

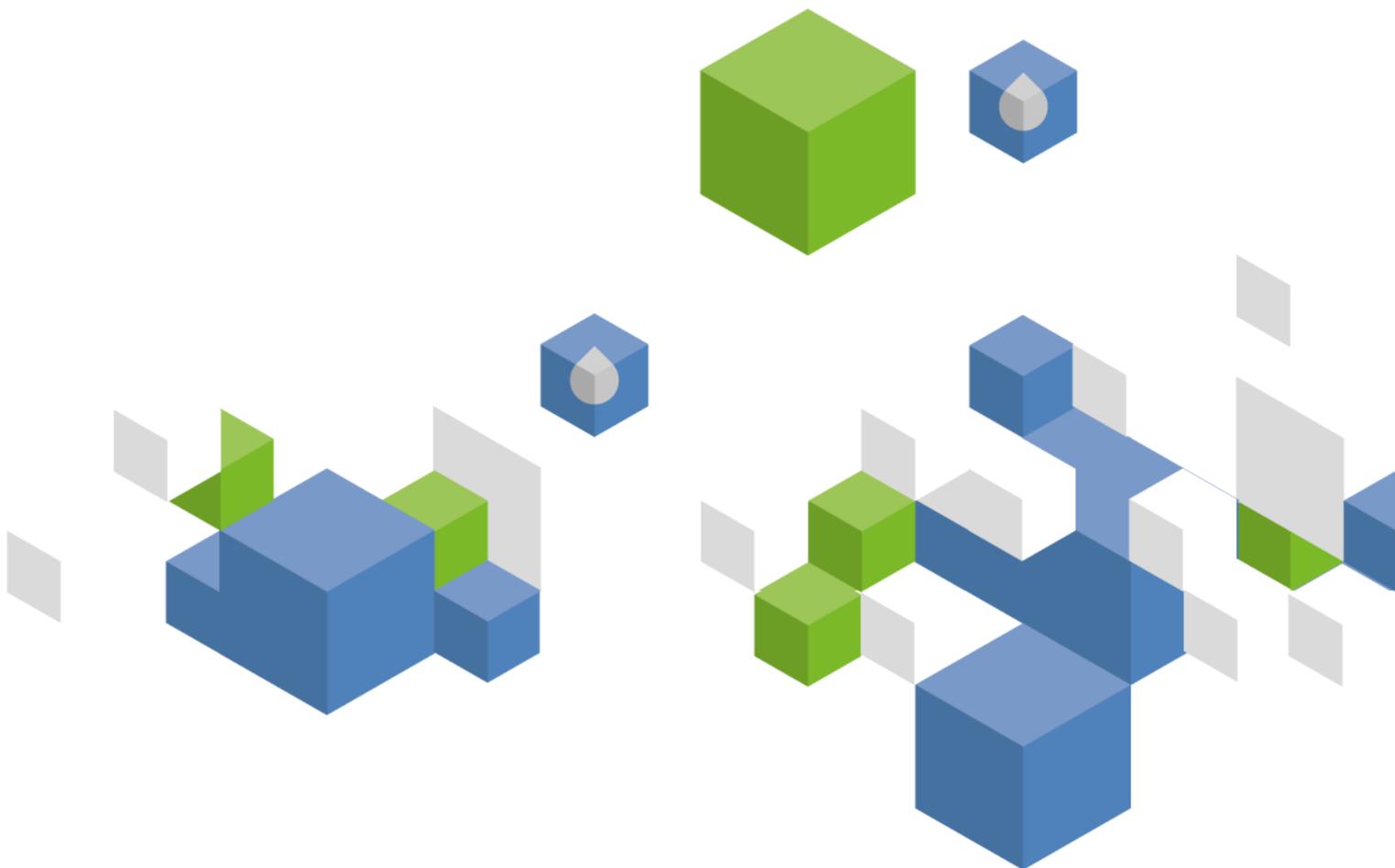


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Armenia

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Armenia, with a total area of 29 800 km², is a landlocked country in the Caucasus region bordered in the north by Georgia, in the east by Azerbaijan, in the southeast by the Islamic Republic of Iran, and in the southwest and west by Turkey. Until 1995, the country was divided into 37 districts. It is now divided into ten marzes (provinces) plus Yerevan, the capital city.

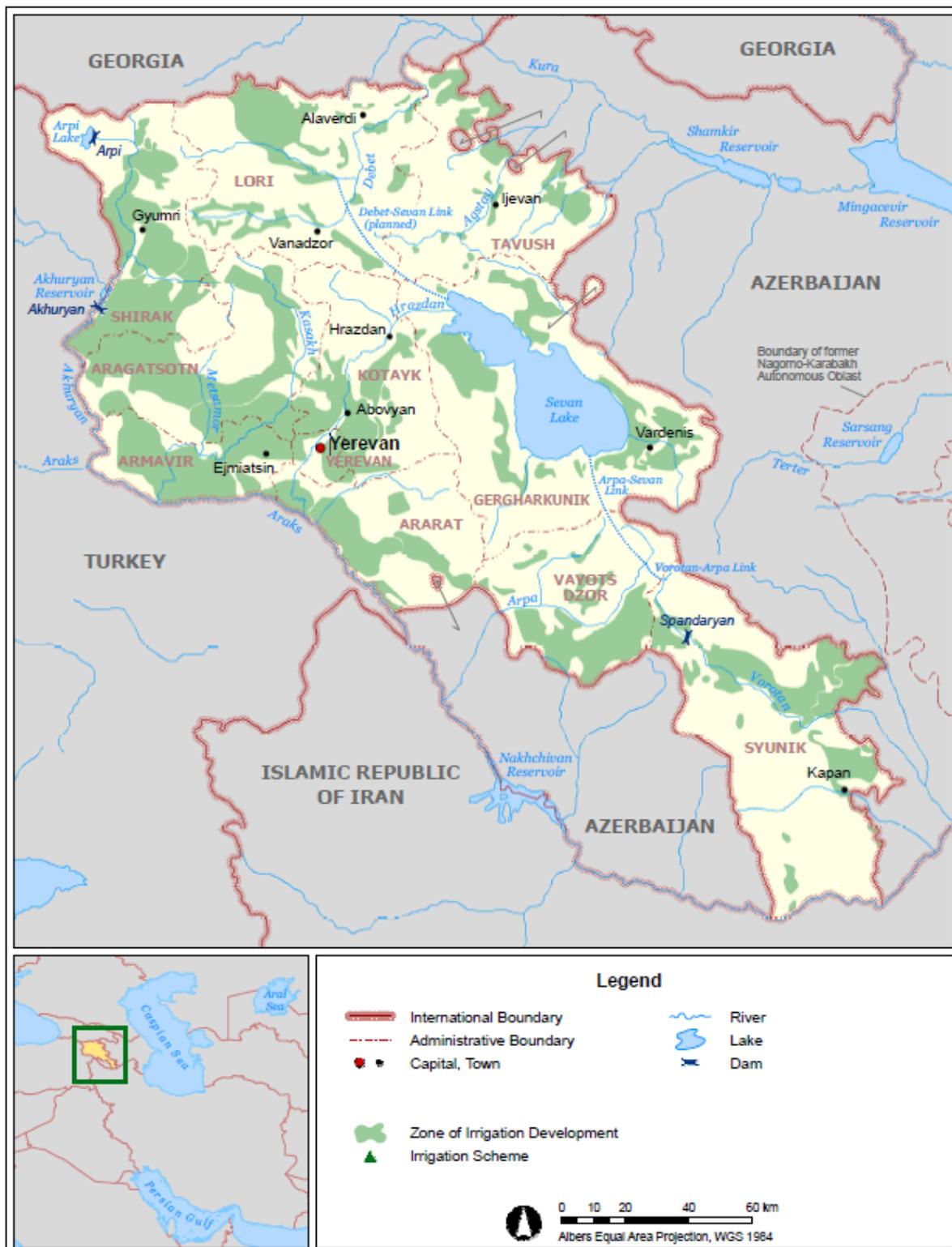
Armenia is a mountainous country, with 77 percent of its territory located at 1 000 to 2 500 m above sea level and with an average altitude of 1 850 m. The highest point is 4 095 m (Mount Aragats) and 42 percent of the area is unusable for habitation (MNR, 2005). The country has a complex combination of uplands, plateaus, river valleys, depressions, and limited land, water and forest resources, with unfavourable engineering-geological conditions in most of the area (high seismicity, abundance of geodynamic processes). The landform in the centre and north of the country consists of rocky high mountain ranges separating narrow fertile valleys. Towards the south are the broad, flat and fertile Ararat valleys along the left bank of the Araks River forming the border with Turkey. To the west and north of Mount Aragat and around Lake Sevan in the east, the landform is generally rolling with rocky outcrops. In the southeast, a few small irregular-shaped valleys are surrounded by high mountain ranges. Pastures dominate at higher altitudes. The country is divided into two major river basins, the Araks Basin in the southwest and the Kura Basin in the northeast, which converge farther downstream in Azerbaijan. The low-lying areas, such as the Ararat plains, have rich, deep soils, but at higher elevations and on steep slopes, soils tend to be shallow.

Agriculture is greatly influenced by the topography, most of the cultivated land lying within an altitude range of 600–2 500 m. The predominant agricultural soils are generally fertile and deep. The cultivable area is estimated at almost 1.4 million ha, which is 47 percent of the total area of the country. In 2005, the cultivated area was estimated at 555 000 ha, of which 495 000 ha were under annual crops and 60 000 ha under permanent crops (Table 1).

Climate

Armenia has a highland continental climate: hot summers and cold winters. The geographical location of the country and its complex mountainous relief have conditioned the diversity of natural conditions across the country. There are six climate zones ranging from dry subtropical to rigorous high mountainous. The average annual temperature is 5.5°C. Summer in Armenia is moderate, with an average temperature in July of around 16–17°C, but ranging from 24 to 26°C in the Ararat Valley. Winters are quite cold; the average winter temperature in Armenia is almost –7°C. Total annual precipitation is 592 mm. The driest regions are the Ararat Valley and the Meghri region, where the annual precipitation is 200–250 mm. The maximum precipitation is observed in high mountainous areas with more than 1 000 mm annually. The multiyear average for annual evaporation in Armenia is 10–11 million m³, equal to about 350 mm over the entire country (UNDP, 2006).

FIGURE 1
Map of Armenia



ARMENIA

FAO - AQUASTAT, 2008

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TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2005	2 980 000	ha
Cultivated area (arable land and area under permanent crops)	2005	555 000	ha
• as % of the total area of the country	2005	18.6	%
• arable land (annual crops + temp. fallow + temp. meadows)	2005	495 000	ha
• area under permanent crops	2005	60 000	ha
Population			
Total population	2005	3 016 000	inhabitants
• of which rural	2005	35.9	%
Population density	2005	101.2	inhabitants/km ²
Economically active population	2005	1 522 000	inhabitants
• as % of total population	2005	50.5	%
• female	2005	51.9	%
• male	2005	48.1	%
Population economically active in agriculture	2005	162 000	inhabitants
• as % of total economically active population	2005	10.6	%
• female	2005	21	%
• male	2005	79	%
Economy and development			
Gross Domestic Product (GDP) (current US\$)	2007	9 180	million US\$/yr
• value added in agriculture (% of GDP)	2007	18	%
• GDP per capita	2005	1 626	US\$/yr
Human Development Index (highest = 1)	2005	0.775	
Access to improved drinking water sources			
Total population	2006	98	%
Urban population	2006	99	%
Rural population	2006	96	%

Population

The total population is slightly more than 3 million (2005), of which about 36 percent is rural (Table 1). The population density is 101 inhabitants/km². The annual demographic growth rate was estimated at – 2.1 percent for the period 2000–2005. In 2006, 91 percent of the population had access to improved sanitation (96 and 81 percent in urban and rural areas, respectively). Access to improved drinking-water sources reached 96 percent (99 and 96 percent for urban and rural population respectively). It is estimated that about half of the population in Armenia lives below the poverty line. The rural population is less vulnerable because of its capacity to provide for basic foodstuffs on a more or less stable basis. The poorest communities in Armenia reside in the mountainous regions and the very poor are principally concentrated in the earthquake zone, in border regions or in regions with a low level of economic activity (FAO and MOA, 2002). More than 90 percent of households have access to an improved/not shared toilet facility (NSS and MOH, 2006).

ECONOMY, AGRICULTURE AND FOOD SECURITY

During the Soviet era, Armenia experienced robust industrial and agricultural development despite its limited natural resources. It became one of the most industrialized republics, providing machinery, chemicals, electronics and software to Russia and other Soviet Republics. In return, Armenia received raw materials and energy.

In December 1988, a devastating earthquake struck Armenia, killing more than 25 000 people and destroying large areas of the industrial heartland. This was followed by the break-up of the Soviet Union in 1991 and the consequent loss of markets and largely subsidized energy. This further led to a rapid decline in industrial output and to high unemployment. By 1993 the Gross Domestic Product (GDP) had fallen by almost two-thirds. Since 1994, however, Armenia has been among the most reform-minded countries of the former Soviet Union. Factors that have contributed to economic growth include: reforms

in the electricity sector; growth in exports in specific sectors, such as cut diamonds, metals, electricity, and processed food; housing construction, and a major programme of international assistance. However, the high levels of economic growth have not yet compensated for jobs lost because of downsizing or the closure of Soviet era enterprises (USAID, 2006).

In 2007, Armenia's GDP was US\$9.2 billion and agriculture accounted for 18 percent (Table 1), down from a share of 41 percent in 1994. Industry on the contrary increased its contribution to GDP between 2000 and 2007 from 35 to 44 percent. Just over 50 percent of the population, 1.5 million people – of whom 21 percent is female - is economically active (2005): 162 000 people, or 11 percent of the labour force, are employed in agriculture whereas in 1994 agriculture employed 15 percent of all workers.

In 2003, crops accounted for 55.8 percent and stock breeding 44.2 percent of agriculture compared with 49.4 and 50.6 percent respectively in 1990. Since the beginning of the transition period the grain sowing areas have expanded by more than 20 percent and areas under cultivated potato by about 40 percent. However, the areas under forage plants have decreased by more than 3 times. In 2004, the main agricultural products were cereals, potatoes, vegetables, forage plants and fruit, especially grapes, given the long tradition of viticulture and wine-making. Agriculture has played a very important role in the economy of the country although it depends heavily on irrigation - half the total cultivated area is currently irrigated.

At present, in the agricultural food products sector, there is a free economy system regulated by the market which includes more than 338 000 farms. More than 98 percent of gross agricultural production comes from the private sector. The contribution of the agriculture and food sectors to the Armenia's international trade has changed considerably since the start of the transition: exports have shrunk while imports have surged. In recent years, there has been a visible and steady trend to sectoral development, but agriculture continues to be vulnerable, mainly because of the relative shortage of suitable land, the lack of sufficient water resources, the small size and detachment of farms formed as a result of land privatizations, the underdeveloped industrial market and social infrastructure, as well as because agriculture does not at present meet the requirements of a market economy.

An important objective of agricultural development is to ensure appropriate levels of food security for the urban and rural population. It is estimated that expenditure on food accounts for between 60 and 70 percent of households' total consumption. It can be as high as 85 percent for the poorest quintile, while it is 57 percent for the richest quintile. In view of the high share of food expenditure in total consumption, an adequate level of food security for the population requires that food is provided at affordable and stable prices. Given that farmgate prices of agricultural products are low and unfavourable to farmers' incomes, increasing food security for the population implies improving significantly the efficiency of the processing and marketing chains for agricultural products. This kind of improvement will be attained primarily through better organization of the markets, increased competition in processing and trade and increased safety of marketed products. Investments in market infrastructure need to be carefully assessed in order to avoid unnecessary costs that would increase retail food prices (FAO and MOA, 2002).

WATER RESOURCES

The internal renewable surface water resources are estimated at 3.948 km³/year and the internal renewable groundwater resources at 4.311 km³/year. The overlap between surface water and groundwater is estimated at 1.400 km³/year. This gives a total of 6.859 km³ of annual internal renewable water resources (IRWR) (Table 2).

TABLE 2
Water resources

Renewable freshwater resources			
Precipitation (long-term average)	-	592	mm/yr
	-	17.642	10 ⁹ m ³ /yr
Internal renewable water resources (long-term average)	-	6.859	10 ⁹ m ³ /yr
Total actual renewable water resources	-	7.769	10 ⁹ m ³ /yr
Dependency ratio	-	11.71	%
Total actual renewable water resources per inhabitant	2005	2 576	m ³ /yr
Total dam capacity	2004	1 399	10 ⁶ m ³

The rivers in Armenia are tributaries of the main rivers of the southern Caucasus, namely the Araks and the Kura. About 76 percent of the total territory is part of the Araks basin and 24 percent of the Kura basin (UNDP/GEF, 2006). Total outflow is equal to the IRWR. The outflow to Georgia through the Debet River is estimated at about 0.89 km³/year and the outflow to Azerbaijan through the Agstay River at about 0.35 km³/year; both these rivers are located in the Kura basin. The total outflow to Azerbaijan through the Araks and its tributaries (Arpa, Vorotan, Vokhchi) is estimated at about 5.62 km³/year. The Araks River forms the border between Turkey and Armenia and further downstream, between the Islamic Republic of Iran and Armenia, it flows into Azerbaijan, joining the Kura River about 150 km before its mouth at the Caspian Sea. The border flow of the Akhuryan (with Turkey) is estimated at 1.03 km³/year and the Araks at 0.79 km³/year. Half of the border flow is accounted for in Armenia's water balance, bringing the total actual renewable water resources to 7.769 km³/year.

The 14 sub-basins of the two main river basins (Kura and Araks) have been grouped into five basin management areas: Akhuryan, Northern, Sevan-Hrazdan, Ararat and Southern basins (USAID, 2006). About 9 500 rivers and streams with the total length of 23 000 km flow in Armenia. Out of that number 379 rivers are around 10–100 km long, and seven, namely the Akhuryan, Debet, Vorotan, Hrazdan, Aghstev, Arpa and Metsamor-Kasakh, are longer than 100 km. The annual distribution of river flow generated in the country by the 14 river basins and their characteristic features are presented in Table 3 (UNDP, 2006). Armenian rivers are typically of a mountainous nature with sharp seasonal variations, spring freshets and low water flow in summer.

Armenia has more than 100 small lakes, some of which regularly dry out in the dry season. The Sevan and Arpi lakes are the most important in terms of size and economic importance. The Hrazdan and Akhuryan rivers originate from these two lakes, the largest of which is Lake Sevan, located in the centre of the country. It lies at 1 900 m above sea level, which makes it a strategic source of energy and irrigation water. The level of the lake, originally with a surface area of about 1 414 km² and 58 km³ of stored water, has fallen since the 1930s due to the lake's increasing use for irrigation and domestic water supply. By 1972, its level had fallen by almost 19 m and its surface area had been reduced to 1 250 km². At present, it covers an area of about 1 200 km², has a volume of approximately 34 km³, and plays a central and important hydrological role in the country. It serves the densely populated Hrazdan river basin and the Ararat Valley where Yerevan, the capital, is situated. Through its regulated surface outflow into the Hrazdan River, the lake's water provides a substantial amount of hydropower and irrigation to croplands in the Ararat Valley. The lake is also an important recreational, natural habitat and cultural resource for the Armenian population (MNP, 2005). Since 1960, two inter-basin transfer schemes were implemented to restore the ecology of the lake and its storage capacity as a strategic water reserve for multi-purpose use. A 48 km tunnel was built from 1963 to 1982 to divert some 250 million m³ of water annually from the Arpa River to Lake Sevan. A similar project, to divert 165 million m³ of water annually from the upper Vorotan River to the Arpa River through a 22 km tunnel, was completed in 2004. In the last few years, the lake's level has risen by about 2.7 m as a result of favourable meteorological conditions and improved management. Electricity generation at the Sevan-Hrazdan Cascade is currently tied to irrigation releases. During the last few years, irrigation releases have ranged from 120 to 150 million m³. The second most important lake is Lake Arpi. It is located in the western part of the Ashotsk depression at an altitude of 2 020 m above sea level. With the construction of a dam to solve irrigation problems, the lake became a reservoir.

TABLE 3
Characteristics of the main river basins in Armenia

N	River Basin	Area	Precipitation	Evaporation	Flow	Flow volume module	Reservoirs (2004)
		km ²	million ³ per year	million m ³ per year	million m ³ per year	million m ³ per km ²	In operation
I	Debet - within Armenia	3 895	2 726	1 457	1 203	0.309	1
II	Aghstay - within Armenia	2 480	1 569	979	445	0.205	5
III	Small tributaries of Kura - within Armenia	810	510	354	199	0.106	4
IV	Akhuryan - within Armenia	2 784	1 653	972	392	0.140	8
V	Kasakh	1 480	979	486	329	0.222	6
VI	Metsamor, without Kasakh	2 240	not available	not available	711	0.317	25
VII	Hrazdan	2 565	1 572	876	733	0.286	7
VIII	Lake Sevan Basin	4 750	not available	not available	265	0.056	4
IX	Azat	952	607	306	232	0.244	2
X	Vedi	998	573	340	110	0.111	1
XI	Arpa - within Armenia	2 306	1 643	768	764	0.331	11
XII	Vorotan – within Armenia	2 476	1 828	811	725	0.293	7
XIII	Voghji - within Armenia	1 341	1 097	448	502	0.374	2
XIV	Meghri	664	470	241	166	0.250	-

Most of the reservoirs were constructed during the Soviet period. In 2004, some 83 reservoirs were operating in Armenia and total capacity was estimated at 1 399 million m³, of which approximately 1 350 million m³ was stored in reservoirs with a capacity of over 5 million m³ each. Most of the water is used for irrigation. Some reservoirs are used for hydropower, recreation, fisheries and environmental protection. In 1995, about 145 million m³ was used for municipal and industrial purposes. The largest reservoir is on the Akhuryan River, which forms the border with Turkey. It has a storage capacity of 525 million m³, is shared with Turkey, and provides water for the irrigation of about 30 000 ha in Armenia. In contrast, many small off-channel reservoirs in the southwest of Aragats (Talish, Talin, Kakavadzor, Bazmaberd, Katnakhpyur), which accumulate spring tide waters, have a capacity of only 10 000–50 000 m³ (UNDP, 2006).

INTERNATIONAL WATER ISSUES

Most river basins are transboundary and through a number of bilateral agreements Armenia assumes obligations related to the development and use of international waters. Armenia has an agreement with Turkey concerning the use of the Araks and Akhuryan rivers, according to which the water of these two transboundary rivers is divided equally between the two countries. Another agreement with Turkey concerns the joint use of the dam and the reservoir of the Akhuryan River. According to an agreement between the Islamic Republic of Iran and Armenia, the water of the Araks River is divided equally between them. Though these agreements were signed by the USSR, Armenia is considered a successor country, and consequently is required to fulfil any related obligations. There have been decrees issued and agreements signed between Armenia and Georgia concerning the Debet River. Corresponding decrees were passed between Armenia and Azerbaijan concerning the use of the water of the Arpa, Vorotan, Aghstay and Tavush rivers.

In 1998, Armenia ratified the agreement with Georgia on environmental protection according to which the governments pledged their cooperation in creating specifically protected areas within the transboundary ecosystems. The Ministry of Nature Protection (MNP) develops and implements international environmental projects, some of which are related to water issues. Part of the Caucasus Initiative, launched by the German Ministry of Cooperation and Development, involves the implementation of the “Ecoregional Nature Protection Programme for the Southern Caucasus”. The programme, covering the three Caucasus countries, is going to be implemented in the very near future and will facilitate the protection and sustainable use of water resources in the region.

In 2002, the Republic of Armenia Commission on Transboundary Water Resources was established, which is chaired by the Head of Water Resources Management Agency. This commission, together with corresponding commissions in neighbouring countries, dealt with issues related to transboundary water resources use and protection.

From 2000 to 2002, USAID, in collaboration with Development Alternatives, Inc. (DAI), implemented the South Caucasus Water Management project which has the aim of strengthening the cooperation among water-related agencies at the local, national and regional levels, to provide integrated water resources management. In parallel, between 2000 and 2006, the EU and the Technical Assistance Commonwealth of Independent States (TACIS) developed the Joint River Management Program on Monitoring and Assessment of Water Quality on Transboundary Rivers, aimed at the prevention, control and reduction of transboundary pollution. The program covers four basins, including the Kura River basin. In addition, regional organisations such as REC and the Eurasia Foundation, as well as numerous local foundations, promote national and regional activities in the field of water resources management and protection (UNDP, 2002). USAID also funded the national project for Sustainable Water Resources Management in Armenia.

From 2002 to 2007, NATO-OSCE developed the South Caucasus River Monitoring Project whose general objectives were “to establish the social and technical infrastructure for an international, cooperative, Transboundary River water quality and quantity monitoring, data sharing and watershed management system among the Republics of Armenia, Azerbaijan and Georgia.” (OSU, 2008).

The project Reducing Transboundary Degradation in the Kura-Araks River Basin, implemented by the UNDP Bratislava Regional Centre in collaboration with the GEF, has involved four of the basin countries - Armenia, Azerbaijan, Georgia and the Islamic Republic of Iran. The project preparation phase lasted 18 months and began in July 2005. It is co-funded by Sweden. The project aims to ensure that the quality and quantity of the water throughout the Kura-Araks river system meets the short and long-term needs of the ecosystem and the communities that rely upon this ecosystem. The project will achieve its objectives by fostering regional cooperation, increasing capacity to address water quality and quantity problems, demonstrating water quality/quantity improvements, initiating the required policy and legal reforms, identifying and preparing priority investments and developing sustainable management and financial arrangements.

There are currently no water treaties between the three South Caucasian countries, a condition directly related to the political situation in the region. Nagorno-Karabakh is one of the main obstacles, making it difficult for Azerbaijan and Armenia to sign a treaty even one relating only to water resource management (Berrin and Campana, 2008).

WATER USE

Since the mid-1980s, there has been a decrease in the total water withdrawal, mainly due to a decrease in agricultural and industrial water withdrawal. In fact, the reduction in water use has been accompanied by a remarkable improvement in surface water quality. In 2006, the total water withdrawal for agricultural, municipal and industrial purposes was 2 827 million m³, of which about 66 percent for agricultural purposes, 30 percent for municipal use and 4 percent for industrial purposes (Table 4 and Figure 2). Agricultural water withdrawal mainly refers to irrigation of crops. Works for the watering of

pastures began in 1956, including providing water for cattle in the pasturing period. Sources of pasture watering are springs, mountain melted snow, and non-discharge water bodies (UNDP 2005). Surface water withdrawals represent 78 percent of the total water withdrawals (Figure 3).

TABLE 4
Water use

Water withdrawal				
Total water withdrawal	2006	2 827	10 ⁶ m ³ /yr	
- irrigation + livestock	2006	1 859	10 ⁶ m ³ /yr	
- municipalities	2006	843	10 ⁶ m ³ /yr	
- industry	2006	125	10 ⁶ m ³ /yr	
• per inhabitant	2005	776.5	m ³ /yr	
Surface water and groundwater withdrawal	2006	2 827	10 ⁶ m ³ /yr	
• as % of total actual renewable water resources	2006	36.4	%	
Non-conventional sources of water				
Produced wastewater	2006	363	10 ⁶ m ³ /yr	
Treated wastewater	2006	89	10 ⁶ m ³ /yr	
Reused treated wastewater	1994	0.1	10 ⁶ m ³ /yr	
Desalinated water produced		-	10 ⁶ m ³ /yr	
Reused agricultural drainage water		-	10 ⁶ m ³ /yr	

FIGURE 2
Water withdrawal
Total 2.827 km³ in 2006

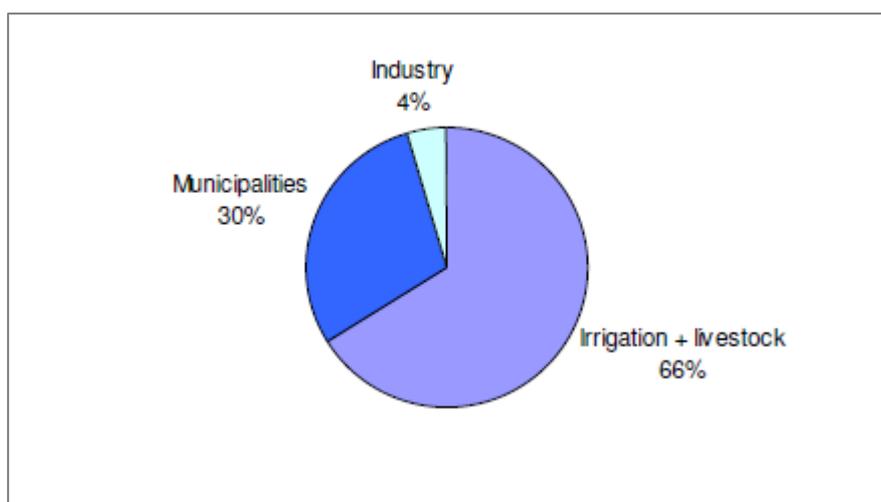
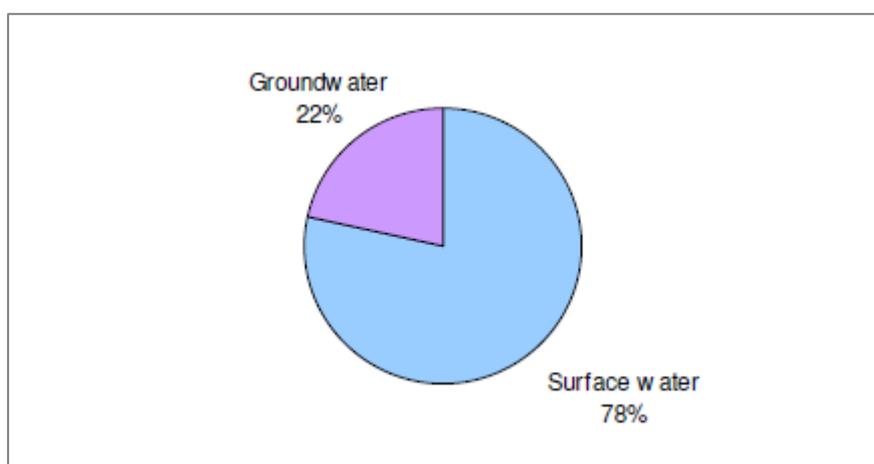


FIGURE 3
Water withdrawal by source
Total 2.827 km³ in 2006



In most of Armenia's territory, it is possible to use groundwater for drinking needs without any additional treatment. Indeed, about 95 percent of the water used for drinking purposes comes from groundwater sources (MNP, 2003). Both surface water and underground springs are used for industrial water supply. Industrial water supply is provided by independently operating water supply systems as well as from the city drinking water supply network. For the past 10–15 years, the water requirements of industrial enterprises have significantly decreased due to the reduction of the activity of many enterprises. It should be mentioned that 40 percent of the industrial enterprises using water are located in Yerevan. The largest water-using industrial enterprise is the Armenian Nuclear Power Plant which uses about 35 million m³/year (UNDP, 2005). There are 35 high and middle capacity hydropower plants in Armenia, nine of which are the plants at the Vorotan and Hrazdan hydropower cascades. As a result of insufficient regulation of volumes, hydropower production is also subject to seasonal variations (MNP, 2005).

While the industrial sector is not considered a major water user, an important problem for this sector is the implementation of industrial wastewater removal and treatment. Most industrial facilities were never equipped individually because they had been connected to the public sewer network during the Soviet Era, and thus were able to access municipal wastewater treatment. Attention should therefore be paid to those industries that have resumed production and from which the wastewater generated is channelled to the municipal wastewater treatment system, where only the mechanical treatment step is currently being operated. Also, the industries that are not connected to a municipal sewerage system discharge their mostly untreated wastewater directly into a stream or river. In general, old industries that resume production are the most polluting.

The total quantity of wastewater produced in 2006 amounted to 363 million m³, of which 89 million m³ was treated.

IRRIGATION AND DRAINAGE

Evolution of irrigation development

Irrigation in Armenia started about 3 000 years ago. Clay pipes were used to transport water to orchards and fields and some are still intact. In the fourth century, the total irrigated area was estimated at about 100 000 ha, in 1920 it had dropped to 60 000 ha, and in 1990 it was 320 000 ha (UNDP, 2006). The actually irrigated area declined from more than 300 000 ha in 1985 to 176 000 ha at present. Major factors that have contributed to this decline are the widespread deterioration of the irrigation conveyance systems, high pumping costs, the disintegration of the former collective farms into many small private farms (with a size of 1 to 2 ha), and drainage problems, particularly in the Ararat Valley, where groundwater tables are shallow.

At present, the area equipped for full or partial control irrigation is estimated at almost 274 000 ha (Table 5). The reason for the decrease in recent years has been, on the one hand, the earthquake of 1988 that destroyed part of the area, and on the other, the difficult economic situation due to the transition period, that has made it difficult to keep or maintain the irrigation infrastructure. The major irrigation schemes are located on the left bank of the Araks River.

The irrigation systems of Armenia were mainly established during the Soviet period. The irrigation infrastructure includes 80 reservoirs (77 of which are used only for irrigation and 3 used for both irrigation and drinking water), together with more than 3 000 km of main and secondary canals, about 15 000 km of tertiary canals, over 400 small and large pumps, 1 276 tubewells, and 945 artesian wells. Eight major conveyance systems distribute irrigation water to some 150 000 ha, and minor systems cover the rest of the areas. The conveyance systems are served by main, branch and secondary canals/pipes. Three-quarters of the canals are lined with concrete or are pipes. The main water structures, together with the main and secondary canals, are under state ownership whereas the tertiary level irrigation system (the intra-community irrigation network) was transferred to community ownership with the establishment of the Local Self-Governments in 1997.

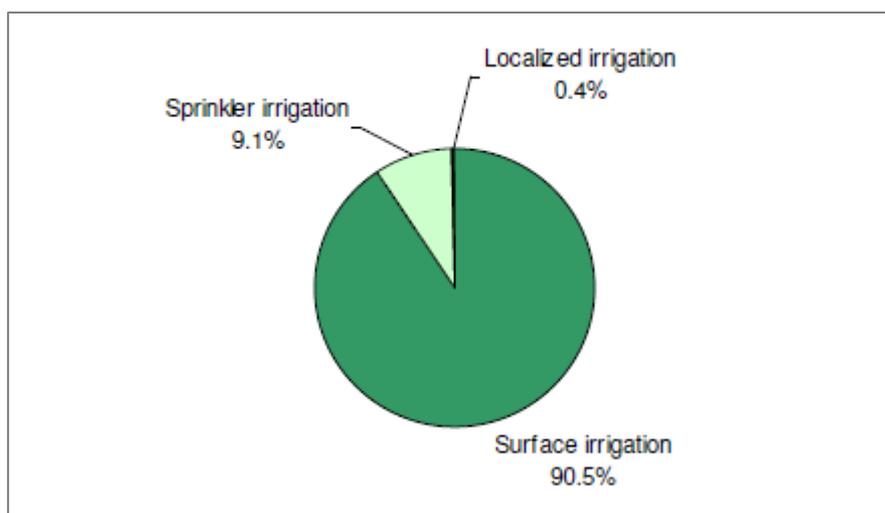
TABLE 5
Irrigation and drainage

Irrigation potential	-	660 000	ha
Irrigation			
1. Full or partial control irrigation: equipped area	2006	273 530	ha
- surface irrigation	2006	247 530	ha
- sprinkler irrigation	2006	25 000	ha
- localized irrigation	2006	1 000	ha
• % of area irrigated from surface water	2006	81.4	%
• % of area irrigated from groundwater	2006	18.6	%
• % of area irrigated from mixed surface water and groundwater	2006	0	%
• % of area irrigated from non-conventional sources of water	2006	0	%
• area equipped for full or partial control irrigation actually irrigated	2006	176 000	ha
- as % of full/partial control area equipped	2006	64.3	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		-	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	2006	273 530	ha
• as % of cultivated area	2006	49.3	%
• % of total area equipped for irrigation actually irrigated	2006	64.3	%
• average increase per year over the last 11 years	1995-2006	-0.40	%
• power irrigated area as % of total area equipped	2002	42.6	%
4. Non-equipped cultivated wetlands and inland valley bottoms		-	ha
5. Non-equipped flood recession cropping area		-	ha
Total water-managed area (1+2+3+4+5)	2006	273 530	ha
• as % of cultivated area	2006	49.3	%
Full or partial control irrigation schemes			
	Criteria		
Small-scale schemes	< 200 ha	2006	55 697 ha
Medium-scale schemes			ha
Large-scale schemes	> 200 ha	2006	217 833 ha
Total number of households in irrigation			-
Irrigated crops in full or partial control irrigation schemes			
Total irrigated grain production (wheat and barley)		-	metric tons
• as % of total grain production		-	%
Harvested crops:			
Total harvested irrigated cropped area	2006	176 000	ha
• Annual crops: total	2006	125 100	ha
- Wheat	2006	35 000	ha
- Barley	2006	5 900	ha
- Maize	2006	3 100	ha
- Potatoes	2006	24 000	ha
- Sugar beet	2006	200	ha
- Pulses	2006	2 000	ha
- Vegetables	2006	23 200	ha
- Tobacco	2006	200	ha
- Fodder	2006	26 000	ha
- Sunflower	2006	200	ha
- Other annual crops	2006	5 300	ha
• Permanent crops: total	2006	50 900	ha
- Other perennial crops	2006	50 900	ha
Irrigated cropping intensity (on full/partial control area actually irrigated)	2006	100	%
Drainage – Environment			
Total drained area	2006	34 457	ha
- part of the area equipped for irrigation drained	2006	34 457	ha
- other drained area (non-irrigated)		-	ha
• drained area as % of cultivated area	2006	6.2	%
Flood-protected areas		-	ha
Area salinized by irrigation	2006	20 415	ha
Population affected by water-related diseases	2001	1 644	inhabitants

Around 80 percent of the total irrigated land is irrigated through the main network operated by the “Vorogum-Jrar” Closed Joint Stock Company (CJSC), while the remaining 20 percent is irrigated through the community-owned networks (WB-IBRD, 2004).

Surface irrigation is practised on over 90 percent of the area equipped for irrigation and can be divided into four categories of irrigation: furrow, borderstrip, flooding or basin, and that using hydrants and flexible hose systems (Figure 4).

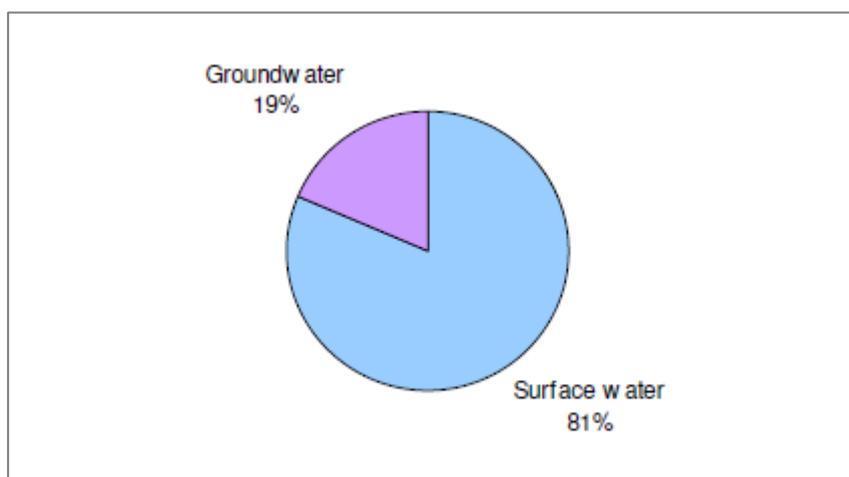
FIGURE 4
Irrigation techniques
Total 273 530 ha in 2006



Flooding is used where soil depth does not permit the grading of either furrows or borderstrips. The water is let out over the land by cutting an irrigation head canal at intervals. In the case of irrigation using hydrants, the hydrants are generally spaced in a 50 x 50 m grid and discharge water directly onto the ground, from where it is distributed by any of the surface irrigation methods. Conveyance of water to the hydrant is by buried steel pipes, but may be by open canals further upstream. Sprinkler irrigation and localized irrigation are practised on the remaining area equipped for full or partial control irrigation.

Groundwater is used for irrigation on 19 percent of the equipped area (Figure 5). The remaining part is irrigated from surface water through reservoirs, river diversion or pumping in rivers.

FIGURE 5
Source of irrigation water
Total 273 530 ha in 2006



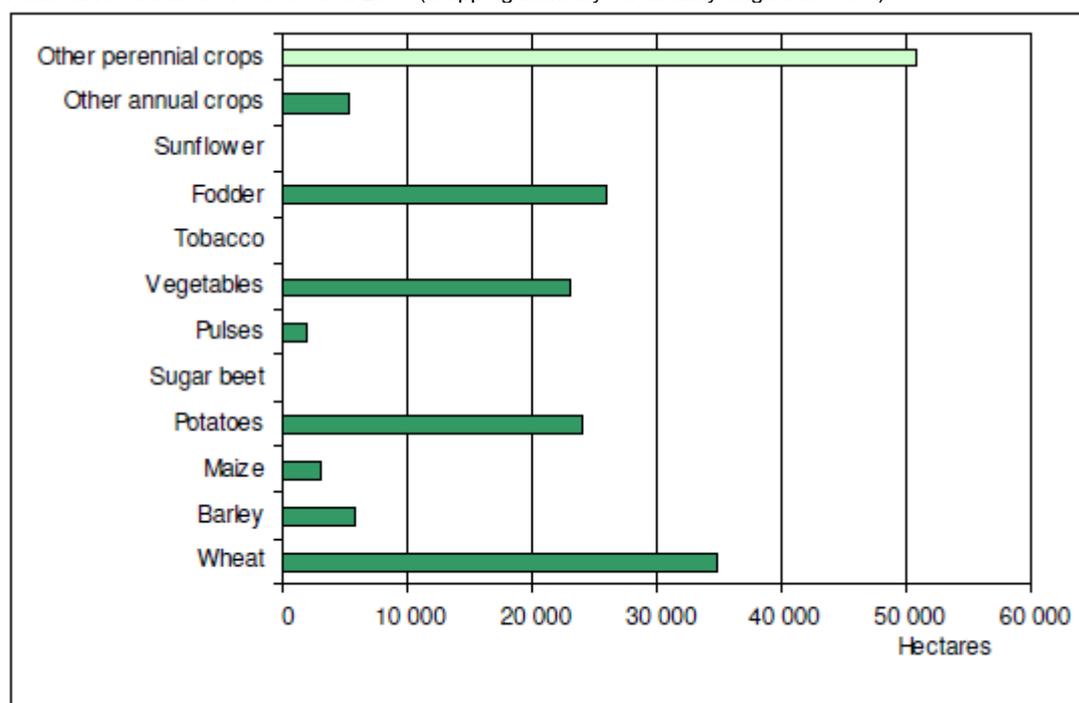
Role of irrigation in agricultural production, the economy and society

The irrigation potential has been estimated at about 660 000 ha and 41 percent of this had been equipped for irrigation in 2006. Almost 71 percent of the irrigated area was occupied by annual crops. Cereals, mainly wheat, covered 20 percent, fodder 15 percent, potatoes 14 percent and vegetables 13 percent (Table 5 and Figure 5).

FIGURE 6

Irrigated crops

Total harvested area 176 000 ha in 2006 (cropping intensity on actually irrigated: 100%)



More than 80 percent of total crop production is produced under irrigation. The difference in productivity between irrigated and rainfed agriculture is estimated at about US\$900 per hectare. Table 6 gives an illustration of estimated returns for irrigation water at the farmgate by main crop and agro-economic zone.

TABLE 6

Net return to irrigation water at the farm gate (US\$ cents per m³)

Crop	Ararat Plain Area	Hilly Area	Mountainous Area	Subtropical Area
Wheat	12	6	5	11
Vegetables	26	2	20	33
Potatoes	54	11	42	29
Alfalfa	1	0	1	0
Fruit	23	72	25	61
Grapes	51	22	-	11

An analysis based on standardized farm models indicates that even without taking into account changing cropping patterns in response to the increased reliability of irrigation, a 30 percent increase in irrigated land for an average farm will generate sufficient incremental net income to lift a family out of poverty, providing that other sources of income remained unchanged. However, an analysis based on information collected from 54 Water Users' Associations (WUAs) revealed that although irrigation in 2005 clearly improved in terms of reliability of supply, only 125 000 ha was actually irrigated out of the 228 000 ha equipped for the service. Three main problems explain this situation. First, the high cost of water supply in areas with predominantly pumping irrigation makes irrigation economically non-viable due to very

inefficient pumping schemes. Second, water losses in secondary and tertiary canals are reported to be in the order of 40–50 percent, which effectively reduces the total irrigated area, since additional water supplies are unavailable in most cases for technical or/and economic reasons. Third, most of the pumping stations have very high levels of electricity consumption compared with their design parameters and high maintenance costs due to frequent service disruptions beyond what was designed.

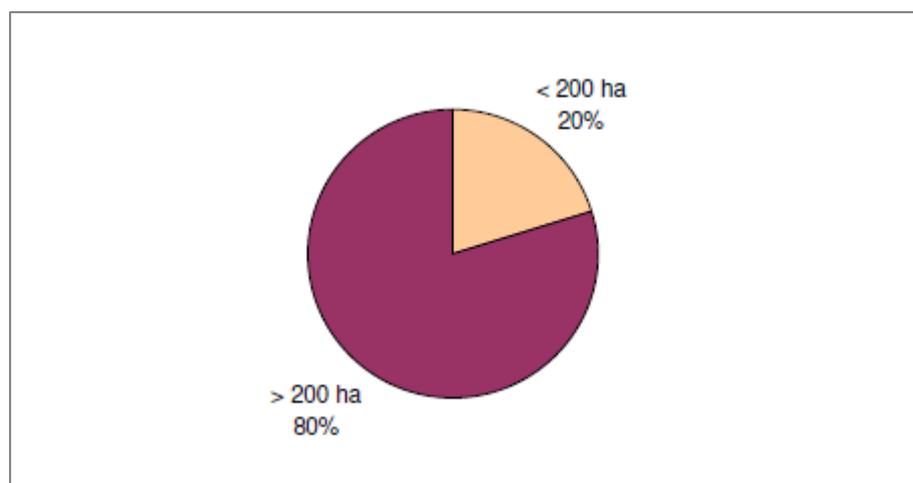
Annual irrigation water demand begins to increase in late April, peaks in early July, and drops off in October. Nearly 40 percent of the irrigation area depends on high-lift pumping, with pumping lifts of more than 100 m. For the larger irrigation systems, losses may amount to 50 percent of the water intake. Information about actually irrigated lands is presented in Table 7, containing data provided by WUAs in 2005 on the demand for water for irrigation purposes.

TABLE 7
Assessment of water demand for irrigation for WUAs (2005)

Marz (province)	Actually irrigated area	Water withdrawal	Water used in the field	Average losses	Water volume for 1 ha of irrigated lands (m ³)	
	(ha)	(million m ³)	(million m ³)	(%)	gross	net
Ararat	27 584	285	169	41	10 332	6 127
Armavir	42 597	525	314	40	12 325	7 371
Kotayk	8 102	85	49	42	10 491	6 048
Aragatsotn	18 899	192	113	41	10 159	5 979
Gegharkunik	4 366	19	12	37	4 352	2 749
Shirak	10 157	31	16	48	3 052	1 575
Vayots Dzor	3 165	17	10	41	5 372	3 160
Syunik	4 703	22	14	36	4 678	2 977
Tavush	2 816	14	9	36	4 972	3 196
Lory	2 875	8	5	38	2 783	1 739
TOTAL	125 264	1 198	711	41	9 564	5 676

There are pronounced differences between the communities with respect to share of irrigated land. In 2003, 24 percent of rural communities did not have access to irrigation, 5 percent had less than 20 percent of their total arable land under irrigation, 24 percent had between 20 and 80 percent under irrigation, while 47 percent had over 80 percent of their total arable land under irrigation (WB-IBRD, 2004). In 2006, small schemes (< 200 ha) covered 20 percent of total equipped area for irrigation, while large schemes (> 200 ha) covered 80 percent (Figure 7).

FIGURE 7
Type of irrigation schemes
Total 273 530 ha in 2006



Crop budgets were prepared based on the monitoring and evaluation of WUAs in 2004 and prices were obtained through farm surveys. The country was divided into four agro-economic zones (valley, upland,

high mountainous and subtropical), in three of which rainfed farming is possible. Composition of crops, yields, incomes per hectare by crop and by zone are presented in Table 8 and Table 9.

TABLE 8
Crop budgets by agro-economic zones (2004)

Crop / Budget	Valley		Hilly		Mountainous		Subtropical	
	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated
Wheat	-	42%	50%	24%	65%	54%	60%	16%
Vegetables	-	20%	-	10%	-	6%	-	9%
Potatoes	-	5%	-	1%	-	27%	-	2%
Alfalfa	-	8%	50%	31%	35%	11%	40%	-
Fruit	-	17%	-	26%	-	2%	-	44%
Grape	-	8%	-	8%	-	-	-	29%
Total	-	100%	100%	100%	100%	100%	100%	100%

TABLE 9
Crop yield and net income by agro-economic zones (2004)

Zone	Yield (kg per ha)		Net Income (US\$ per ha)	
	Non-irrigated	Irrigated	Non-irrigated	Irrigated
Valley				
Wheat		3 350		470
Vegetables		37 810		2 098
Potatoes		30 750		4 196
Alfalfa		11 920		75
Fruit		5 600		1 631
Grapes		12 410		3 596
Weighted average				1 385
Hilly				
Wheat	1 200	2 760	57	303
Vegetables	-	16 200	-	141
Potatoes	-	13 000	-	540
Alfalfa	3 000	7 000	13	14
Fruit	-	11 850	-	4 297
Grapes	-	5 860	-	1 291
Weighted average				1 316
Mountainous				
Wheat	1 400	2 570	116	286
Vegetables	-	22 500	-	992
Potatoes	-	21 070	-	2 110
Alfalfa	2 500	6 200	12	57
Fruit	-	6 100	-	1 265
Weighted average				820
Subtropical				
Wheat	2 300	6 000	366	1 137
Vegetables	-	28 700	-	2 615
Potatoes	-	19 700	-	1 436
Alfalfa	3 000	-	35	-
Fruit	-	10 000	-	4 243
Weighted average				2 328

Status and evolution of drainage systems

In 2006 drainage was practised on 34 457 ha, of which 7 729 ha of horizontal closed drainage, 26 408 ha of horizontal open drainage and 320 ha of vertical drainage. The part of the irrigated land that is waterlogged is 18 722 ha.

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

The most important institutions involved in water resources development and management are:

- The National Water Council (NWC): the highest advisory body in the water sector, chaired by the Prime Minister. It advises on water management issues, and makes recommendations on policies, legal documents, and the National Water Program.
- The Ministry of Nature Protection, with:
 - the Underground Resources Protection Department;
 - the Environmental Protection Department;
 - the Water Resources Management Agency, which controls the use of water resources through water use permits;
 - the Climate Change Information Center;
 - the State Environmental Inspectorate.
- The Ministry of Agriculture: responsible for the development of agriculture policy and strategies, including irrigation and drainage policies, with:
 - the Planning of Agricultural and Social Development of Rural Areas Department;
 - the Crop Production, Forestry and Plant Protection Department.
- The Vorogum-Jrar Closed Joint Stock Company (CJSC): brings together State organizations with responsibilities for the provision of irrigation and drainage services. This company pumps or diverts the water from the river, operates and maintains the primary canals, and sells the water to WUAs under seasonal water supply contracts.
- The Public Services Regulatory Commission (PSRC): responsible for the economic regulation of natural monopolies in the irrigation and municipal water sectors. The main responsibilities are water infrastructure use permits, the monitoring of the quality of service provisions, and setting of tariffs.
- The Ministry of Territorial Administration, with:
 - the State Committee on Water Systems (SCWS), which is responsible for the management and operation of state-owned municipal and irrigation water supply, sewerage and wastewater treatment systems; it includes the “Melioration” CJSC, which is responsible for operation and maintenance of drainage systems;
- The Armenian State Hydrometeorological and Monitoring Service (Armstatehydromet) and Environmental Impact Monitoring Center (EIMC): provide surface water monitoring data;
- The Hydrogeological Monitoring Center: responsible for monitoring all groundwater bodies.

Water management

Reforms in the water sector have been initiated since the implementation of the World Bank-supported “Integrated Water Resources Management Project” in 1999–2000. The idea of river basin management was also proposed through the introduction of annual and perspective planning mechanisms for water resources. One of the most important steps towards reform in the water sector was the adoption of a new Water Code on 4 June 2002 and, in order to ensure its enforcement, 80 regulations have been adopted by the Government since 2002, which relate, among others, to the procedures for water use permit provisions, transparency and public participation in the decision-making processes, accessibility of information, establishment of the state water cadaster, formation of water resources monitoring, management of transboundary water resources. The Code also contains the idea of integrated river basin management, for which a methodology of developing integrated water basin management plans has been developed, making it possible to use economic tools for water resources management and cost recovery. In order to promote more efficient, targeted and decentralized management of water resources, five territorial divisions (Basin Management Organizations) have been established under the umbrella of the Water Resources Management Agency: Northern, Akhuryan, Araratian, Sevan-Hrazdan and Southern. The Law on “Fundamental Provisions of the National Water Policy” was adopted in 2005; this

represents a forward-looking development concept for water resources and water systems' strategic use and protection. Since 2005 the water basin management principle is being applied in the sector of water resources management. In addition to this, a law concerning the "National Water Programme" has been developed. This law is the main document for the prospective development of water resources and water systems management and protection. As a result of the above-mentioned legal and institutional reforms, Armenia is currently one of the leaders in the region in the sector of water resource management.

By law, local mayors are responsible for providing the water service within a municipality unless the water sources and facilities serve more than one municipality, in which case one of the five State-owned water companies provides the water service. In 2006, about 80 percent of the population was served by the State water companies. The remainder of the population is served by small municipal systems and numerous community-based organizations. The "Yerevan Djur" CJSC is the largest of the five State companies and provides water and sewer services to the city of Yerevan and 28 neighbouring villages, covering around 50 percent of the total population. It operates under a recently signed lease contract with a French water company. The next largest State water company is the Armenian Water and Sewerage Company (AWSC) which operates under the terms of a management contract with another French water company. AWSC provides service to roughly 22 percent of the population. The other three State water companies, Lori, Shirak and Nor Akunk are managed with significant input from foreign consultants under the terms of a financing agreement between the State and a German lending agency. At the beginning of 2006, the average monthly water bill for most residential customers in Armenia was less than US\$2. The collection rate has been improving but is still less than desirable.

Hydropower accounts for 20 percent of electricity generation. The total installed hydropower generating capacity of Armenia is about 1 100 MW, of which 1 050 MW is operational. Almost 95 percent of this capacity is installed along two important hydropower cascades: the Sevan-Hrazdan Cascade and the Vorotan Cascade. Electricity generation at the Sevan-Hrazdan Cascade is tied to irrigation releases from Lake Sevan on the basis of an annual water allocation plan (USAID, 2006).

USAID designed the Programme for Institutional and Regulatory Strengthening of Water Management in Armenia (2004-2008) to provide technical assistance, training and equipment to improve water resource management and the regulation of the increasingly decentralized irrigation and municipal water sectors. The programme will lay the foundation for effective water resource management and planned investment in the Armenian drinking water, sewerage, and irrigation sectors and assist the Government and leading water sector agencies to enhance their effectiveness through initiatives based on international best practices adapted for the Armenian context.

Finances

Currently, the State funds about 50 percent of the annually assessed Operation and Maintenance (O&M) requirements of the water services for irrigation. For 2005, the O&M requirements were estimated to be US\$16 million, with a contribution from the State budget of US\$8 million, which essentially covers the electricity costs for operating the pumping stations. The irrigation tariffs that WUAs or other users pay to the Vorogum-Jrar differ by region and mode of water delivery (pumped or gravity) and are capped at approximately US\$20/1 000 m³ or US\$150/ha. Maintenance is still inadequate to sustain the irrigation systems due to an underestimation of the annual O&M requirements and lower than expected tariff collection rates. The real O&M costs may vary from US\$5/1 000 m³ or US\$40/ha for gravity schemes to more than US\$50/1 000 m³ or US\$400/ha for some high-lift pumped schemes. The latter costs are higher than the incremental income earned by many subsistence farmers as a result of irrigation and may range from US\$200/ha to US\$400/ha per year (USAID, 2006).

Investments, such as the recently approved grant of US\$236 million from the US Millennium Challenge Corporation may go a long way toward stabilizing the irrigation subsector. The grant will support a five-year programme of strategic investments in irrigation and rural roads, aimed at increasing agricultural production. The grant will also fund the improvement of drainage facilities, the rehabilitation of

irrigation infrastructure, the strengthening of the Vorogum-Jrar and WUAs, and a water-to-market project that will provide training and access to credit for farmers who want to make the transition to more profitable, market-oriented agricultural production (USAID, 2006)

Policies and legislation

As mentioned in the “Water management” section above, the legal and institutional structure of the water sector is based on the National Water Code adopted in 2002. The Water Code defines three major functions in the water sector: management of water resources, management of water systems, and regulation of water supply and wastewater services.

ENVIRONMENT AND HEALTH

Most of the drinking water is provided by groundwater, which has high organoleptic properties and is very pure. Due to the poor state of the water supply networks, however, the risk of water contamination is high. Due to the lack of liquid and lime chlorine, and the electric power deficit, in most cases, water is supplied without chlorination. In many places sewage and drinking water supply networks are put together and at present the sewage system is in an emergency situation: 63 percent of the network is more than 20 years old and 22 percent requires immediate renewal. According to the data provided by the Ministry of Health, during 1984–1991, no infection outbreak episodes related to drinking water quality were recorded in Armenia. However, since 1992 such episodes have been periodically registered. During the 1999–2002 period, 18 outbreak episodes related to water pollution were recorded with the total number of 5 690 diseased persons (UNDP, 2005). In 2003, 21 839 incidents were recorded, 5 839 of which (26.7 percent) occurred in Yerevan.

Solonetzic soils, which are characterized by a tough, impermeable hardpan that may vary from 5 to 30 cm or more below the surface soils, are widespread. These soils are most of all exposed to the risk of irrigation-related salinization, mainly as a result of rising groundwater in the plains, where the majority of irrigated lands are located. In the Ararat plain, solonetzic soils cover about 10 percent of the area. In 2006, the part of the irrigated land that is salinized was 20 415 ha, of which 15 137 ha weakly salinized, 2 385 ha medium salinized, and 2 893 ha strongly salinized (MTA, 2007).

The malaria situation was stable in Armenia until 1994. In subsequent years, a downgrading of malaria prevention services and a weakening of the malaria surveillance system resulted in a steady increase in the number of malaria cases, reaching 1 156 by 1998. Over 98 percent of these cases were detected in the Masis district of the Ararat Valley, an area bordering Turkey. In recent years, owing to epidemic control interventions, the number of autochthonous malaria cases has continued to decrease, dropping to 8 in 2003. However, although numbers have been on the decline, the situation must be monitored closely, because of the existence of favourable conditions for malaria transmission. In 2003, Armenia redefined and adjusted the present malaria control strategy, objectives and approaches, bearing in mind the results achieved to date, the extent of the problem, and potential threats in the country (MTA, 2007).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

To reduce the burden of high expenditure in the State budget for government bodies engaged in water resource management, steps have been taken to involve the private sector.

Within the framework of the Agricultural Sustainable Development Strategy, the main priorities in the development of crop production are an increase in crop yield and a reduction in expenses per production unit through the application of advanced agro-technologies.

Main and secondary canals with high water losses, the collector-drainage system in the Ararat valley, and the tertiary irrigation systems need rehabilitation. About half of the total amount of the Agreement (US\$113 million), signed between US Government Millennium Challenge Corporation and Armenia, will be directed to solve the main problems in the irrigation sector.

The main directions in the development of the irrigation sector are as follows:

- a. Improvement of the managerial structure and technical conditions of the irrigation system;
- b. Substitution of pumped irrigation with gravity irrigation conveyance systems and introduction of clear mechanisms for the management, supply and stock-taking of irrigation water;
- c. Support to the establishment of water users' unions, as well as to the development of water users' associations;
- d. Support to the rehabilitation of inter-farm irrigation networks;
- e. Implementation of the "Cleaning and maintenance of the collector-drainage network programme" to regulate the level and mineral content of subsoil water located in the irrigated areas under the drainage systems, to prevent secondary salinization, floods and infectious diseases, to reclaim land and to provide a sustainable yield from agricultural crops;
- f. Decrease in water tariffs; provision of sustainable water supply; decrease in water losses and water utilization prices through improvement of the water systems; increase in efficiency of farming activities due to the additional water supply; creation of favourable conditions for the utilization of the irrigation systems and denationalization of maintenance procedures; improvement of efficient management of the network through implementation of structural reforms, provision of transparency for water tariffs and switching to self-financing of the network by the end of the programme;
- g. Implementation of the first and second dam safety programmes. The first programme aims at the provision of dam safety for a population of 360 000 and at increased efficiency in the supply of the irrigation system. The programme includes rehabilitation of the 20 most dangerous 20 dams and some other activities besides. The second programme includes the rehabilitation of 47 dams;
- h. Implementation of the sub-programme on "Irrigated agriculture" under the Millennium Goal programme. According to the programme, US\$113 million will be spent on solving the existing problems in the irrigation system (over 5 years). The programme includes irrigation schemes for 21 districts and the construction of 18 gravity-fed systems, 5 new water reservoirs and rehabilitation of 2 non-finished water reservoirs, rehabilitation of 6 big water pipes for a total length of 200 km, rehabilitation and re-equipping of 68 pump stations, rehabilitation of inter-farm irrigation networks on a total area of 75 000 ha with the assistance of water users; and rehabilitation of the Ararat valley irrigation-drainage network and, as a result, ensuring soil quality improvement over an area of 25 000 ha. The implementation of the programme will enable a decrease in electricity use of 30 percent, and a rehabilitated irrigation network covering 30 000 ha, thus a decrease in total expenses of 20 percent;
- i. Implementation of the programme on the watering of natural pastures. Annually, over US\$530 000 (160 million AMD at 2008 rate) will be spent on these activities, with the aim of increasing the crop yield of the pastures and net income, which will promote poverty reduction;
- j. Implementation of the programme on improvement of soil quality of the secondary salinized irrigated land of the Ararat valley. As a result, the subsoil water level will be regulated over about 8 000 ha, secondary salinization and flooding of the settlements will be prevented, and sustainable crop yield will be ensured thus promoting poverty reduction;
- k. Implementation of the programme on the definition of irrigation norms and regimes for agricultural crops. The programme aims to develop new norms and regimes to replace those in place for the last thirty years. The new norms will meet the actual requirements, supplying crops with sufficient water for growth. Moreover, there will be a saving of water resources in the order of 10–15 per cent. (FAO and MOA, 2002).

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