Plant Genetic Resources (CA-TCN/PGR, established in 1996), The West Asia and North Africa Network on Plant Genetic Resources (WANANET, established in 1992–1998) have been active for the collection, conservation and sustainable use of the unique agrobiodiversity of the region. The other regional network, for rangeland seed information, was established with two subregion nodes: the Mashreq countries (Iraq, Jordan and Syria) and the Maghreb countries (Algeria, Morocco and Tunisia). Turkey is also a member of the European Cooperative Program for Plant Genetic Resources (EC/PGR).

The International Technical Conference on Plant Genetic Resources placed emphasis on the need for coordination between local and distant approaches. The Global Plan of Action agreed upon by 150 governments at the technical conference identifies the promotion of in situ conservation of wild crop relatives and wild plants for food production as one of its 20 priority areas (FAO, 1996b). Those activities are an excellent guide to the national programs of the region.

International agreements and conventions are also important in agriculture and biodiversity. Most notable was the international Convention on Biological Diversity (CBD), which was agreed upon at the UN Conference on Environment and Development at Rio in 1992. The CBD recognized the significance of biodiversity for agriculture. This has led the FAO to request member countries to negotiate, through the FAO Commission on Genetic Resources for Food and Agriculture, the revision of the international undertaking on plant genetic resources in agriculture. The International Treaty for Plant Genetic Resources for Food and Agriculture came into force on 29 June 2004; a few countries of the region participated, in harmony with the CBD. In addition, within the overall context of the CBD, the Biosafety Protocol was agreed upon in over 130 countries. This was the first major international agreement to control trade in genetically modified organisms (GMOs), covering food, animal feed and seeds. Other related international conventions include, for example, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973, www.cites.org), the Convention on Wetlands (Ramsar Convention, 1971, www.ramsar.org). Some countries of the region are signatory to those of the agreements and completed the ratification. The awareness of the countries of the region to the participation of those agreements is not enough. The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1971, www.coe.int/T/E//Cultural_Co-operation/Environment) is signed only by Turkey and enforced with various projects. Additionally, some countries are members of the World Trade Organization (WTO, www.wto.org) and bound to its rules, the World Intellectual Property Organization (WIPO, www.wipo.int) and the Patent Cooperation Treaty. The Uruguay Round Agreement of negotiations under the General Agreement on Tariffs and Trade (GATT, www.wto.org) produced the Trade-Related Intellectual Property Rights (TRIPS) Agreement, which commits all members of the WTO to adopt and enforce minimum protection for intellectual property rights (IPR). Article 27.3(b) of the agreement on TRIPS calls for members to develop plant variety protection legislation (www.wto.org).

Bioversity International’s (former IPGRI) work in CWANA started as early as 1977 with a FAO project jointly conducted with the Aegean Agricultural Research Institute (AARI) in Izmir, Turkey. The Bioversity International regional office for the WANA region was located in Aleppo, Syria, in 1993, at the International Center for Research in the Dry Areas (ICARDA). In 1997, the office broadened its mandate to include Central Asia and changed its name accordingly into CWANA. A subregional office was opened in Tashkent, Uzbekistan, in 1998 at the ICARDA Facilitation Unit for Central Asia. The ultimate goal of IPGRI CWANA is to strengthen the national and regional capacities to achieve the effective conservation and sustainable use of plant genetic resources. Five other centers of the Consultative Group on International Agricultural Research (CGIAR) (CIAT, CIMMYT, CIP, ICRISAT and IRRI) have subregional offices and carry out activities on plant genetic resources on mandated crops and agrobiodiversity conservation.

Ex situ conservation has been predominant for conserving plant genetics for food and agriculture in the region. In recent years, the need for integrated conservation strategies for conserving plant genetics coordinating in situ and ex situ approaches has become clear. The first attempt at local conservation was the project implemented by Turkey in a multiple site and multispecies approach. Now there are various projects in the region for both in situ conservation of wild relatives of crops and farm conservation of the traditional crops in agrobiodiversity and some in ecosystems. The documentation of biodiversity has become important. National programs and formal and informal institutions of CWANA countries have started to create databases on various agrobiodiversity topics. In Turkey, a comprehensive and complementary database management system linked with the geographical information system (GIS) exists for all related activities and for a better understanding of agrobiodiversity (Tan and Tan, 1998a, 1998b).

UNEP and the World Bank have a global program on biodiversity and genetic resources and have mobilized funds across CWANA, through the Global Environment Facility’s support of biodiversity country strategies along with major in situ conservation projects, such as In Situ Conservation of Genetic Diversity in Turkey (Tan and Tan, 2002) and Design, Testing and Evaluation of Best Practices for In Situ Conservation of Economically Important Wild Species, with Demonstration in Egypt, Lebanon, Morocco, Turkey (UNEP, 2003). The UNDP regional office for the Near East approved an important regional collaborative project in 1998, Agrobiodiversity In Situ Conservation, involving Jordan, Lebanon, Palestine and Syria. It was coordinated by ICARDA, with technical backup by IPGRI and ACSAD and through GEF support, a regional date palm project for the Maghreb oases.

*In situ conservation of genetic biodiversity of Turkey: case study 1:* This five-year project, associated with the Bank's Eastern Anatolia Watershed Rehabilitation Project, started in 1993 and worked to address Turkey's natural resource degradation through in situ and ex situ conservation as supported by the World Bank GEF (Zencirci et al., 1998; Tan and Tan, 2002). Project goals: Permit genetic evolution through in situ conservation (Kaya et al., 1998).

- Protect in situ the genetic resources and wild relatives of important crop and forest tree species. The southeastern, southern central Anatolian and Aegean regions have been identified as important biodiversity centers for wild relatives of cultured crops
- Establish the complementary conservation ex situ and in situ wild relatives of selected crops, fruit and forest species
- Establish ex situ conservation of associated species of target species in selected sites
- Establish natural reserves or gene management zones (GMZs) for target species
- Plan management for selected GMZs
- Prepare national plan for in situ conservation
- Create a comprehensive database management system linked with GIS

*Strengthening the scientific basis of in situ conservation of agricultural biodiversity on farm: case study 2:* In 1995, IGPRI and its nine national partners (Burkina Faso, Ethiopia, Hungary, Mexico, Morocco, Nepal, Peru, Turkey and Vietnam) formed the project Strengthen the Scientific Basis of In Situ Conservation of Agricultural Biodiversity On Farm (Jarvis and Hodghin, 1998; Jarvis, Myer et al., 2000). The nine countries are all within regions of primary diversity for crop genetic resources with world importance. The countries all have national programs organized to conserve crop genetic resources, including ex situ conservation facilities; additionally, all have a strong interest in developing the national capacity to support in situ conservation. The project serves to strengthen the relationships between formal institutions and farmers and local institutions. Project objectives are to develop global and national management frameworks for implementing in situ conservation, collecting and analyzing information to define the genetic diversity in farmers' fields and to develop the criteria for the successful maintenance of existing diversity. It intends to broaden and conserve agricultural biodiversity by farming communities and other groups.The IPGRI CWANA group is closely involved in this project and has two participating countries, Morocco (Birouk et al., 1998) and Turkey (Tan, 2002).

This project has created comprehensive database management systems for each national project. It provided a model to other countries for future projects. The Training Guide for In Situ Conservation On-Farm was produced (Jarvis, Sthapit et al., 2000) and tested through the GEF/UNDP Project on Conservation and Sustainable Use of Dry Land Agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria.

*Conservation and sustainable use of dryland agrobiodiversity: case study 3:* The five-year project was launched in 1999 to promote in situ conservation and sustainable dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria, with financial support from the GEF/UNDP (www.icarda.org/Gef/P1.html). In addition to the country institutions, ICARDA, IPGRI and ACSAD are involved in the project.

Genetic erosion of some animal breeds has been occurring at an unabated rate from lack of incentives for conservation and population pressure, ecological changes, natural catastrophes and adverse economics. This depletion is an immense threat to the livelihood of the local pastoral communities. Conservation of these animal genetic resources by governments and other stakeholders would ensure the well-being of pastoralists and prevent genetic losses. Conservation of animal genetics is essential to enable farmers to adapt to different environments and consumer demand and to fully realize the investment made over generations in developing these breeds. Also, conservation of wild species will provide opportunity to develop the livestock sector. FAO has led efforts to sustainably use, develop and conserve animal genetic resources and since 1993 has engaged in preparing the Global Strategy for the Management of Farm Animal Genetic Resources. The global strategy is to serve as a strategic framework for international efforts in animal genetic resources.

The First Report on the State of the World's Animal Genetic Resources is an essential element of the global strategy. Countries were invited by FAO in March 2001 to produce and submit country reports (www.fao.org, www.dad.fao.org). The first report will provide a comprehensive review of current global livestock diversity and direction for better management of it. Country reports and the First Report of the State of the World's Animal Genetic Resources will provide a strategic planning framework for the animal genetic resources component of agricultural biological diversity, supporting the development and implementation of national, regional and global policies and programs. It will highlight opportunities, challenges, biological characteristics, institutional infrastructure and operational considerations influencing management of plant and animal genetic resources. It will also include main threats to livestock genetic resources and outline areas of greatest opportunity to better manage these resources. Some countries in the region have already prepared their country reports and set up projects to conserve farm animal genetics.

#### 2.1.7.8 Exploitation and use of agrobiodiversity

Exploitation and use of genetic resources postulates knowledge and evaluates the characters expressed by the genome and identify desirable characteristics for breeding. As indicated in the Global Plan of Agriculture for the Conservation and the Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, “the broadening of the genetic base of crops will contribute to increasing crop stability and performance” (FAO, 1996b). In most crop species, populations have been reduced dramatically as a result of breeding and selection. For years, plant breeders have limited their programs to a small part of the diversity in the region. However, wild relatives and ancestors, old varieties, landraces and weedy forms were collected from different institutions and maintained in the national, regional and CGIAR gene banks. Those collections are a valuable but relatively unexploited source of genetic variability. To broaden the genetic base and enhance the ability to respond to abiotic and biotic stress, systematic evaluation and use are needed of the genetic diversity of the region. In well-organized CWANA countries national programs collaborate in breeding, evaluating and using genetic diversity (FAO, 1996a). In Turkey, many varieties are released from national collections (Tan and Inal, 2003). Collaboration with CGIAR has led countries to exploit and use their genetic diversity to adapt even to extreme conditions.

Participatory variety selection and plant breeding are effective at identifying new material for farmer conditions, preferences and needs. Participatory methods allow farmers to select new materials, enhancing diversity where traditional cultivars have been lost. Participation of farmers in the initial stages of breeding, when the genetic variability is untapped, will fully exploit the potential gains by adding farmers’ perception of their needs and knowledge of the crop. Farmer participation has been established in some countries in the region by several agencies and ICARDA. Opportunities for interaction and cooperation between formal breeding station work and farmer expertise need to be fully explored. Research is also needed on transferring appropriate technology among farming systems to manage great diversity. Research support is needed for traditional seed production, emphasizing farmers and natural selection pressures, insect pests, diseases, storage conditions and soil fertility. Participatory plant breeding allows the farmers’ diversity to be maintained on farm. This approach is a main component of in situ conservation programs.

*Decentralized participatory barley breeding, ICARDA: case study:* At ICARDA, the gradual change from centralized and nonparticipatory to decentralized participatory barley breeding was implemented in Syria between 1997 and 2003 in three steps. The model and concepts developed during were gradually applied in Egypt, Eritrea, Tunisia, Jordan, Morocco and Yemen.

The first was an exploratory step with the main objectives of building human relationships, understanding farmers' preferences, measuring farmers' selection efficiency, developing scoring methods and enhancing farmers' skills. The exploratory work included selecting farmers and sites and establishing one common experiment for all participants (Ceccarelli et al. 2000, 2003). The second step was primarily about methods and implementing the breeding plan, choosing and testing designs and analysis, refining farmer methods and planning village seed production.

A common finding of participatory breeding programs is that different farmers in different communities select different varieties. Data collected on barley suggested that farmer selection may narrow biodiversity in the breeding material. However, because different farmers select different material, the biodiversity is maintained or increased (Ceccarelli and Grando, 2002). Through participatory breeding several farmers became aware of the value of landraces and were interested in conserving them.

## 2.2 Policies, Institutions and Regulations

### *2.2.1 Development strategies and agricultural policies*

In CWANA, as in other developing countries, agricultural development strategies have had successive shifts since the late 1950s. In the early postindependence era, the late 1950s to the early 1970s, development was strongly influenced by the "import substitution model", which was dominant and aimed to promote rapid industrialization. This meant heavy taxation of the agricultural sector, including taxes on commodity exports, overvalued currency exchange rates and high import tariffs.

Many governments attempted to correct the bias against agriculture by intervening in agricultural markets through price measures, setting up compulsory state monopolies, providing basic services, credit, essential inputs, technical and market information and by marketing and distributing (FAO, 2002). In the early 1980s, growing account deficits, external debt problems and foreign exchange crises imposed a shift in development strategies. Most developing countries implemented structural adjustment policies.

From the 1980s to the 1990s, structural adjustment involved import tariff reduction, market deregulation, privatization, fiscal stabilization through currency realignments and significant budget cuts. For agriculture, the primary objective was to make it more market oriented. Budget cuts were often made in subsidized credit, inputs, extension systems and in investment in research and infrastructure. Agricultural reforms often reduced or eliminated the state in trading, eliminated domestic price controls and gradually removed state procurement programs (FAO, 2002).

These policies had mixed results on the agricultural sector. While allowing for an increase of agricultural exports and the intensification of farm production in some countries of the region (Egypt, Morocco, Tunisia, Turkey), they disrupted markets and often resulted in deteriorating food security and increased poverty in many other countries.

While still focusing on improving the competitiveness through farm productivity growth, integrating more farmers in supply and developing standards and labels, current development policies increasingly integrate poverty reduction. Development policies that take into account the diversity of farmers are increasingly recognized. Still, the farming sector in CWANA is facing major national and international constraints, in particular unfavorable markets, persistent subsidies in the North, a growing technical divide between the North and the South and increasing environmental risks.

Agricultural development strategies in CWANA (Table 2-7) are faced with major challenges. How can agriculture ensure economic development objectives of food self-sufficiency and better position on the international market while reducing rural poverty and protecting the environment? What should be the connection between agricultural policies and rural development policies, especially where market orientation and intensifying farm production reduce the agricultural labor force? How can a multifunctional approach to agriculture, take into account the social and environmental functions of agriculture and diversify economic activities in rural areas?

**INSERT Table 2-7. Agricultural development strategies (Source: Giger, 2006).**

### *2.2.2 Land tenure including agrarian reform*

Existing land-tenure systems in the region descend from Islamic and customary law, colonial legacy and national land policies. In the postindependance era, land reform extended state control over land through nationalization and granted rural communities land through privatization and reform of customary property rights. In most countries, institutional reforms were promoted to enhance the performance of farm households and communities.

Land policies in Morocco and Tunisia give priority to privatization to promote rural development by granting private rights to both farmers and tribal communities. The partial privatization approach was mainly applied in Jordan and Lebanon; the state retained land ownership, the beneficiaries were granted use rights. To achieve better distribution of land and promote agricultural development, agrarian reforms were implemented in Algeria, Iraq, Libya and Syria. Many small farmers and herders received lands and were organized into cooperatives to facilitate access to credit and inputs.

In central Asia, under Soviet agricultural production, 95% of agricultural lands were controlled by large-scale collective and state farms. After independence in 1991, agrarian reforms favored the emergence of smallholder farming and a large part of the agricultural output is from household plots. Agrarian policies have tended to focus on “decollectivization” of large state enterprises and privatization of holdings. Land reforms have not been adequately accompanied by other reforms, resulting in poor management of land and water.

In countries in the Middle East and North Africa, structural adjustment policies and liberalization movements since the late 1980s affected land-tenure systems. State withdrawal from direct involvement in agricultural production has been important in most countries. Morocco promoted the privatization of state, collective and religious-endowed land. Algeria sold “inefficient” state farms and reformed tenure arrangements in favor of family farms (Bush and Abdel Aal, 2004). Tunisia has achieved privatization of state and cooperative farms. Still, land-tenure systems and farmland distribution are major constraints for agricultural production and do not provide enough incentives to farmers to invest in enhancing productivity. In several countries, many farmers lack property titles and have limited access to bank loans. Demographic growth and no appropriate regulations have often fragmented land and contributed to a decrease in small farm viability. On the other hand, privatization and liberalization have favored larger plots and concentrated production, mainly to the detriment of family farming. Most countries are experiencing a consolidation of large farms, well integrated into national and international marketing and smallholders limited to household survival.

### *2.2.3 Trade policy, international and regional agreements and the World Trade Organization*

Trade policy and international markets are a theme in the CWANA-IAASTD because they access AKST. The adoption of agricultural knowledge, science and technology depends on commodities markets because the knowledge comes from the demand of the final utput products. Access to markets is prerequisite to AKST development. International agricultural markets are important to adopting AKST for development.

### 2.2.3.1 Trade arrangements in the region

Although global trade liberalization is the goal of multilateral trade negotiations under the WTO, all WTO members have entered into regional or bilateral agreements. This subtle shift from WTO objectives is mainly from WTO failure to achieve consensus about trade agreements and the ease of forming regional blocs. The CWANA region is not an exception. It has seen many regional and bilateral trade agreements emerge among neighboring countries. For instance, Egypt concluded 30 to 40 agreements (ESCWA, 1998b). Turkey entered in a customs union with the EU in 1996 and the Maghreb Union was established in February 1989. With the establishment of WTO in 1994, it was expected these countries and regional blocs would review their trade policies to make them compatible with multilateral trading principles. According to article 24 of the General Agreement on Tariffs and Trade (GATT), regional blocs should facilitate trade among the members without restricting trade with other WTO members. The main concerns of these countries with WTO are the compatibility of common tariff rates to which they are committed by joining WTO; specific binding restrictions in market access; domestic supports and exports subsidies; a common market with GATT provisions for regional blocs to foster their position in multilateral trade negotiations; and tariff structures under the most-favored-nation status in previous bilateral or regional trade agreements (Zaibet et al., 2003).

Since the 1990s, many countries of the Mediterranean region (namely North African and Middle Eastern countries) have signed partnership agreements with the European Union (EU). These countries are liberalizing their economies under the euro partnership conditions, a process which is strongly influenced by the EU's common agricultural policy (CAP). Since negotiations have started, trade policies have been revised, local and regional structural programs have been undertaken and a lot of changes have taken place at the internationally level. As a result of the above transformations the CWANA countries have expressed concern with regard to open market policies and access to industrialized country markets.

### 2.2.3.2 Trade negotiations and expected benefits

By joining WTO, developing countries in particular have sought more access to industrialized country markets and to gain advantages in international markets. The Doha Declaration has set milestones on a number of trade and nontrade issues known as the Doha Development Agenda. However, given the achievements of past negotiations, observers remain skeptical that a new comprehensive round can be completed in the coming years (Miner, 2001). The big players are expected to make additional policy reforms (e.g., trade legislation in the USA and CAP reforms in the EU) before undertaking strong concessions and commitments in the upcoming negotiations.

Benefits from agricultural trade liberalization have not materialized for two reasons. First, negotiations on agriculture alone do not consider comparative advantages. As a result, the Doha Declaration provided for broad trade negotiations to further trade liberalization for industrial products and services in which nations may take advantage (Merlinda, 2002). Second, national policies and legislations are creating additional transaction costs and limiting liberalization. Gerber (2000) pointed out that trade relations remain far denser within nations than between nations and indicate significant transaction costs across national boundaries.

Besides recurrent issues, new concerns are presumed to be on the table during coming negotiations (Zaibet et al., 2003). The main issues already identified in GATT on agriculture involved market access, export competition and domestic support. However, new trade and nontrade concerns are emerging (Tables 2-8 and 2-9). The agreement on agriculture included food security issues, food safety and quality, environment concerns, resource conservation and rural development (Miner, 2001). Additional issues raised in the last meetings included animal welfare, biotechnology, species preservation, safeguarding the landscape, poverty reduction and preservation of rural culture (Miner, 2001).

**INSERT Table 2-8. Traditional vs. newer issues in trade and nontrade negotiations (Source: Zaibet et al., 2003)**

**INSERT Table 2-9. Shallow vs. deep integration measures (Source: Zaibet et al., 2003).**

Newer border and trade topics included rules of origin, standards and technical barriers, intellectual property rights, SPS standards, dispute settlement and the role of small countries (Gerber, 2000). Among the nontrade, domestic policy issues are foreign investment, competition policies and labor and environmental standards.

Export markets for many developing countries are in a few countries in the North because of proximity and historic links (Diao et al., 2002). As a result, trade negotiations will be shaped by regional blocs. North African and Middle Eastern countries are increasingly interested in the EU agricultural markets and the EU agricultural reforms under the CAP agenda 2002 (Table 2-10).

**INSERT Table 2-10. Relevance to the European Union and to the region (Source: Zaibet et al., 2003)**

The work program annexed to the Barcelona Declaration has the following objectives for the countries that signed the declaration:

- Integrate rural development
- Support policies implemented by the Mediterranean countries to diversify production
- Reduce food dependency
- Promote environment friendly agriculture

2.2.3.3 Challenges and relevance to AKST

*Effects of the European Union enlargement:* Enlargement of the EU to the Central and Eastern European countries is integral to the EU Agenda 2000. The process started following the decisions of the European Council in 1993 in Copenhagen and 1994 in Essen to be achieved by 2004. The enlargement of the EU could open new frontiers to more exports. It may, however, divert foreign investment to the eastern EU countries and prevent CWANA access to new technology.

*Food safety and environmental quality standards:* With the decline in traditional trade barriers, such as tariffs and quotas, there is evidence that technical and regulatory barriers are increasingly used instead (Wilson, 2001). In developed countries, many firms are moving toward adopting environmental standards. This move is relatively slow in CWANA countries and might be an obstacle to international trade.

*Environmentally friendly agricultural practices:* Current trends to protect the environment are illustrated by the EU provision of direct payment to farmers complying with environmental regulations and support of agricultural methods that protect the environment. These trends could spread low tillage or no tillage techniques along the region and could replace current practices.

### *2.2.4 Professional and community organizations*

*Turkey -- case study*: Although agricultural education and research was started 80 years ago, agricultural organizations were set up in the last 50 years. Farmer chambers were first established in 1881; they became active mainly after the 1960s. Similarly, agricultural credit cooperatives were set up in the 1930s, but only started to act effectively in the 1950s. Extension services function under the Ministry of Agriculture and Rural Affairs in each province and county. Additionally, some agricultural cooperatives focus on one crop or crop group. Agricultural producer organizations in Turkey can be classified into cooperatives, producer unions and agricultural chambers (Table 2-11).

**INSERT Table 2-11. Agricultural producer organizations by main types in 2006 (Source: Ministry of Agriculture and Rural Affairs; www.tarim.gov.tr)**

Turkey has over 700 agricultural chambers, with about four million producer members. They mostly provide vocational services and represent farmers. These organizations specialize in certain products or product groups and in provinces or districts. As the legal framework for these organizations is recent, the number of unions and members are rather low but show a strong increase.

The Milk Producer Central Union has seven milk producer associations. Agricultural credit cooperatives are organized with a central association and 16 subassociations with about 1.5 million members. Agricultural cooperatives are composed of agricultural development cooperatives, irrigation cooperatives, fisheries cooperatives and sugar beet cooperatives. The agricultural development cooperatives promote activities related to producing and marketing crops, livestock and husbandry. These organizations are often multipurpose and usually not specialized.

Agricultural sales cooperatives and associations are generally specialized in crop products, processing and sales. The agricultural sales cooperatives purchase the products of their members. The unions take all the necessary measures for these products to be utilized in the best circumstances. They handle storage, standardization, first processing, transporting, packaging, export and domestic sales of finished and semi-finished products, provide all the inputs for agricultural production and support shareholders with credits and insurance for the producers.

In addition to these organizations, there are some small local farmer unions and cooperatives. The government has recently started to encourage farmers to become organized by setting up new regulations. Some professional associations have also been established.

#### *2.2.5 Agricultural risk management policies, including drought risk*

Agriculture is regarded as one of the most risky activities because of price, inelastic demand, short-run supply and exposure to natural shocks. In CWANA, agricultural risks also have extremely variable climate and recent economic changes that came with liberalization, which profoundly affected farm operations. Worldwide, economic changes and degradation of natural resources, diminishing water resources, pollution and climate change have prompted additional attention to risk. Interest in strategies and tools for managing market risk has increased in recent years.

This section examines the diverse risks affecting agriculture in CWANA. It analyses the risk management strategies at the farm to reduce household income variation. Finally, it focuses on the development of agricultural risk management policies in the region.

2.2.5.1 Main risks affecting agricultural activity in CWANA

The diverse risks affecting agricultural activity in CWANA are (1) production risks, related to weather, including drought and pests and diseases, (2) ecological risks from managing natural resources, such as water, (3) market risks, mainly from variable output and input prices and from particular markets, such as quality and safety requirements for exports and (4) institutional risks linked to state intervention.

Although it has great diversity in climate and natural environment, CWANA in general has low, highly variable annual rainfall and a high degree of aridity. In the largest part of CWANA, especially in North Africa and the Near East, drought is recurrent, resulting from physical determinants and social factors. Increased cultivation of marginal and fragile arid lands, soil erosion and runoff exacerbate the region's vulnerability to drought and often lead to irreversible desertification.

In recent years, most countries of the region have had severe drought and consequently, growing water shortages. In North Africa, the Near East, Middle East, Afghanistan and Pakistan recent reports of the Intergovernmental Panel on Climate Change (IPCC) confirm some global warming and indicate that water scarcity, which was already a major constraint, may worsen substantially. Because of continued drought between 1999 and 2001, Algeria, Morocco, Tunisia, Turkey, Jordan, Iran and the Gulf countries saw an important decline in their agricultural output, especially in cereals and livestock. Drought adversely affected the livelihoods of much of the rural population, especially dryland farmers and nomadic livestock owners, particularly in Iran. FAO (2002) reported the incidence of poverty in the region went up significantly toward the end of the decade because of drought, with a proportion of the population living on less than $2 per day increasing from 25 to 30%.

The unpredictable and variable climate prevailing in the region and the different farming practices aggravate the risk of disease and pest epidemics across CWANA. Pests, including sunn pest, Hessian fly and cyst and root lesion nematodes, significantly damage cereal production. For this reason, the development of disease- and pest-resistant wheat varieties has been a key component of breeding programs to improve food security across CWANA. Agricultural production in CWANA is increasingly threatened by exotic pests, such as the peach fruit fly (*Bactrocera zonata*), red palm weevil (*Rhynchophorus ferrugineus*) and Bayoud disease of palm

(*Fusarium oxysporum* fsp. *albedinis*), among others, indicating a lack of adequate phytosanitary controls.

Animal diseases are a major threat to livestock production in CWANA countries. In addition to screwworm infestation, at least three animal diseases have major economic impacts, especially in North Africa, the Middle East and the Arab Peninsula: foot-and-mouth disease, rinderpest in the Middle East, including Egypt and Sudan; and brucellosis, endemic in the whole region. These diseases seriously affect the potential in the region for livestock production. Their elimination would require well-focused pest and disease control, still lacking in most countries.

In CWANA, agricultural risks are related to the management of natural resources, such as water. The region's irrigation systems are under considerable environmental strain, with almost all countries experiencing problems with salinity and waterlogging. A major concern is the overexploitation of groundwater, particularly in the Persian Gulf region (FAO, 2002). The current water crisis calls into question the sustainability of most irrigation systems.

Drought and water scarcity place substantial strains on the environment, causing significant damage to biological diversity. As the FAO report points out, "wildlife has been severely affected as a result of the shortage of drinking water, lack of feed, dried wetlands and degradation of wildlife habitats. … in the Hamoun wetlands of Iran, which are of international importance, aquatic life has disappeared. Herbivores are among the first animal species to be affected by a lack of feed. Drying of wetlands and natural lakes has also occurred in Morocco, as well as other countries of the region, causing similar and probably irreversible environmental damage. In Jordan, the continued drought during 1999 and 2000 caused visible damage to the natural and artificial forest" (FAO, 2002).

Risks affecting agriculture in CWANA increasingly result from rapid changes in input and output markets. Many farmers still practice subsistence agriculture. When a farm household's production is barely sufficient for its own consumption, market risks are clearly not important. But the increasing integration of farm producers in national and international markets place them at risk if there is price instability. Market risks faced by farm producers in CWANA are related to poorly organized national marketing circuits, significant increases in input prices and production costs, state intervention in pricing basic food products, difficult access to export markets from growing competition for fruit and vegetables and increasingly severe safety and quality requirements.

#### 2.2.5.2 Risk management to reduce farm household income variation

The extremely variable climate prevailing in the region and economic liberalization affecting agricultural policies make farm producers particularly vulnerable. In this highly risky environment, farm households have developed strategies to mitigate risks and reduce income variation. Two strategies are ex ante risk management and ex post coping (Dercon, 2000). Ex ante involves crop management, technological choice, diversification of income by spreading risk among activities and market strategies. Risk coping deals with the consequences (ex post) and involve self-insurance through precautionary savings; informal insurance, such as kin sharing risk; and informal credit. Coping strategies may involve attempting to earn extra income to compensate for losses, selling livestock and making use of government aid.

In CWANA, drought is by far the greatest risk. Recent droughts have seriously affected dryland farmers and herders, resulting in severe loss of income through loss of harvests and partial loss of flocks. Sales of animals and off-farm activities are among the most common strategies adopted to cope with drought. Loss of harvests pushes farmers to rely on purchased animal feed to avoid further livestock losses. Harvest losses make it necessary for farms to rely more on to short-term bank credit or informal credit to meet farm costs the following year, resulting in increased indebtedness.

Fall in income caused by drought leads small-scale farmers to give out their land to sharecroppers, a way to cope with little money and secure part of the expected farm production. Small-scale farmers also rely on state aid programs, such as seed and animal feed distribution, to reduce the hardship caused by drought. In hardship, family networks are used by farm households. They allow transfer of money from family members working in urban areas or abroad. These coping strategies, however, are not available to all farm households. The same holds for off-farm work, which has decreased in most countries of the region because of economic restructuring.

Among ex ante strategies in CWANA, farmers are diversifying farm production to reduce climate and economic shocks. Most farmers in the Maghreb countries combine livestock, mainly small ruminants, with cereal crops and olive trees. In this system, livestock allows better management of the farm treasury through the sale of animals to finance farm inputs and household expenses. In addition to combining livestock and crops to minimize risks, farmers in semiarid areas usually diversify animal production. Mixed species herds represent a way to spread risk, make better use of resources and reduce farm expenses by integrating low-cost production.

Diversifying income through wage labor and small trade is also a major risk-management strategy farmers of the region use. Small-scale and medium-scale farmers in the Maghreb and the Middle East have a high rate of engaging in a number of activities; almost 45% of Tunisian farmers have an off-farm activity. In the Maghreb countries, off-farm activities have been important for funding and developing agriculture. Now they have become rather "scarce, in the new national and international context due to emigration controls, decrease of national demand in nonskilled labour and high unemployment …" (Alary, 2005).

Ex ante risk management used by some groups of farmers in CWANA include crop management and improved farming techniques. These techniques include using drought-resistant crop varieties, fertilization and pest management to increase yields or minimize production failure. However, improved varieties can be more vulnerable to moisture stress and pests. They do better in assured rainfed or irrigated agriculture. Using new technology can generate environmental risk, such as pollution and carries some long-term risks in soil depletion and genetic uniformity (Ramaswami et al., 2003). These are increasingly affecting farming in intensive production areas of the region, but farmer awareness and management strategies are still lacking.

In several areas of the region, minimizing farm risks includes developing irrigated farming. It stabilizes yields and allows for more intensive and more profitable production. This has led to development of surface and underground irrigation, which in several CWANA countries has led to overexploitation of water resources and increased soil degradation.

The shift from dryland to irrigated farming can generate new risks for farmers. They include environmental problems, the necessity to rely on the credit system, new farming techniques, integrating into collective water management, insufficiently organized marketing circuits and price instability.

Markets for horticulture products are liberalized in most CWANA countries, but they remain poorly organized. Farmers, especially small-scale and medium-scale ones, are usually vulnerable to market risks. These risks can be aggravated by state intervention geared to maintaining low food prices through importing fruits and vegetables. In several irrigated areas of Morocco and Tunisia many farmers have ceased irrigating because of the difficulty in selling their products profitably (Gana and El Amrani, 2006) and returned to dryland farming. Some have shifted the water from horticulture to cereals and forage.

Cereal crops benefit from more stable producer prices, as they are usually state controlled. The high variability of prices for fruits and vegetables, which is also due to the weakness of farmer organizations, is a major hindrance to developing high-value crops in the region. This explains the risk management favored by many farmers is cultivating cereal crops, even if they could diversify or develop other crops. However, a growing proportion of farmers in intensive irrigated farming in Morocco, Tunisia and Egypt have found forward contracting a way to reduce market risks.

Among livestock producers, risk management varies according to the size of the farm. Ex ante strategies can use integrating cropping and livestock by cultivating forage crops. These strategies are mostly available to medium and large farms in favored climates. In dry areas, herders often have to resort to the market for forage supply, where prices are unstable and vulnerable to market shock. Finally, ex ante risk management includes crop insurance, which is mostly available to farmers integrated into the bank credit system.

#### 2.2.5.3 Agricultural risk management policies in CWANA

Despite the strategies farm households put in place to mitigate risks, they remain vulnerable to fluctuations in production, consumption and poverty. Therefore the state should intervene. Governmental intervention can include price supports, credit policy, natural resource management policy, promotion of technical change and development of insurance schemes and safety net programs.

In the CWANA region, recent droughts have pushed most countries to implement measures and policies to limit social and economic damage (see next section for drought management policies in CWANA). Policy in Iran, Jordan and Morocco established a national drought program monitored by an intergovernmental committee (National Drought Task Force), usually headed by the Ministry of Agriculture. This political body proposes a set of emergency measures and funds to ease the adverse effects of the drought and assist the affected rural populations. Emergency measures include emergency purchase and distribution of concentrate feed to livestock owners, seed distribution, veterinary prophylaxis, water development and wells for people and livestock, special access to credit, debt relief or agricultural tax relaxation and creation of job opportunities.

However, while these measures helped to mitigate the loss of animals from drought, they have been financially costly. Where they had untargeted distribution of subsidized livestock feed they primarily benefited the larger flock owners. The FAO report stresses that, “Moreover, they have created dependencies on feed supplements and have encouraged the maintenance of larger numbers of animals on the rangelands for longer periods each year, thus accelerating resource degradation. Consequently, the contribution of the natural grazings to total feed supply has fallen dramatically in nearly all Mashreq & Maghreb countries, while concentrate feed use has escalated”. (FAO, 2002).

Drought management and mitigation in the region consist mostly of short-term drought relief. Drought early warning systems are virtually nonexistent and national integrated drought-monitoring programs are not operational. Mostly they have limited coordination of information on water supply from irrigation authorities, agricultural extension services and meteorological departments about the extent and impact of drought (De Pauw, 2001). Yet coordinating this information is essential for drought monitoring systems. Hence, there is an urgent need to establish national plans to manage drought more comprehensively and consistently and move from reacting to drought to managing it. Drought could be treated as an integral component of production and a structural feature of the climate.

Besides drought management, agricultural risk management policies in CWANA include programs to improve crop management and animal production techniques, crop and animal protection programs, irrigation facility and water management programs, price support programs, (in particular guaranteed purchase prices for grains) and to improve input subsidy programs that have decreased substantially in recent years and to develop credit and insurance systems and safety net programs. These measures and development programs are unequally implemented in the region and substantial progress is needed in risk management policies.

In animal protection, risk management differs among North Africa, the Middle East and Central Asia, due to their different epidemiological situations. In Central Asia, diagnostic capacities for epidemics remain limited. Cattle are the main target of preventive vaccination, which is used more to prevent economic loss from disease than to prevent the spread of the infection. Turkey and Iran also vaccinate small ruminants in specific areas to prevent diseases being introduced from neighboring countries. In North Africa, risk management is more focused on emergency preparedness and limiting the diffusion of the disease when it is diagnosed. Effective control from quarantine and mass vaccination are used. Vaccination campaigns target cattle in Algeria and Morocco and both cattle and sheep in Tunisia. Still, animal diseases seriously affect the livestock production potential. Eliminating the diseases would require implementing focused pest and disease control operations, lacking in several countries.

Another important policy area to reduce agricultural market risks is food safety and quality. In several countries of the region, initiatives have been taken to reform and improve food control systems: development of a national strategy for food control (Morocco, Tunisia), implementation and development of food legislation complying with international requirements (Cyprus, Egypt, Jordan, Lebanon, Morocco, Oman, Pakistan, Sudan and United Arab Emirates) and review and update of food standards and regulations (Iran, Sudan and Syria). Some countries have harmonized their food standards with Codex and Tunisia has introduced quality assurance systems. Despite the effort made by several countries to improve food control systems and to harmonize national food regulations with international standards, often with FAO support, further progress needs to be made to increase the efficiency of food safety systems, first in order to meet national public health requirements (for locally produced and imported products) and second to meet the food quality and safety requirements of export markets.

What is thus at stake for most countries of the CWANA region is the design and implementation of a comprehensive and proactive risk policy, which would include and coordinate the following elements:

- Establishment of drought early warning systems
- Development of crop insurance schemes, now available in only a few countries
- Increased public investment in public works, water management and agricultural research and extension
- Implementation of policies that protect the environment and discourage cultivation of marginal land
- Reinforcement of marketing systems and promotion of farmer organizations
- Development of new and improved food safety systems to comply with food safety standards in export markets

#### 2.2.5.4 Drought risk management in CWANA

Drought is a recurrent phenomenon across CWANA countries. It has a severe effect on the populations and weighs heavily on all economic activities, particularly agriculture. Drought has a negative influence on aquatic and land ecosystems and on the quantity and quality of underground and surface water because of salinization. Regional and international organizations are putting in place various strategies to combat drought. The strategies may be divided into two groups:

- Improvement of countries' hydraulic equipment to collect and store water, rural water and soil water conservation development programs and range improvement schemes
- Reinforcement of institutions to integrate the risks of "drought" into economic planning, give rural zones the means to resist drought and start emergency programs as soon as a drought is detected

*Hydraulic equipment and the fight against drought:* During the 1970s and 1980s, significant efforts were made in the entire region to construct large dams (see section 2.1.4). In some countries, such as Tunisia, recent preference has been for small and medium hydraulic works (Albergel and Rejeb, 1997), creating an agricultural revolution. The three-year drought in Tunisia, from 1993 to 1995, was overcome without rationing water to agriculture, towns, tourism or industry because the hydraulic infrastructure was well proportioned for the country's needs.

On the contrary, Afghanistan faces a food crisis each time there is inadequate rainfall during the winter or during the months of April and May. FAO assesses that 6.5 million people are seasonally or chronically food insecure in this country because of the lack of adequate hydraulic infrastructure. In 1999 to 2000, Afghanistan was hit by a serious drought as a consequence of low rainfall and snow melt over the winter. Central and southeastern Afghanistan was the worst affected, with the drought reaching crisis in some places when the population resorted to eating wild grasses and roots and drought deaths were reported (Marsden, 2000).

The Achilles heel of reservoirs in drought management is the high evaporation rate and, in particular, the sediments that come in the dams each year. It is estimated that in Morocco, $9\ 10^9$ $m^3$ of water evaporate every year, or 33% of the $30\ 10^9$ $m^3$ of rainfall. In Tunisia, large dams have an average volume loss of 25 million cubic meters per year, or about 2%. For small dams, the volume lost is 5% (Boufaroua et al., 2000). By 2020, many countries in CWANA will have to manage an after period, already a problem in Algeria. To reduce the silting up of dams and the loss of agricultural land, countries have launched water and soil conservation policies.

Today, storing water in aquifers seems the best method for combating dry intervals. It protects water collected during excess rainfall years from evaporation. The reservoirs do not shrink in size. The only risk is pollution by compounds that are not stopped while the water is traversing the porous environment during infiltration. Many countries have converted some dams to refill groundwater. The El Aouareb Dam on the Merguelill, in Tunisia, now is managed to release water to refill the water table in the Kairouan Valley downstream. This experiment, which interests all countries in the region, is monitored within the research network, "Wadi Hydrology," of the International Hydrological Program of UNESCO.

The karstic systems of limestone rocks also show potential for storing water. The Figeh source, which supplies some potable water to Damascus, has a flow of 20 to 30 $m^3\ s^{-1}$ in winter and only 3 $m^3\ s^{-1}$ in summer. The plan is to stock the winter surplus, when demand is only 15 $m^3\ s^{-1}$, in the subsoil (Miski and Shawaf, 2003). A technical study on this is now under way and more scientific research is proposed with the European Union's programs.

*Institutional reinforcements:* From past experience, emergency programs in case of drought should revolve around the following points:

- Provide potable water to cities and countryside and water to livestock

- Safeguard livestock using knowledge of the forage deficit
- Provide financial support for farmers most affected by the drought
- Provide seeds to farmers, keeping in mind that employment in the countryside prevents rural and agricultural exodus

To plan and implement these programs, governments should set up structures to forecast and identify droughts. They must have access to diverse, reliable data sufficiently processed to be easily interpreted by decision makers. Such information is either a forecast or an observation. Forecasts deal with climate trends, precipitation, evaporation, water that is available and collectible, grazing ranges and harvests. Observations are made at the first sign of the drought and deal with the crisis in each region and on the efficiency of the measures implemented; they must be made during the entire drought to better prepare for future droughts.

In a FAO study on planning antidrought strategies in Morocco, M. Bernardi (1996) recommends a four-level structure where the roles of each entity are well defined:

- A base includes the information providers who regularly monitor key indicators and forecasts (Agrometeorological Committee on Drought Monitoring)
- A second level determines the impact of the drought on different sectors in country (Drought Impact Evaluation Committee)
- A third level proposes measures based on the information received (Drought Monitoring Cell)
- A top level, the prime minister's cabinet, in coordination with the planning, finance and agricultural ministers, authorizes emergency actions and proposes medium- and long-term intervention plans to the government to mitigate the effects of the drought

The strategy depends greatly upon the first level, where tools remain the least effective and to which AKST could contribute greatly:

- *Long-term forecasting:* Reliable information on future seasons would facilitate preparing and executing the most effective policies to combat drought. The investments and international support needed to mitigate its effects should be foreseen and mobilized. Long-term forecasting always is difficult and remains at continental and regional scale. On the northern shores of the Mediterranean, many programs have been started to research the consequences of global warming on water flows and on their new distribution amid the water cycle (European Environmental Research Programs).

- *Medium-term forecasting:* Medium-term forecasting is the area with the greatest expected benefits. These benefits are rapid alert systems, the rationalization of planning for strategic cereal reserves and improved exchanges of foodstuffs among countries. This gives governments the possibility of integrating climate variability into economic management (Bernardi, 1996). This forecasting relies particularly on hydraulic infrastructure, meteorological and hydrological networks and observation of agricultural production and range. WMO, UNESCO and Sahel and Sahara Observatory (OSS) programs encourage sharing information and forecasting: Med Hycos program, Alpine and Mediterranean Hydrology (AMHY) program and the environmental observatories of the Long Term Ecological Monitoring Observatories Network (ROSELT).

- *Short-term forecasting:* Forecasting during a single season is fundamental to improving forecasts for filling dams, the level of underground water tables and crop yields. Better performing models, with high spatial and temporal resolution, could furnish more reliable information during a season. This information, integrated with other data such as zones and land use, is the base of an early alert system. Progress in satellite imagery and in geographic information has contributed greatly to the development of these models.

#### 2.2.5.5 Environmental policies and regulations

Environmental problems in CWANA are desertification, deforestation, rarefaction of water resources, pollution and disease and pest epidemics. They result from human activity, technical change and climate change. Global warming could drastically change the world's agroecological zones and destabilize weather patterns, leading to an increase in incidence of severe disasters, such as drought. The environmental problems of intensive and high-input agriculture are recognized globally. In the region, main AKST environmental problems are linked to farm mechanization resulting in soil erosion, irrational use of chemical inputs and pesticides resulting in water pollution and irrigated farming resulting in overexploitation of groundwater and salinization.

The increased awareness of the challenges to environmental sustainability has led to environmental regulations and policies, which, however, are unequally implemented by the CWANA countries. In several countries, measures are being taken to diversify agricultural practices and improve efficient resource use. Crop diversity will supply useful traits. Diversity of species can provide alternative crops for agricultural diversification.

Crop diversity provides the raw material for breeding new crop varieties that can adapt to climate change. It can also provide more flexible production, better adapted to stresses like drought or salinity and can reduce soil erosion. Crop improvement can meet the challenges posed by pests and diseases and can also help reduce chemical use. A more environmentally friendly agriculture requires both crop varieties and species that can grow with fewer fertilizers, pesticides and other agrochemicals. This is a shift in breeding programs away from yield alone and may require a rethinking of crop breeding. Among many things, it will require that farmers and breeders have access to a wider range of crop diversity—including traditional varieties—as sources of useful genes and genotypes.

Organic farming is often more environmentally friendly than conventional agriculture, but may require organic farming information, standards, certification and labeling, purchase of fertilizers, pesticides and animal health care products. Organic farming has developed in Egypt, Lebanon (http://www.earthfuture.com/economy/sekemegypt.asp), Morocco, Palestine, Tunisia and Turkey (Aksoy, 1999; Kenanoğlu and Karahan, 2002).

## 2.3 History of Public and Private Sector Investment in AKST

### *2.3.1 Investments in agricultural research and development*

The investments and institutions of agricultural research and development (R&D) are undergoing rapid changes. Growth in public spending on agricultural research and development has not been consistent in CWANA. In some countries it has slowed, in others it has stalled and for some it has declined. In addition to the changes in public research, private sector investment in agricultural research has grown only in Jordan, Pakistan and Sudan.

Despite these rapid changes, information and policy analysis to inform and guide the changes underway in many CWANA countries is scant. Research is particularly lacking concerning public policies that can improve agricultural science and technology institutions, including their productivity, environmental and poverty consequences.

Investment in agricultural R&D is mostly done by public agencies in all CWANA countries. Apart from Jordan and Sudan, private sector investment is not worth mentioning, if even data on it were available. In Jordan, only 6% of agricultural research and development is private and mainly involves high-value crops and fruit trees. In Sudan, private investment accounts for 8%, mainly in sugar cane. The most private research is in Pakistan, above 15% (Ahmad and Nagy, 2001).

Among public agencies, most agricultural research is conducted by research institutions. The remaining public investment is done by higher education institutions (Table 2-12). In Syria nearly 83% of public investment is done by research institutions, the remaining 17% by agencies of higher education. In Morocco the contribution of higher education is as high as 36%, while major research, 64%, is done by research institutions.

**INSERT Table 2-12. Composition of agricultural research expenditures in selected CWANA countries, 2002 (%) (Sources: Numbers in parentheses are the percentages of researchers; ASTI, 2003a, 2003b, 2003c, 2004, 2005, 2006a, 2006b).**

In poorer countries, such as Mauritania and Somalia, public agricultural research is mostly done by research institutions. Higher education contributes little to public research in these countries. Similar patterns of research staff allocation are evident between public agencies and private enterprises and between research institutions and higher education. Most researchers are in public research institutions.

### *2.3.2 History of public agricultural research*

Detailed historical information on agricultural R&D for all CWANA countries is not readily available. The agricultural research in Tunisia, for example, began over a century ago (Aubry et al., 1986) (Table 2-13). Formal research began later in other countries.

**INSERT Table 2-13. A short history of government-based agricultural research for selected CWANA countries (Sources: Ahmad and Nagy, 2001; ASTI, 2003abc, 2004, 2005, 2006abc).**

### *2.3.3 Human resources in public agricultural research and development*

During the last three decades the number of agricultural research staff in many CWANA countries grew steadily, to more than 2%. Also, the quality of research staff has improved considerably over the last years.

In Jordan, nearly 61% of the 245 full-time researchers had postgraduate training and more than a third held a doctorate degree. The percentage of postgraduates in Morocco (ASTI, 2005) and Tunisia (ASTI, 2006a) was over 90% In contrast, only 25% of the agricultural researchers in Syria held masters of science and doctorate degrees (ASTI, 2006b).

Despite a rise in the number of women pursuing scientific careers worldwide, female researchers are still underrepresented in senior scientific positions. In 2003, less than 13% of the researchers in Jordan were female. This is low compared with other countries, such as Morocco (18%), Syria (23%) and Tunisia (28%). Women represented 5% of researchers with a doctorate degree, 17% with a master's and 19% with a bachelor's. In Syria, 23% of all researchers employed in public institutions in 2003 were female, including 5% holding a doctorate degree, 36% with a master's degree and 26% with a bachelor's (Table 2-14).

**INSERT Table 2-14. Educational attainment of researchers and share of female researchers for selected CWANA countries (Sources: ASTI, 2003abc, 2004, 2005, 2006ab).**

In Sudan, 79% of the 591 researchers had postgraduate training and one-third held a doctorate degree. In 2000, nearly 28% of full-time researchers were female, including 17% holding a doctorate degree and 26% with a master's degree.

In 2002, approximately 91% of the 362 researchers in Tunisia had done postgraduate work and 70% held doctorates. By comparison, 34% of agricultural researchers in Morocco held doctorates in 2002. Tunisia's particularly high PhD share is partly because the minimum qualification required for researchers in Tunisia's higher-education institutions is a master's in science (ASTI, 2006a). On average, 28% of all agricultural researchers were female. This is considerably higher than the 18% for Morocco in 2002. Both the share of female researchers overall and of those holding doctorate degrees are expected to rise in the near future. Over 50% of currently enrolled students of agriculture are female and many are finishing PhD degrees (ASTI, 2005).

### *2.3.4 Research intensity in public agricultural research and development*

Total agricultural R&D spending as a percentage of agricultural output (Ag GDP), defined as research intensity, is commonly used to compare research investments across countries (Table 2-15). Jordan, for example, invested US$2.83 for every US$100 of agricultural output in 2003, which was a substantial increase over the 1996 ratio of US$1.61 (ASTI, 2006c). The 2003 ratio was also considerably higher than the average for CWANA, 0.66% and for the industrialized world as a whole, 2.36%. The high ratio of research intensity in Jordan does not reflect high research investment in agriculture; rather it indicates agriculture's small share of the country's gross domestic product (GDP).

**INSERT Table 2-15. Research intensity in public agricultural R&D in selected CWANA countries (Sources: ASTI, 2003abc, 2004, 2005, 2006ab)**

Syria invested US$0.53 in agricultural research for every US$100 of agricultural output in 2003. This was similar to the reported 2000 average for the developing world, but was lower than the average for CWANA, US$0.66. In 2000, Sudan invested US$0.17 for every US$100 of agricultural output. Sudan's research intensity declined, considerably lowering its ranking among other countries in the region. The 2000 intensity ratio was less than half of that in 1981 and 1995., Even though 1995 had 0.33% intensity, it was low compared with averages for Africa, 0.84% and for the developing world 0.62% (ASTI, 2003c).

In 2002, Tunisia invested US$1.04 for every US$100 of agricultural output. This was an increase over the 1996 intensity ratio of 0.78% and was slightly higher than the 0.95% in 2002 for Morocco (ASTI, 2005). Tunisia's and Morocco's 2002 intensity ratios were higher than the 2000 ratios for the CWANA region, 0.66% and the developing world as a whole, 0.53%. The low world investment in agricultural research requires greater investment in CWANA countries.

### *2.3.5 Returns to investments*

Investments in agricultural research have contributed greatly to the well-being of farmers, processors and consumers through new knowledge and technology. However, there remain more than 800 million undernourished people, mostly in developing countries, including CWANA, who need significant increases in local production to improve their food security (CGIAR, 2005). For CWANA countries and other developing countries increases in agricultural production and technology that improve disease resistance and drought tolerance and sustain natural resources are needed to lessen the widening food security gap.

The benefits of investing in agricultural research greatly outweigh the costs. To sustain research that will alleviate poverty and reduce food insecurity, governments must invest more in agricultural research. The effect of research achievements go far beyond the outputs by research organizations. It involves all players between R&D, including research organizations, communities, extension systems, development agencies and policy makers.

Previous studies provided overwhelming evidence that investment in agricultural research has delivered real benefits to poor farmers and consumers through new crop, livestock, fish, forest and farming technology. These improve both productivity and farmer income and help protect the environment, thereby contributing to poverty reduction (Evenson and Gollin, 2003).

The Science Council of the CGIAR commissioned an independent study to compare the benefits from its research against the cost of operating the whole CGIAR system up to 2001. The most conservative assessment yielded a benefit to cost ratio of 1.9:1, meaning the CGIAR generated an indisputable return of nearly two US dollars for every US dollar invested (Raitzer, 2003; CGIAR, 2005). The most generous scenario yielded a benefit to cost ratio of 17.2:1 (CGIAR, 2005). This means the total investment in CGIAR from 1960 to 2001 of US$7 thousands Million will generate US$ 123 thousands Million in benefits by 2011 (all calculated in 1990 US dollars). Yet even this highly favorable result probably understates the total return on investment because it does not include the following points (Gregersen, 2003):

- Benefits from CGIAR's many research areas that are inadequately documented or inherently difficult to assign a value, such as influence on policy and natural resource management
- The multiplier effect, by which every US dollar of farm income contributes an additional US$0.5 to US$1 to the local nonfarm economy through higher demand for other products and services
- Land savings and their invaluable contribution to protecting biodiversity and watersheds, gained from intensified cropping of existing farmland.

While the CGIAR system has demonstrated great international influence through scientific achievements and its pivotal role in the Green Revolution, it accounts for only a small fraction of the global agricultural R&D expenditures. In 2002, CGIAR accounted for 1.5% of the USD 23 thousands Million global, public investment in agricultural research and just 0.9% of all public and private agricultural research (CGIAR, 2005).

In line with food production trends in other developing countries, food production increases in CWANA the last four decades are attributed to many factors. These include crop genetic improvements and other research contributions, expansion in fertilizer use and pesticides, expansion in irrigation with improved efficiency, mechanization, better farmer education, improvement in transportation and marketing infrastructure and policy reform.

Evenson and Gollin (2003) assessed the effect of crop variety improvement on productivity:

- For all crops combined, the rate of improved varieties production increased each decade the last 40 years.
- Technological advances occurred in all crops, on all continents and in all agroecological zones, although these advances have been uneven.
- The progress achieved is related to the effort expended on research and the existing "stock" of research done on similar crops and growing environments. The internal rates of return on research suggest that public expenditures in agricultural research achieve high dividends. Studies of international and national investments in barley germplasm improvement, for example, indicate the return rate was up to 51% for Morocco. Iraq and Tunisia attained a return rate 38% for their research investment, while Egypt had 32% and Jordan had 31%. Algeria, Ethiopia and Syria estimated return rates lower than 30% (Aw-Hassan and Shideed, 2003).

The rate of adopting improved barley varieties is growing in several CWANA countries. High adoption was reported in 1997 for Egypt (50%), Jordan (50%) and Tunisia (40%). Relatively low adoption was reported in Morocco (19%), Iraq (14%) and Ethiopia (11%). Algeria and Syria, two large producers, had the least adoption, 5% or less of the total barley (Aw-Hassan and Shideed, 2003).

Similar adoption patterns of improved lentils are reported for some CWANA countries. The national research program of Pakistan reported about 32% of the lentil area in the targeted region is planted with improved lentil varieties. About 25% of lentil area in Iraq and Syria is planted with improved varieties.

## 2.4 Market Trends and Socioeconomic Evolution

### *2.4.1 Agriculture market shares of CWANA in global and regional markets*

The comparative advantages and natural endowments in some countries form the basis of their competitiveness in international markets. South Asia and West Asia standout as important exporters of most agricultural products, while the Nile Valley and Red Sea and the North African countries are importers of agricultural products.

#### 2.4.1.1 Place of CWANA in international trade of cereals

South Asian and West Asian countries are leading players in grain exports. Their grain exports increased tremendously, climbing from less than 100,000 Tonnes from 1961 to 1965 to more than $5\ 10^6$ Tonnes in 2001 to 2004. Grain exports also increased considerably between the mid-1980s and mid-1990s. Kazakhstan is the most important exporter in the region, followed by Pakistan and Turkey. The CWANA region’s share in total world exports is only 4%, despite these three countries. North America had 37% of the total grain exports for 2001 to 2004, while Western Europe had about 20%. Together, these two blocs had half of the world’s grain exports. However, the export grains differ from one country to another; Kazakhstan and Turkey mostly export durum wheat, Pakistan exports rice.

Despite these significant cereal exporters, CWANA stands out as a net cereals-importing region. Aside from Central Asia and the Caucasus, all CWANA subregions have negative trade balances and the gap between the exports and imports of the CWANA region has widened annually at an average rate of 5.1% between 1961 and 2004. With a deficit of approximately $43\ 10^6$ Tonnes of cereals from 2001 to 2004, the region is just behind Asia. The North Africa, Nile Valley and Red Sea subregions have the highest demand for cereal imports (figure 2.4). However, the biggest increase in cereal imports is in the North African countries. This dependence on international markets for food supply is a great economic constraint for the North African, Nile Valley and Red Sea countries, resulting in significant public budget deficits. Poor natural endowments for grain production coupled with poor rural livelihood and increasing rural to urban migration create considerable social and economic instability.

**[INSERT Figure 2.4]**

The processing industry is developing all over the world. Developing countries improved the technology and productivity of their food processing industries. Wheat flour milling is a primary industry that flourished in CWANA from the 1960s and the present. As a consequence, wheat flour exports increased considerably, to almost a fifth of the world total wheat flour exports in the 2000s. More than half the CWANA exports, 56%. is generated by South Asia and West Asia. Among the different regions worldwide, CWANA stands out with the most biggest annual average growth rate, 8.2%. This comes from the large increases in Central Asia, Caucasus, South Asia and West Asia (Table 2-16). North Africa increased its total exports during 1996 to 2000, while exports of wheat flour from the Nile Valley and Red Sea subregions witnessed a significant drop during the 2000s. Meanwhile, the market shares of developed regions, North America or Western Europe, saw a tremendous decrease since the early 1990s, a consequence of the development of the milling industry in developing regions. This U-turn will probably continue for food processing in industrialized regions specializing in high-value products. The developing world will invest more in primary processing for the domestic market and exports.

**INSERT Table 2-16. Evolution of the cereals trade balance of CWANA region and other main regions of the world between 1961 and 2004 (1,000 tonnes) (Source: FAOSTAT).**

2.4.1.2 Place of CWANA in international trade of oil crops

Most CWANA subregions that exported oilseeds in the 1960s became dependent on the international markets for their domestic supply. The downward trend started during the mid-1980s, pulling the region's trade balance toward the deficit side since the early 1990s. The abandonment of public policies encouraging oilseed production, mostly in Turkey, had a negative effect on production. The established oil-processing industries started to import most of their raw material from international markets. This deliberately chosen strategy, designed in Turkey and agreed upon by both public authorities and oil processors, saw advantage in the low world prices. Because of this deliberate choice in most CWANA countries, the entire region became dependent on international commodity markets for oilseed. Other developing regions more or less followed the same trend; North America, Latin America, the Caribbean and Oceania saw their shares increase tremendously. Western Europe, already dependent on international oilseed markets for its domestic supply, witnessed its deficit deepen. The most significant oilseed deficit is in Asia. This region had a surplus oilseed trade balance of more than 1.5 $10^6$ Tonnes in the early 1960s, but it had a 7.7 $10^6$ Tonnes oilseed deficit in 2001 to 2004, primarily from the sourcing strategies of multinational enterprises. This international division of world commodity markets may be an important constraint for CWANA, if these countries cannot develop activities to creating wealth to replace products abandoned the last four decades.

2.4.1.3 CWANA in international trade of processed food

A direct result of urbanization and the increase in urban purchasing power is the increased demand for processed food. As economic employment of women increases, family structures move toward nuclear families. In nuclear families the parents and children form the nucleus, so meals prepared by female family members other than the mother decrease. At the same time, families are starting to live farther and farther away from work and school, causing a decrease in time spent at home and an increase in the demand for ready-to-eat meals. In addition, the share of meals eaten out by families increases. In the CWANA countries, a rather hybrid sociocultural structure can be observed. When there are extended family structures including grandparents and younger siblings of the parents, typical fast-food consumption patterns are developing. Accordingly, industrial processing enterprises focus on generic products; fresh dairy products, cheese, biscuits and pasta, beer and soft drinks are being manufactured at a rapid pace. Also, export industries, based on traditional agricultural products, are developing an industrial structure. In this panorama, exports increase as a result of the gain in international competitiveness among the national food processing enterprises, while processed food imports also increase from increasing domestic demand for more sophisticated, high-value food.

In CWANA, the total processed food exports doubled between 1961 and 2004, the highest increase realized by Turkey. However, as the other regions developed their processed food exports more rapidly than CWANA, the CWANA share in processed food exports worldwide fell from 14.3% in 1961 to 1965 to 2.7% from 2001 to 2004. The main winner in this development is Asia. China’s industrialization in food now challenges the Western European food processing industry. Latin America and the Caribbean also are promising challengers.

In the evolution of processed food imports, the CWANA share increased from 5.7% of world imports from 1961 to 1965 to 6.6% from 2001 to 2004. Just behind South Asia and West Asia, the Arabian Peninsula is an important importer. North Africa, Nile Valley and the Red Sea also drastically increased their imports in processed foods.

2.4.1.4 CWANA in international trade of fresh fruits and vegetables

Most CWANA countries have comparative advantages in fresh fruits and vegetables. Increasing demand from developed countries for fresh produce has had a positive spillover on organizing and developing exports. Morocco and Egypt have long had an export tradition. During the last three decades they have gained important organizational skills in this area. Turkey, Iran, Syria and Pakistan are relative newcomers, having entered the export scene in the early 1980s; their export volume, however, is increasing at a growing pace. As other regions of the world also have gained important market shares in fruits and vegetables, the CWANA world share fell from 12.2% to 8.9% between 1961 and 2004 and its annual average growth rate stayed slightly lower, 2.6%, than the annual average growth rate worldwide, 3.4%. The winners were in Asia. High growth came to China, India, Latin America and the Caribbean. Because of the high value of fruits and vegetables, North America and Western Europe have remained strong in world competition and have increased their exports with annual growth rates between 3 and 4%.

CWANA exports are not yet very significant: fresh fruit and vegetable exports from Central Asia and the Caucasus, 7.1% per year and the Arabian Peninsula, 9.5% per year. But these grew faster than exports from other CWANA subregions. Total export volumes of South Asia, West Asia, the Nile Valley and he Red Sea constantly increased, while those from North Africa trended downward during the last four and a half decades. Among the traditional exporting countries, Turkey increased its exports volume by 16 times and had 2.3% of the fresh fruits and vegetables exports worldwide from 2000 to 2004.

#### 2.4.1.5 CWANA in worldwide imports of meat

Demographic pressure in the entire CWANA region had negative effects on its international trade balance. Meat imports increased with an annual growth rate of 8.2% from 1961 to 2004, with the most significant increase in the Arabian Peninsula. Despite big increases in total meat production within the different countries, the total dependence ratio of most CWANA countries increased from high demographic pressure. As a result, CWANA is the most important meat importer in the world, just behind Asia and just before Latin America and the Caribbean. The annual average increase of total imports in the region is two times, 8.2%, the world annual average increase, 4.3%. Large increases in poultry meat production are not enough to fill this gap, which widens each year. Meat imports in the Arabian Peninsula multiplied tenfold between 1961 and 2004. Meat import volumes of the other CWANA subregions multiplied 10 to 20 times. Lebanon, Jordan and Iran in South Asia and West Asia, Algeria and Morocco in North Africa, Kazakhstan in Central Asia and Egypt and Yemen in the Nile Valley and Red Sea stand out as the most significant meat importers. All regions in the world, developing and industrialized countries, increased their meat imports during these four decades, although the annual average increase rates in industrialized regions were lower than the rates in the developing regions.

#### 2.4.1.6 CWANA in world imports of feeding stuff

While the meat and milk imports of CWANA increase at a significant pace, government subsidies and other measures to encourage the development of livestock production in most of the countries continue. As a result, feed imports increased considerably in volume and value in most countries. While milk husbandry and poultry became dependent on feed imports, extensive transhumant animal raising still continues to prevail as the significant system in Algeria, Egypt, Iran, Morocco and Yemen as well as in the Caucasus, Central Asia and West Asia. As a consequence of importing feed in CWANA, its share in world imports increased from 0.9% from 1961 to 1965 to 7.5% from 2001 to 2004.The imports took off in the mid-1970s. Despite this significant growth, CWANA lags far behind Western Europe's and Asia's shares in world imports. Western Europe had a 52% share and Asia 20% of animal feed imports from 2001 to 2004. In light of the growing need for animal feed in livestock production, the upward trend of world imports seems likely to continue, most particularly imports in CWANA.

### *2.4.2 Changing lifestyles, consumer preferences and demands*

Urbanization is, by far, behind the changes in people's lifestyles. Economic, social, cultural and spatial factors are pushing urban families to live and to consume differently. Changes in family structure, in work, residential patterns and improvement in urban infrastructure drive many urban consumers towards standardized, industrialized and globalized consumption patterns, even if their habits and preferences are largely influenced local tastes and traditions.

Despite these changes, enhanced by urbanization and elite urban groups, purchasing power is still the main determinant of consumption in developing countries. Food expenditures are more than 40% of household expenditures in most CWANA countries and exceed 60% of in rural households. In comparison, approximately 15% is spent for food in developed countries. The high ratios show the vulnerability of consumption patterns in CWANA and the importance that food has in a transition toward a market economy. If households cannot achieve satisfactory disposable income, they will rapidly be exposed to undernourishment.

Most of the countries in CWANA have human development index (HDI) numbers lagging drastically behind industrialized countries. Highly skewed income distribution, lack of rural infrastructure and poor urban squatter districts result in unequal access to education, health facilities and healthy food. The oil-rich countries of the Arabian Peninsula have HDIs higher than those of other CWANA countries. Oman showed the most dynamic evolution, nearly doubling its HDI between 1975 and 2004. The countries of Central Asia and the Caucasus have HDIs stagnating or falling since the 1990s, illustrating how difficult it is for these countries to develop free market economies. Uzbekistan and Tajikistan seem to be the worst off. In South Asia and West Asia, all countries have HDIs around 0.71 and 0.77, according to 2004 UNDP estimates, except Pakistan, which has an HDI well below the CWANA average. 0.539. Trends from 1975 to 2004 are positive, showing a dynamic evolution for most of the countries of South Asia and West Asia. In North Africa, Mauritania has 0.486 and Morocco,0.64, the lowest HDIs, far below the world average. In the Nile Valley and Red Sea subregions, all countries have HDIs below the world average. The high disparities in the standards of living, coupled with poor rural livelihoods, reinforce the high risks concerning the food security, especially in countries with difficult living conditions—Djibouti, Mauritania, Pakistan, Sudan and Yemen,

In 1969/1970, food production within some CWANA countries was almost adequate to meet demand; the self-sufficiency ratio for all cereals was nearly 90%. However, the food gap continued to widen over the last three decades. Expanding agricultural production, 2.9% annually, failed to keep pace with the rapid growth in demand and self-sufficiency ratios declined. According to FAO estimates, this trend is expected to continue (Alexandratos, 1995). However, throughout CWANA, undernourishment has been under control since the late 1960s. In the Arabian Peninsula, North Africa, the Near East and Middle East, less than 10% of the population is declared undernourished. The exceptions are Pakistan and the Occupied Territories of Palestine. In the Nile Valley and Red Sea subregion, Egypt stands out as the country with the least of its population undernourished, but in both Djibouti and Sudan one-quarter of the population is undernourished and in Yemen more than one-third. Difficult economic conditions in Central Asian countries have negatively affected food security since the early 1990s. In Armenia, Tajikistan and Uzbekistan, one-quarter to one-half of the populations are estimated to be undernourished, according to preliminary FAO data. Azerbaijan and Kyrgyzstan seem to have reduced undernourishment since the early 1990s.

The general nutritional status of the CWANA countries has improved. Significant progress was made in raising the per capita daily food consumption in kcalories per person, the key variable measuring and evaluating the world food situation. The average national food consumption per person in CWANA has increased quite satisfactorily since the 1960s and will likely continue. This is projected to increase from 3006 kcalories in 1997–1999 to 3090 kcalories in 2015 and close to 3170 kcalories by 2030. (figure 2.5).

**[INSERT Figure 2.5]**

In addition, the per capita daily food intake changed, particularly in the oil-rich Arabian Peninsula countries. The increased consumption of meat, particularly poultry and eggs, milk and milk products, fats, oils and nuts has been spectacular. North African countries, thanks to imports, increased dramatically their consumption of cereals, starchy roots (mostly potato), sugar and other sweeteners, milk and milk products. All, particularly South Asian and West Asian countries, are great consumers of fruits and vegetables, although the difference between the world average and the CWANA average seems narrow. While the average consumption worldwide of fruits and vegetables has increased, the consumption in CWANA has decreased from their high consumption in the 1960s. The average daily food intake in all CWANA continues to be dominated by vegetables, with animal products, especially meat, eggs, fish and seafood lagging far behind world averages. When compared with consumption in industrialized Western countries, this gap is even wider. The relatively high consumption of pulses somewhat narrows this protein gap.

Finally, it must be remembered that the progress shown by the positive figures for daily food intake between the 1960s to the 2000s do not reflect the uneven food distribution among the socioeconomic classes and poor rural areas.

### *2.4.3 Local markets and marketing channels*

Market accessibility is becoming key to rural development. The lack of links between rural and urban areas is the largest constraint to improving rural livelihood. In addition, most farmers in CWANA are small landholders and have limited money to invest in new technology to improve their yields.

Since the mid-1980s, governments have improved the facilities for agricultural produce and market access for small landholders. In Tunisia and Morocco milk collection centers have considerably helped increase marketed milk. In Turkey, successive governments oriented public credits through agricultural cooperatives to install greenhouses in horticultural regions and improve the conditioning facilities for fresh produce. However, despite these measures, most agricultural and livestock production is marketed through long marketing channels where middlemen keep much of the value created in supply chains; landholders mostly receive less than 30% of the final market price.

Traditional marketing channels, from the farmer to the consumer, comprise many marketing agents: the village tradesman, commissioner, wholesaler, industrial processor, retailer for the domestic market and the village tradesman, commissioner, wholesaler and exporter for exported products. These long marketing channels are harmful for the quality of agricultural and food products and for the food safety. The poor quality and small volume of agricultural produce create bottlenecks for industrial processors and exporters. In addition, the many middlemen increase the price consumers pay for food, while farmers do not benefit.

The penetration of large Western retailers is changing the domestic markets of developing countries (Reardon and Berdegué, 2002). Countries of CWANA are no exception to this new trend. Large-scale retailers bring their logistic services and the effects within domestic markets are rapid and spectacular. The high volume and standardized products demanded by these large retailers rapidly transform the structure and functioning of the supply chains and much consolidation happens amid the domestic wholesalers and retailers. Suppliers diminish in number and the small, family-owned, traditional grocery shops quickly disappear. Agrifood market institutions are greatly affected by the rapid rise in private standards and a gradual rise in contract use (FAO, 2004).

### *2.4.4 Labor market*

Rural to urban migration and urbanization in CWANA countries since the early 1970s changed the structure of labor markets considerably. The migration dropped significantly the percentage of the economically active population in agriculture (figure 2.6). Even in the Nile Valley and Red Sea subregion, where the percentage of those active in agriculture is highest, the drop is considerable, an average of 72.6% from 1961 to 1965. 55.9% from 1986 to 1990 and 44.6% from 2001 to 2003. Central Asia and the Caucasus have 24% of the economically active population in agriculture and the Arabian Peninsula 9%. In North Africa, where rural-to-urban and cross-border migration is significant, the share of agriculture in the economically active population fell drastically, to less than 30%. In South Asia and West Asia this share is uneven from one country to another. In Afghanistan 66.3%, Pakistan 46.1% and Turkey 44.8% of the total economically active population was still occupied in agriculture in 2001 through 2003; in Lebanon only 3.2% for the same period.

**[INSERT figure 2.6]**

Another prominent point is the increasing participation of women in economic activities in this region. The average for the economically active female population in the total economically active population for CWANA was around 33% for 2001 through 2003, while the world average was around 41%. However, there are important differences from one subregion to another and from one country to another. Central Asia and the Caucasus 46.9%, Egypt 45.7%, Mauritania 47.6% and Somalia 43.4% have ratios above the world average. Turkey has around 38%. In other CWANA countries the share of economically active women is between one-quarter and one-third of the total population. These two trends affect the overall labor supply growth figures. These figures continue to grow at high rates, reflecting high population growth, inflows from rural-to-urban migration and increasing female economic participation (Tzannatos, 2000). However, the urban formal sector is not sufficiently developed to absorb this labor excess because of the slow industrial growth rate. Informal activities are the largest source of income for the recently urbanized populations (Tzannatos, 2000). This large shift from high-paying formal jobs to low-paying informal jobs reduces the income of recently urbanized households considerably. A vicious cycle is in place; less educated people are employed only informally, diminishing household income and giving less chance for their children to become well educated and attain higher-paying formal jobs.

These negative trends are accentuated by macroeconomic changes in most of these countries. In some Arab countries relying on oil exports, the decline in oil prices during the 1980s negatively affected the investments in these countries. In Algeria, Egypt, Morocco, Turkey and Central Asian countries the retirement of the public sector from economic activities negatively affected public employees. Last but not least, after the Iran–Iraq and Gulf wars, countries with significant out-migration, Egypt, Jordan and Turkey, faced falling demand for their citizens abroad. Remittances and social compensations from workers in Western Europe and oil-rich Arab States declined in Algeria, Mauritania and Sudan and stagnated in Turkey. This result hurt the purchasing power of many urban and rural households in CWANA. Most CWANA countries are not ready to absorb the increasing labor supply and huge infrastructure investments needed to boost the nonagricultural labor demand. The quality of this labor is another huge problem for which simple solutions cannot be soon found; long-term investments are necessary.

#### *2.4.5 Findings*

The different development of CWANA countries must be reiterated. There is a great need to establish field studies using local surveys to analyze and assess the marketing conditions in the different regions of these countries. A global view does not take into account the important differences among countries and among the regions within countries. Problems in the Turkish agricultural sector cannot be considered similar to problems in Algeria, Djibouti or Sudan, nor can improvements in the agricultural sector of Pakistan be compared with improvements in Saudi Arabia.

This global assessment indicates that CWANA countries are losing their comparative advantage in most agricultural sectors. Recently developed sectors, livestock raising or fresh fruits and vegetables, create a certain dependence on modern inputs. No country can function with complete autonomy; all these countries need each other for products for which they do not have comparative advantage. Nonetheless, this need must create value and wealth for the developing CWANA countries and emphasize the urgent need to develop knowledge and technology to challenge the world status quo.

### 2.5 Technology Transfer and Adoption

#### *2.5.1 Scaling-out approaches for technology adoption and transfer*

The generation of improved technology and assuring that farmers use them are key to crop productivity and improving farmer livelihoods. The lack of trained research and extension staff in most developing countries is largely responsible for these improved technologies being generated but not used. Technology transfer requires close cooperation among all concerned stakeholders, including farmers, research and extension staff and governmental and nongovernmental organizations. International agricultural research centers (IARCs) in the region, of which ICARDA is one, can work closely with national policy and decision makers and with various stakeholders.

NARS in the CWANA region differ in their human and physical resource capacities, needs and operational resources. In most countries of the region, priorities for agricultural research and human resource development depend, to a large extent, on the available financial resources and stem from a national desire to decrease dependence on food imports. Priorities, often set by policy makers belonging to different institutions, are transferred to research, extension and training specialists with limited room for interaction or feedback.

In most CWANA countries, agricultural research and extension are still handled by separate public institutions, with different mandates and operating systems. In the prevailing model for generating, transferring and adopting technologies, the new technologies—either superior genetic material or improved production packages—are developed by researchers then passed on to extension agents to demonstrate and disseminate to farmers. This model does not incorporate a feedback system from farmers to researchers or among research, extension and development agents. This drawback has deterred the development and transfer of technology appropriate for small-scale, resource-poor farmers, particularly those in low-potential, heterogeneous agroecological areas.

Adaptive research, such as on-farm verification and demonstration trials in farmer fields, must complement research to realistically evaluate any new technology. It provides an excellent opportunity for the farmers whom the new technology is meant to benefit to participate, learn about and gain confidence. Adaptive research also builds up and strengthens the research–extension–farmer–policy maker dialogue. Social and economic value and aspects of the tested technologies can also be evaluated and compared with existing practices. On-farm research ensures a feedback mechanism among farmers, scientists and policy makers. Such a mechanism, if effectively linked with extension services, helps research systems set priorities and adjust continuously and adequately to evolving farm circumstances (Swanson et al., 1988).

In collaboration with NARS in CWANA, ICARDA conducts adaptive trials and demonstrations in farmer fields that offer excellent opportunities for organizing field days and visits to promote new technologies. Scientists, extension specialists, farmers, seed specialists, government officials, representatives from international and regional organizations and representatives from universities and the donor community participate in the field days, to discuss the new technologies applied under farmer conditions.

To achieve higher development and uptake of innovations, it has been recently proposed (Ceccarelli and Grando, 2007) that the traditional linear sequence of researcher to extension to farmer be replaced by a team approach, with scientists, extension staff and farmers all participating in all major steps of developing a new technology.

#### 2.5.1.1 Agricultural extension and applied research project: case study

A pilot travel and visit (T&V) extension approach was introduced in Turkey in 16 towns through the Agricultural Extension and Applied Research Project (TYUAP) (Kumuk and van Crowder, 1996; www.aari.gov.tr). Reorganization of extension in towns and villages under the T&V system emphasized a group of specialists who do research and train in addition to extension work.

The major differences between conventional extension and the T&V approach are extension and research links, individual instead of group contacts and regular on-the-job training. The T&V approach tends not to involve extension workers in supplying inputs for farmers and focuses more on specific crops.

The T&V extension experience in Turkey suggests that the extension team approach is a more effective way to tackle the problems of mixed-crop farming systems. Multidisciplinary extension teams live and work in towns and villages, focusing on local problems using farming systems approaches and participatory methods. Extension workers and farmers supported by researchers who are subject matter specialists collaborate to make decisions and to analyze problems, plan solutions, implement activities and evaluate results. Farmers, collaborating with extension agents and researchers, participate in designing, evaluating and adapting proposed agricultural technologies. As this case study shows, the T&V approach has scope to contain a participatory team. The characteristics of this approach are described here (Kumuk and van Crowder, 1996):

- Emphasis in all activities on farmer participation to achieve extension relevance and sustainability; emphasis oriented toward issues and problems, on organizing farmers to participate in developing and disseminating technologies and on assessing farmer problems, needs and resources for proposing farming modifications
- Extension efforts oriented toward farming systems and household economy of groups of farmers as opposed to focusing on particular crops or commodities
- Use of both mass media and face-to-face communication, with farmers participating in designing and delivering the message, which is communicated to audiences with similar characteristics

- Strong links established with research, other development efforts in the area and farmers through a team approach that emphasizes consulting and collaborating with farmers
- Emphasis on providing advice, to educate rather than transfer technology, to provide regular in-service training for extension workers and team farmers and to assess the technology by using group activities

When basic elements of the T&V system are maintained, such as regular in-service training and an improved research-to-extension link and the extension team approach is introduced in towns and villages, the resulting extension system should be better suited to the needs of Turkish farmers, giving them an active role in generating, evaluating and diffusing technology. The design of such a system will require harmonizing T&V with the existing system and using a participatory team approach to extension.

During the project life, extension expenditures increased eight-fold. In the project area, the extension cost per farmer was 27% higher than the national average and the expenditure per extension worker was about 28% higher. Project costs were associated with increases in extension staff, increases in coverage and intensity of extension activities and increases in operational and training costs. The impact was impressive: about 65% of the 85,300 farmers in the area were in direct contact with extension through the various field activities. In production increases, wheat increased 76%, barley 64%, rice 86%, cow milk 65% and goat milk 128%. Overall, agricultural productivity in the project area, measured by the value of the agricultural domestic product in the two provinces, increased 11-fold. While other factors undoubtedly contributed to this increase, improved extension was a major factor.

For the further improvement of TYUAP, a new program called TAYEK (Agricultural Research, Extension and Training Coordination) was organized and applied to better coordinate all sectors and stakeholders of agriculture, facilitating technology transfer for development. TAYEK also includes the farmer field school (FFS) approach. The collaboration with TYUAP and further with TAYEK was helpful for the public and for raising local awareness about in situ and on-farm conservation of genetic and plant diversity in Turkey.

#### 2.5.1.2 Farmers field schools

Farmer field schools (FFS) have become an innovative, participatory and interactive model for educating farmers in Asia, many parts of Africa, Latin America and more recently in the Middle East, North Africa and Eastern and Central Europe. The approach was originally developed to help farmers tailor integrated pest management (IPM) practices in diverse and dynamic ecological conditions. The knowledge acquired as they learn enables farmers to adapt current technologies or to test and adopt new technologies to be more productive, profitable and responsive to changing conditions.

Farm field schools in IPM started in 1989 in Indonesia to reduce farmer reliance on pesticides in rice. Policy makers and donors were impressed with the results and the program rapidly expanded. The experience generated in Asia was used to help initiate IPM FFS programs in other parts of the world. New commodities were added and these programs were encouraged to adapt them locally and institutionalize them. At present, various IPM FFS programs are being conducted in over 30 countries.

In the Near East and North Africa, FFS were first introduced in Egypt in 1996 with two Egyptian-German projects implementing IPM FFSs on cucumber, tomato, citrus, mango and cotton. Several modifications were made to adapt to local conditions and the FFS were renamed farmer learning groups. Several other initiatives followed to organize pilot FFS based on the original concepts. In 2003 ICARDA started a regional FFS project in Syria, Iran and Turkey to extend IPM for sunn pest management in wheat and barley. In Kyrgyzstan the FFS approach was introduced in 2003 for cotton. Uzbekistan introduced it through an FAO-supported project on managing irrigated lands that were salt affected and gypsiferous.

A two-year regional IPM project in the Near East started in 2004, funded by the Italian government, to develop a strategy adapted to local ecosystems that would achieve high-quality production in fruits and vegetables compatible with export requirements to target European markets. The project involved Egypt, Iran, Jordan, Lebanon, Palestinian Territory (Gaza and the West Bank) and Syria. It was expected to establish and strengthen the FFS extension approach to promote IPM technology among Near East farmers.

Another FAO-supported regional project began in 2004 in Algeria, Egypt, Ethiopia, Morocco, Sudan, Syria and Tunisia on training in management of a parasitic weed, orobanche, in leguminous crops (Braun et al., 2006).

### *2.5.2 Traditional knowledge in CWANA*

Traditional knowledge (TK) is a cumulative body of knowledge, know-how and practices maintained and developed by people with extended histories of interaction with the natural environment (ICSU, 2002). It developed from experience gained and adaptations made to the local culture and environment. It is mainly practical in nature and provides the basis that enables communities to make decisions about many fundamental aspects of day-to-day life.

TK is the adaptive and decision-making skills of local people, learned and transmitted through family members over generations; strategies and techniques developed by local people to cope with sociocultural and environmental changes; time-tested natural resource management practices that farmers accumulate through experimentation and innovation (Warren and Rajasekaran, 1993). Traditional knowledge related to agriculture includes information on which farmers, consciously or unconsciously, base decisions related to their production systems (Brokensha et al., 1980; Warren et al., 1989, 1995).

Traditional knowledge is dynamic, resulting from continuous experimentation, innovation and adaptation. It is difficult to determine the historical depth of traditional practices when documentation on the past is lacking or insufficient. For example, since the birth of agriculture, farmers, fishers, pastoralists and forest dwellers have been managing genetic diversity by selecting plants and animals to meet environmental conditions and food needs in the Near East, North Africa and Central Asia. Farmers transfer this knowledge from one generation to the next. People originate TK; recognized and experienced people transmit it. Such knowledge supports diversity and enhances local resources.

Traditional and local knowledge is part of a complex system; it cannot be reduced to a list of technical solutions or restricted to a series of different applications for results to be attained. Its efficacy depends on the interaction among several factors that need to be carefully considered to understand the historical successes it has achieved and to use its internal logic to find modern solutions.

Each traditional practice is not an expedient to solve a specific problem but always a studied and often multifunctional method applied in an integrated approach including society, culture and economy. It is closely linked to a concept based on careful management of local resources.

Many experts and scientists have doubts about the basis of TK and do not give it enough credence in development planning (Howes and Chambers, 1980). Thus development projects may be designed without taking into consideration the effectiveness of traditional agricultural practices.

Ethnographic studies in CWANA on traditional farming systems indicate that local farmers have detailed knowledge of their local environment. Most practices are not arbitrary, even if some farmers may not be able to explain them. In traditional sustainable systems, the cumulative experience of generations of farmers shapes a wide range of practices that contribute to crop productivity and protection in different ways. It is important to examine the range of practices in traditional systems because they are key to sustainability. The system is often designed to prevent or minimize pest and disease problems through indirect methods.

Traditional knowledge represents the accumulated body of experience of people who are well aware of their situation, physical and biological environment and production systems. They are also aware of the possible effect a change in one factor will have on the other parts of the system. The quality and amount of TK varies among community members; it also depends on age, gender, social status, intellectual capability and professional occupation (Warren and Rajasekaran, 1993).

Traditional knowledge is usually specific to locality. A good example is the agricultural calendar used by people of a region. Local farmers set the time for planting not by written schedules but by their observations of star risings and settings, the position of the sun's shadow and observable changes in the seasonal cycle, such as bird migration and the appearance of certain insects or plants. With this TK calendar the farmer determines a planting time that will provide a productive crop given the probability of rain and flooding and the menace of pests and diseases. In Yemen, for example, farmers use the local shadow scheme or local star calendars to define planting time. Those observations are rarely applied outside a specific context or local region (Serjeant, 1974; Varisco, 1985, 1993).

In recent years, working to recognize, validate and maintain traditional knowledge has been a substantial project component. Initiatives have been developed that strengthen traditional knowledge systems. The more extractive approaches of traditional ethnobotanists keep TK in context and not completely protected. In fact, the number of international forums considering how best to protect traditional technologies and knowledge has been rapidly increasing. The trend is growing toward recognizing or creating rights of control in farming communities over genetic resources and related knowledge.

Thus far TK has not been captured and stored systematically; the danger is that it may be lost altogether. Even now, TK about cultivated and wild species is rapidly being lost. Genetic information coded in wild species and traditional crop varieties could be lost as intensive monocultural production favors newer high-yielding crops. The collective knowledge of biodiversity and how to use and manage it are maintained in cultural diversity; conserving biodiversity often helps strengthen cultural integrity and values (WRI et al., 1992).

In an effort to conserve and promote a better understanding of indigenous knowledge systems, UNESCO launched the Local and Indigenous Knowledge Systems (LINKS) project in 2002. Since its inception, LINKS has supported several field documentation efforts. In addition to empowering communities in biodiversity governance by recognizing them as knowledge holders, the project seeks to maintain the vitality of local knowledge within communities. The key is to strengthen ties between elders and youth, to reinforce the transmission of indigenous knowledge and know-how from one generation to the next. The International Treaty on Plant Genetic Resources for Food and Agriculture (www.fao.org), already ratified by several countries in the region, recognizes the enormous contribution that farmers and their communities have made and continue to make to the conservation and development of plant genetic resources. This is the basis for farmers' rights, which include protection of TK and the right to participate equitably in sharing benefits and in national decision making about plant genetic resources. Farmers possess invaluable knowledge, including the ability to choose appropriate varieties or breed for particular agricultural ecosystems. Their contribution is increasingly being recognized, as is their right to receive more benefits, including monetary benefits.

In CWANA the number of publications on the relevance of TK in several areas has grown exponentially. Helping local people use their own knowledge of indigenous foods and agriculture provides better prospects for long-term sustainability than imposing solutions from outside. To date, however, little has been documented about the foods grown and used in poorer parts of the region, particularly as to how these foods are preserved for later use in a hostile environment. Today in rural Sudan various foods are being considered from the perspective of nutrition and food microbiology and for their part in the social fabric and the struggle for survival (Dirar, 1993). Information was gathered from elderly rural women who traditionally hand down such knowledge from generation to generation. With increased urbanization and dislocation of family structures, there is danger that such knowledge will be lost unless it is documented.

#### 2.5.2.1 Plants

North Africa has one of the oldest and richest traditions using medicinal plants, important especially in rural areas, because they are frequently the only medicine available. Even in many urban areas, the price of modern medicine is increasing and people are turning back to traditional plant remedies.

The demand for medicinal plants is currently increasing in both developed and developing countries because of their accessibility, affordable cost and the growing recognition that natural products have fewer side effects. Therefore, a number of important plant species have become scarce in areas where they were previously abundant and some species may become threatened with extinction if their collection is not regulated. The theme of medicinal plants, relevant in most countries in North Africa, is a good entry point for biodiversity conservation. Use depends on local knowledge, which is based on traditional techniques linked to local identity.

Local communities, such as the Bedouins in Egypt, possess invaluable knowledge of nature. This TK is being gathered, documented and fed into a regional compendium on medicinal plants. Most Egyptians rely on modern medicines, although herbalists and their shops still thrive. The Bedouin communities, with much stronger traditional culture, have a real interest in medicinal plants. The demand for medicinal plants in Egypt is big, but most are for export to the USA and Europe. Of the 2,000 species of plants in Egypt, 1,000 occur within 30 km of the Mediterranean coast. Many of Egypt's plants have become rare or extinct from habitat destruction, overgrazing and overharvesting.

The Center and Garden for Conservation of Threatened Plants was built near El Hammam to conserve medicinal plants under threat in North Africa and to serve as an education and awareness center for the entire region. The garden undertook trials to cultivate plants under different conditions and propagate them. Transplants and propagules were exchanged with Bedouin nurseries, so they could cultivate plants in micronurseries. Four micronurseries and about 20 smaller ones established with the Bedouin communities on Bedouin lands focus on sustainable use of medicinal plants.

The cultivation of these plants, a new concept for the Bedouins, has slowly caught on because plants in the wild are diminishing in number and they realize that a market can be found for medicinal and culinary plants. These nurseries have been decisive in significantly reducing the uncontrolled gathering of endangered plant species (http://iucn.org/places/medoffice/nabp/index.html).

*Food barley: importance, uses and local knowledge*

*Case study 1:* This ICARDA study highlights food barley production in over 14 countries (Grando and Gomez Macpherson, 2005). It includes a review of food barley farming systems, bottlenecks in production, research efforts in improvement, major cultivated varieties, quality characteristics that consumers desire and constraints to production and research. Local crop development is based on farmer knowledge of local crop varieties, their skills in adapting them to their environmental and socio-economic conditions and contributions of local seed systems. Papers presented in the book focus on describing varietal characteristics important to farmers; how farmers observe, select and experiment with crop varieties; and the techniques they employ for storing and distributing seed.

Barley grain is used as feed, malt and food. Our ancestors depended on barley as a staple food more than we do now. Barley was important in the origin and development of the Neolithic culture. Early barley remnants from Mesopotamia and Egypt suggest that barley was more important than wheat in the human diet. Nowadays, barley is an important staple food in several developing countries; generally it is the most viable option in places with harsh living conditions and home to some of the poorest farmers in the world.

Barley is still a major staple food in several regions of the world: some areas of North Africa and Near East, the highlands of Central Asia, the Horn of Africa, the Andean countries and the Baltic states. Food barley is often found in regions where other cereals grow poorly because of altitude, low rainfall or soil salinity. It remains the most viable option in dry areas (< 300 mm of rainfall) and in production systems where alternatives for food crops are limited or absent, such as in highlands and mountains.

Food barley consumption has decreased considerably in the last 40 years with the increase of urban populations and often with the introduction of national policies supporting wheat consumption. In Morocco, food barley consumption decreased from 87 kg per person per year in 1961 to 57 kg in 1999. In 1961, yearly consumption per person was 27 kg in Algeria, 35 kg in Libya and 15 kg in Tunisia.

Food barley use is associated with local knowledge on preparation, health and nutritious attributes. Food barley is used either to make bread, usually mixed with bread wheat, or in specific recipes. Its cultivars have particular characteristics consumers appreciate that make them irreplaceable by feed or malting barley. Now local knowledge and unique genetic material are under risk of being lost for future generations.

Archaeobotanical and archaeozoological analyses of archaeological sites, in addition to ethnobotanical and subsistence base studies in contemporary rural societies, have indicated the likelihood that most of the ancient ways of obtaining food and materials have remained in use (Anderson and Ertuğ-Yaras, 1998). In Anatolia, for instance, about ten to twelve thousand years after domestication was successfully accomplished, wild plant gathering is still an active tradition in several parts of the country (Ertuğ, 1998, 1999, 2000a, 2000b, 2000c).

*Wild plant gathering in agricultural societies*

*Case studies 2 and 3:* Two case studies, conducted in Aksaray in central Anatolia and Muğla in southwestern Anatolia, indicate that people have adopted various ways of using their environment for food, medicine, fuel, fodder, building materials and many other purposes (Ertuğ, 2006).

In a single village and its surroundings in Aksaray, 300 locally used and named plants have been recorded. The villagers consider over 100 plant species edible, while others are used for medicine, fuel, fodder, building material, dye, gum and glue. In the Bodrum Peninsula in the Muğla area, about 360 useful wild plants have been recorded during a two-year study; 140 were used for food, about 100 were medicinal and others were used for various purposes such as making baskets, brooms and mats.

It is almost impossible to find two identical patterns of managing faunal and floral resources; some variations are apparent even within the same unit of study. Different wild plants are gathered in two adjacent regions and even within the villages in both regions. In both regions, however, although they now have access to fresh vegetables all year round, wild plants available in winter and spring continued to supplement the villagers' diets, during periods when, historically, fresh vegetables were scarce. This continuity of gathering may well be explained by nutritional needs of people and their search for ”traditional tastes”. While several plant uses, such as for plaiting mats and fuel, are decreasing, gathering wild edibles is still more or less consistent in rural areas.

*Inventory of traditional knowledge to combat desertification*

*Case study 4:* UNESCO launched a global program, the Traditional Knowledge World Bank, for an inventory assigned to the IPOGEA Research Centre on Traditional and Local Knowledge to Combat Desertification. The project gathers and protects historical knowledge and promotes and certifies innovative practices based on modern restoration of tradition (Laureano, 2005).

Traditional knowledge and techniques were identified by surveys and studies in the field as well as by collecting photographs and current project documents. An iconographic system has been designed to show and easily identify the techniques and their use. Each technique matches an icon.

Each technique is linked to photographs, charts and drawings, project reports, bibliographical documents, analysis of exact references and geographic and chronological dissemination maps. All this information is in clusters of competence and in several categories, including Agriculture, Water Management, Soil and Environment Protection, Breeding, Hunting and Harvesting.

A case study in Wadi Mzab in Algeria classified traditional techniques according to natural context, rural settlement and urban settlement.

#### 2.5.2.2 Water management

Large-scale water management techniques was developed by the ancient empires that flourished on the alluvial sediments of silt, loess and sand along the Afro-Asian river basins in the five subregions of CWANA. Great civilizations known as hydraulic societies prospered not only near rivers like the Nile, Euphrates and Tiger and in arid areas and oases. They developed hydraulic infrastructures to elevate water from rivers, such as the noria system of lifting water in buckets on a current-driven wheel in the Orontes River in Southwest Asia, for stoking and transporting water and for rain harvesting. The knowledge concerning water management and irrigation was transmitted down generations.

The validity of traditional knowledge on water management and the practices derived from it have been studied and documented since the 1980s. Research begun more than 20 years ago on traditional water techniques has aimed at overcoming a top-down approach to transferring water management technologies and at achieving a participatory relationship to foster sustainability (Brokensha et al., 1980). Many international bodies, such as the International Labour Organisation (ILO) (Bhalla, 1977), the Organisation for Economic Co-operation and Development (OECD), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the World Bank, have declared TK validity in research and documents. The interest of the United Nations conventions is clearly highlighted in the report entitled “Building Linkage between Environmental Conventions and Initiatives” (UNCCD, 1999).

#### 2.5.2.3 Water harvesting

Water harvesting can be traced through human history almost as far as the origin of agriculture. This ancient practice sustained populations when conditions would have otherwise totally prevented agriculture and many peoples in the world have continued to rely on water harvesting. Harvested water is used for drinking (although less commonly now, because even rainwater is less safe), irrigation, livestock drinking and groundwater recharge.

Various forms of water harvesting have been used throughout the centuries. Some of the earliest Middle East agriculture diverted wadi flow (spate flow from normally dry watercourses) onto agricultural fields. Reviewing archaeological evidence, Prinz (1994) notes indications of water-harvesting structures in Jordan, believed to have been constructed over 9,000 years ago and in southern Mesopotamia from 4,500 BCE (Bruins et al., 1986). A number of distinctive historical examples that incorporate effective water-harvesting systems survive in many CWANA countries. These include the cut-stone reservoirs of the Nabatean city of Petra in Jordan and the underground cisterns found in the country's Umayyad desert palaces, Crusader period castles and traditional village houses.

A sequence of reviews and manuals produced over the last 20 years provides a good inventory of old and new water-harvesting techniques, as well as essential information for their implementation (Frasier, 1974; GDRC, 1983; Pacey and Cullis, 1986; Reij et al., 1988; Critchley and Siegert, 1991; FAO, 1994; Prinz, 1999). Farmer innovations, ancient and modern, have stimulated research and research has started to solve problems on the farm.

In the early 1990s, several studies on traditional water-harvesting infrastructures were published (Prinz, 1996; Prinz and Wolfer, 1999). These techniques, which deeply mark the landscapes of the arid and semiarid areas, are regarded as part of our world inheritance. In North Africa, Saharan tourism has vigorously helped to promote them. In South Tunisia for example, several water-harvesting techniques given up in the 1960s have been reestablished to produce fresh fruits and vegetables for hotels and ecotourism.

In poorer regions, the productivity of land and water in rainfed areas is greatly enhanced by harvesting water. Marginal lands with annual rainfall of less than 300 mm a year can be cultivated if limited but controlled additional water is made available (Oweis et al., 1999; Rodriguez, 1996; Rodriguez et al., 1996). In many instances, appropriate water-harvesting techniques can provide an incremental water supply.

Modernization and diffusion of these ancient technologies have to be sought to increase agricultural productivity and provide a sustained economic base. The choice of technique depends on the rainfall and its distribution, land topography, soil type and depth and local socioeconomic factors, so these systems tend to be very site specific. The water-harvesting methods strongly depend on local conditions and include widely differing practices—bunding, pitting, microcatchments and harvesting flood- and groundwater (Critchley et al., 1992; Prinz, 1996).

Rainwater harvesting areas are not well mapped and few statistics are available nationally or regionally. Several experiences are quoted in specialized literature but little information is given about their importance in concerned areas, benefits to people and economic return. AQUASTAT FAO databases for CWANA are available only for Egypt (133,000 ha), Iran (40,000 ha), Lebanon (500 ha) and Tunisia (898,000 ha).

Work in Tunisia may be divided broadly into two types: description and rehabilitation of indigenous systems and the large-scale technical development program of the Departement de la Conservation des Eaux et du Sol. This program is one of the few in CWANA that integrates soil and water conservation into hydrological priorities (Selmi, 1994). As well as constructing bunds and terraces for conservation, it includes building small dams on watercourses high in the catchments of major rivers. Purposes include flood control, recharge of shallow groundwater for irrigation and reduction of siltation of major dams supplying domestic and industrial needs. Among the spinoffs is that hill farmers will have water form small dams to use in supplemental irrigation. This program seeks to conserve soil and water by focusing primarily on engineering works. Unfortunately, the socioeconomic problems and different options for land users are essentially neglected.

Indigenous systems in Tunisia have recently been described in two monographs, by Ennabli (1993) and Alaya et al. (1993). The former provides detailed descriptions of nearly 30 traditional systems for capturing and using water in the dry areas of Tunisia. The water interception, concentration, conveyance and storage techniques reported (many still in use) illustrate the wealth of ingenuity in human adaptation to dry environments. Alaya et al. (1993) focus on *tabia*, the earthen bunds widely and variously used in Tunisia to intercept and redirect runoff water to crops and trees. Though primarily an implementation manual, this book is also rich in descriptions of traditional practices.

The *meskat* system, using tabias to support olive plantations, covers about 300,000 ha in central Tunisia (Prinz, 1994). It comprises catchments of about 500 $m^2$ surrounded by tabia and spillways to control runoff flow into bunded plots of trees. This is a successful system, but according to Reij et al. (1988) it suffers heavily from increasing land pressure, resulting in a decrease of catchment areas and leading to lower efficiency.

The *jessour* system is based upon cultivating sediments built up behind large tabia, often stone-reinforced and with stone spillways, constructed in water cascading down narrow mountain valleys in southern Tunisia. Akrimi et al. (1993), from the Institut des Regions Arides (IRA) near Medinine, reported a multidisciplinary study involving jessour cultivators in the Matmata Mountains. Maintaining the tabia and spillways is a major problem in some areas, due partly to the degree of outmigration. It is Tunisian government policy to assist with jessour rehabilitation. Proposals for further research by the same IRA team note the launching of major development schemes for soil conservation and rainwater harvesting, but comment that community participation has been weak because the schemes have failed to take account of local traditions and existing production systems.

Development schemes in Jordan involve building earth dams that divert runoff to improve pastures and bunds to conserve soil and moisture on steep land. Research was started in 1987 by the University of Jordan to explore the development potential, particularly the water-harvesting potential of a 70-$km^2$ catchment under low rainfall (100–250 mm per annum) east of Amman (Taimeh, 1988). Irrigation from wadi flows trapped by earthen dams and microplots supporting fruit trees are two techniques that have shown promise, both socioeconomically and technically. Currently data collected on this catchment are used to develop a coupled prediction-optimization model for harvesting, storing and using water in similar dry areas of Jordan and elsewhere (Sarraf and Taimeh, 1994).

Other ongoing regional activities include a relatively large development project, with an included research component, in a steppe in southern Syria using the integrated management of soil, water and vegetation (Rashed, 1993). The project uses water supplied by various harvesting techniques and a limited groundwater supply to enhance production, particularly of forage crops and shrubs.

In Yemen, a major research focus is to conserve the ancient terrace system, parts of which have fallen into disrepair following socioeconomic changes. The terraces are not just to conserve soil and water but also to control water, including harvesting water for human consumption, flowing from the high, often degraded pasture lands and to protect the low-lying intensively cultivated banks of the main wadis and the flood irrigation systems. A new multidisciplinary project with a participatory approach addresses the socioeconomic, institutional and policy issues that are involved (Mouhred, 1994).

The rainfed coastal areas of Egypt have received considerable R&D attention over recent decades. Initially the aim was to settle the Bedouin population. Projects were undertaken to rehabilitate degraded rangeland and increase use of runoff, through terracing wadis, similar to Tunisian jessours and enhancing indigenous runoff farming systems (Perrier, 1986). More recently, the coastal areas have come to be seen as another small but potentially productive national agricultural resource and emphasis has shifted toward more intensive development. However, natural resource issues—water quantity and quality, population growth, environmental deterioration—remain the same (Abdel-Kader et al., 1994).

In highland Balochistan, in Pakistan, an indigenous *khuskaba* system uses bunds to guide runoff water and promote infiltration. Rodriguez et al. (1996) found 1 : 1 treatments (catchment : production area ratio) in valley floors increased seven-year wheat yields over controls, higher ratios having a risk of waterlogging in wetter years. Farmers practicing the indigenous khuskaba system adjust the size of the catchment according to soil moisture at planting and rainfall expectations for the season.

Several water storage practices have been passed down from generation to generation. The individual cistern is an ancient method that has been in continuous use with some modifications. Cisterns have long been used by people without access to adequate and safe water or villages lacking a local water source or not connected to a water supply network. Harvested rainwater stored in cisterns during the short rainy months can adequately sustain the water supply in isolated habitations. Cisterns can also be a multiuse resource; besides water for drinking and cooking, households can use extra water for irrigating productive home gardens and for watering livestock. In 1982, studies were conducted on traditional cisterns and what was necessary to build, modernize and manage more of them (Bourges et al., 1979; Fujimura, 1982).

The region is also rich in traditional knowledge related to irrigation—*kharez* in Pakistan and Afghanistan, *qanat* in Iran, *foggarras* in Tunisia and Algeria and *khettaras* in Morocco. The survival of these ancient irrigation systems is testimony to brilliant local engineering. Presumed to be of Persian origin and introduced to the Maghreb during the Arab conquest, these systems were partly responsible for the wealth of the former *ksours* along the trans-Saharian trade routes of the past.

A kharez (qanat) is an unlined tunnel in the hillside, bringing water by free flow from underground aquifers to be used for surface irrigation. Dug by local craftsmen from shafts at close intervals, they are small in size but may be many kilometers long. In Afghanistan, data of the last inventory, conducted in 1967, estimated that 6,470 kharez still supply water to 167,750 ha. Kharez are often used for the domestic water supply.

In North Africa, the simplicity and ingenuity of these underground systems allow the capture and distribution of groundwater over thousands of kilometers. The system works through a complex network of underground channels and storage chambers set 10 to 15 meters deep, to avoid loss through evaporation. Hundreds of conduits (*seguias*) carry water, bringing it eventually to the surface and thanks to a slight slope, leading it to gardens at a flow of 3 to 12 liters per second.

2.5.2.4 Intellectual property rights

Several proposals have been made, within and outside the IPR system, to "protect" traditional knowledge (Correa, 2001). Such proposals often fail to set out clearly the rationale for its protection. Any system of protection, however, is an instrument for achieving certain objectives. Therefore, a fundamental question, before considering how traditional knowledge may be protected, is to define why it should be.

Some understand the concept of protecting IPR, where protection means to exclude unauthorized use. Others regard protection as a tool to preserve traditional knowledge from uses that may erode it or negatively affect the life or culture of the communities that have developed and applied it. Overall, the main arguments for protecting traditional knowledge include:

- equity considerations
- conservation concerns
- preservation of traditional practices and culture
- prevention of unauthorized parties appropriating traditional knowledge components
- promotion of its use and its importance in development

### *2.5.3 Human capacity enhancement*

Enhancing human capacity is important for agricultural development; therefore, capacity building is primary in development programs. Capacity is built so that country scientists and extension staff become more able to carry out integrated agricultural research, disseminate the information, demonstrate techniques and transfer technologies.

National programs in the region vary widely in their development, capability and needs. Countries benefit through collaborating with regional international institutions operating in CWANA and by networking to improve and strengthen the capacity for adopting and transferring technology. ICARDA and other CGIAR centers in the region play a catalytic role in helping various regional countries.

Since its establishment in 1977, ICARDA has considered training, capacity building and networking as essential for institutions and individuals to keep pace academically and professionally with the rapid development in agricultural sciences, especially in developing countries. ICARDA recognizes that a well-trained cadre of agricultural technicians, scientists and managers is essential to develop effective and sustainable national agricultural research systems (NARS). The center has responded by working closely with NARS to develop and implement training programs that address their changing needs.

Based on the needs of NARS, the center offers many training options, including long-term courses, specialized short-term courses, individual nondegree training and MSc and PhD degree-related studies. ICARDA organizes regional, subregional and country courses, which are usually conducted in close collaboration with NARS. International courses are also organized in collaboration with other international and regional organizations on subjects of mutual interest. Training at ICARDA changes annually in response to NARS training priorities. These priorities are usually presented by national scientists and discussed during the annual national, subregional and regional meetings with NARS and during regular work visits.

ICARDA has improved its training program to better address human capacity development (www.icarda.org) by

- refining selection procedures of training participants
- decentralizing large parts of training activities from its headquarters to national programs
- placing more emphasis on specialized training courses, including the degree-related training programs
- conducting regular follow-up studies on training
- improving training materials and creating and updating a computerized database of training participants

Using national, regional and global networks is an effective way to develop, transfer, adopt and use new technology. Research and training networks are effective for linking national scientists with each other and with regional and international organizations. These networks also insure a continuous flow of information among interested scientists; they provide opportunities for donor organizations to allocate financial support to networks that suit their priorities and interest. A number of donor organizations and cooperating countries support and coordinate these networks in CWANA.

Training at CGIAR centers and most regional institutions has been considered an integral component of the overall activities. It is recognized as an educational process that requires more than information giving or skill development; it also requires a thorough understanding of training and the value of continuous, vigorous evaluation. Success in reaching training objectives can only be judged when those who receive training apply what they have learned and when changes can be observed in practice.

Regional institutions include the International Center for Advanced Mediterranean Agronomic Studies (CIHEAM), an international organization dedicated to postgraduate and specialized education, applied research and the development of Mediterranean agriculture.

IARCs training programs are not based on a professor–student relationship but rather on a mature partnership and are regarded as a two-way learning process through which exchange of experience becomes a natural outcome. So the training participants, regardless of their positions or duties, become future collaborators. Participants are mostly the future leaders of their national projects or programs. They can certainly play an active role in technology transfer and therefore in improving food production in their own countries. Centers offer a wide variety of training activities to meet the evolving needs of client countries. These include long-term group courses, specialized short-term courses, individual nondegree and degree courses, regional and subregional courses and in-country training courses. The last three types are usually conducted in close collaboration with the concerned NARS. Each of these training programs is aimed toward improving the professional skills of the training participants and hence developing their national programs (Bunting and Araujo, 1987).

Workshops, traveling workshops, seminars, meetings and exchange of visits of national program representatives comprise important components for strengthening national programs and serve as a forum for exchanging ideas and deciding on future collaborative activities with NARS staff. The national programs in most countries in the region conduct these activities, some of which, at the request of national scientists, are organized either at ICARDA headquarters or outside.

Some crop-based expert systems have recently been established in the WANA region, like the Wheat Expert System (WANA Wheat). Its aims are to establish an expert system that all countries in the WANA region can use, to disseminate information about the system on the Web and to train extension workers on how to use the developed system (www.claes.sci.org).

Information technology (IT) has played an important role in disseminating information and knowledge in the last decade. Many institutions have investigated using this technology to transfer information and knowledge in the agriculture domain. Both formal and informal sectors in most of the involved countries have established a Web-enabled system for transferring agricultural information to scientists, extension services and growers to inform and train them in how to adopt these new technologies. Regional and international agricultural research centers strengthen cooperation with their partners involved in technology transfer by providing improved services in the areas of publications, translation, library search and training. The centers also contribute to and participate in most of the regional and international agricultural information networks. Through its Communication, Documentation and Information Services (CODIS), ICARDA places high priority on increasing and further improving the quality of agricultural information and its subsequent dissemination and adoption by national programs in the WANA region and beyond.

IARCs in the region do not conduct specific research on agricultural extension or offer training in it. However, they recognize that unless farmers adopt an improved technology, it is almost useless. Therefore, IARCs play an important if indirect role in developing and transferring technology by various means, including on-farm testing, organizing field days and visits for farmers and policy makers and organizing traveling workshops, training courses and roundtable discussions for farmers, researchers, extension workers and government officials. They also assist in producing field guides and extension publications related to using the new technology. Such joint activities help bridge the gap between researchers and extension specialists and improve technology transfer and use.

#### 2.5.3.1 Technology transfer and adoption activities in Central Asia and the Caucasus

Under the ICARDA coordinated program for Central Asia and the Caucasus (CAC), NARS are being strengthened to become more efficient and responsive to the emerging challenges in the region. So far, over 2,500 scientists have either been trained or given the opportunity to participate in various meetings, workshops and conferences (see www.icarda.org)

*Plant genetic resources and germplasm development:* In cooperation with Bioversity International (formerly IPGRI), plant genetic resource units have been established in each of the eight CAC countries. Collection missions have been undertaken and different crops collected and added to their genebank collections. New varieties of winter wheat have been developed based on material from the joint CIMMYT/ICARDA/Turkey Program on Winter Wheat Improvement.

#### 2.5.3.2 Natural resource management

Encouraging progress has been made with the introduction and adoption of improved soil and water management technologies. This has been achieved under the project on Soil and Water Management initiated in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan and financed by the Asian Development Bank.

- Improved irrigation technologies, developed and tested on-farm, increased the average yield of winter wheat by more than 40%, reduced soil erosion by almost 60% and increased water use efficiency by 50–100%. These technologies are ready for adoption on approximately 1.4 million ha in Uzbekistan.
- In southern Kazakhstan, improved irrigation technologies have led to about 30% less water being used than with traditional furrow irrigation. It has also reduced the pressure on the drainage system by 40%.

- Experiments using treated wastewater to irrigate fodder and industrial crops and tree plantations in Kazakhstan and Tajikistan have led to promising potentials for saving scarce water resources.
- Under the rainfed semiarid conditions of northern Kazakhstan, minimum and zero tillage techniques have resulted in grain yields 15% higher than those from deep plowing. Zero tillage has already been adopted by farmers on approximately 10,000 ha.
- Reduced tillage has led to promising results in Turkmenistan; water productivity increased by 25% compared with traditional deep-plowing practices.
- In Uzbekistan and Tajikistan, cotton planted as a double crop after winter wheat gave similar yield under no-tillage when compared with traditional deep plowing and monocropping. The no-tillage practice has now been introduced on about 4,000 ha in the two countries.
- Wheat–cotton rotation is becoming popular with the introduction of conservation tillage, varietal adjustments and alternate furrow irrigation technologies. It is expected that the area under this rotation in the CAC region will increase to about 200,000 ha in the next two to three years.

## 2.6 AKST and Its Impact on Agricultural Production and Development Goals

### *2.6.1 Impact on agricultural production and development goals*

Increased agricultural productivity in the twentieth century has greatly contributed to the alleviation of poverty and hunger and enhanced economic growth. These results have mainly been attributed to increased investments in agricultural R&D (R&D). Globally, nearly US$731 thousands Million (or 1.7% of the world's GDP) was invested in all the sciences in 2000, including research conducted by public and private institutions (Pardey et al., 2006a).

Among the developing countries, real research expenditures between 1995 and 2000 increased the most in the Asia-Pacific (11.9%) and the Middle East and North Africa (11.5%) regions. The overall average of the annual growth rate in research spending for developing countries was 8.6% over the 1995–2000 period. The lowest annual growth rates were 1.9% for "other developing countries" (which includes several former Soviet states) and 3% for sub-Saharan Africa. China and India achieved the highest annual growth rates in research expenditures of 19.7% and 12.2%, respectively.

Similarly, trends of public spending in agricultural R&D reveal that investments increased by 51% worldwide over the last two decades, from US$15.2 thousands Million in 1981 to US$23 thousands Million in 2000 (Pardey et al., 2006b). During the 1990s, developing countries as a group undertook more of the world's public agricultural research than did industrialized countries. The Asia-Pacific region has accounted for the largest share of the developing-country total since

1981, accounting for 32.7% of the global total agricultural spending on research in 2000. China and India alone accounted for 39.1% of the developing world's agricultural R&D expenditure in 2000, a large increase from their combined share of 22.9% in 1981.

Five developing countries (Brazil, China, India, South Africa and Thailand) accounted for 53.3% of the developing world's public investments in agricultural research in 2000, up from their 40% share in 1981. Meanwhile, only 6.3% of the global investment in agricultural R&D was conducted in 80 countries (mainly low income and home to 625 million people).

Research intensities (that is, agricultural R&D spending expressed as a percentage of agricultural GDP) provide relative measures of R&D investments. Industrial countries as a group spent 2.36% of agricultural GDP in 2000 on R&D, a noticeable increase over the 1.41% in 1981. Developing countries, on the contrary, have not experienced a measurable growth in the intensity of agricultural research since 1981. These countries spent only 0.53% of their agricultural GDP on R&D in 2000. These figures indicate that the scientific or knowledge intensity of agricultural production grew at a much faster rate in rich countries than in poor ones, suggesting an increased intensity gap over the past three decades (Pardey et al., 2006b). The Asia-Pacific region has experienced the lowest research intensity, < 0.5%, since 1981. The West Asia and North Africa region is the second lowest region in terms of research intensity. Although most sub-Saharan countries had lower 2000 intensity ratios than in 1981, the research intensity in this region is still higher than it is in the Asia-Pacific and WANA regions.

Per capita agricultural R&D spending is another research intensity ratio. It reveals that rich countries spent US$692 per agricultural worker in 2000, while poor countries spent just US$10.

Historically, agricultural innovations in the form of improved crop varieties, livestock breeds and farm management practices were typically the result of farmer experimentation through adapting and developing earlier ideas and then passing on inventions to younger generations. Publicly funded research is relatively new. It began in the early to mid-1700s as part of the efforts of the agrarian societies that formed throughout the United Kingdom and Europe at that time. Consequently, the publicly funded and operated agricultural experiment stations developed around the mid-1800s (Pardey et al., 2006b). Both public and private agricultural R&D continued to evolve, from trial-and-error efforts of many individuals to large-scale input supply firms investing in their own private R&D facilities.

In agriculture, however, it is difficult for individuals to gain full advantage from their research investments. Thus it is widely held that government needs to invest in R&D for the public good.

Even so, private investments are evident in agricultural R&D. About 36% of global spending on it in 2000 was by private firms and the remaining 64% by public agencies. Most of the private R&D investment (about 93%) was in rich countries and is extremely limited in developing countries at 6.3%. In industrialized countries 54% of the agricultural R&D is private; in developing countries, it is predominantly public and there are large disparities in the private contribution figures among the different regions of the developing countries. In the Asia-Pacific region, nearly 8% of the agricultural R&D investments are private compared with 3.5% in the Middle East and North Africa region. Among developing countries, private investment in agricultural R&D is lowest (1.7%) in sub-Saharan Africa (Table 2-17).

**INSERT Table 2-17. Estimated global public and private agricultural R&D investments, circa 2000 (Source: Pardey, et al., 2006b).**

This pattern of private contributions to agricultural R&D investments has important implications for the intensity of agricultural research in all countries. In 2000, developing countries as a group had an agricultural R&D intensity ratio of 0.53% compared with 5.16% for industrial countries. This results in an intensity ratio of 9.2:1 compared with a 4.5:1 ratio if only public research investment were considered (Pardey et al., 2006a). Previous information on agricultural R&D expenditures suggests the following conclusions:

- There has been a slowdown of support for publicly funded agricultural research among developed countries. This is partially attributed to a shifting emphasis from publicly to privately funded agricultural R&D and to a shift in government spending priorities. In developing countries, including CWANA countries, the public sector undertakes most of the investment in agricultural R&D. The contribution of private funding is and will continue to be, limited. Thus, the public sector needs to fund future expansion in agricultural R&D investments.
- There is a clear reorientation of agricultural R&D in industrialized countries away from intensifying productivity in food staples toward concerns over the environmental effects of agriculture, as well as food quality and medical, energy and industrial applications of agricultural commodities. Such research reorientation has important implications for the links between industrialized and developing countries in improving the productivity of staples, which is still a priority research area for developing countries. This is particularly in line with current trends in research expenditure of international agricultural research centers toward environmental sustainability and policy at the expense of research on increasing productivity.
- Although limited, most private agricultural R&D in developing countries is oriented toward research on crop improvement or on export crops such as cotton, corn and sugar cane. This implies that the private R&D contribution is expected to stay minimal in research to increase

productivity of staple crops. Publicly funded agricultural R&D will continue as the main source of such research in CWANA countries.

### 2.6.2 Options and insights for making more effective use of agricultural science and technology

To enhance the effectiveness of public investments in agricultural science and technology in the CWANA region, we suggest the following:

- Enhance technology strategies and priority setting. CWANA countries are invited to develop their strategies and research priority settings in line with their comparative advantages, resource endowments and contribution to the developmental goals of poverty alleviation, food security enhancement and natural resource sustainability. Regional research priorities for CWANA have already been developed by ICARDA in 2002 (Belaid et al., 2003) New efforts to orient national research priorities in CWANA countries need to capitalize on the new research focus of international agricultural research centers (represented by the CGIAR centers), which is directed toward agricultural development in developing countries.
- Define options and opportunities for optimizing the contribution of agricultural R&D and determine the best application of resources to meet research priorities.
- Develop and maintain appropriate agricultural science and technology databases. These include quantitative and qualitative information on changing research and funding environments as well as national, regional and global institutional changes.
- Identify complementary roles of different research partners, including NARS, advanced research institutions and CGIAR centers. ICARDA in its R&D continuum clearly draws the roles of different partners in the whole R&D chain. It also monitors changes in the research environments at all levels for implications on strategies and priorities of different organizations.
- Carry out ex ante and ex post research evaluation for accountability and resource allocation. This evaluation should lead to developing appropriate processes and mechanisms for allocating research resources for maximum effectiveness.
- Improve incentives to generate, access and use new technology. Investments in agricultural R&D can contribute significantly to feeding poor people. The potential benefit can be greatly enhanced if successful partnerships are further developed.

### 2.6.3 Dynamic influencing the role of women in agriculture

#### 2.6.3.1 Land and agrarian reforms

According to the first resolution of the United Nations Subcommission on the Prevention of Discrimination and the Protection of Minorities "continued discrimination faced by women in all matters [related] to land and property is the single most critical factor in the perpetuation of gender inequality and poverty." (United Nations, 1995). Laws and social norms in many CWANA countries restrict women's ability to buy or inherit land, particularly agricultural land and resources, negatively affecting women's participation in agriculture.

In Iraq, land and agrarian reforms assigned plots to men and women alike and the law guaranteed gender-equal inheritance rights. The state recognized and supported women's roles as landowners and farmers. (Customary law, however, often prevails over state law and ownership of land continues to be predominantly excusive to men.) In Syria, on the contrary, land reform assigned plots only to the male heads of household. Women became "helpers" rather than farmers in their own right. Their access to agricultural basics was limited and thus they lost independent access to food production and their control over produce revenue.

Since women lack control of the means for production and entitlement to what they produce, their access to loans and social security is often restricted, their autonomy and decision-making power are limited and consequently their ability to achieve food security is curtailed. Women's limited access to markets also curtails their control of farm income. As shown in a study on Jordan, women working on land they own, rent or sharecrop, rather than on household land, are much more likely to engage in marketing activities, control the income earned on the land and allocate household expenditures. Agriculture, however, is mainly a male activity in Jordan and land is predominantly owned by men. The percentage of women farming their own land is low, approximately 1% of Jordanian population and 11% of the female agricultural labor force (Flynn and Oldham, 1999).

#### 2.6.3.2 Migration

Many countries in CWANA region have been characterized by male rural-to-urban migration and by out-migration, mainly to the Gulf states. As a consequence, the number of female-headed households has increased substantially over the years. This has often been paralleled by agricultural intensification trends that in Jordan as in Egypt (Taylor, 1984), Gaza (Esim and Kuttab, 2002), Lebanon and Syria have caused an increasing demand for women's labour in agriculture (World Bank, 2005, 2006). Women more and more work as unpaid family laborers, their agricultural duties added to their domestic ones. In some countries female farmers have started also working off-farm in agriculture since revenue sent by migrated relatives is often not sufficient for survival and plots are too small to sustain the family. These situations have led to growing feminization of agriculture with increasing rates of women working in unpaid, informal systems. These systems are characterized by gender-based wage differentials, precariousness and lack of social services, all of which contribute to women's economic vulnerability. The increase in household workload also involves children, affecting their school attendance, free time and health.

These changes in the management of rural households have not been followed by adjustments to legal rights—such as property ownership, assets entitlements or labor rights—or to the agrarian systems—such as distribution of agricultural basics, market arrangements, technology introduction—that generally assume farmers to be male, thus favoring their needs, preferences and rights. These inequalities negatively affect women's agricultural work and arguably their agricultural productivity.

Migration also influences intrahousehold dynamics. Women may gain independence because of men's absence. They participate in decision making by managing small household budgets and their mobility is increased as they sometimes go to the market to sell their products even if they still rely on male relatives for major decisions such as the sale of an animal (cow, calf, sheep) (CNEA, 1996). Or women may lose independence if a male relative manages the household during the absence of the migrant man. In Syria, women seem to perform most of the agricultural work but do not have management or decision-making control, which has remained in the hands of male relatives (Abdelali-Martini et al., 2003). A study on Egypt in the 1980s reported that only women in independent households gained more control of their own lives if their husband migrated. In extended families, their autonomy was reduced by the increased control of the mother-in-law (Taylor, 1984).

#### 2.6.3.3 Conflict

Women's rights to property, access to land and entitlement to agricultural basics are not effectively protected by either legal structures or social norms. In conflict and postconflict situations, when the number of female-headed households increases, these rights are even more difficult to demand and women's means for a sustainable livelihood are undermined. Women thus often resort to working in the informal sector, despite the constraints with regard to assets, markets, services, regulatory frameworks and the larger gender-based wage differential (Esim and Kuttab, 2002).

According to a study on the Palestinian conflict, women face the repercussions of the occupation, the gender-based discrimination to property rights and the obstacles due to traditional, patriarchal practices (Esim and Kuttab, 2002). Agriculture is the second most important sector of employment for women and feminization of agriculture is a growing phenomenon. Apart from problems in claiming their rights to land and resources, women have to deal with an old agricultural system and techniques, since not much investment was ever made in agriculture because of the continuous occupation. Moreover, in 2001, women's agricultural activities were shrinking because land was confiscated and donor support for agriculture decreased. "In this context informal employment has become a survival mechanism, especially for households maintained by women" (Esim and Kuttab, 2002, p. 3).

In Iraq, women-headed households are numerous in the rural areas and women are increasingly becoming a vulnerable group because of the ongoing violence. Women farmers are particularly vulnerable because they have limited control over production resources such as land and technology and reduced access to support services (United Nations and World Bank, 2003).

### 2.6.3.4 Mechanization and technology

Mechanization and labor-saving technology have radically changed agricultural production and work organization in rural areas. These changes have been beneficial to women in some cases and detrimental in others. Home-based technology, such as piped water and electricity, has helped reduce female domestic drudgery by reducing the amount of work necessary to collect fuel and water. Agricultural machinery, however, is usually designed for male users, thus reinforcing the gender division of labor. Big handles and heavy levers can impede women's use of machines. Social biases that associate machinery with men further limit women's use of technological improvements (Brandth, 2006). This is confirmed by a research project on Lebanese agriculture, according to which the low involvement of women in technology is due to practical difficulties in access and cultural restrictions on use. In addition, women's crops and livestock are usually disregarded as research priorities (ESCWA, 2001).

In the 1960s, when Egypt started mechanizing agricultural production, men's work began to change radically while women's work remained labor intensive (Saunders and Mehenna, 1986). The introduction of new agricultural technology in the Syrian countryside brought many farmers who had migrated back to the fields with prospects of increased production. Men took over the use of the machinery for land preparation or harvesting while women and children were assigned tedious manual jobs such as weeding and thinning. In some cases, the new machines have freed women from performing time-consuming tasks (FAO, 1995).

### 2.6.3.5 Globalization trends

Many countries of the CWANA region, such as Egypt, Jordan, Syria and Turkey, are moving toward structural adjustment policies that reduce agricultural subsidies, increase the role of the private sector and free market, decrease government expenditures and increase efficiency. Evidence shows that liberalization measures have mainly disfavored small-scale farmers and unskilled and informal workers. Women constitute a large part of these categories and are increasingly suffering from job insecurity. The increasing precariousness of work has affected mainly women, who are the first to be discriminated against in employment patterns. At the same time, the potential benefits connected to globalizing the labor force do not benefit women, whose working choices are restricted, for social reasons, to the internal labor market and eventually to conditions of limited reward.

Policies of market liberalization suffer from gender biases and market dynamics have marginalized petty trading, which primarily involves women. Gender discrimination in state and market institutions and intrahousehold inequalities all reduce women's control over the income from their work (Baden, 1998). Social policies to counteract the marginalization of disadvantaged sectors have not been put in place. On the contrary, the retreat of the state from providing social security has greatly affected women, who have suffered from the lack of support. For example, women and girls are forced to compensate for the weakened public health system by caring for the old and sick at home. Migration trends have continued to intensify the female labor load in rural areas. Environmental degradation is adding pressure by affecting the ecosystem many depend on for their livelihoods (Sindzingre, 2004).