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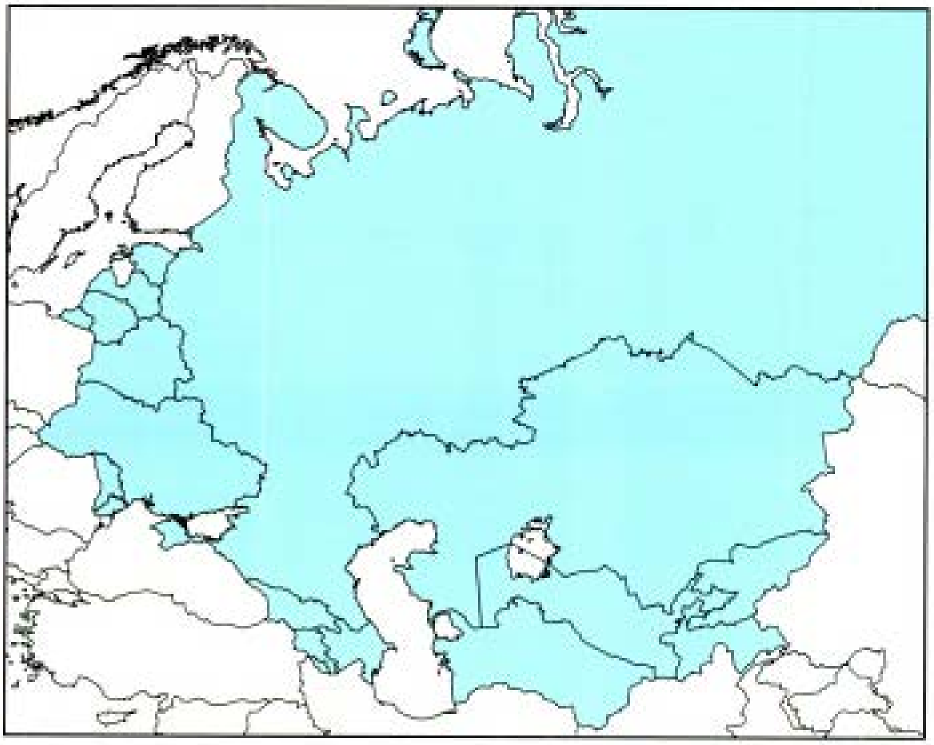

IRRIGATION IN THE COUNTRIES OF THE FORMER SOVIET UNION IN FIGURES

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Foreword

FAO's AQUASTAT programme, initiated in 1993, aims to meet the demand for information on water resources and use at regional level, with particular emphasis on irrigation and drainage. The objectives of the programme are to collect and present, in a systematic way, data on rural water use at country level.

With an area of more than 22 million km², the former Soviet Union (FSU) covers about 17% of the world and presents a wide range of climatic and physiographic situations, from the arctic zones of Siberia to the arid deserts of Central Asia.

To these conditions correspond a large variety of agricultural water management situations. Irrigation predominates in the Central Asian countries (in total, the FSU countries concentrate about 9% of the world's irrigated land), while in the temperate countries of the north drainage is of major importance to agricultural productivity.

The FSU countries are currently in a transitional period which is affecting the agricultural sector. New policies are being designed and implemented, new institutional structures are replacing those of the Soviet Union and, in general, the move towards a market-oriented economy is inducing rapid changes in cropping patterns. These changes have a direct and often radical impact on irrigation and drainage, with major challenges to come in the fields of irrigation management transfer and infrastructure maintenance.

Furthermore, the issues related to international water courses and the stress on water resources in the most arid parts of the FSU represent another challenge to the new countries. Their governments now have to develop mechanisms for the sustainable management of their water resources.

This publication presents a description of the irrigation and drainage subsector in the FSU countries, with relevant tables and maps, together with a regional synopsis. It is hoped that the information provided here will be of use to all those interested in issues related to water resources management, irrigation and drainage in the region.

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The publication has been edited by Julian Plummer and prepared for printing by Chrissi Smith Redfern.

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List of abbreviations

ARSWR	Actual Renewable Surface Water Resources
ARWR	Actual Renewable Water Resources
BWO	Basin Water Organization
FSU	Former Soviet Union
GDP	Gross Domestic Product
ICAS	Interstate Council for the Aral Sea problem
ICWC	Interstate Commission for Water Coordination
IFAS	International Fund for the Aral Sea
ILO	International Labour Organization
IRSWR	Internal Renewable Surface Water Resources
IRWR	Internal Renewable Water Resources
O&M	Operation and Maintenance
RSWR	Renewable Surface Water Resources
RWR	Renewable Water Resources
SSR	Soviet Socialist Republic
USA	United States of America
USSR	Union of Soviet Socialist Republics
WUA	Water Users Association

UNITS

Volume:
$1\ km^3 = 1 \times 10^9\ m^3 = 1\ 000 \times 10^6\ m^3 = 1\ 000$ million m^3

Area:
$1\ km^2 = 100$ ha

Power:
$1\ GW = 1 \times 10^3\ MW = 1 \times 10^6\ kW = 1 \times 10^9\ W$
$1\ W = 1\ J/s$

Energy:
$1\ GWh = 1 \times 10^3\ MWh = 1 \times 10^6\ kWh$
$1\ kWh = 3.6 \times 10^6\ J$

The information presented in this publication is collected from a variety of sources. It reflects FAO's best estimates, based on the most accurate and up-to-date information available at the date of printing.

Presentation of the survey

INTRODUCTION

In 1993, FAO started to develop a programme named AQUASTAT, which is an information system on water use for agriculture and rural development. Its aim is to collect information at country and sub-country level and to make it available, in a standard format, to users interested in global, regional and national perspectives. In 1994-95, the 53 African countries were surveyed, which resulted in FAO Water Report 7 'Irrigation in Africa in figures'. In 1996, the 29 country members of FAO's Regional Office for the Near East were surveyed, which resulted in FAO Water Report 9 'Irrigation in the Near East region in figures'. The present survey concentrates on the 15 countries of the former Soviet Union (FSU)[1].

The purpose of the survey is twofold:

- To provide a clear picture of the situation of rural water resources management on a country basis, with emphasis on irrigation and drainage, and featuring major characteristics, trends, constraints and perspectives;

- To help support continental and regional analyses by providing systematic, up-to-date and reliable information on water for agriculture and rural development, and to serve as a tool for large-scale planning and forecasting.

In order to obtain information that was as reliable as possible, the survey was developed and carried out for each country as follows:

1. Review of literature and existing information on the country and the region.
2. Data collection by means of a detailed questionnaire.
3. Data processing and critical analysis of the information, with the assistance of the AQUASTAT data processing software and selection of the most reliable information.
4. Preparation of a country profile.

Lastly, regional and sub-regional tables and maps and a general summary were prepared. Cross-checking of the information took place wherever possible.

COUNTRY PROFILES

Each country profile describes the situation regarding water resources and use in the country, with special attention to the water resources, irrigation and drainage subsectors. Its aim is to emphasize the particularities of each country, as well as the problems encountered in rural water

[1] They are: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

management and irrigation. It also summarizes the trends of irrigation in the countries, as described in the available literature. It was a deliberate choice to try and standardize the country profiles as much as possible. All profiles follow the same pattern, organized in six sections:

- geography and population;
- climate and water resources;
- irrigation and drainage development;
- institutional environment;
- trends in water resources management;
- main sources of information.

Standardized tables are used for all country profiles. Where information was not available, this is indicated by a dash (-). As most of the available data relate to a limited number of years only, the most recent reliable data are used in the tables, with an indication of the year to which they refer.

DATA COLLECTION, PROCESSING AND RELIABILITY

The main sources of information were:

- national water resources and irrigation master plans;
- national yearbooks, statistics and reports;
- reports from FAO or other organizations;
- international surveys;
- results from surveys made by national or international research centres.

In total, 70 variables were selected and these are presented in the tables attached to each country profile. They are grouped into categories corresponding to the profile sections. A detailed definition of each variable is given below.

In most cases, a critical analysis of the information was necessary to ensure consistency between the different data collected for a given country. Where several sources gave different or contradictory figures, preference was always given to information collected at national or sub-national level and, unless proved incorrect, to official rather than unofficial sources. In the case of shared water resources, a comparison between countries was made to ensure consistency at river basin level.

Nevertheless, the accuracy and reliability of the information vary greatly between regions, countries and categories of information, as does the year in which the information was gathered. These considerations are discussed in the country profiles.

DEFINITION OF THE MAIN VARIABLES

The main variables presented in the tables in the country profiles are listed in the order in which they appear in the tables and are defined as follows:

Area of the country: (ha) The total area of the country, including area under inland water bodies. Data in this category are obtained from the United Nations Statistical Office.

Cultivable area: (ha) Area of land potentially fit for cultivation. This term may or may not include part or all of the forests and rangeland (see note on cultivable land and agricultural land in the next section).

Cultivated area: (ha) Area under temporary (annual) and permanent crops. This refers to the physical area actually cultivated and does not include land which is temporarily fallow (see note on arable versus cultivated land in the next section).

Annual crops: (ha) Physical area under temporary (annual) crops.

Permanent crops: (ha) Area cultivated with crops that occupy the land for long periods and that do not need to be replanted after each harvest. This does not include woodland and forests.

Total population: (inhabitants) The figures are the UN estimates for 1996.

Rural population: (%) The figures are the UN estimates for 1996.

Economically active population engaged in agriculture: (%) The figures for the total economically active population engaged in agriculture are extracted from the FAO statistics database for 1996, and are based on assessments made by the International Labour Organization (ILO). The gender-desegregated figures have been found in various national sources.

Water supply coverage: (%) The percentage of urban and rural population with access to safe drinking water (criteria may vary between countries).

Average precipitation: (mm/year and km^3/year) Double average over space and time of water falling on the country in a year.

Internal renewable water resources: (km^3/year) Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation.

Total (actual) renewable water resources: (km^3/year) The sum of internal renewable water resources and incoming flow originating outside the country, taking into consideration the quantity of flows reserved to upstream and downstream countries through formal or informal agreements or treaties. This gives the maximum theoretical amount of water actually available for the country (see note on the computation of water resources in the next section).

Dependency ratio: (%) That part of the total renewable water resources originating outside the country.

Total dam capacity: (10^6 m^3) The total cumulative capacity of all dams.

Water withdrawal: (10^6 m^3/year) Gross amount of water extracted from the resources for a given use. It includes conveyance losses, consumptive use and return flow (see note on water withdrawal in the next section).

Agricultural water withdrawal: (10^6 m^3/year) Annual quantity of water withdrawn for agricultural purposes including irrigation and livestock watering (see note on agricultural water withdrawal in the next section).

Domestic water withdrawal: (10^6 m^3/year) Annual quantity of water withdrawn for domestic purposes. It is usually computed as the total amount of water withdrawn by public distribution networks, and normally includes the withdrawal by those industries connected to public networks.

Industrial water withdrawal: (10^6 m^3/year) Annual quantity of water withdrawn for industrial purposes. It usually refers to self-supplied industries not connected to any distribution network (see note on industrial water withdrawal in the next section).

Total water withdrawal: (10^6 m^3/year) Annual quantity of water withdrawn for agricultural, domestic and industrial purposes. It does not include other withdrawals (see below).

Other water withdrawal: (10^6 m^3/year) This includes all other sectors: energy, mining, recreation, navigation, fisheries and environment. These sectors usually have a very low consumption rate.

Produced wastewater: (10^6 m^3/year) Annual quantity of wastewater produced in the country. This does not include agricultural drainage water.

Treated wastewater: (10^6 m^3/year) Annual quantity of wastewater which is treated.

Re-used treated wastewater: (10^6 m^3/year) Annual quantity of treated wastewater which is re-used.

Agricultural drainage water: (10^6 m^3/year) That part of the irrigation water withdrawal which returns to the river system or is collected by a drainage network.

Desalinated water: (10^6 m^3/year) Installed capacity of desalination plants.

Irrigation potential: (ha) Area of land suitable for irrigation development, taking into account land and water resources. It includes land already under irrigation. The definition may vary among countries (see note on irrigation potential in the next section).

Full or partial control irrigation: equipped area: (ha) Irrigation schemes carried out and managed either by government, private estates or farmers, and where a full or partial control of the water is achieved. Gardening is included in this category.

Surface irrigation: (ha) Part of the full or partial control area under surface irrigation: furrow, border, basin, and flooded irrigation of rice.

Sprinkler irrigation: (ha) Part of the full or partial control area irrigated by aspersion (sprinkler).

Micro-irrigation: (ha) Part of the full or partial control area irrigated by micro-irrigation.

Percentage of area irrigated from groundwater: (%) Part of the full or partial control area irrigated from wells (shallow wells and deep tube-wells) or springs.

Percentage of area irrigated from surface water: (%) Part of the full or partial control area irrigated from rivers or lakes (reservoirs, pumping or diversion).

Percentage of area irrigated from non-conventional sources: (%) Part of the full or partial control area irrigated from non-conventional sources of water such as (un)treated wastewater, desalinated water or agricultural drainage water.

Percentage of equipped area actually irrigated: (%) Part of the full or partial control area which is actually irrigated. Often, the whole area equipped is not irrigated for various reasons, such as lack of water, absence of farmers, damage, organizational problems, and so forth. It concerns the actual physical areas. Irrigated land that is cultivated twice a year is counted once.

Spate irrigation area: (ha) Area of land equipped for spate irrigation.

Equipped wetlands and inland valley bottoms: (ha) Part of cultivated wetlands and inland valley bottoms which have been equipped with water control structures (intake, canals, etc.). Developed mangroves are included in this category.

Total irrigation: Area equipped to provide water to the crops. It includes areas equipped for full and partial control irrigation, spate irrigation areas, and equipped wetland and inland valley bottoms. It does not include flood recession cropping areas. In the text it is also referred to as *irrigated area* or *area under irrigation*.

Power irrigated area as percentage of irrigated area: (%) Part of the irrigated area where pumps are used for water supply. It does not include areas where water is pumped with human- or animal-driven water lifting devices.

Full or partial control irrigation schemes: (ha) Areas of large, medium and small schemes, following the criteria used by the country, with the criteria given.

Total number of households in irrigation: Total number of households living directly on earnings from full or partial control irrigation schemes.

Total irrigated grain production: (t) The total quantity of cereals harvested annually in the irrigated area.

Harvested crops under irrigation: (ha) Total harvested irrigated area for the crop for the given year. Areas under double cropping should be counted twice. For permanent crops data generally refer to the total planted area.

Drained area: (ha) The area equipped with subsurface or surface (open) drains. It can be broken down into *drained areas in full or partial control irrigated areas; drained areas in equipped wetland and inland valley bottoms;* and *other drained areas*, which are equipped for drainage but not irrigation. Flood recession cropping areas are not considered as being drained.

Area salinized by irrigation: (ha) Total irrigated area affected by salinization as a result of irrigation. This does not include naturally saline areas.

OTHER DEFINITIONS AND CONVENTIONS

Notwithstanding the detailed description of each variable, some problems persist due to the fact that the available literature does not always indicate clearly which definition has been used in computing the figures. The most frequent problems encountered in computing the figures are listed below. In addition, a number of terms used in the country profiles, though not in the tables, are also explained below.

Arable versus cultivated land: The official definition of arable land is 'land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens, and land temporarily fallow'. In this study, 'land cultivated with annual crops' has been preferred to 'arable land' and refers to the physical area actually cultivated with temporary crops, excluding the temporarily fallow land. However, the way multiple cropping and intercropping are accounted for is not always clearly explained in the literature.

Cultivable land: The notion of cultivable land in arid areas is closely linked to the capacity to provide water to the crops. Assumptions made in assessing cultivable land vary from country to country. In this survey, national figures have been used where available, despite possible large discrepancies in computation methods.

Agricultural land: In most of the countries of the FSU, there is no clear distinction between agricultural land, cultivable land or cultivated land. The definition varies from country to country and is explained in the country profiles.

Irrigation potential: Assumptions made in assessing irrigation potential vary from country to country. In most cases it is computed on the basis of available land and water resources, but economic and environmental considerations may also have been taken into account. Some countries include the possible use of non-conventional sources of water for irrigation. Except in a few cases, no consideration is given to the possible double counting of shared water resources. Wetland and floodplains are usually, but not systematically, included in irrigation potential.

Water withdrawal: This term includes all the water used for agricultural, domestic and industrial purposes. The possible use of agricultural drainage water, desalinated water and (un)treated wastewater is included. These three sources of water are also referred to as *non-conventional sources of water*.

Agricultural water withdrawal: Methods for computing agricultural water withdrawal vary from country to country. The figure was reviewed for each country on the basis of crop water requirements and irrigated areas, and comments are given in the country profiles to explain the figure where necessary. In some countries, rural domestic water withdrawal is included in agricultural water withdrawal.

Livestock water withdrawal: By default, livestock water withdrawal is accounted for in agricultural water withdrawal. However, some countries include it in domestic water withdrawal.

Industrial water withdrawal: In many countries of the FSU, both hydropower water use and water used for nuclear power plant cooling are included in industrial water withdrawal, although this is rather water use than water withdrawal in view of the very low consumption rates involved. Where separate figures for these items were given, they have been included in other water withdrawal instead of industrial water withdrawal.

Return flow: That part of the agricultural, domestic and industrial water withdrawal which flows back to the river system or is collected by a drainage network.

Computation of water resources: The following terms have been used in the computation of water resources: *Internal renewable water resources* is the average annual flow of rivers and recharge of groundwater generated from endogenous precipitation. A critical review of the data was made to ensure that double counting of surface water and groundwater was avoided. *Total natural renewable water resources* is the sum of internal renewable water resources and natural incoming flow originating outside the country. Special rules were used to take the flow of border rivers into account. *Natural incoming flow* is the average annual amount of water which would flow into the country in natural conditions, i.e., without human influence. This figure is not time dependent. *Total actual renewable water resources* is the sum of internal renewable water resources and incoming flow originating outside the country, taking into account the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and the reduction of flow due to upstream withdrawal. It corresponds to the maximum theoretical amount of water actually available for a country at a given moment. The figure may vary with time. *Manageable water resources*, or *development potential*, refers to that part of the resources which is considered to be available for development under specific economic conditions. This figure considers factors such as the dependability of the flow, floods, extractable groundwater, minimum flow required for non-consumptive uses, etc.

Safe yield of groundwater: The definition varies from country to country and is explained in the country profiles. It may or may not include fossil water.

Kareze or Qanat: Unlined tunnel in the hillside, bringing water by free flow from underground aquifers to the surface.

Phytomelioration: In Central Asia, agricultural drainage water is diverted from the collector-drainage network to ponds, where crops are grown to concentrate the salts present in the water and thus filter the water. The main crops grown in such ponds are the common reed (*Phragmites communis*), narrow leafed reedmace (*Typha angustifolia*) and great bulrush (*Scirpus lacustris*). The crop harvest is re-used as raw material for construction. This method is also called biological treatment of water.

Total water managed area versus total irrigation: Total water managed area is the sum of total irrigation (see definition above), flood recession cropping areas and other cultivated wetland and inland valley bottoms. It does not include water harvesting areas. Flood recession cropping areas (area along rivers where cultivation occurs in the areas exposed as the flood recedes) and other cultivated wetland and inland valley bottoms (wetland and inland valley bottoms not equipped with water control structures but used for cropping) are not reported present in the countries of the FSU. Total water managed area thus corresponds to total irrigation in these countries.

General summary

INTRODUCTION

The former Soviet Union (FSU), which covers part of the European and Asian continents, comprises 15 countries. The area extends from the Baltic Sea in the west to the Pacific Ocean in the east and from the Arctic Ocean in the north to the Black Sea and the Caspian Sea in the south.

For the purpose of this study, the 15 countries have been grouped in five regions, based primarily on geographic conditions and, as far as possible, on hydro-climatic homogeneity, although the Russian Federation is, due to its size, subject to a wide variation of geographic and hydro-climatic conditions. The regions, listed by size and presented in Figure 3, are here referred to as: Russian Federation, Central Asia, Eastern Europe, Caucasus and Baltic States[1].

GEOGRAPHY, CLIMATE AND POPULATION

The total area of the FSU is about 22.3 million km^2, which is almost 17% of the total area of the world (Tables 1 and 10). The Russian Federation alone covers 17.1 million km^2, which is almost 13% of the total area of the world. Kazakhstan, with an area of 2.7 million km^2, covers 2% of the total area of the world, while the remaining 13 countries combined also cover 2% of the total area of the world.

TABLE 1
Regional distribution of the population

Region	Area		Population			% of economic active population engaged in agriculture
	km^2	% of FSU	inhabitants	inhabitants per km^2	rural population %	
Russian Federation	17 075 400	76.7	148 126 000	9	24	12
Central Asia	3 994 400	17.9	54 588 000	14	54	30
Eastern Europe	845 000	3.8	66 400 000	79	30	19
Caucasus	186 100	0.8	16 674 000	90	40	25
Baltic States	174 900	0.8	7 703 000	44	27	16
Former Soviet Union	**22 275 800**	**100.0**	**293 491 000**	**13**	**32**	**17**
World	134 223 000		5 767 775 000	43	54	47
FSU as % of World	17%		5%	31%		

The total population of the FSU was about 293 million in 1996, which represents 5% of the world population (Tables 1 and 11). About 32% of the total population of the countries of the

[1] Distribution of the 15 countries of the former Soviet Union in the five regions:

Russian Federation: Russian Federation
Central Asia: Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan
Eastern Europe: Belarus, Moldova, Ukraine
Caucasus: Armenia, Azerbaijan, Georgia
Baltic States: Estonia, Latvia, Lithuania

FSU is rural, compared with 54% for the whole world, varying from 24% in the Russian Federation to 54% in Central Asia. About 17% of the economically active population is engaged in agriculture, compared with 47% for the whole world, varying from 12% in the Russian Federation to 30% in Central Asia. This reflects the importance of agriculture in Central Asia, while industry is largely predominant in the northern regions of the FSU. The population density is 13 inhabitants/km^2, compared with 43 inhabitants/km^2 for the whole world, varying from 9 inhabitants/km^2 in the Russian Federation to 90 inhabitants/km^2 in the Caucasus. The population growth between 1995 and 1996 was less than 0.06%, compared with a world average of 1.4%. While in the 1980s the annual demographic growth rate was still positive, many countries of the FSU have shown a negative growth rate since independence in 1991. The main reason for this has been the difficult economic situation prevailing since independence, which has led to lower birth rates, and the migration of part of the population to other countries.

Russian Federation

The Russian Federation is the largest country in the world and its territory includes a wide variety of physical features. European Russia, which traditionally means the part of the Russian Federation to the west of the Ural mountains, and western Siberia are rather flat. The Ural mountains provide only a symbolic barrier between European Russia and Asian Russia, their mean altitude being only 500 m above sea level, with a peak at 1 894 m above sea level. In the south, between the Black Sea and the Caspian Sea, the area is more undulating until it reaches the foothills of the Greater Caucasus mountain range in the far south with a peak at 5 642 m above sea level. To the east of the western Siberian plains is the central Siberian plateau with high mountain ranges on the southern border with Mongolia. Eastern Siberia and the far east are dominated by several mountain ranges, which extend in a series of peninsulas and islands in the Pacific Ocean. The Kamchatka peninsula has 100 active volcanoes, the altitude of the highest being 4 800 m above sea level. The northern regions of both European and Asian Russia are inhospitable areas, much of the territory being covered by permafrost.

The climate of the Russian Federation is extremely varied. The central western regions have the same climatic conditions as central and eastern Europe, although in a more extreme form. There are wide temperature differences between summer and winter and there is considerable snow in winter. The average temperature in Moscow is 19°C in summer and -9°C in winter. In the south, along the Black Sea coast, the climate is more temperate. In the northern areas and in much of Siberia the climate is severe, with arctic winters and short, hot summers. Average temperatures in southern Siberia vary from 18°C in summer to -18°C in winter. In the far north of Siberia, the average winter temperature is -47°C. The far east combines the extreme temperatures of Siberia with some monsoon-type conditions. Average temperatures at the coast in the far southeast vary from 21°C in summer to -14°C in winter. Over a large part of the territory, temperature is a major constraint on cropping.

The average annual precipitation in the Russian Federation is about 590 mm, varying from less than 200 mm at the mouth of the Volga River in the southwest, to more than 1 000 mm in the mountains of the far east (Figure 4). Water is generally in excess in the northern regions, drainage being the main issue, while in the southern regions the lack of water during the cropping season makes irrigation necessary.

The population was almost 148 million in 1996, over 50% of the total population of the FSU. The population density was 9 inhabitants/km^2 (Table 11). In the Russian far east province, the population density was only 1 inhabitant/km^2.

Central Asia

The total area of the five Central Asian countries is almost 4 million km^2, which represents almost 18% of the area of the FSU. Kazakhstan alone covers 68% of this area of 4 million km^2 (Tables 1 and 10). The relief in this region is extremely varied. In the east are the Tien Shan and Pamir mountain ranges. The highest mountain of the FSU, the Peak of Communism at 7 495 m above sea level, is located in the northern Pamirs in Tajikistan. Much of the mountain region is permanently covered with ice and snow and there are many glaciers. Mountain ranges in the south of the region include the earthquake prone Kopetdag range along the border with Afghanistan. In the northeast of the region lies the second largest crater lake in the world, the Issyk-Kul in the Kyrgyz Republic. On the border between the Kyrgyz Republic, Tajikistan and Uzbekistan is the Fergana valley, which is a major agricultural area in this region. In the southwest lies the Kara-Kum or Black Sand desert, which is one of the largest sand deserts in the world and which covers over 80% of Turkmenistan. Another large desert, the Kyzyl-Kum or Red Sand desert, extends over Kazakhstan and the north of Uzbekistan. The west of the region is dominated by the depressions of the Caspian Sea. The Aral Sea, in the central western part, is located on the border between Kazakhstan and Uzbekistan. It is known to have become one of the world's most serious environmental disaster areas (see the section on the Aral Sea basin).

The climate in the region is continental, but varies considerably according to altitude. Average winter temperatures vary between -3°C and -20°C, but can fall below -45°C in the mountain regions in Tajikistan. Average summer temperatures vary between 19°C and 32°C, but often reach 50°C in the southeastern Kara-Kum in Turkmenistan.

The average annual precipitation in this region is 338 mm, varying from less than 70 mm in the plains and deserts to 2 400 mm in the mountains of central Tajikistan. One half of the total irrigated area of the FSU is located in Central Asia. The two major land quality problems related to irrigation in the region are the interrelated issues of salinity and waterlogging caused by high groundwater levels. This makes drainage important in this region.

The total population was almost 54.6 million in 1996, 18.6% of the total population of the countries of the FSU. The population density in this region was 14 inhabitants/km^2, with a minimum of 6 inhabitants/km^2 in Kazakhstan, which is less than half the population density of the FSU (Tables 1 and 11).

Eastern Europe

The countries referred to as Eastern Europe (Belarus, Moldova and Ukraine) are located in the west of the FSU to the north of the Black Sea. Their total area is 845 000 km^2, which represents 3.8% of the total area of the FSU (Tables 1 and 10). The north of this region is flat and low with numerous lakes, swamps and marshes. The southern part consists of steppe lowland, bordered by uplands to the west and southwest. The highest peak is 471 m above sea level in western Ukraine. This region is famed for its fertile black soils.

In the north of this region, the climate is continental, with average temperatures of 19°C in summer and -5°C in winter. In the south, the climate is temperate and very favourable for agriculture with long, warm summers and relatively mild winters. Average temperatures are around 21°C in summer and -5°C in winter.

The average annual precipitation is 547 mm, varying from 360 mm in the Crimean peninsula, where irrigation is necessary to satisfy the summer crop water requirements, to 1 600 mm in the Carpathian mountains of northwest Ukraine (Figure 4). Droughts are frequent in the southern areas. In the north of this region, drainage is more important than irrigation. In fact, irrigation is mainly found in areas where the groundwater level has fallen too much due to excessive drainage, so making also irrigation necessary.

The population was 66.4 million in 1996, 22.6% of the total population of the countries of the FSU. The population density was 78 inhabitants/km^2, six times the average population density for the FSU (Tables 1 and 11).

Caucasus

The Caucasus includes Armenia, Azerbaijan and Georgia, and is located in the southwest of the FSU, between the Black Sea and the Caspian Sea. Its total area of 186 100 km^2, or 0.8% of the total area of the FSU, is only slightly larger than that of the Baltic States (Tables 1 and 10). The region is located at the southern foothills of the Greater Caucasus mountain range, which is considered as the boundary between Europe and Asia. The highest peak in the region stands at about 5 000 m above sea level. Large areas around the Black Sea, the Caspian Sea and the river deltas are lowlands.

The climate varies from warm, humid, subtropical in the northeast near the Black Sea coast, with average temperature in summer of 22°C and in winter of 5°C, to typical dry continental, with average summer temperatures up to 27°C.

The average annual precipitation is 735 mm, varying from 200 mm in the Ararat valley in central Armenia to 1 700 mm in western Georgia (Figure 4). In the southern and eastern parts of this region irrigation is necessary, but drainage is also required in large areas to reduce irrigation induced salinization. In the high rainfall region of western Georgia drainage is important.

The population was 16.7 million in 1996, 5.7% of the total population of the countries of the FSU. With 90 inhabitants/km^2, the population density in this region is the highest of the FSU (Tables 1 and 11).

Baltic States

The total area of the three Baltic states (Estonia, Latvia and Lithuania), located in the northwest of the FSU, is 174 900 km^2, which represents 0.8% of the total area of the FSU (Tables 1 and 10). The region is mainly flat along the coast and somewhat undulating farther inland. The highest elevation is 312 m above sea level. There is a dense network of waterways in this region and there are numerous lakes and marshes.

The climate is influenced by the region's position between the Eurasian land mass and the Baltic Sea. Average temperatures are around 17°C in summer and -5°C in winter.

The average annual precipitation is 716 mm, varying from 500 mm in parts of Lithuania to 850 mm in the uplands of Latvia (Figure 4). In this mainly low-lying, flat region, drainage is more important for agriculture than is irrigation. Large areas can only be cultivated intensively if drained. Irrigation is generally limited to supplementary irrigation.

The population was 7.7 million in 1996, 2.7% of the total population of the countries of the FSU. The population density was 44 inhabitants/km^2, more than three times that of the FSU (Tables 1 and 11).

ORGANIZATION OF THE AGRICULTURAL SECTOR

In 1990, there were about 52 000 large farms in the Soviet Union, 45% of which were *sovkhoz* (state farms) and 55% *kolkhoz* (collective farms). About half of them (25 000) were located in the Russian Federation. The average size of the *sovkhoz* was 15 300 ha and of the *kolkhoz* 5 900 ha. The size of the *sovkhoz* and *kolkhoz* tended to increase from west to east and there were relatively more *kolkhoz* in the western (European) part of the FSU and relatively more *sovkhoz* in the eastern (Asian) part. Together, the *sovkhoz* and *kolkhoz* accounted for up to 75% of the gross value of agricultural output in 1990.

Before 1990, the private sector consisted of personal household plots (also called individual subsidiary farms), allocated to *sovkhoz* and *kolkhoz* workers, and of garden and vegetable plots, allocated to urban workers. The average size of the household plots was approximately 0.5 ha, although size varied considerably according to local conditions. There were about 35 million household plots and 15 million garden and vegetable plots in 1990. Within the private sector, a distinction was made between subsidiary farms, producing mainly to satisfy family needs, and private farms, producing not only for personal use but also for the market. In 1990, the private sector produced about 25% of the value of the gross agricultural product.

However, irrespective of who farmed the land, all agricultural land was owned by the state, as private ownership of land had been abolished at the beginning of the communist period. Rent had also been abolished and the use of land was free. However, by the end of the 1980s, within the Soviet Union, discussion had started about the questions of land rent, the misuse and degradation of land by state organizations, the rights of the republics and the possibility of introducing private landownership. In fact, discussion on rent payments for land had already been going on for decades and by the beginning of the 1990s the need for it had been accepted in the Soviet Union.

During the Soviet period, agriculture was characterized by heavy mechanization; heavy use of chemical fertilizers and pesticides; development of monoculture in certain regions, like cotton in large parts of Central Asia; and the use of excessive quantities of water for irrigation. As a result, soil deterioration has been dramatic. In recent decades the deterioration of the fertile black soils, especially in Ukraine and the Russian Federation, has received much attention in discussions between Soviet experts. Loss of organic matter in the black earth soils, resulting from mechanization and the use of chemical fertilizers, has been stressed. Irrigation of these black soils was also criticized by Soviet specialists. It was said that the inappropriate transfer of desert technology to the steppe environment, with its very high seepage from open canals, the use of mineralized water, overwatering and the use of heavy machinery, had caused waterlogging, salinization, formation of surface hard crust, loss of organic matter and water erosion. However, according to Soviet specialists the consequences of the use of excessive quantities of water for irrigation in Central Asia had even more far-reaching negative effects, with the drying up of the Aral Sea (see the section on the Aral Sea basin).

It was generally considered that the reason for the waste of the natural resources in the FSU was that the land was no longer controlled by the farmers themselves, but by bureaucratic organizations mainly interested in short-term results. It was hoped to improve the situation by privatization. Since independence, almost all countries have started a re-organization of the agricultural sector. Several forms of re-organization of the *sovkhoz* and *kolkhoz* can be distinguished, the choice of which depends on the country:

- Joint stock companies, in which members receive shares with the right to dividends as well as debt obligations, in proportion to their property shares. Operationally, members and/or brigades work under an annual contract, which specifies production obligations as well as the responsibilities of the farm management.

- Collective enterprises, covering a wide spectrum of arrangements from an aggregate of small units to a large unit which may preserve the former management structure with the exception that the manager is elected by farm members. If the latter, land certificates do not relate to specific holdings unless a member leaves the group and establishes a separate farm.

- Farmers' associations, which can include individual farms as well as cooperatives. The overall management increasingly provides services, rather than direction.

- Comrade associations, which are similar to collectives except that individual farmers execute an annual contract with the management. Profits are shared in relation to effort as well as success in meeting targets.

- Private enterprises, which include both single ownership farms and other arrangements under which farmers essentially function as employees.

Since independence, land status has been changing continuously in the various countries with privatization becoming increasingly widespread. However, it is very difficult to obtain a clear picture of the overall situation. In each country profile an effort has been made to quantify the different land property systems at the time of the survey, but these situations are liable to change rapidly.

WATER RESOURCES

The survey has concentrated on renewable water resources. Information has been compiled on internal and actual renewable water resources. *Internal renewable water resources* (IRWR) is that part of the water resources (surface water and groundwater) generated from endogenous precipitation. It is computed by adding up surface runoff and groundwater recharge occurring inside the countries' borders. Special care is taken to avoid double counting of their common part (overlap). *Actual renewable water resources* (ARWR) refers to the sum of IRWR and external flow. It is the maximum theoretical amount of water actually available for a country. Actual flow takes into account abstraction in upstream countries and the volumes allocated through formal and informal agreements or treaties between countries. The internal renewable water resources figures are the only water resources figures that can be added up for regional assessment and they have been used for this purpose.

Particular attention should be given to some specific issues related to the computation of water resources in the FSU countries. In the arid areas, mostly in Central Asia, the complex interrelation between surface water and groundwater makes it difficult to assess their common part. In cases of extreme complexity, groundwater resources in one country may come from infiltration of runoff generated in an upstream country, so making it difficult to distinguish between internal and external water resources. Exchanges between countries are further complicated by the fact that rivers often cross the same border several times. Part of the incoming water flow may thus originate from the same country which it enters, making it necessary to calculate a 'net' inflow to avoid double counting the resources.

In general, due to the important withdrawal which has been taking place for a long time, the assessment of surface water runoff in those areas is also made difficult by the absence of chronological series of natural flow measurements. Indeed, most of the available flow data relate to measurement of actual runoff rather than natural flow. In addition, most of the figures quoted in reports, especially in Central Asia, correspond to the agreements on shared water resources.

In the computation of groundwater, a distinction is usually made between groundwater resources, which correspond to the average annual recharge of the aquifers, and extractable groundwater, which is usually computed on the basis of aquifer productivity and a theoretical network of wells. The figures in this survey refer to groundwater resources. However, most of the references on groundwater in the FSU rely on an estimate of extractable groundwater, which is usually less than groundwater resources. The computation of groundwater resources and of its overlap with surface water resources may thus be quite approximative.

The annual renewable water resources (RWR) of the FSU are 12% of the world's RWR. However, as the FSU contains only 5% of the world's population, the annual IRWR per inhabitant, over 16 000 m^3, are more than twice the world average. There is a wide variation by region: Eastern Europe, with the highest population density, having only 1 375 m^3/year per inhabitant of IRWR and the Russian Federation, with the lowest population density, having over 29 000 m^3/year per inhabitant (Table 2). However, the water resources in the Russian Federation are very unevenly distributed in relation to the population. In the more densely populated western part, the annual renewable surface water resources (RSWR) are estimated at around 2 000 m^3 per inhabitant, while in the Siberian and far east regions the figure can reach 190 000 m^3 per inhabitant.

TABLE 2
Regional distribution of internal renewable water resources (IRWR)

Region	Annual precipitation		Annual internal renewable water resources			
	mm	km^3	mm	km^3	% of precipitation	m^3 per inhabitant
Russian Federation	589	10 067	253	4 313	43	29 115
Central Asia	338	1 351	52	206	15	3 771
Eastern Europe	547	462	108	91	20	1 375
Caucasus	735	137	405	75	55	4 517
Baltic States	716	125	257	45	36	5 843
Former Soviet Union	**545**	**12 133**	**212**	**4 730**	**39**	**16 117**
World	820	110 000	298	40 000	36	6 935
FSU as % of World		11%		12%		

In Moldova, the IRWR per inhabitant are only 225 m^3/year; in Turkmenistan 327 m^3/year (Table 12). However, looking at the ARWR, these figures are 2 622 and 5 949 m^3/year per inhabitant respectively, thanks to the importance of flow coming from neighbouring countries: Moldova depends for over 91% on other countries for its water resources and Turkmenistan for over 97%, most of the water being brought to Turkmenistan through the Kara-Kum canal. To a lesser extent, but still over 50% dependent on other countries are: Uzbekistan (77%), Azerbaijan (73%), Ukraine (62%) and Latvia (53%) (Figure 5). However, Latvia is, with 6 685 m^3/year per inhabitant, already well endowed with IRWR, while for Azerbaijan and Ukraine IRWR are just over 1 000 m^3/year per inhabitant and for Uzbekistan only 700 m^3/year. All the other countries have more than 2 000 m^3/year per inhabitant of IRWR and four countries have more than 10 000 m^3/year (Figure 6). For all countries, the ARWR exceed 2 000 m^3/year per inhabitant (Figure 7).

For the Central Asian countries, a water allocation system exists between the five republics concerning the waters of the Amu Darya and Syr Darya rivers. As the computation of ARWR integrates those allocations, these resources are less than the IRWR for the two upstream countries (Kyrgyz Republic and Tajikistan), while for the other three countries the ARWR are more than the IRWR.

WATER WITHDRAWAL

Table 3 shows the distribution of water withdrawal by region between the three major sectors of water use: agriculture (irrigation and livestock), communities (domestic water supply) and industries. Water requirements for energy, navigation, fisheries, mining, environment and recreation, although they may represent a significant part of the water resources, have a negligible net consumption rate. For this reason, they are not included in the computation of the regional water withdrawal. However, as it was not always possible to obtain separate figures for water use for cooling in the nuclear power plants, for hydropower and for industrial water withdrawal, the first two might sometimes be included in the figure for industrial withdrawal without knowing the different quantities.

TABLE 3
Regional distribution of water withdrawal

Region	Annual water withdrawal by sector									
	Agricultural		Domestic		Industrial		Total withdrawal			
	million m^3	% of total	million m^3	% of total	million m^3	% of total	million m^3	% of FSU	m^3 per inhab.	in % of IRWR
Russian Federation	15 300	20	14 300	18	47 500	62	77 100	28.6	521	2
Central Asia	125 527	91	4 227	3	7 710	6	137 464	50.9	2 518	67
Eastern Europe	9 578	30	5 514	17	16 596	53	31 688	11.7	477	35
Caucasus	15 614	68	2 371	10	4 941	22	22 926	8.5	1 375	30
Baltic States	53	7	450	65	194	28	697	0.3	90	2
Former Soviet Union	**166 071**	**62**	**26 863**	**10**	**76 941**	**28**	**269 875**	**100.0**	**920**	**6**
World	2 236 000	69	259 000	8	745 000	23	3 240 000	100.0	562	8
FSU as % of World	7%		10%		10%		8%		164%	

In the FSU, 62% of the water withdrawal is directed towards agriculture, compared to 69% for the whole world. Central Asia has, with 91%, the highest level of water withdrawal for agriculture (Figure 8 and Table 13). This is the region where the largest area is irrigated (50% of the total irrigated area of the FSU) and where the annual agricultural water withdrawal per irrigated hectare, 12 400 m^3, is by far the highest. As a comparison, the annual agricultural water withdrawal per irrigated hectare is only 1 600 m^3 in the Baltic States, 2 500 m^3 in the Russian Federation, 3 100 m^3 in Eastern Europe and 7 200 m^3 in the Caucasus. In the low-lying Baltic States, where drainage is a necessity prior to irrigation, only 7% of the total water withdrawal is directed towards agriculture. Industrial water withdrawal is particularly important in the Russian Federation and in Eastern Europe, mainly because of the importance of the industries in those countries, but also because of the possible account of water use for nuclear power plant cooling. In absolute terms, Central Asia represents over 50% of the total water withdrawal of the FSU. The water withdrawal per inhabitant varies from less than 70 m^3/year in Lithuania to more than 5 700 m^3/year in Turkmenistan, compared to 560 m^3/year for the whole world (Figure 9 and Table 13). The water withdrawal per inhabitant in Central Asia is almost 30 times that in the Baltic States.

Water withdrawal, expressed as a percentage of IRWR, is an indicator of a region's or country's capacity to rely on its own renewable sources of water. Values above 100% indicate that, in addition to the IRWR, either other sources of water (fossil groundwater, wastewater, desalinated water, drainage water) or water flowing into the region or country from outside are used. For all the regions of the FSU, total water withdrawal is less than the IRWR. However, at country level this is not the case for four countries: Turkmenistan, Uzbekistan, Moldova and Azerbaijan (Figure 10). This is explained by the withdrawal in these countries of water coming from upstream countries or border rivers.

While Central Asia uses almost 67% of its IRWR (the figure would be close to 100% for the Aral Sea basin only, if losses from rivers and canals were included), the Baltic States uses only 1.5%. The FSU as a whole uses less than 6% of its RWR, compared with 8% for the whole world (Table 3).

Water withdrawal, expressed as a percentage of ARWR, which take into account the incoming or border flows and the existing agreements, is also a good indicator of the pressure on the RWR. Roughly, it can be considered that pressure on water resources is high when this value is above 25%, which is the case for all five Central Asian countries, as well as for Moldova, Armenia and Azerbaijan (Figure 11 and Table 13). Except for Uzbekistan, total water withdrawal is always lower than the ARWR (Figure 11). The reason for this exception is probably that Uzbekistan re-uses a large part of the return flow (4.5 km^3/year), which is not computed as part of the RWR. Moreover, the upstream countries probably do not use the total quantity of water allocated to them, leaving more water available for Uzbekistan than the quantity allocated according to the agreement.

Use of non-conventional sources of water

The total quantity of produced wastewater in the FSU is reported to be about 48 km^3/year, of which about 25% is treated. Information on the re-use of treated wastewater was available for only 6 of the 15 countries: 0.32 km^3/year, of which 0.27 km^3/year in Kazakhstan. The total quantity of re-used domestic and industrial wastewater in the Aral Sea basin is reported to be about 3 km^3/year, which means that most of the re-used wastewater is untreated. In general, the re-use of treated or untreated wastewater concerns a relatively low quantity compared to the produced wastewater quantity. This is probably related to the fact that in many countries water is not scarce.

Figures on agricultural drainage water are only available for the Central Asian countries, where it plays a significant role. In 1993, the total agricultural drainage water was estimated at about 49 km^3/year, of which 40 km^3/year in the Aral Sea basin. About 15% was reported to be directly re-used for irrigation in the Aral Sea basin (see the section on the Aral Sea basin).

IRRIGATION

Irrigation potential

The methods used to estimate the irrigation potential vary from country to country. Hence, comparisons between countries should be made with caution (Table 10).

For the Russian Federation, the irrigation potential is estimated at 29 million ha for permanent irrigation and 74 million ha for supplementary irrigation.

In Central Asia, the figures on irrigation potential refer to the total area which would be potentially suitable for irrigation development up to 2010. Irrigation potential for the five countries together is estimated at more than 14 million ha, of which over 80% is already equipped for irrigation, ranging from 48% in the Kyrgyz Republic to 95% in Kazakhstan and Tajikistan (Figure 12 and Table 14).

In the northern countries, drainage is more important for cultivation than is irrigation, except in areas where the groundwater level has fallen too much due to excessive drainage. For this reason, figures on irrigation potential for these countries are rather arbitrary and of little use.

Irrigation development

Irrigation covers almost 23 million ha in the FSU, half of which is located in Central Asia and about one-quarter in the Russian Federation (Table 4).

The part of the cultivated area which is irrigated varies considerably from region to region and country to country. For the FSU as a whole, 11% of the cultivated area is irrigated (Table 4). In the Caucasus, 67% of the cultivated area is irrigated, ranging from 44% in Georgia to 80% in Azerbaijan. For Central Asia as a whole, 26% of the cultivated area is irrigated, ranging from 10% in Kazakhstan to over 99% in Turkmenistan (Figure 13 and Table 14). On the other hand, in the Baltic States less than 1% of the cultivated area is irrigated (Table 4).

TABLE 4
Regional distribution of irrigation methods

Region	Irrigation in hectares					Cultivated area ha	Irrigation in % of cultivated
	Full or partial control	Equipped wetland	Spate irrigation	Total irrigation	% of FSU		
Russian Federation	6 124 000	0	0	6 124 000	26.9	116 900 000	5.2
Central Asia	10 134 100	138 700	1 104 600	11 377 400	49.9	43 448 300	26.2
Eastern Europe	3 048 000	0	0	3 048 000	13.4	39 449 900	7.7
Caucasus	2 176 467	31 500	0	2 207 967	9.7	3 278 182	67.4
Baltic States	32 927	0	0	32 927	0.1	4 650 736	0.7
Former Soviet Union	**21 515 494**	**170 200**	**1 104 600**	**22 790 294**	**100.0**	**207 727 118**	**11.0**
% of total irrigation	94%	1%	5%	100%			
World				246 408 529			
FSU as % of World				9%			

Full or partial control irrigation is by far the most widespread type of irrigation, covering 94% of the area (Table 4). Spate irrigation, accounting for 5% of the total, is reported only in Kazakhstan, where it represents one-third of the total irrigation. The remaining 1% consists of wetland equipped for irrigation and is reported in Kazakhstan and Georgia (Table 14).

In several countries, the area equipped for irrigation has diminished during recent years. This is mainly related to the fact that, because of the difficult economic situation, countries have not been able to maintain the sprinkler irrigation and micro-irrigation systems, leading to their complete abandonment.

Irrigation techniques

The irrigation techniques vary considerably from region to region and country to country. For the FSU as a whole, surface irrigation is, with 58.3%, the most widely used technique, followed by sprinkler irrigation with almost 41.7%. Micro-irrigation is practised on 0.05% of the irrigated area (Table 5).

TABLE 5
Irrigation techniques by region

Region	Full control irrigation: area equipped						
	Surface irrigation		Sprinkler irrigation		Micro-irrigation		Total irrigation
	ha	% of total	ha	% of total	ha	% of total	ha
Russian Federation	245 000	4.00	5 879 000	96.00	0	0.00	6 124 000
Central Asia	9 542 590	94.16	586 600	5.79	4 910	0.05	10 134 100
Eastern Europe	830 000	27.23	2 214 400	72.65	3 600	0.12	3 048 000
Caucasus	1 926 249	88.50	247 400	11.37	2 818	0.13	2 176 467
Baltic States	0	0.00	32 927	100.00	0	0.00	32 927
Former Soviet Union	**12 543 839**	**58.30**	**8 960 327**	**41.65**	**11 328**	**0.05**	**21 515 494**

Surface irrigation predominates in Central Asia and the Caucasus, ranging from 76% in Kazakhstan to 100% in Tajikistan (Table 15). Sprinkler irrigation is predominant in the Baltic States, the Russian Federation and Eastern Europe, ranging from 80% in Ukraine to 100% in the three Baltic states and Belarus. An exception is Moldova, where surface irrigation predominates (Figure 14).

Origin of irrigation water

Surface water, groundwater and non-conventional water (treated wastewater or agricultural drainage water) are used for irrigation in the FSU. For the Russian Federation, Lithuania and Belarus, no details were available and it has been estimated that all irrigation water is surface water, which certainly is by far the major source of irrigation water in these countries. In all countries, the origin of irrigation water is mainly surface water, used on over 96% of the irrigated area, and for over half of the countries it is the only source of irrigation water (Tables 6 and 16). Groundwater is used in two of the three countries of the Caucasus and in the Central Asian countries, being used on around 6% of the irrigated area.

The use of non-conventional water is limited to the Central Asian countries. In most cases it is not possible to make a distinction between the use of (un)treated wastewater and of agricultural drainage water. These two sources are usually mixed before re-using. Moreover, it is not always clear whether the agricultural drainage water is considered as surface water or as non-conventional water. For this reason, the figures in Table 6 should be considered as being of indicative value only.

TABLE 6
Origin of irrigation water by region

Region	Full control irrigation: area equipped						
	Surface water		Ground-water		Non-conventional water		Total irrigation
	ha	% of total	ha	% of total	ha	% of total	ha
Russian Federation	6 124 000	100.0	0	0.0	0	0.0	6 124 000
Central Asia	9 491 870	93.7	572 130	5.6	70 100	0.7	10 134 100
Eastern Europe	3 048 000	100.0	0	0.0	0	0.0	3 048 000
Caucasus	2 045 109	94.0	131 358	6.0	0	0.0	2 176 467
Baltic States	32 927	100.0	0	0.0	0	0.0	32 927
Former Soviet Union	**20 741 906**	**96.4**	**703 488**	**3.3**	**70 100**	**0.3**	**21 515 494**

Irrigated crops

Information on irrigated crops often relies on national planning figures rather than on figures for actually cropped areas, which are much more difficult to assess. Bearing this in mind, the different irrigated crops found in the FSU have been grouped into six major categories and the results are summarized in Table 7.

TABLE 7
Regional distribution of the main irrigated crops (areas in hectares)

Region	Fodder crops	Cereals and pulses	Cotton	Potatoes and vegetables	Other annual crops	Permanent crops	Total crops
Russian Federation	2 553 000	1 217 000	0	208 000	117 000	0	4 095 000
% of crops	*62.3%*	*29.7%*	*0.0%*	*5.1%*	*2.9%*	*0.0%*	*100.0%*
% of FSU	*36.4%*	*23.5%*	*0.0%*	*21.1%*	*10.3%*	*0.0%*	*22.2%*
Central Asia	2 881 300	2 538 870	2 668 240	381 230	771 460	973 300	10 214 400
% of crops	*28.2%*	*24.9%*	*26.1%*	*3.7%*	*7.6%*	*9.5%*	*100.0%*
% of FSU	*41.1%*	*49.1%*	*92.7%*	*38.7%*	*68.0%*	*75.2%*	*55.3%*
Eastern Europe	1 473 400	890 600	0	287 500	167 400	43 100	2 862 000
% of crops	*51.5%*	*31.1%*	*0.0%*	*10.0%*	*5.8%*	*1.5%*	*100.0%*
% of FSU	*21.0%*	*17.2%*	*0.0%*	*29.2%*	*14.8%*	*3.3%*	*15.5%*
Caucasus	66 259	523 418	210 445	94 101	70 614	278 086	1 242 923
% of crops	*5.3%*	*42.1%*	*16.9%*	*7.6%*	*5.7%*	*22.4%*	*100.0%*
% of FSU	*0.9%*	*10.1%*	*7.3%*	*9.5%*	*6.2%*	*21.5%*	*6.7%*
Baltic States	33 600	3 700	0	14 520	8 000	200	60 020
% of crops	*56.0%*	*6.2%*	*0.0%*	*24.2%*	*13.3%*	*0.3%*	*100.0%*
% of FSU	*0.5%*	*0.1%*	*0.0%*	*1.5%*	*0.7%*	*0.0%*	*0.3%*
Former Soviet Union	**7 007 559**	**5 173 588**	**2 878 685**	**985 351**	**1 134 474**	**1 294 686**	**18 474 343**
% of crops	***37.9%***	***28.0%***	***15.6%***	***5.3%***	***6.1%***	***7.0%***	***100.0%***
% of FSU	***100.0%***	***100.0%***	***100.0%***	***100.0%***	***100.0%***	***100.0%***	***100.0%***

The most widespread irrigated crops are fodder crops, which represent almost 38% of the irrigated crop area of the FSU. Except for the Caucasus, they are the main irrigated crop in each region, accounting for from 28% of the irrigated crop area in Central Asia to 62% of that in the Russian Federation.

Cereals (which include pulses in the statistics of the FSU) are the second most important group of crops, representing 28% of the irrigated crop area of the FSU. Over one-third of the area is covered by wheat. Irrigated cereals are the main irrigated crop in the Caucasus, covering 42% of the irrigated crop area in that region.

The area with irrigated cotton, 16% of the total irrigated crop area, ranks third in the FSU. Central Asia is the major cotton producing area, representing almost 93% of the total irrigated cotton area of the FSU. Cotton also covers, with 26%, the second largest area of irrigated crops within Central Asia. Apart from the Central Asian countries, only Azerbaijan is reported as growing irrigated cotton in the FSU.

Potatoes and vegetables represent 5% of the total irrigated crop area of the FSU. In the Baltic States, they represent 24% of the irrigated crop area.

Irrigated permanent crops (mainly grapes and fruit trees), representing 7% of the total irrigated crop area in the FSU, are mainly grown in Central Asia. This region accounts for 75% of the irrigated permanent crop area in the FSU, while the Caucasus accounts for 22%. Within the Caucasus, permanent crops represent the second largest irrigated area.

DRAINAGE

The drained area covers almost 25 million ha in the FSU (Tables 8 and 17).

In the northern regions, like the Baltic States, parts of Eastern Europe and the Russian Federation, drainage is necessary to cultivate the low-lying and/or swampy areas. In addition, drainage might be necessary for construction purposes. This is why, for example, in the Baltic States the drained area is larger than the cultivated area (Figure 15). The percentage of the total area of the region drained is also by far the largest for the Baltic States (Table 8).

TABLE 8
Regional distribution of drainage methods

Region	Drained area							
	Surface drainage		Subsurface drainage		Total drainage			
	ha	% of total	ha	% of total	ha	% of FSU	% of area of region	% of area cultivated
Russian Federation	4 161 000	56	3 238 000	44	7 399 000	30	0.4	6
Central Asia	3 533 064	74	1 239 762	26	4 772 826	19	1.2	11
Eastern Europe	1 941 700	31	4 268 300	69	6 210 000	25	7.3	16
Caucasus	499 720	61	325 390	39	825 110	3	4.4	25
Baltic States	597 854	11	4 760 647	89	5 358 501	22	30.6	115
Former Soviet Union	**10 733 338**	**44**	**13 832 099**	**56**	**24 565 437**	**100**	**1.1**	**12**

In the drier areas of Central Asia and in part of the Caucasus, drainage is related to irrigation. One of the measures necessary to prevent irrigation induced waterlogging and salinization in arid and semi-arid areas is the installation of drainage facilities. Drainage, in combination with adequate irrigation scheduling, enables the leaching of excess salts from the plant root zone. Information on salinization through irrigation was given for only seven countries, including all five Central Asian countries. The area salinized varied from 5 to 50% of the irrigated area (Table 17). In Central Asia, all the drained area is located in the area equipped for irrigation.

In Lithuania, almost 92% of the area equipped for irrigation is drained (Figure 16). Drainage was initially used to remove excess water. However, due to over-drainage it subsequently became necessary to irrigate. Although no detailed information is available, the same might be true for Belarus, Estonia and Latvia.

Subsurface drainage is practised on 56% of the drained area. It is most widespread in the regions where drainage is more important than irrigation, like in the Baltic States, where 89% of the drained area is drained through subsurface drains (Figure 17 and Table 8). In Central Asia, drainage takes place mainly through open drains. Subsurface drainage in this region is practised on only 26% of the drained area, ranging from less than 4% in Kazakhstan to 44% in the Kyrgyz Republic (Table 17). In general, newly reclaimed areas are equipped with subsurface drainage facilities rather than surface drains.

In the more humid regions, where, in order to enable cultivation, drainage is necessary to remove excess water, crops yields may be lower than for irrigated or rainfed crop yields. The reason for this might be that drained land is already of marginal quality with very poor, low pH soils. However, without drainage no cultivation at all would be possible. Another reason for the lower yields might be the advanced state of degradation of large parts of the drained land. The most important crops on drained lands are fodder, including meadow and pasture areas, followed by cereals, potatoes and vegetables.

THE ARAL SEA BASIN

The Aral Sea basin, located in Central Asia, has undergone many changes in the recent past. The Aral Sea, the world's fourth largest lake before 1960, has been progressively drying up. With the end of the Soviet era, the international community has become aware of this problem and focused on what is considered one of the major anthropogenic environmental degradations in the world. The purpose of this section is to present the Aral Sea basin, the causes of the drying up of the lake, the present trends and the solutions being studied by the governments of the countries of the region.

Water resources of the Aral Sea basin

The Aral Sea, located in a depression in the Turan plain, is fed by two major rivers: the Amu Darya in the south, and the Syr Darya in the north, which rise in the southwestern Pamir and Tien Shan mountain ranges respectively. The combined hydrologic basin of these two rivers has a total area of about 1.9 million km^2 and extends over six countries (Figure 18 and Table 9). In Kazakhstan, all the flow of the Turgay, Sarysu, Chu and Talas rivers is lost in the desert or is directed to natural depressions. These rivers can be considered as not being part of the Aral Sea basin.

The assessment of natural flow in the basin is hampered by the large amounts of water withdrawn from the rivers since the 1950s. By reconstructing long-term time series, the average annual RSWR in the Aral Sea basin are estimated at 115.6 km^3, of which 78.46 km^3 in the Amu Darya basin and 37.14 km^3 in the Syr Darya basin (Table 9). For a 20-year return period, the values are 46.9 km^3 for the Amu Darya and 21.4 km^3 for the Syr Darya.

Before 1960, the level of the Aral Sea was more or less stable. Its surface area was about 66 000 km^2 and its volume about 1 060 km^3. The combined average discharge of the Amu Darya and Syr Darya rivers to the sea was about 47-50 km^3/year, to which could be added 5-6 km^3/year of groundwater inflow and 5.5-6.5 km^3/year of precipitation over the sea. This total volume of 57.5-62.5 km³/year compensated the evaporation over the lake, estimated at about 60 km³/year. The Aral Sea level was then fluctuating at around 50-53 m above sea level. The difference between the IRSWR of the Aral Sea basin, estimated at 115.6 km³/year, and the necessary discharge to the sea for a stable water balance, estimated at 47-50 km³/year, was available for use in the basin, i.e., about 65.6-68.6 km³/year. The average mineral content of the Aral Sea's water was estimated at 10 g/litre in 1960. Fish capture was about 40 000 t/year, and many fish-processing industries were established on the shores of the Aral Sea. Together with fishing, these industries provided employment to much of the local population.

TABLE 9
Renewable surface water resources of the Aral Sea basin

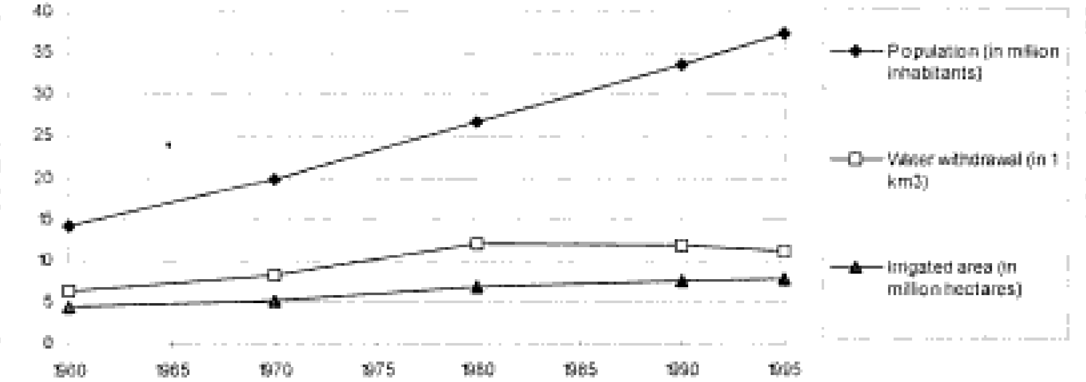
Country or Zone	Area			Renewable Surface Water Resources					
				Amu Darya basin		Syr Darya basin		Aral Sea basin	
	km²	% of basin area	% of country area	km³ per year	% of basin	km³ per year	% of basin	km³ per year	% of basin
South-Kazakhstan	540 000	28	20	-	0.0	4.50	12.1	4.50	3.9
Turkmenistan	466 600	24	96	0.98	1.2	-	0.0	0.98	0.8
Uzbekistan	447 400	23	100	4.70	6.0	4.84	13.0	9.54	8.3
North-Afghanistan	234 800	12	36	6.18	7.9	-	0.0	6.18	5.3
Tajikistan	141 670	7	99	62.90	80.2	0.40	1.1	63.30	54.8
Kyrgyz Republic	117 500	6	59	1.93	2.5	27.25	73.4	29.18	25.2
Total	1 947 970	100		76.69	97.7	36.99	99.6	113.68	98.3
Basin *				78.46	100.0	37.14	100.0	115.60	100.0

* Time series and methods used for water resources computation for the basin as a whole and for each country may vary, which explains the difference between the total of countries and the value for the whole basin.

Irrigation development in the basin and the drying up of the Aral Sea

In the 1960s, the Soviet policy assigned Central Asia the role of raw material supplier, notably cotton. Irrigation was necessary due to the arid climate prevailing over the lower reaches of the Amu and Syr Darya basins. The development of irrigation in the Soviet part of the Aral Sea basin was spectacular: from about 4.5 million ha in 1960, it rose to almost 7 million ha in 1980 (Figure 1). The population increased from 14 million inhabitants in 1960 to about 27 million inhabitants in 1980. The total water withdrawal increased from 64.7 km³

FIGURE 1
Evolution of population, irrigation and water withdrawal in the Aral sea basin

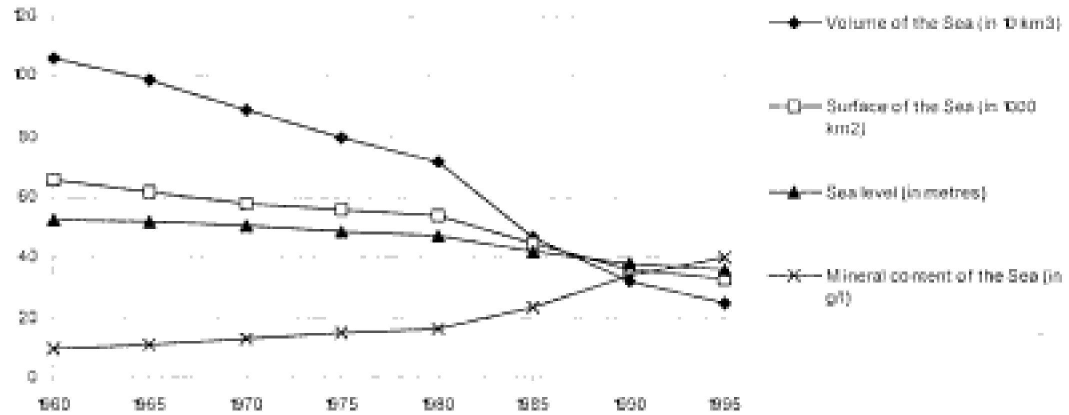


in 1960 to 120 km^3 in 1980, of which more than 90% for agricultural purposes (Figure 1). It resulted in the disruption of the prevailing water balance in the basin.

The consequences of this huge irrigation development are numerous:

- Many tributaries have been exploited to such an extent that they no longer contribute directly to the flow of the Amu Darya and Syr Darya rivers. They are: the Zeravshan and Kashkadarya in the Amu Darya basin, and the Arys and Akhangaran in the Syr Darya basin.
- The intensification of irrigated agriculture has led to major waterlogging and salinization. In 1995 the irrigated area was almost 8 million ha, compared with 4.5 million ha in 1960 (Figures 19 and 20). The main causes of this soil deterioration are: the low irrigation efficiencies, due particularly to the small percentage of lined canals (28% on average in the basin for the inter-farm network and 20% for the on-farm network); and the absence of a drainage network, or its poor state due to the lack of maintenance particularly in the most recent years. In 1994, about 40% of the irrigated land in the basin was saline. Agriculture in the Aral Sea basin has been practised with a high level of inputs, particularly fertilizers and pesticides, and this has resulted in the deterioration of surface water and groundwater quality. The salt content of groundwater in the lower reaches of the river basins varies between 1 and 30 g/litre.
- The traditional ecosystem of the two deltas of the Amu Darya and Syr Darya has perished. The marshes and wetland which covered some 550 000 ha and were a reservoir of biodiversity until the 1960s have almost disappeared (only 20 000 ha were left in 1990) giving way to sand deserts. More than 50 lakes, covering 60 000 ha in the deltas, have dried up.
- The Aral Sea is drying up. Its level has dropped by 17 m, its surface area has fallen by a half and its volume by three-quarters (Figure 2). At present, the sea consists of three sections: the Small Sea or Northern Sea on the territory of Kazakhstan; the Central Sea; and the Western Sea, which is the deepest one, mostly located on the territory of Uzbekistan. The mineral content of the water has increased fourfold to 40 g/litre, preventing the survival of most of the fish and wild life in the Aral Sea. The current fish capture is negligible, leaving most of the people unemployed. All commercial fishing ceased in 1982. Moreover, the former seashore villages and towns are 70 km away from the present shoreline. The exposed seabed now consists of vast salt tracts, whose sand and dust, polluted with pesticides, are carried by the wind to neighbouring areas and up to a distance of 250 km. The eolian transfer of dust and sand from the exposed seabed has been estimated at 15-75 million t/year.
- With the reduction of the size of the Aral Sea, its climate modifying function has been lost. The climate around the sea has changed, becoming more continental with shorter, hotter, rainless summers and longer, colder, snowless winters. The growing season has been reduced to an average of 170 days per year. Desert storms are frequent, occurring on more than 90 days a year.
- Communities face appalling health conditions. In Karakalpakstan, drinking water supply is too saline and polluted. The high contents of metals such as strontium, zinc and manganese cause diseases and prevent iron absorption, causing anaemia. In the last 15 years, kidney and liver diseases, especially cancer, have increased at least 30-fold, arthritic diseases 60-fold and chronic bronchitis 30-fold. The infant mortality rate is one of the highest in the world.

FIGURE 2
Trends in the Aral Sea



Measures adopted to mitigate the environmental problems

Aware of the above problems, in the 1980s the government of the Soviet Union decided to develop a Water Resources Master Plan for the Syr Darya and Amu Darya river basins. The principle of a strict limitation of water withdrawal per hectare was adopted in 1982 and it was decided to share the available water resources among the riparian republics. Decisions were taken by the Ministry of Water Management of the Soviet Union in July 1984 for the Syr Darya waters and in March 1987 for the Amu Darya waters. Two Basin Water Organizations (BWO) were established to operate and maintain the main hydraulic infrastructures and to monitor water use.

After the end of the Soviet period, the newly independent states decided to prepare a Regional Water Resources Management Strategy, but to respect the existing principles until the adoption of a new agreement on water resources sharing. At the initiative of the five republics, an Interstate Commission for Water Coordination (ICWC) was established. The ICWC supervises the two BWOs and a Scientific Information Centre, and is in charge of regulating water distribution in the basin and of consolidating the country positions for the adoption of a regional water strategy. The preparation of this water strategy, as well as regional studies and pilot projects for a new approach in water management, have received attention and funding from several international organizations and bilateral cooperation agencies. The International Fund for the Aral Sea (IFAS) and the Interstate Council for the Aral Sea Problem (ICAS) have been established in order to subordinate the initiatives and the financial resources to a regional approach.

Water supply management

The first solutions envisaged to face the problems listed above were based on water supply management. During the Soviet period, the possibilities of water diversion from the Ob River to the Amu Darya River through a 2 200 km-long canal or from the Volga River to the Aral Sea were studied. These options were abandoned with the ending of the Soviet Union. Currently, a proposal to transfer water from the Caspian Sea to the Aral Sea is being studied.

Greater use of agricultural drainage water and wastewater, as well as the introduction of more salt-tolerant crops, have also been envisaged and in part implemented. In 1993, agricultural drainage water was estimated at about 40 km^3/year and the re-use of industrial and domestic wastewater was about 3 km^3/year. About 6 km^3/year of agricultural drainage waters or wastewater are directly re-used for irrigation. Some 37 km^3/year return to natural depressions or rivers where they are mixed with freshwater and can be re-used for irrigation or other purposes.

Dam construction and canal regulation have also been undertaken to make the water supply meet the water demand in a more timely fashion.

Although these options have enabled further irrigation development, the improvements induced have not been sustainable.

Water demand management

The governments of the five Central Asian republics have thus decided to focus on demand management, which is now a key element of the national and regional water strategies. The countries have started implementing programmes which all aim to reduce the water withdrawal per hectare, but which have the primary objective of satisfying crop water requirements.

From a technical point of view, all the measures aim to increase the global irrigation efficiency: through canal rehabilitation and/or lining, which leads to a reduction of the losses; and through canal regulation for better irrigation scheduling. However, in view of the very limited funds available, these measures will be implemented gradually, relying mostly on international assistance and funding.

From an economic point of view, several countries have introduced water fees and fines for the use of water in excess of the allocation per farm. Moreover, with the move towards a market-oriented economy, farmers' responsibility has increased. For example, the decision on the crops to be grown on irrigation schemes, which has direct consequences on the water requirements, is the farmers' responsibility. In Kazakhstan, rice, a large water consuming crop, has been replaced by other cereals. In Turkmenistan and Uzbekistan, the area grown with cotton, also a large water consuming crop, has decreased while the area grown with grain has increased substantially. Although these measures may lead to a reduction of the water withdrawal, they make planning and monitoring water distribution more difficult.

Future prospects

Much progress has already been made since 1990. The total water withdrawal in the basin has now stabilized at about 110-120 km^3/year (Figure 1). However, further improvement is needed to meet the increasing demand from new water users. The living standards of the population near the sea are also a major concern, with most socio-economic indicators (life expectancy, health, drinking water supply, etc.) being dramatically negative. The responsible authorities are expected to take the necessary measures.

It has been estimated that at least 73 km^3/year of water would have to be discharged to the Aral Sea for a period of at least 20 years in order to recover the 1960 level of 53 m above sea level. The governments of the riparian countries do not consider this a realistic objective.

Other more feasible options for the future of the Aral Sea have been envisaged by different parties:

- The stabilization of the Aral Sea at its 1990 level (38 m above sea level) would require a total inflow of about 35 km³/year, including the demand for the delta area. However, this would not end the environmental degradation and desertification in the exposed seabed.
- The restoration of the Small Sea, or Northern Sea, to the level of 38-40 m above sea level would require an inflow of at least 6-8 km³ in that part of the Aral Sea for the next five years.
- The restoration of wetlands in the Amu Darya delta and the conservation of the Western Sea would require an inflow of 11-25 km³/year, with at least 5-11 km³ of freshwater. Since 1989, a project has been implemented in Uzbekistan which aims to bring more water to the delta through the collector-drainage network. This water, combined with freshwater, is used to replenish shallow lakes. It has allowed the re-development of flora and wildlife in the abandoned areas and stopped the eolian erosion of the former exposed seabed. Another result of this project has been a higher fish capture, estimated at 5 000 t/year in 1993, compared with 2 000 t/year in 1988.

Because the water resources of the basin are more or less stable, or even slightly decreasing due to the climatic change induced by the Aral Sea drying up, all extra water flowing to the Aral Sea should be saved from upstream existing uses. Major efforts should be made to: reduce losses in the rivers and canals, notably through lining and automatization of the distribution; stop irrigation expansion; to generalize micro-irrigation and other water saving techniques on existing irrigated areas; redirect drainage water and other spilled reservoir and canal water directly to the sea; return the non-consumed fraction of the water diverted into irrigation schemes to the Aral Sea. According to the World Bank, the introduction of a water market could help save more water.

Water quality problems increase from upstream to downstream due to the increasing salinity and pesticide content of agricultural return flow and the poor state of wastewater treatment plants in the basin. The defining of water quality standards and their observance may significantly affect the quantity of water considered as available for use. The introduction of a polluter pays tax would then be possible.

If they were sure that the water would actually go to the Aral Sea, the upstream countries would be ready to release more water. One important measure for the future would be to consider the Aral Sea and the two deltas as a sixth entity, in addition to the five Central Asian republics, to which a water allocation should be given. In the round of discussions between the countries, a figure of 20 km³/year in normal humid years has been advanced for this environmental water demand, reduced to 12 km³/year in the one dry year out of ten.

All these options and solutions have been studied for the regional water strategy exercise, which is the result of a cooperation of the riparian countries. This has been made possible by the setting up of an institutional framework to address the Aral Sea problem through selected national macro-economic and sectoral policies for achieving sustainable land, water and other natural resources development. This institutional framework currently includes only the countries of the FSU. However, Afghanistan, which covers about 12% of the Aral Sea basin, will probably become a greater water user as its stability increases, so reducing the flow of the Amu Darya tributaries accordingly. At a later stage, Afghanistan should be included in the agreements regarding the Aral Sea basin in order to guarantee sustainable water resources management in the basin.

Summary tables

TABLE 10

Land use and irrigation potential in the former Soviet Union countries

Country	Area of the country	Cultivable area	Cultivated area					Irrigation potential		Country
			year	annual	permanent	total	% of		% of	
	ha	ha		ha	ha	ha	cultivable	ha	cultivable	
ARMENIA	2 980 000	1 391 400	1995	346 413	61 734	408 147	29	653 651	47	ARMENIA
AZERBAIJAN	8 660 000	4 318 860	1993	1 543 130	261 150	1 804 280	42	1 720 000	40	AZERBAIJAN
BELARUS	20 760 000	11 910 000	1993	5 979 000	95 100	6 074 100	51	-	-	BELARUS
ESTONIA	4 510 000	1 368 000	1995	850 664	12 660	863 324	63	150 000	11	ESTONIA
GEORGIA	6 970 000	2 987 473	1996	758 990	306 765	1 065 755	36	725 000	24	GEORGIA
KAZAKHSTAN	271 730 000	222 328 500	1993	34 060 400	312 000	34 372 400	15	3 768 500	2	KAZAKHSTAN
KYRGYZ REPUBLIC	19 850 000	10 100 000	1994	1 306 800	36 200	1 343 000	13	2 247 300	22	KYRGYZ REPUBLIC
LATVIA	6 460 000	2 540 300	1994	1 192 000	21 900	1 213 900	48	-	-	LATVIA
LITHUANIA	6 520 000	3 925 766	1990	2 514 712	58 800	2 573 512	66	-	-	LITHUANIA
MOLDOVA	3 370 000	2 559 700	1992	1 735 400	466 400	2 201 800	86	1 500 000	59	MOLDOVA
RUSSIAN FEDERATION	1 707 540 000	686 900 000	1994	114 900 000	2 000 000	116 900 000	17	29 000 000	4	RUSSIAN FEDERATION
TAJIKISTAN	14 310 000	1 571 000	1994	689 400	80 500	769 900	49	755 200	48	TAJIKISTAN
TURKMENISTAN	48 810 000	7 013 000	1994	1 511 200	244 000	1 755 200	25	2 353 000	34	TURKMENISTAN
UKRAINE	60 370 000	44 830 000	1993	30 173 700	1 000 300	31 174 000	70	5 500 000	12	UKRAINE
UZBEKISTAN	44 740 000	25 447 700	1993	4 529 700	678 100	5 207 800	20	4 915 000	19	UZBEKISTAN
Former Soviet Union	**2 227 580 000**	**1 029 191 699**		**202 091 509**	**5 635 609**	**207 727 118**	**20**			**Former Soviet Union**

TABLE 11

Population of the former Soviet Union countries

Country	Area of the country		Population 1996					% of econ. active pop. engaged in agriculture	Country
			Total			Rural			
	km²	% of FSU	inhabitants	% of FSU	inhabitant per km²	inhabitants	% of total		
ARMENIA	29 800	0.1	3 638 000	1.2	122	1 125 000	31	15	ARMENIA
AZERBAIJAN	86 600	0.4	7 594 000	2.6	88	3 330 000	44	30	AZERBAIJAN
BELARUS	207 600	0.9	10 348 000	3.5	50	2 901 000	28	18	BELARUS
ESTONIA	45 100	0.2	1 471 000	0.5	33	391 000	27	13	ESTONIA
GEORGIA	69 700	0.3	5 442 000	1.9	78	2 232 000	41	25	GEORGIA
KAZAKHSTAN	2 717 300	12.2	16 820 000	5.7	6	6 698 000	40	21	KAZAKHSTAN
KYRGYZ REPUBLIC	198 500	0.9	4 469 000	1.5	23	2 716 000	61	31	KYRGYZ REPUBLIC
LATVIA	64 600	0.3	2 504 000	0.9	39	670 000	27	14	LATVIA
LITHUANIA	65 200	0.3	3 728 000	1.3	57	1 016 000	27	18	LITHUANIA
MOLDOVA	33 700	0.2	4 444 000	1.5	132	2 109 000	47	30	MOLDOVA
RUSSIAN FEDERATION	17 075 400	76.7	148 126 000	50.5	9	34 881 000	24	12	RUSSIAN FEDERATION
TAJIKISTAN	143 100	0.6	5 935 000	2.0	41	4 016 000	68	37	TAJIKISTAN
TURKMENISTAN	488 100	2.2	4 155 000	1.4	9	2 283 000	55	36	TURKMENISTAN
UKRAINE	603 700	2.7	51 608 000	17.6	85	15 064 000	29	18	UKRAINE
UZBEKISTAN	447 400	2.0	23 209 000	7.9	52	13 553 000	58	33	UZBEKISTAN
Former Soviet Union	**22 275 800**	**100.0**	**293 491 000**	**100.0**	**13**	**92 985 000**	**32**	**17**	**Former Soviet Union**

TABLE 12

Renewable water resources in the former Soviet Union countries

Country	Annual average precipitation		Annual renewable water resources						Country
			Internal			Total actual		Dependency ratio %	
	mm	million m^3	million m^3	m^3 per inhab. '96	% of precipitation	million m^3	m^3 per inhab. '96		
ARMENIA	526	15 675	9 071	2 493	58	10 529	2 894	14	ARMENIA
AZERBAIJAN	541	46 851	8 115	1 069	17	30 275	3 987	73	AZERBAIJAN
BELARUS	700	145 320	37 200	3 595	26	58 000	5 605	36	BELARUS
ESTONIA	632	28 503	12 712	8 642	45	12 808	8 707	1	ESTONIA
GEORGIA	1 065	74 231	58 130	10 682	78	63 330	11 637	8	GEORGIA
KAZAKHSTAN	344	934 751	75 420	4 484	8	109 610	6 517	31	KAZAKHSTAN
KYRGYZ REPUBLIC	533	105 801	46 450	10 394	44	20 580	4 605	0	KYRGYZ REPUBLIC
LATVIA	743	47 998	16 740	6 685	35	35 449	14 157	53	LATVIA
LITHUANIA	748	48 770	15 560	4 174	32	24 900	6 679	38	LITHUANIA
MOLDOVA	450	15 165	1 000	225	7	11 650	2 622	91	MOLDOVA
RUSSIAN FEDERATION	589	10 057 411	4 312 700	29 115	43	4 498 240	30 368	4	RUSSIAN FEDERATION
TAJIKISTAN	691	98 882	66 300	11 171	67	15 980	2 693	17	TAJIKISTAN
TURKMENISTAN	191	93 227	1 360	327	1	24 720	5 949	97	TURKMENISTAN
UKRAINE	500	301 850	53 100	1 029	18	139 550	2 704	62	UKRAINE
UZBEKISTAN	264	118 114	16 340	704	14	50 410	2 172	77	UZBEKISTAN
Former Soviet Union	545	12 132 547	4 730 198	16 117	39				**Former Soviet Union**

TABLE 13

Water withdrawal in the former Soviet Union countries

Country	Year	Annual water withdrawal									in % of internal renewable water res.	in % of total actual renewable water res.	Country
		Agricultural			Domestic		Industrial		Total				
		million m^3	% of total	m^3 per irrigated ha	million m^3	% of total	million m^3	% of total	million m^3	m^3 per inhab. (1996)			
ARMENIA	1994	1 940	66	6 792	865	30	120	4	2 925	804	32	28	ARMENIA
AZERBAIJAN	1995	11 631	70	8 003	778	5	4 124	25	16 533	2 177	204	55	AZERBAIJAN
BELARUS	1990	948	35	7 237	608	22	1 178	43	2 734	264	7	5	BELARUS
ESTONIA	1995	8	5	2 228	88	56	62	39	158	107	1	1	ESTONIA
GEORGIA	1990	2 043	59	4 356	728	21	697	20	3 468	637	6	5	GEORGIA
KAZAKHSTAN	1993	27 413	81	7 708	583	2	5 678	17	33 674	2 002	45	31	KAZAKHSTAN
KYRGYZ REPUBLIC	1994	9 496	94	8 816	301	3	289	3	10 086	2 257	22	49	KYRGYZ REPUBLIC
LATVIA	1994	36	13	1 815	157	55	92	32	285	114	2	1	LATVIA
LITHUANIA	1995	8	3	876	205	81	40	16	254	68	2	1	LITHUANIA
MOLDOVA	1992	775	26	2 484	269	9	1 919	65	2 963	667	296	25	MOLDOVA
RUSSIAN FEDERATION	1994	15 300	20	2 498	14 300	19	47 500	62	77 100	521	2	2	RUSSIAN FEDERATION
TAJIKISTAN	1994	10 961	92	15 241	412	3	501	4	11 874	2 001	18	74	TAJIKISTAN
TURKMENISTAN	1994	23 291	98	13 354	349	1	139	1	23 779	5 723	1 748	96	TURKMENISTAN
UKRAINE	1992	7 855	30	3 015	4 637	18	13 499	52	25 991	504	49	19	UKRAINE
UZBEKISTAN	1994	54 366	94	12 701	2 582	4	1 103	2	58 051	2 501	355	115	UZBEKISTAN
Former Soviet Union		**166 071**	**62**	**7 287**	**26 863**	**10**	**76 941**	**29**	**269 875**	**920**	**6**		**Former Soviet Union**

TABLE 14

Irrigation in the former Soviet Union countries

Country	Irrigation in hectares					in % of cultivated area	in % of irrigation potential	Country
	Year	full/partial control	equipped wetland	spate irrigation	total irrigation			
ARMENIA	1995	285 649	-	-	285 649	70.0	43.7	ARMENIA
AZERBAIJAN	1995	1 453 318	-	-	1 453 318	80.5	84.5	AZERBAIJAN
BELARUS	1993	131 000	-	-	131 000	2.2	-	BELARUS
ESTONIA	1995	3 680	-	-	3 680	0.4	2.5	ESTONIA
GEORGIA	1996	437 500	31 500	-	469 000	44.0	64.7	GEORGIA
KAZAKHSTAN	1993	2 313 100	138 700	1 104 600	3 556 400	10.3	94.4	KAZAKHSTAN
KYRGYZ REPUBLIC	1994	1 077 100	-	-	1 077 100	80.2	47.9	KYRGYZ REPUBLIC
LATVIA	1995	20 000	-	-	20 000	1.6	-	LATVIA
LITHUANIA	1995	9 247	-	-	9 247	0.4	-	LITHUANIA
MOLDOVA	1994	312 000	-	-	312 000	14.2	20.8	MOLDOVA
RUSSIAN FEDERATION	1990	6 124 000	-	-	6 124 000	5.2	21.1	RUSSIAN FEDERATION
TAJIKISTAN	1994	719 200	-	-	719 200	93.4	95.2	TAJIKISTAN
TURKMENISTAN	1994	1 744 100	-	-	1 744 100	99.4	74.1	TURKMENISTAN
UKRAINE	1994	2 605 000	-	-	2 605 000	8.4	47.4	UKRAINE
UZBEKISTAN	1994	4 280 600	-	-	4 280 600	82.2	87.1	UZBEKISTAN
Former Soviet Union		**21 515 494**	**170 200**	**1 104 600**	**22 790 294**	**11.0**		**Former Soviet Union**
% of total irrigation		***94.4***	***0.7***	***4.8***	***100.0***			***% of total irrigation***

TABLE 15

Irrigation techniques in the former Soviet Union countries

Country	Full or partial control irrigation: equipped area (in ha)								% of equipped area actually irrigated	Country
	Year	Surface irrigation	% of total irrigation	Sprinkler irrigation	% of total irrigation	Micro-irrigation	% of total irrigation	Total irrigation		
ARMENIA	1995	257 949	90.30	27 500	9.63	200	0.07	285 649	60	ARMENIA
AZERBAIJAN	1995	1 301 700	89.57	149 000	10.25	2 618	0.18	1 453 318	-	AZERBAIJAN
BELARUS	1993	0	0.00	131 000	100.00	0	0.00	131 000	-	BELARUS
ESTONIA	1995	0	0.00	3 680	100.00	0	0.00	3 680	44	ESTONIA
GEORGIA	1996	366 600	83.79	70 900	16.21	0	0.00	437 500	63	GEORGIA
KAZAKHSTAN	1993	1 763 500	76.24	549 600	23.76	0	0.00	2 313 100	100	KAZAKHSTAN
KYRGYZ REPUBLIC	1994	1 040 100	96.56	37 000	3.44	0	0.00	1 077 100	100	KYRGYZ REPUBLIC
LATVIA	1995	0	0.00	20 000	100.00	0	0.00	20 000	100	LATVIA
LITHUANIA	1995	0	0.00	9 247	100.00	0	0.00	9 247	-	LITHUANIA
MOLDOVA	1994	305 000	97.76	3 400	1.09	3 600	1.15	312 000	-	MOLDOVA
RUSSIAN FEDERATION	1990	245 000	4.00	5 879 000	96.00	0	0.00	6 124 000	-	RUSSIAN FEDERATION
TAJIKISTAN	1994	719 200	100.00	0	0.00	0	0.00	719 200	100	TAJIKISTAN
TURKMENISTAN	1994	1 743 700	99.98	0	0.00	400	0.02	1 744 100	100	TURKMENISTAN
UKRAINE*	1994	*525 000*	20.15	2 080 000	79.85		0.00	2 605 000	-	UKRAINE
UZBEKISTAN	1994	4 276 090	99.89	0	0.00	4 510	0.11	4 280 600	98	UZBEKISTAN
Former Soviet Union		**12 543 839**	**58.30**	**8 960 327**	**41.65**	**11 328**	**0.05**	**21 515 494**		**Former Soviet Union**

* *Area with surface irrigation estimated. Very small area with micro-irrigation not known.*

TABLE 16

Origin of irrigation water in the former Soviet Union countries

Country	Full or partial control irrigation: equipped area								Country
	Year	Total irrigation	Origin of irrigation water						
			Surface water		Groundwater		Non-conventional water		
		ha	ha	%	ha	%	ha	%	
ARMENIA	1995	285 649	251 000	87.9	34 649	12.1	0	0.0	ARMENIA
AZERBAIJAN	1995	1 453 318	1 356 609	93.3	96 709	6.7	0	0.0	AZERBAIJAN
BELARUS*	-	131 000	*131 000*	*100.0*	-	-	-	-	BELARUS
ESTONIA	1995	3 680	3 680	100.0	0	0.0	0	0.0	ESTONIA
GEORGIA	1996	437 500	437 500	100.0	0	0.0	0	0.0	GEORGIA
KAZAKHSTAN	1993	2 313 100	2 089 000	90.3	179 000	7.7	45 100	1.9	KAZAKHSTAN
KYRGYZ REPUBLIC	1994	1 077 100	1 070 100	99.4	7 000	0.6	0	0.0	KYRGYZ REPUBLIC
LATVIA	1995	20 000	20 000	100.0	0	0.0	0	0.0	LATVIA
LITHUANIA*	1995	9 247	*9 247*	*100.0*	0	0.0	-	-	LITHUANIA
MOLDOVA	1994	312 000	312 000	100.0	0	0.0	0	0.0	MOLDOVA
RUSSIAN FEDERATION*	-	6 124 000	*6 124 000*	*100.0*	-	-	-	-	RUSSIAN FEDERATION
TAJIKISTAN	1994	719 200	626 200	87.1	68 000	9.5	25 000	3.5	TAJIKISTAN
TURKMENISTAN	1994	1 744 100	1 700 500	97.5	43 600	2.5	0	0.0	TURKMENISTAN
UKRAINE	1994	2 605 000	2 605 000	100.0	0	0.0	0	0.0	UKRAINE
UZBEKISTAN	1994	4 280 600	4 006 070	93.6	274 530	6.4	0	0.0	UZBEKISTAN
Former Soviet Union		**21 515 494**	**20 741 906**	**96.4**	**703 488**	**3.3**	**70 100**	**0.3**	**Former Soviet Union**

* *No details available; all equipped area considered to be irrigated from surface water.*

TABLE 17

Salinization and drainage in the former Soviet Union countries

Country	Total irrigation		Area salinized by irrigation		% of irrigated	Drained area in ha				Country
	year	ha	year	ha	area	year	Surface	Subsurface	Total	
ARMENIA	1995	285 649	1994	33 700	11.8	1994	48 780	11 620	60 400	ARMENIA
AZERBAIJAN	1995	1 453 318	1995	184 000	12.7	1995	330 400	269 570	599 970	AZERBAIJAN
BELARUS	1993	131 000	-	-	-	1990	706 100	2 180 900	2 887 000	BELARUS
ESTONIA	1995	3 680	-	-	-	1995	81 524	650 835	732 359	ESTONIA
GEORGIA	1996	469 000	-	-	-	1996	120 540	44 200	164 740	GEORGIA
KAZAKHSTAN	1993	3 556 400	1993	242 000	6.8	1993	417 500	15 600	433 100	KAZAKHSTAN
KYRGYZ REPUBLIC	1994	1 077 100	1994	60 000	5.6	1994	83 700	65 300	149 000	KYRGYZ REPUBLIC
LATVIA	1995	20 000	-	-	-	1995	93 100	1 490 300	1 583 400	LATVIA
LITHUANIA	1995	9 247	-	-	-	1995	423 230	2 619 512	3 042 742	LITHUANIA
MOLDOVA	1992	312 000	-	-	-	1992	12 600	29 400	42 000	MOLDOVA
RUSSIAN FEDERATION	1990	6 124 000	-	-	-	1990	4 161 000	3 238 000	7 399 000	RUSSIAN FEDERATION
TAJIKISTAN	1994	719 200	1994	115 000	16.0	1994	191 000	137 600	328 600	TAJIKISTAN
TURKMENISTAN	1994	1 744 100	1994	652 290	37.4	1995	699 164	322 962	1 022 126	TURKMENISTAN
UKRAINE	1994	2 605 000	-	-	-	1994	1 223 000	2 058 000	3 281 000	UKRAINE
UZBEKISTAN	1994	4 280 600	1994	2 140 550	50.0	1994	2 141 700	698 300	2 840 000	UZBEKISTAN
Former Soviet Union		**22 790 294**					**10 733 338**	**13 832 099**	**24 565 437**	**Former Soviet Union**

TABLE 18

The former Soviet Union countries compared to the world

Variable	Unit	World	Countries of the FSU	FSU as % of World
Total area	km^2	134 223 000	22 275 800	17
Total population 1996	inhabitants	5 767 775 000	293 491 000	5
Population growth 1995-96	%/year	1.4	0.06	
Population density	inhabitants/km^2	43	13	
Rural population	%	54	32	
Economic active population engaged in agriculture	%	47	17	
Precipitation	km^3/year	110 000	11 678	11
Renewable water resources:				
Total	km^3/year	40 000	4 730	12
Per inhabitant 1996	m^3/year	6 935	16 117	
Water withdrawal:				
- agricultural	km^3/year	2 236	166	7
- % of total	%	69	62	
- domestic	km^3/year	259	27	10
- % of total	%	8	10	
- industrial	km^3/year	745	77	10
- % of total	%	23	29	
Total water withdrawal	km^3/year	3 240	270	8
- in % of renewable water resources	%	8	6	
- per inhabitant 1996	m^3/year	562	920	
Irrigation	ha	251 205 223	22 790 294	9

Figures

Country profiles

Armenia

GEOGRAPHY AND POPULATION

With a total area of 29 800 km^2, Armenia is the smallest country of the FSU. It is a landlocked country, located south of the Caucasus mountains. It is bordered in the north by Georgia, in the east by Azerbaijan, in the south by Iran and in the west by Turkey. A part of Azerbaijan is located to the southwest of Armenia and bordered by Turkey, Armenia and Iran. Until 1995, the country was divided into 37 districts. It is now divided into ten *marzes* (provinces) plus the Yerevan municipality, which is the capital of Armenia.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	2 980 000	ha
Cultivable area	1995	1 391 400	ha
Cultivated area	1995	408 147	ha
- annual crops	1995	346 413	ha
- permanent crops	1995	61 734	ha
Population:			
Total population	1996	3 638 000	inhab.
Population density	1996	122	inhab./km^2
Rural population	1996	31	%
Economically active population engaged in agriculture	1996	15	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population	1994	100	%
Rural population	1994	95	%

The average altitude of the country is 1 800 m above sea level, ranging from 380 to 4 090 m (Mount Aragat). More than 90% of the country lies above 1 000 m and 72% above 1 500 m. The landform in the centre and north of the country comprises 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.

Agriculture is greatly influenced by the topography, most of the cultivated land lying within an altitude range of 600-2 500 m. The cultivable area is estimated at almost 1.4 million ha, which is 47% of the total area of the country. In 1995, the cultivated area was estimated at 408 147 ha, of which 346 413 ha were occupied by annual crops and 61 734 ha by permanent crops.

Official figures on the progress of privatization indicate that by the end of 1993 about 87% of the land so earmarked had already been privatized. Individual private farms have become the dominant form of farming. At the end of 1994, there were nearly 300 000 private farms with holdings averaging less than 2 ha.

The total population is about 3.64 million (1996), of which 31% is rural. The average population density is 122 inhabitants/km^2. In 1994, agriculture employed 15% of the economically active population and its contribution to GDP was 41%.

ARMENIA

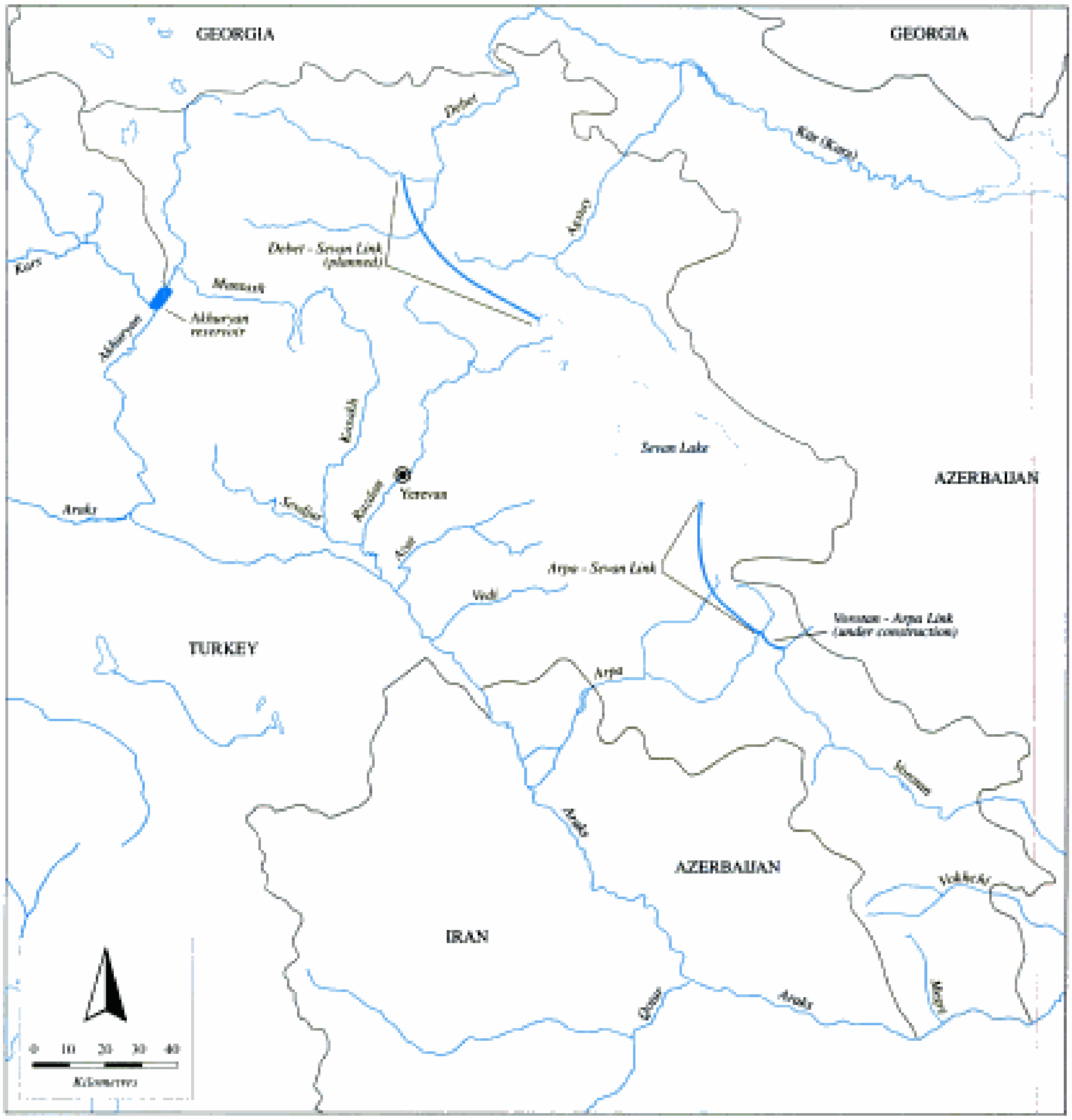

GEORGIA
GEORGIA
Debet
Kur (Kura)
Aghstev
Debet - Sevan Link (planned)
Kars
Akhuryan
Akhuryan reservoir
Kasakh
Sevan Lake
AZERBAIJAN
Yerevan
Araks
Arpa - Sevan Link
Vedi
Vorotan - Arpa Link (under construction)
TURKEY
Arpa
Vorotan
Araks
AZERBAIJAN
IRAN
Araks
0 10 20 30 40
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		526	mm/yr
		15.67	km^3/yr
Internal renewable water resources		9.071	km^3/yr
Total (actual) renewable water resources	1997	10.529	km^3/yr
Dependency ratio	1997	13.9	%
Total (actual) renewable water resources per inhabitant	1996	2 894	m^3/yr
Total dam capacity	1993	1 155	10^6 m^3
Water withdrawal:			
- agricultural	1994	1 940	10^6 m^3/yr
- domestic	1994	865	10^6 m^3/yr
- industrial	1994	120	10^6 m^3/yr
Total water withdrawal		2 925	10^6 m^3/yr
per inhabitant	1994	825	m^3/yr
as % of total (actual) renewable water resources		27.9	%
Other water withdrawal	1994	200	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1994	817	10^6 m^3/yr
- treated wastewater	1994	415	10^6 m^3/yr
- re-used treated wastewater	1994	0.1	10^6 m^3/yr
Agricultural drainage water		-	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

CLIMATE AND WATER RESOURCES

Climate

Depending on altitude, Armenia enjoys a variety of climatic conditions. The Ararat valley is characterized by hot dry summers and cold dry winters, with a total annual precipitation of 200-300 mm. Precipitation increases towards the mountains, up to 1 000 mm on Mount Aragat. It is highest from April to June and lowest from December to February. The average precipitation for the country is estimated at 526 mm/year.

River basins and water resources

Armenia lies wholly within the Kür (Kura) River basin. The basins of the tributaries flowing directly to the Kür River cover less than 25% of the country in the northeast. Here the outflow to Georgia through the Debet River is estimated at about 0.890 km^3/year and the outflow to Azerbaijan at about 0.555 km^3/year. The Araks River, which forms the border between Turkey and Armenia and further downstream between Iran and Armenia, flows into Azerbaijan where it joins the Kür River about 150 km before its mouth at the Caspian Sea. The total outflow to Azerbaijan through the tributaries of the Araks River (Arpa, Vorotan, Vokhchi) is estimated at about 1.791 km^3/year.

The RSWR originating inside the country are estimated at 6.271 km^3/year and the internal renewable groundwater resources at 4.200 km^3/year. The overlap between surface water and groundwater is estimated at 1.400 km^3/year. This results in 9.071 km^3 of total annual IRWR. The border flow of the Araks River between Turkey and Armenia is estimated at 1.929 km^3/year; that of the Akhuryan River, also between Turkey and Armenia, at 0.986 km^3/year. Half of these flows, or 1.458 km^3/year, is accounted for in Armenia's water balance. The total ARWR are thus estimated at 10.529 km^3/year, of which 7.729 km^3 surface water, 4.200 km^3 groundwater and 1.400 km^3 overlap.

TABLE 3
Irrigation and drainage

Irrigation potential	1993	653 651	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1995	285 649	ha
- surface irrigation	1995	257 949	ha
- sprinkler irrigation	1995	27 500	ha
- micro-irrigation	1995	200	ha
% of area irrigated from groundwater	1994	12.1	%
% of area irrigated from surface water	1994	87.9	%
% of area irrigated from non-conventional sources	1994	0.0	%
% of equipped area actually irrigated	1995	60.4	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1 + 2 + 3)	**1995**	**285 649**	**ha**
- as % of cultivated area		70.0	%
- increase over last 10 years	1985-95	minus 3.9	%
- power irrigated area as % of irrigated area	1995	45.0	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production	1995	135 000	t
as % of total grain production	1995	52	%
Harvested crops under irrigation	**1995**	**172 578**	**ha**
- permanent crops: total	1995	55 000	ha
- annual crops: total	1995	117 578	ha
. potatoes and fodder	1995	32 600	ha
. wheat	1995	31 000	ha
. barley	1995	28 000	ha
. vegetables	1995	21 000	ha
. other annual crops	1995	4 978	ha
Drainage - Environment:			
Drained area	1994	60 400	ha
- drained area in full or partial control irrigated areas		-	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1994	11 620	ha
- area with surface drains	1994	48 780	ha
Drained area as % of cultivated area		14.8	%
Power drained area as % of total drained area	1994	4.6	%
Area salinized by irrigation	1994	33 700	ha
Population affected by water-borne diseases		-	inhabitants

Lakes and dams

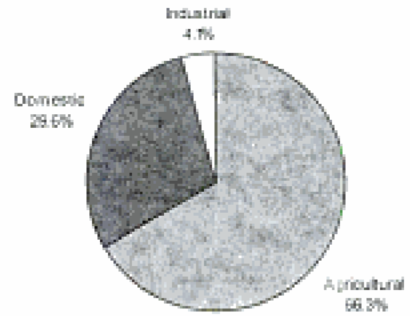
Lake Sevan

The largest lake in Armenia is Lake Sevan, located in the east of the country. It lies at 1 925 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 km^2 and 58 km^3 of stored water, has fallen since the 1930s due to the lake's increasing use for irrigation, hydropower and domestic water supply. By 1972, its level had fallen by almost 19 m and its surface area had been reduced to 1 250 km^2. Since 1972, unforeseen changes in the lake's ecology (loss of fish population), water quality (entrance of sewage) and microclimate (freezing of the lake in winter) have occurred. The government attempted to raise the water level of the lake again through reduced water take-off (for example, no water use for hydropower production during winter since 1978); the construction of pumping stations; and inter-basin water transfer: from the Arpa and Vorotan rivers, through the Arpa-Sevan link (constructed) and the Vorotan-Arpa link (under construction), and from the Debet River, through the Debet-Sevan link (planned). The measures met with initial success and the lake rose about 1 m between 1978 and 1990. However, demands on the water increased more rapidly at the beginning of the 1990s, when electricity was again generated during the winter. This resulted in the 1 m gained being lost again. Work has begun on the construction of more pumping stations and balancing reservoirs to raise the level of the lake. Especially because of the present energy shortages in the country, the construction of balancing reservoirs is both important and urgent, as year-round hydropower production from Lake Sevan is mining its water at an alarming rate without the possibility of winter water being stored for irrigation in the summer. If stored, some of this water would then allow summer releases from Lake Sevan to be reduced by some amount depending upon electricity requirements in the summer.

Dams

In 1995, the total capacity of reservoirs was estimated at 1 155 million m^3, of which 1 108 million m^3 was stored in reservoirs behind dams with a capacity of over 5 million m^3 each. Most water is used for irrigation. About 145 million m^3 is 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 m^3, is shared with Turkey, and provides water for the irrigation of about 30 000 ha in Armenia. New dams, under construction or identified, could store an additional almost 1 000 million m^3 of water.

FIGURE 1
Water withdrawal
Total: 2 925 million m^3 in 1995



Water withdrawal and wastewater

In 1994, the total water withdrawal for agricultural, domestic and industrial purposes was 2 925 million m^3, of which 66% for irrigation purposes (Figure 1). 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 (Figure 2). Around 200 million m^3 of water was estimated to be necessary for fisheries, recreation and power generation.

The total quantity of produced wastewater in 1994 amounted to 817 million m^3, of which 415 million m^3 was treated and only 0.1 million m^3 re-used.

IRRIGATION AND DRAINAGE DEVELOPMENT

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 A.D. the total irrigated

FIGURE 2
Evolution of water withdrawal

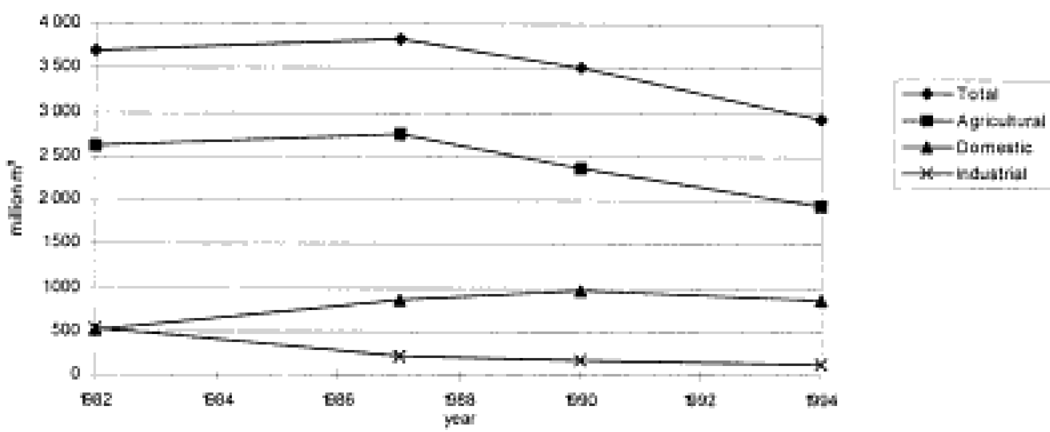
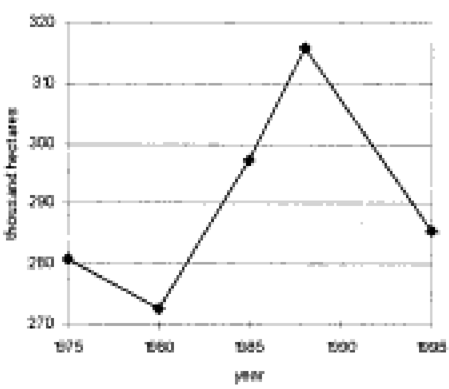


FIGURE 3
Evolution of irrigation



area was estimated at about 100 000 ha, in 1920 it had dropped to 61 000 ha, and in 1988 the area equipped was almost 316 000 ha. At present, the area equipped for full or partial control irrigation is estimated at almost 286 000 ha (Figure 3). 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.

On over 90% of the area equipped for irrigation, surface irrigation is practised. This surface irrigation can be divided into four categories: furrow irrigation; borderstrip irrigation; flooding; and irrigation using hydrants and flexible hose systems (Figure 4). Flooding is used where soil depth does not permit 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 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 micro-irrigation are practised on the remaining 10% of the area equipped for full or partial control irrigation.

On 12% of the equipped area, groundwater is used for irrigation. The remaining part is irrigated from surface water through reservoirs, river diversion or pumping in rivers (Figure 5).

FIGURE 4
Irrigation techniques
Total: 285 649 ha in 1995

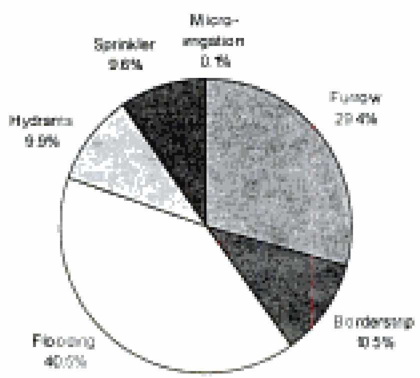


FIGURE 5
Origin of irrigation water
Total: 285 649 ha in 1994

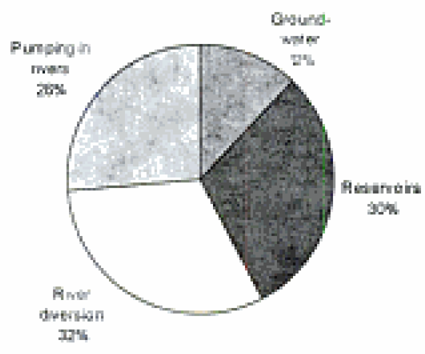
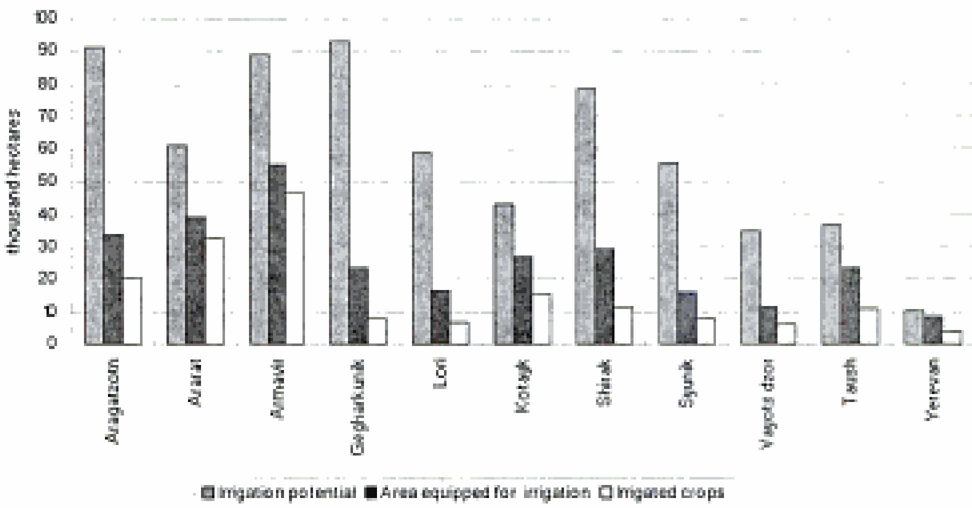


FIGURE 6
Irrigation potential, area equipped for irrigation and irrigated crops in 1995



The irrigation potential has been estimated at 653 651 ha. Figure 6 shows the irrigation potential by province, the area equipped for irrigation, and the irrigated cropped area. In 1995, 44% of the irrigation potential had already been equipped for irrigation in the country, while a little over 60% of the area equipped for irrigation was actually cropped. In 1994, the area salinized by irrigation was estimated at 33 700 ha.

In 1995, almost one-third of the irrigated area was occupied by permanent crops, mainly grapes. Cereals, mainly wheat and barley, covered a little over one-third of the irrigated area (Figure 7).

Drainage development

The total drained area increased from 6 900 ha in 1975 to 60 400 ha in 1994, with a major increase from 1989 onwards (Figure 8). Most of the drainage is surface drainage.

FIGURE 7
Irrigated crops
Total: 172 578 ha in 1995

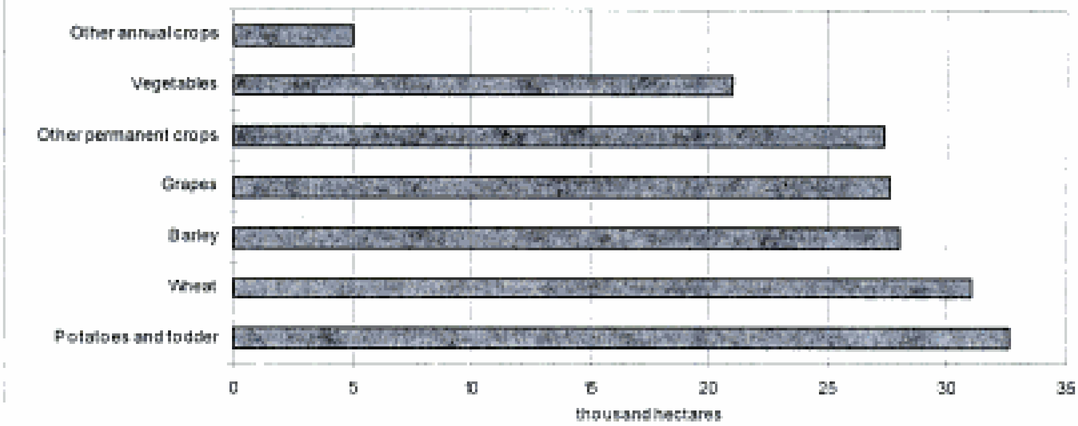
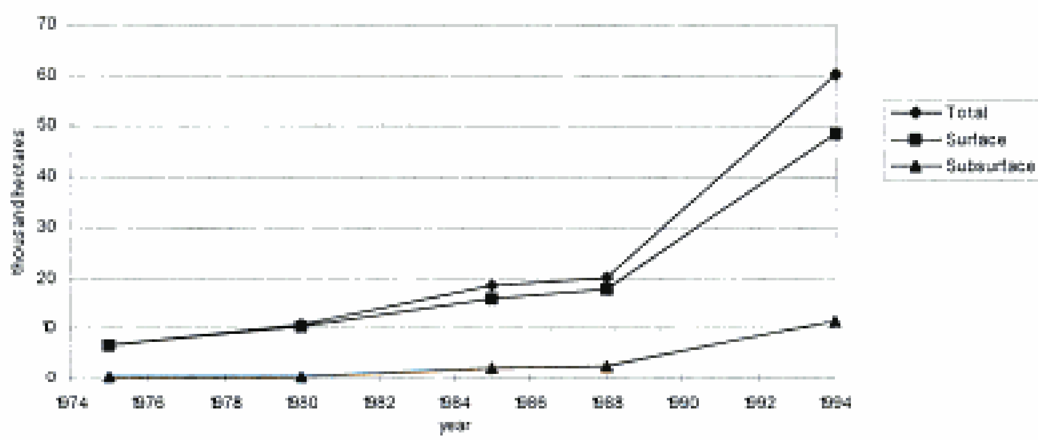


FIGURE 8
Evolution of the drained area



INSTITUTIONAL ENVIRONMENT

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

- The Ministry of Food and Agriculture with:
  - The Department of Water Economy and Improvement, including the 'Hayjirtntes' State Enterprise, which is in charge of the maintenance of irrigation schemes:
    - . The Central Water Board, which is in charge of all matters relating to the utilization of the water resources, including water quality;
    - . The Research Centre of Water Problems and Hydrology, which is involved in the complex utilization of water resources, their allocation, as well as in studies concerning hydro-engineering;
    - . The 'Jrambar' State Enterprise, which is in charge of the maintenance of irrigation dams;

- The 'Hayjirnackhagits' Institute, which is in charge of designing irrigation schemes and of studying the future prospects for water utilization;

• The Ministry of Environment and Groundwater:

- The Department of Geology and Geological Engineering, which is in charge of exploring the groundwater resources;
- The Department of Water Resources Utilization, which is in charge of the effective utilization of water resources and their conservation;

• The Ministry of Urban Development:

- The 'Hayjirmughkojughi' State Enterprise, which is responsible for the maintenance of the domestic water supply network in the country, except in Yerevan city, where it is the responsibility of Yerevan's 'Hayjirmughkojughi' Department;

The Administration of Hydrometeorology is involved in the study of the water bodies (rivers, lakes, ponds, etc.).

TRENDS IN WATER RESOURCES MANAGEMENT

Much of Armenia's agriculture is based on irrigation. At present, 70% of the cultivated area is equipped for irrigation. However, the irrigation systems are in a deteriorating condition, which may lead to extreme environmental damage. Almost 70% of the equipped area needs rehabilitation. In addition, the management of irrigation systems requires adjustments to meet the needs of the recently privatized farms. According to a World Bank country study, the rehabilitation of critical water infrastructure facilities and the adjustment of irrigation management practices should receive very high priority.

The overall water use efficiency, from water source to crop, is estimated to be less than 35% for gravity systems. Potentially, with large savings along the existing irrigation systems and the development of new, non-utilized water resources, much more land could be irrigated. The World Bank has proposed several measures to increase the efficiency of the irrigation system: the setting up of pilot projects to test alternative delivery unit sizes; water meters and field distribution systems; and the organization of WUAs to be responsible for operating and maintaining facilities associated with their members' farms. All institutions related to irrigation use should then be directed to improving their services to the water users.

From an environmental perspective, the restoration of Lake Sevan's ecosystem is very important and should take priority.

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Azerbaijan

GEOGRAPHY AND POPULATION

Azerbaijan, located on the southeastern slopes of the Caucasus mountains, has a total area of 86 600 km^2. It is bordered in the east by the Caspian Sea, in the south by Iran, in the southwest by Turkey, in the west by Armenia, in the northwest by Georgia and in the north by the Russian Federation. The Nakhchivan Autonomous Republic of Azerbaijan in the southwest is separated from the rest of the country by Armenia.

About 43% of the area of Azerbaijan is situated above 1 000 m above sea level. Five main physiographic regions can be distinguished:
- The Greater Caucasus mountain range in the north, extending from the Black Sea in the west to the Caspian Sea in the east over the northern part of Georgia and Azerbaijan and the southern part of the Russian Federation;
- The Lesser Caucasus mountain range, south of the Greater Caucasus mountain range, covering the south of Georgia and Azerbaijan and the north of Armenia;
- The lowlands around the Kura and Araks rivers;
- The Talish mountains with the adjoining Lankaran lowland in the southeast along the border with Iran;
- The Nakhchivan Autonomous Republic in the southwest.

The cultivable area is estimated at about 4.32 million ha, which is 50% of the total area of the country. Almost all the land is shared between the *sovkhoz* (state farms) and the *kolkhoz* (collective farms). In 1993, the cultivated area was 1.80 million ha, or 42% of the cultivable area, of which 1.54 million ha were annual crops and 0.26 million ha permanent crops.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	8 660 000	ha
Cultivable area	1993	4 318 860	ha
Cultivated area	1993	1 804 280	ha
- annual crops	1993	1 543 130	ha
- permanent crops	1993	261 150	ha
Population:			
Total population	1996	7 594 000	inhab.
Population density	1996	88	inhab./km^2
Rural population	1996	44	%
Economically active population - engaged in agriculture	1996	30	%
of which: - men	1995	64	%
- women	1995	36	%
Water supply coverage:			
Urban population	1996	72	%
Rural population	1996	28	%

The total population is 7.6 million (1996), of which 44% is rural. The average population density is 88 inhabitants/km^2. In 1996, agriculture employed 30% of the economically active population. Women make up about 36% of the rural labour force. The rural female labour force accounts for 48.5% of the total female labour force. The share of agriculture in GDP dropped from 39% in 1990 to 31% in 1995, due to the prevailing situation in the rural areas.

AZERBAIJAN

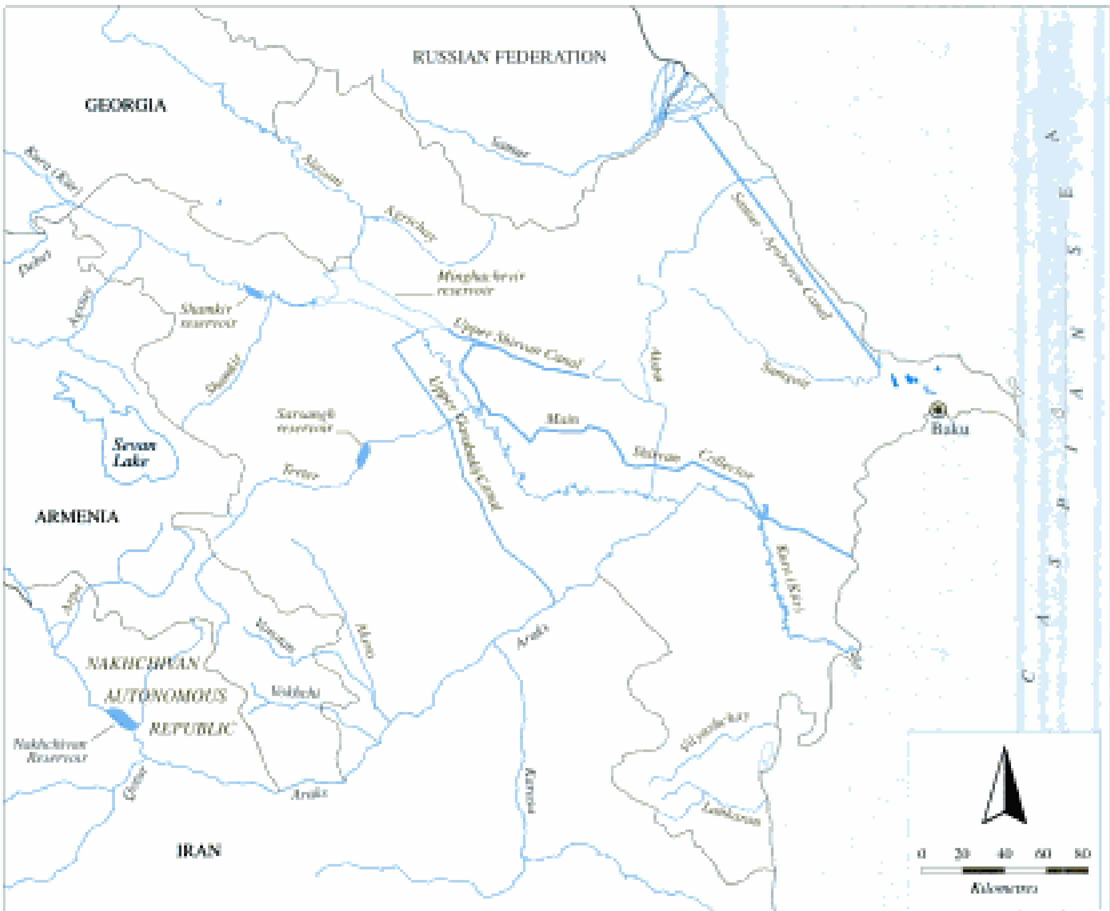

RUSSIAN FEDERATION
GEORGIA
ARMENIA
IRAN
Samur
Kura (Kür)
Agrichay
Minghachevir reservoir
Shamkir reservoir
Upper Shirvan Canal
Samur - Apsheron Canal
Sumgait
Baku
Sevan Lake
Sarsangh reservoir
Terter
Main
Shirvan
Collector
Upper Garabagh Canal
Kura (Kür)
Araks
NAKHCHIVAN
AUTONOMOUS
REPUBLIC
Nakhchivan Reservoir
Araks
Lankaran
C A S P I A N S E A
0 20 40 60 80
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		541	mm/yr
		46.9	km³/yr
Internal renewable water resources		8.115	km³/yr
Total (actual) renewable water resources	1997	30.275	km³/yr
Dependency ratio	1997	73.2	%
Total (actual) renewable water resources per inhabitant	1996	3 987	m³/yr
Total dam capacity	1991	21 450	10^6 m³
Water withdrawal:			
- agricultural	1995	11 630.73	10^6 m³/yr
- domestic	1995	778.30	10^6 m³/yr
- industrial	1995	4 124.00	10^6 m³/yr
Total water withdrawal		16 533.03	10^6 m³/yr
per inhabitant	1995	2 195	m³/yr
as % of total (actual) renewable water resources		54.6	%
Other water withdrawal	1995	570.00	10^6 m³/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1996	570.8	10^6 m³/yr
- treated wastewater	1996	102.7	10^6 m³/yr
- re-used treated wastewater		-	10^6 m³/yr
Agricultural drainage water		-	10^6 m³/yr
Desalinated water		-	10^6 m³/yr

CLIMATE AND WATER RESOURCES

Climate

The climate in Azerbaijan is continental. Arid weather with average summer temperatures above 22°C is observed in the lowlands. In the mountain regions, temperatures can be below 0°C in winter and in Nakhchivan severe frost may occur. Humid tropical weather is observed in the coastal zone near the Caspian Sea, mainly in the Lankaran lowlands in the southeast. The average precipitation is estimated at 541 mm/year.

River basins and surface water resources

Four major river basins can be distinguished, two of which are international:

- The basin of the Kura and Araks rivers. It is by far the largest basin in the country. The Kura River rises in the Kars upland in northeast Turkey. It then flows into Georgia and crosses the border to Azerbaijan in the northwest. The total length of the Kura River system is 1 515 km, of which 900 km is located within Azerbaijan. The total annual inflow from Georgia is estimated at 11.910 km³. The Araks River also rises in the northeast of Turkey. After forming the border between Turkey and Armenia, Turkey and Azerbaijan, Iran and Azerbaijan, Iran and Armenia, and Iran and Azerbaijan again, it flows into Azerbaijan in the east of the country. About 100 km downstream of the border it flows into the Kura River, which continues to flow southeast towards the Caspian Sea. The total annual inflow of the main Araks River is estimated at 6.724 km³. The total annual inflow of the tributaries of the Kura and Araks rivers coming from Armenia is estimated at 2.346 km³. The total inflow into Azerbaijan is thus estimated at 20.980 km³/year.

TABLE 3
Irrigation and drainage

Irrigation potential		1996	1 720 000	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1995	1 453 318	ha
- surface irrigation		1995	1 301 700	ha
- sprinkler irrigation		1995	149 000	ha
- micro-irrigation		1995	2 618	ha
% of area irrigated from groundwater		1995	6.7	%
% of area irrigated from surface water		1995	93.3	%
% of area irrigated from non-conventional sources		1995	0.0	%
% of equipped area actually irrigated			-	%
2. Equipped wetland and inland valley bottoms (i.v.b.)			-	ha
3. Spate irrigation			-	ha
Total irrigation (1+2+3)		**1995**	**1 453 318**	**ha**
- as % of cultivated area		1995	80.5	%
- increase over last 10 years		1985-95	14.5	%
- power irrigated area as % of irrigated area		1995	35	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 20 000 ha	1995	1 183 309	ha
Medium-scale schemes		1995	192 591	ha
Small-scale schemes	< 10 000 ha	1995	77 418	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production			-	t
as % of total grain production			-	%
Harvested crops under irrigation *		**1995**	**762 844**	**ha**
- permanent crops: total		1995	118 116	ha
- annual crops: total		1995	644 728	ha
. wheat		1995	296 128	ha
. cotton		1995	210 445	ha
. barley		1995	110 715	ha
. other cereals		1995	10 148	ha
. other annual crops		1995	17 292	ha
Drainage - Environment:				
Drained area		1995	599 970	ha
- drained area in full or partial control irrigated areas		1995	599 970	ha
- drained area in equipped wetland and i.v.b.		1995	-	ha
- other drained area		1995	-	ha
- area with subsurface drains		1995	269 570	ha
- area with surface drains		1995	330 400	ha
Drained area as % of cultivated area			33	%
Power drained area as % of total drained area		1995	28	%
Area salinized by irrigation		1995	184 000	ha
Population affected by water-borne diseases			-	inhabitants

* *Does not include the areas located in the occupied zone and the zone declared neutral in May 1994*

- The Samur River basin. It is located in the northeast of the country. The Samur River rises in the Russian Federation and then forms the border between the Russian Federation and Azerbaijan with an annual discharge estimated at 2.36 km^3, half of which is considered to be available for Azerbaijan. Before flowing into the Caspian Sea, the river divides into several branches.

- The coastal river basins in the northeast between the Samur and Kura river basins.

- The coastal river basins in the Lankaran region in the southeast, south of the Kura River basin.

The internally generated surface water resources are estimated at 5.955 km^3/year. The total RSWR, including incoming and bordering flows, are estimated at 28.115 km^3/year. For the

Kura and Araks rivers, which are shared between Turkey, Georgia, Armenia, Iran and Azerbaijan, discussions are underway on water sharing between the countries.

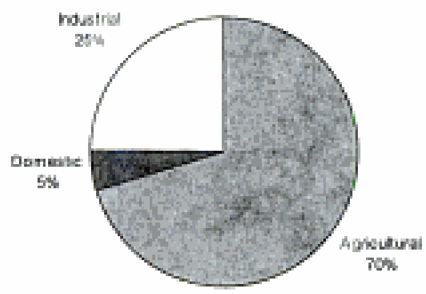
Groundwater resources

The internal renewable groundwater resources are estimated at 6.51 km^3/year, of which 4.35 km^3/year are common to surface water. The groundwater resources are famed for their quality as mineral drinking water and are also used for medical purposes. The Nakhchivan Autonomous Republic is especially rich in mineral groundwater. The total number of artesian wells is estimated at about 7 000 with a total discharge of about 2.1 million m^3/year.

Lakes and dams

The total reservoir capacity of large dams (larger than 100 million m^3 each) is estimated at 21.35 km^3. The four largest reservoirs are the Minghachevir and Shamkir on the Kura River, the Nakhchivan on the Araks River, and the Sarsangh on the Terter River. The total capacity of smaller reservoirs for irrigation purposes is estimated at 100 million m^3.

FIGURE 1
Water withdrawal
Total: 16.53 km^3 in 1995



Water withdrawal and wastewater

In 1995, the total water withdrawal for agricultural, domestic and industrial purposes was 16.53 km^3, of which over 70% for agricultural uses and almost 25% for industrial purposes (Figure 1). On the Apsheron peninsula, where the capital Baku is located, the share of industrial water withdrawal is 70%. In 1975, the total water withdrawal was 12.14 km^3, of which 77% for agricultural uses and 19% for industrial purposes (Figure 2).

The annual production of wastewater is about 571 million m^3. Most wastewater is produced by industries like the cotton cleaning, cotton oil production, fish-curing and grape processing industries. It is estimated that 18% of the produced wastewater is treated, which is about 103 million m^3/year or 280 000 m^3/day.

IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

Based on soil and water resources, the irrigation potential is estimated at 1.72 million ha. In the last century, irrigation was concentrated alongside the rivers. At the beginning of this century, the construction of large irrigation canals started. In 1913, 582 000 ha were irrigated. The most intensive development took place after the Second World War. In 1975, the area equipped for irrigation was 1.17 million ha. In 1995, it was 1.45 million ha, which is 84% of the irrigation potential (Figure 3).

FIGURE 2
Evolution of water withdrawal

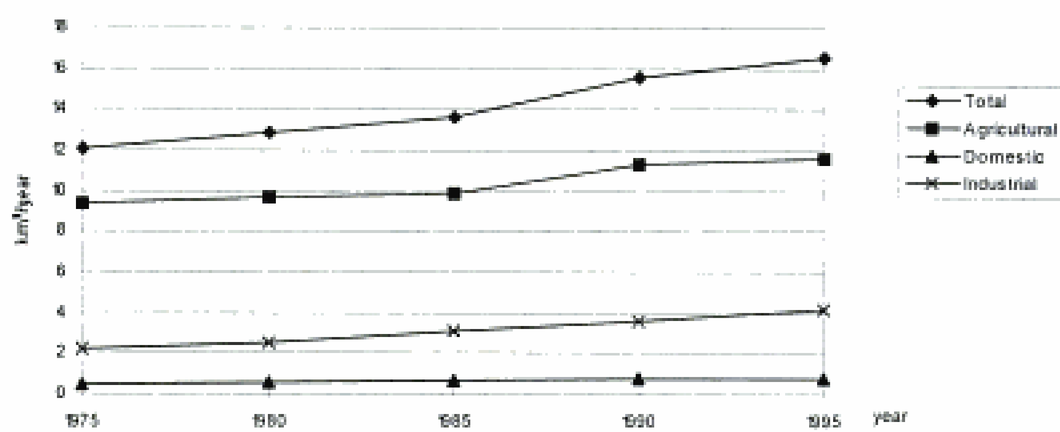


FIGURE 3
Evolution of irrigation

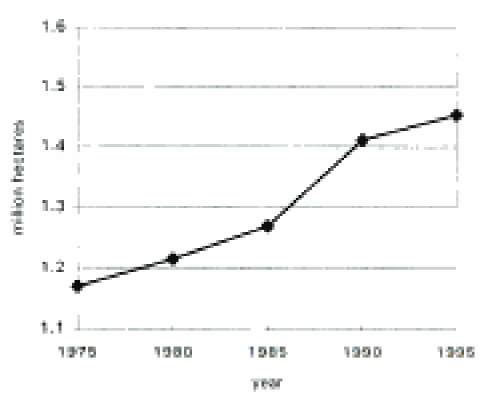
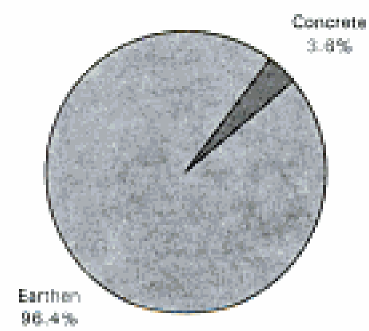


FIGURE 4
Typology of irrigation canals
Total: 65 900 km in 1995



The total length of all irrigation canals is 65 900 km, of which only 2 400 km, or 3.6%, are concrete canals (Figure 4). Irrigation efficiency at national level is estimated at 55%. The largest canals are the Upper Garabakh, the Upper Shirvan and the Samur-Apsheron canals, all earthen.. The Upper Gabarakh canal runs southeast from the Mingachevir reservoir to the Araks River. Its length is about 174 km and its capacity 113.5 m^3/s. About 85 000 ha are irrigated from this canal. The Upper Shirvan canal also starts from the Mingachevir reservoir and runs east to the Akhsu River. Its length is about 126 km and its capacity 78 m^3/s. About 91 100 ha are irrigated from this canal.

Almost 90% of the irrigation is surface irrigation, mainly furrow and borderstrip irrigation (Figure 5). Sprinkler irrigation and micro-irrigation are mainly used on perennial plantations and vineyards. Surface water is used on 93% of the area, mainly from reservoirs and through direct pumping in rivers and canals (Figure 6). About 96 700 ha are irrigated by groundwater through more than 5 000 wells. The power irrigated area is estimated at 511 000 ha.

FIGURE 9

Irrigated crops (excluding the areas in the occupied and neutral zones)

Total: 762 844 ha in 1995

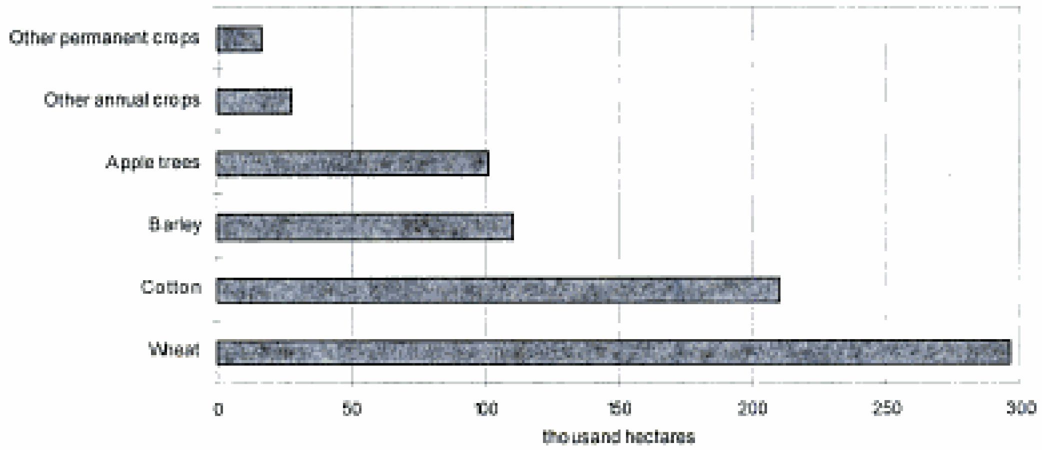
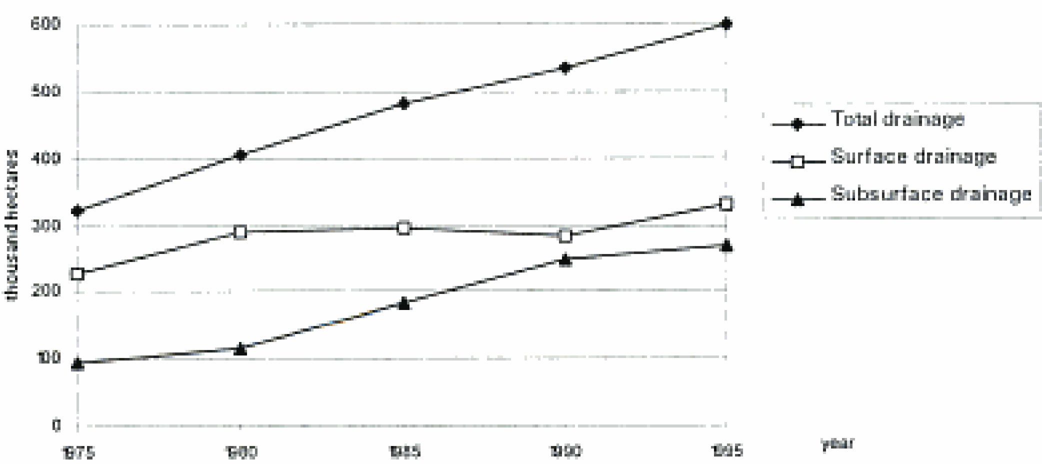


FIGURE 10

Evolution of the drained area



INSTITUTIONAL ENVIRONMENT

The main institutions involved in water resources management, all state institutions, are:

- The Committee of Land Improvement and Water Economy, in charge of land improvement activities and the operation and maintenance (O&M) of the infrastructure;
- 'Azervodstroy', in charge of the construction of infrastructure;
- 'Azselkhozvodosnabzheniye', in charge of agricultural water supply;
- 'Azkomunpromvod' and the Committee of Domestic-Municipal Services, in charge of domestic water supply and the O&M of the sewage system;

- The Committee of Ecology and Nature Use, in charge of the monitoring of salinization and water resources pollution.

In July 1996, a land reform law was adopted by the National Assembly (Milli Majlis). This law establishes private property rights to land. The land is to be transferred to all rural inhabitants free of charge. It can then be sold freely, exchanged, transferred by right of succession, leased or used as mortgage.

A land improvement and irrigation law has also been adopted. This law establishes the legal basis of activities on land improvement and irrigation under the new landownership conditions and provides for the transition to paid water use.

TRENDS IN WATER RESOURCES MANAGEMENT

The rehabilitation of irrigation and drainage systems to ensure the sustainability of the irrigation subsector is a priority for the near future. Major policy changes in landownership and irrigation management are expected to play an important role in improving irrigation performance.

Erosion control is seen as another major issue. According to the data of the Ecological Committee, almost 43% of the country is subject to erosion. Effective measures to combat water erosion are the creation of a field protecting wood belt, as well as wood belts along the banks of large rivers, canals and reservoirs.

International issues of critical importance are the sharing and joint management of the Kura and Araks rivers and of the Caspian Sea to prevent further pollution and ensure sustainable development of their resources.

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Belarus

GEOGRAPHY AND POPULATION

Belarus is a landlocked country in eastern Europe with a total area of 207 600 km^2. It is bordered in the northeast and east by the Russian Federation, in the southeast and south by Ukraine, in the southwest by Poland and in the northwest by Lithuania and Latvia. It declared its independence from the Soviet Union in August 1991. For administrative purposes, the country is divided into six provinces (*oblasts*).

Belarus is part of the east European lowland, covered with young glacial formations, mainly gravel and sand. From the southwest to the northeast the moraine Belarus rampart, where several larger rivers rise, crosses the country. In the south is the vast, marshy land of Polesye. The peak of the highest hill is at 345 m above sea level.

The cultivable area, which according to Belarus statistics corresponds to the land belonging to all types of agricultural farms (state, cooperative, private), is estimated at 11.9 million ha, which is 57% of the total area of the country. In 1993, the cultivated area was estimated at about 6.1 million ha, of which about 98% was occupied by annual crops. Belarus was heavily affected by the accident at the nuclear power plant at Chernobyl, which is located just over the border in neighbouring Ukraine close to the Pripyat River. The nuclear accident occurred in April 1986 and 70% of the radiation is estimated to have fallen on Belarus, as prevailing winds carried the heaviest radioactive releases into Belarus. About 20% of the agricultural land in Belarus is estimated to be contaminated, including almost all the drained area in the southern and southeastern Polesye. However, in spite of this contamination, cropping has not been suspended.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	20 760 000	ha
Cultivable area	1993	11 910 000	ha
Cultivated area	1993	6 074 100	ha
- annual crops	1993	5 979 000	ha
- permanent crops	1993	95 100	ha
Population:			
Total population	1996	10 348 000	inhab.
Population density	1996	50	inhab./km^2
Rural population	1996	28	%
Economically active population engaged in agriculture	1996	17	%
of which: - men	1995	62	%
- women	1995	38	%
Water supply coverage:			
Urban population	1993	96	%
Rural population	1993	64	%

Agriculture is almost exclusively in the hands of the *sovkhoz* (state farms) and *kolkhoz* (collective farms). On 1 October 1995, there were 3 000 private farms in Belarus, owning a total of 62 100 ha of land (Figure 1).

The total population is almost 10.3 million (1996), of which 28% is rural. The average population density is 50 inhabitants/km^2, rather evenly distributed over the country. Only in Minsk province, where the capital Minsk is located, does the population density reach

BELARUS

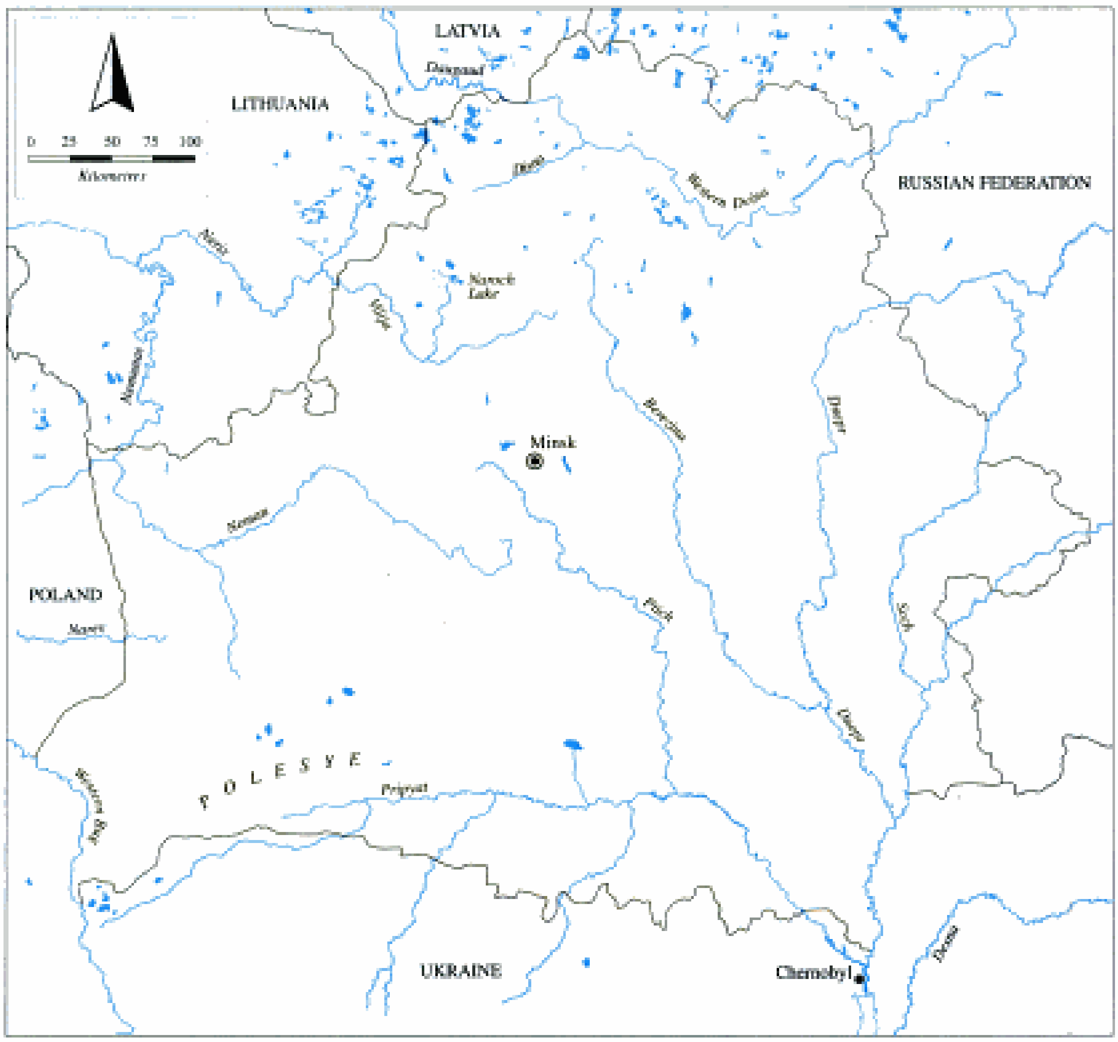
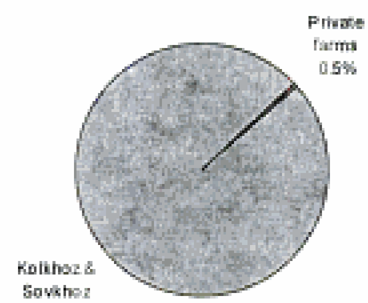

LATVIA
LITHUANIA
0 25 50 75 100
RUSSIAN FEDERATION
Naroch
Lake
Minsk
Neman
POLAND
Pripyat
P O L E S Y E
UKRAINE
Chernobyl

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		700	mm/yr
		145.3	km^3/yr
Internal renewable water resources		37.2	km^3/yr
Total (actual) renewable water resources	1997	58.0	km^3/yr
Dependency ratio	1997	35.9	%
Total (actual) renewable water resources per inhabitant	1996	5 605	m^3/yr
Total dam capacity	1991	3 080	$10^6\ m^3$
Water withdrawal:			
- agricultural	1990	948	$10^6\ m^3/yr$
- domestic	1990	608	$10^6\ m^3/yr$
- industrial	1990	1 178	$10^6\ m^3/yr$
Total water withdrawal		2 734	$10^6\ m^3/yr$
per inhabitant	1992	265	m^3/yr
as % of total (actual) renewable water resources		4.7	%
Other water withdrawal	1990	777	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1993	993	$10^6\ m^3/yr$
- treated wastewater	1993	882	$10^6\ m^3/yr$
- re-used treated wastewater		-	$10^6\ m^3/yr$
Agricultural drainage water		-	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

82 inhabitants/km^2, while in Vitebsk province in the northeast, the population density is lowest at 36 inhabitants/km^2. The annual population growth decreased from 1.1% in 1990 to 0.2% in 1993 and to -0.7% in 1995. In 1996, agriculture employed 17% of the economically active population. While women constitute 51% of the total labour force, their percentage in agriculture is only 38%. This is due to the predominance of women in other professions, such as in education and health services. About 13% of the total female labour force and 26% of the total male labour force is engaged in agriculture. In 1996, agriculture accounted for almost 22% of GDP.

FIGURE 1
Land categories
Total: 11 910 000 ha in 1995



CLIMATE AND WATER RESOURCES

Climate

The west of the country is characterized by the transitional climate between maritime and continental, the climate in the central and eastern parts is continental. The average annual midday temperature is 6°C, varying from -7°C in January to 18°C in July. The average annual precipitation is 700 mm, ranging from 550 mm in the southeast to 800 mm on the highest areas in the centre of the country. About 70% of the precipitation falls during the

TABLE 3
Irrigation and drainage

Irrigation potential		-	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1993	131 000	ha
- surface irrigation		-	ha
- sprinkler irrigation	1993	131 000	ha
- micro-irrigation		-	ha
% of area irrigated from groundwater		-	%
% of area irrigated from surface water		-	%
% of area irrigated from non-conventional sources		-	%
% of equipped area actually irrigated		-	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1+2+3)	**1993**	**131 000**	**ha**
- as % of cultivated area		2.2	%
- increase over last 10 years		-	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production	1990	82 500	t
as % of total grain production	1990	1	%
Harvested crops under irrigation	**1990**	**149 000**	**ha**
- permanent crops: total	1990	77 400	ha
- annual crops: total	1990	71 600	ha
. fodder crops	1990	38 800	ha
. cereals and pulses	1990	21 600	ha
. vegetables	1990	7 588	ha
. potatoes	1990	2 912	ha
. other annual crops	1990	700	ha
Drainage - Environment:			
Drained area	1993	3 001 000	ha
- drained area in full or partial control irrigated areas		-	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1990	2 180 900	ha
- area with surface drains	1990	706 100	ha
Drained area as % of cultivated area		49	%
Power drained area as % of total drained area		-	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

summer months. The east of the country is covered with snow for up to 120 days per year, the west for fewer than 80 days.

Due to the climatic conditions, there is a need for drainage rather than irrigation in the country, except in areas where the groundwater level has fallen too much due to excessive drainage.

River basins and water resources

The country can be divided into four main river basins:

- The Dnepr basin. This basin covers about 81.5% of the country. The Dnepr River rises in the Russian Federation and enters Belarus in the northeast. Within the country it flows to the south and, after forming the border with Ukraine over some 100 km, it flows into Ukraine and finally the Black Sea. The largest tributary of the Dnepr within Belarus is the Pripyat, which rises in Ukraine, enters the country in the south, flows east and leaves the country again in the southeast to flow into the Dnepr within Ukraine.

- The Western Dvina basin. This basin covers about 10% of the country. The Western Dvina River rises in the Russian Federation and flows into Belarus in the northeast. It then flows to the west and leaves the country in the northwest to flow into Latvia, where it is called the Daugava, flowing to the Baltic Sea.

- The Neman basin. This basin covers about 6% of the country. Its main source is in the centre of the country near the capital Minsk. It flows to the west and enters Lithuania, where it is called the Nemunas River, which flows to the Baltic Sea. The Vilija River, also rising in Belarus to the north of the Neman River, flows west into Lithunania, where it becomes the Neris River that flows into the Nemunas River. Some smaller tributaries rise in Poland and flow east into Belarus into the Neman River.

- The Western Bug basin. This basin covers about 2.5% of the country in the southwest. The main Bug River rises in Ukraine, and forms the border, first between Ukraine and Poland and then between Belarus and Poland, before entering Poland.

Renewable surface water resources (RSWR) by river basin

Name of river basin	Area within Belarus	Internal RSWR	Inflow		Total RSWR	Outflow
	(km^2)	(km^3/year)	(km^3/year)	from:	(km^3/year)	to:
Dnepr:	169 190	18.5	13.5		32.0	Ukraine
of which:- Dnepr		11.6	7.7	Russian Federation	19.3	
- Pripyat		6.9	5.8	Ukraine	12.7	
Western Dvina	20 760	7.1	7.2	Russian Federation	14.3	Latvia
Neman:	12 460	9.3	0.1	Poland	9.4	Lithuania
of which:- Neman		6.8	-		6.8	
- Affluents		2.5	0.1	Poland	2.6	
Western Bug:	5 190	2.3	-		2.3	Poland
of which:-West. Bug		0.2	-	Border with Poland	0.2	
- Affluents		2.1	-		2.1	
Total	**207 600**	**37.2**	**20.8**		**58.0**	

The total ARSWR are estimated at 58.00 km^3/year, of which 37.2 km^3/year are generated within the country (Figure 2). The renewable groundwater resources are estimated at about 18.0 km^3/year, which are considered to be drained entirely by the surface water network (overlap).

Lakes and dams

There are about 10 800 freshwater lakes with a total area of 1 600 km^2, or 0.8% of the total area of the country, and a total capacity of 7.2 km^3. The largest lake is Lake Naroch, with an area of 80 km^2 and an average depth of 9 m. There are also about 1 550 small and shallow natural ponds in the country with a total area of 350 km^2 and a total capacity of 0.5 km^3.

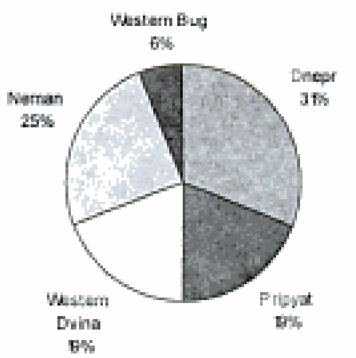
Location of dams

Name of (sub)basin	Number of dams
Pripyat	49
Dnepr	43
Neman	22
Western Dvina	17
Western Bug	9
Total	140

There are 140 dams and tanks each with a capacity of at least 1 million m^3, of which 89 have been built for irrigation purposes. Their total capacity is estimated at 3.08 km^3 and their total surface area about 880 km^2.

The gross theoretical hydropower potential of Belarus is estimated at 7 500 GWh/year, a third of which being economically feasible. Hydropower installed capacity is only 6 MW, generating 0.06% of electricity of the country.

FIGURE 2
Internal renewable surface water resources by major river basin
Total: 37.2 km^3/year



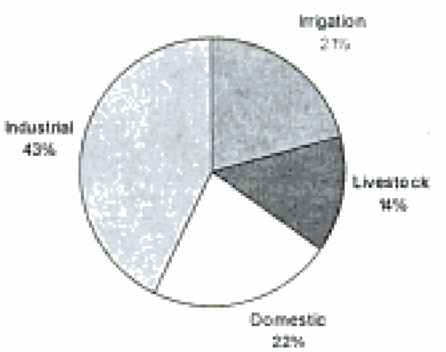
International agreements

Since 1992, some agreements with Poland have been reached on water quality issues and navigation on the Western Bug River. However, no agreements exist with neighbouring countries on the sharing of water of international rivers.

Water withdrawal and wastewater

In 1990, the total water withdrawal for agricultural, domestic and industrial purposes was 2.7 km^3, of which 21% for irrigation (Figure 3). The total water withdrawal in 1995 was estimated at 3.0 km^3. In 1993, 993 million m^3 of wastewater was produced, of which 882 million m^3 was treated.

FIGURE 3
Water withdrawal
Total: 2 734 million m^3 in 1990



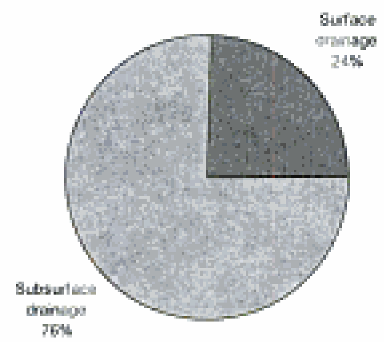
IRRIGATION AND DRAINAGE DEVELOPMENT

Drainage development

The history of drainage in Belarus dates back to the second half of the eighteenth century in the then Polish state. On huge private estates, marshes were drained to turn them into meadows, mainly by open canals. In the final quarter of the nineteenth century, large-scale drainage works were carried out in the Polesye region, where about 4 700 km of canals were built with an average depth of 1.1 m. These works were also intended to facilitate wood exploitation and the floating of timber down to Ukraine. Drainage work stopped at the beginning of the twentieth century but restarted in the 1920s, independently in the western part (Poland) and the eastern part (the Soviet Union). During the Second World War, work was suspended again and when it restarted after the war it was initially on a small scale. Following the 'Land Draining and Sovkhoz Building Act' of 1966, large-scale drainage work started again. Most of the drainage work was concentrated in the Polesye region, where 85 000 ha had been drained by 1939, and this drained area amounted to 560 000 and 1 400 000 ha in 1966 and 1986 respectively. In the period 1966-1986, mainly subsurface drainage systems were built. Most of this drained land in the Polesye region was contaminated after the accident at the Chernobyl nuclear power plant.

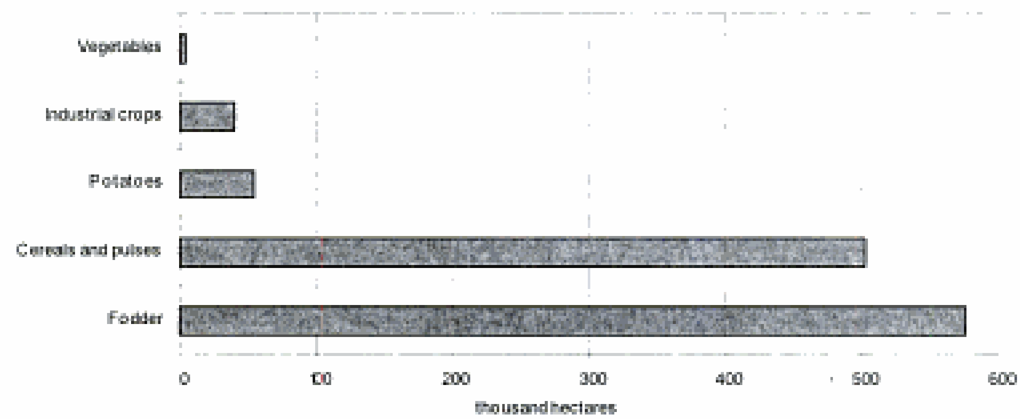
As at 1993, about 3 million ha had been drained for agricultural purposes. In addition, land is drained for non-agricultural purposes, such as construction. On average there are 250 m of drains per hectare of drained land. Subsurface drains exist on more than 75% of the drained area, the remaining 25% being drained by open canals (Figure 4). The total length of the irrigation and drainage network exceeds 800 000 km, which is almost nine times the total length of the natural rivers in the country. The total area where drainage infrastructure could be developed has been estimated at 7.9 million ha.

FIGURE 4
Drainage techniques
Total: 2 887 000 ha in 1990



Most of the drained area is used for meadows and pasture. In 1990, crops were grown on 1 177 200 ha. About 49% of the area was cultivated with fodder crops, 43% with cereals and pulses and the remaining 8% with potatoes, industrial crops and vegetables (Figure 5). The yields on drained land are slightly lower than those on undrained land. This is due to the fact that drained areas consist mainly of swampy, infertile soils, with a low pH.

FIGURE 5
Main crops grown on drained areas
Total: 1 177 200 ha in 1990



Irrigation development

Irrigated areas first appeared in the statistics in 1974. All irrigation takes place on land that has been excessively drained. In fact, there is no real need for irrigation, except in areas where the groundwater has been lowered too much by excessive drainage. For this reason, no figure on irrigation potential is available. Irrigation water is provided by canals, groundwater and retention tanks. In total, 89 retention tanks have been constructed for irrigation purposes, with a total capacity of 0.5 km^3. About 77% of the area is reported to be irrigated from these reservoirs.

In 1993, the area equipped for irrigation was equal to 131 000 ha. It was largest in 1980, with 163 000 ha (Figure 6). The whole area is reported to be sprinkler irrigated, using moving sprinkler irrigation systems. With this type of irrigation, the area equipped for irrigation may vary from year to year. The variation depends mainly on whether precipitation is sufficient or not.

Of the total irrigated area of 149 000 ha in 1990, 77 400 ha (52%) were covered by meadows and pasture (Figure 7). Fodder crops were grown on 38 000 ha, cereal and pulses on 21 600 ha, vegetables and potatoes on 10 500 ha and industrial crops on 700 ha.

FIGURE 6
Evolution of irrigation

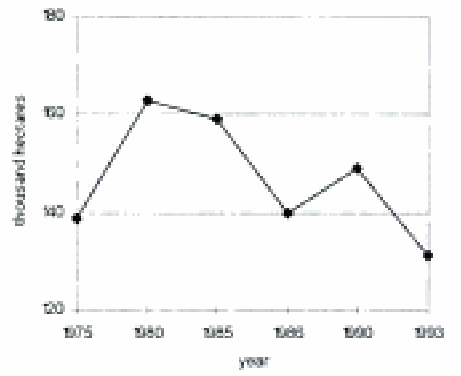
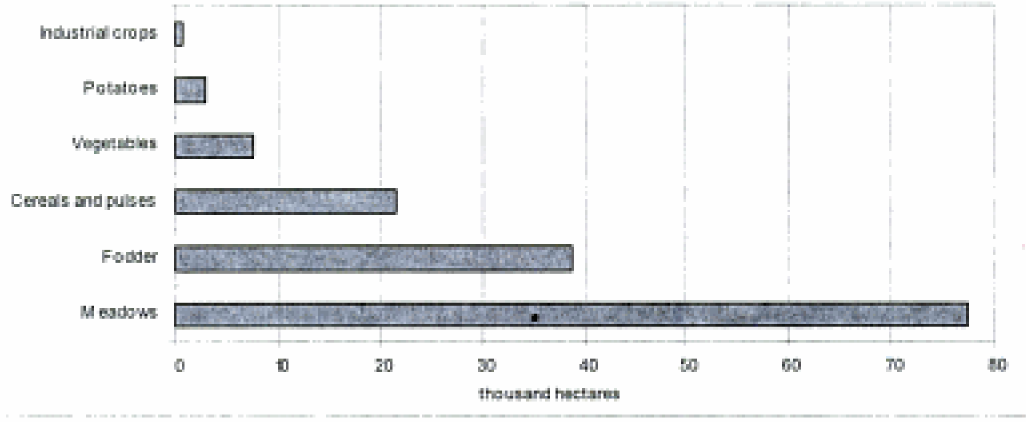


FIGURE 7
Irrigated crops
Total: 149 000 ha in 1990



INSTITUTIONAL ENVIRONMENT

During the Soviet period, all water investments were the responsibility of the Ministry of Water Administration (Minvodkhoz). At present, several institutions are involved in water resources management:

- The Ministry of Agriculture is responsible for all issues relating to drainage and irrigation. It supervises the Belarus Scientific and Research Institute for Water Management and Meadows Cultivation.
- The Ministry for Natural Resources and Environmental Protection controls water use and quality.
- The Central Scientific and Research Institute for Complex Utilization of Water Resources is the only institution that remains from the former Ministry of Water Administration. At

present, it reports directly to the government. In addition to research work, it also monitors water use and water quality.

- The Department of Geography at Minsk State University carries out scientific research on water resources.

- The Ministry for Emergency Situations and Protection of the Population from the Aftermath of the Chernobyl Nuclear Power Station Disaster. All investments in water and agricultural development in southeast Belarus must obtain the permission of this ministry.

TRENDS IN WATER RESOURCES MANAGEMENT

Cultivation on drained and irrigated areas is rather extensive. Three periods can be distinguished in the development of drainage and irrigation in Belarus:

- Slow, relatively steady development of drainage systems from the middle of the eighteenth century till 1966. Cultivation on drained land expanded and crop yields were higher than on undrained land.

- Rapid drainage development from 1966 to 1986, until the Chernobyl nuclear accident. In this period, the drained area more than doubled. However, excessive drying up appeared in some drained areas, and water guns, taking water from specially constructed tanks, had to be used to irrigate these drained lands.

- The Chernobyl nuclear accident, combined with the difficult economic situation, has resulted in a deterioration of the drainage and irrigation systems since 1986, and cultivation on part of these lands has been abandoned. However, statistical data for this period are far from complete.

The radioactive contamination after the Chernobyl nuclear accident affected a large part of the country, especially the southeast. In spite of the fact that the extent of the contamination is known, it is difficult to predict the consequences for the local population. Although these lands should be completely excluded from agricultural production on health grounds, this is not the case at present. Due to this contamination, it is hard to sell agricultural products abroad. At markets in the Russian Federation, they can only be sold at very low prices.

After a period when the transition to a market-oriented agriculture has resulted in the privatization of areas, measures indicate that re-nationalization and the liquidation of private farms could be envisaged in the near future. The difficult economic situation in the country has resulted in a high inflation rate which, combined with the difficulty of selling agricultural products, compromises investment in agriculture.

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Estonia

GEOGRAPHY AND POPULATION

Estonia, with a total area of 45 100 km^2, is one of the three Baltic states. It is bordered in the north by the Gulf of Finland, in the east by the Russian Federation, in the south by Latvia and in the west by the Baltic Sea. Restoration of its independence from the Soviet Union took place in August 1991. The main administrative units are 15 counties, 209 municipalities and 45 towns.

Estonia is situated on the southern slope of the Fennoscadian shield. The territory of Estonia rose from the sea bed and its surface is relatively flat with an average altitude of 50 m above sea level. The higher areas are the Haanja uplands in the southeast, with a peak of 318 m, and the Pandivere uplands in the northeast, with a peak of 166 m.

More than 1 500 islands in the Baltic Sea are part of Estonia, constituting 9% of the territory. There are over 1 400 lakes, covering over 6% of the total area of the country, and about 21% of the total area is swamp. The soils of Estonia are generally heavy and stony. The quaternary deposits are unevenly distributed, almost absent at the northern coast while being up to 200 m thick in the south.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	4 510 000	ha
Cultivable area	1996	1 368 000	ha
Cultivated area	1995	863 324	ha
- annual crops	1995	850 664	ha
- permanent crops	1995	12 660	ha
Population:			
Total population	1996	1 471 000	inhab.
Population density	1996	33	inhab./km^2
Rural population	1996	27	%
Economically active population engaged in agriculture	1996	13	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population		-	%
Rural population		-	%

The cultivable area is estimated at almost 1.4 million ha, which is 30% of the total area of the country. In 1995, the total cultivated area was 863 324 ha, of which 98.5% was covered by annual crops.

Since independence, the agricultural sector has been going through a process of privatization. Before the Second World War, Estonia had approximately 140 000 private farms, which were collectivized into 360 *sovkhoz* (state farms) during the Soviet era. After independence at the end of 1991, there were still 120 *sovkhoz* occupying about 30% of the agricultural land, 265 *kolkhoz* (collective farms) occupying 57% of the agricultural land, and 7 227 registered private farms occupying the remaining 13% of the agricultural land. Today, the agricultural sector is almost fully privatized.

The total population is about 1.5 million (1996), of which 27% is rural. About 41% of the urban population lives in the capital Tallinn. The rural population lives in rural villages and

ESTONIA


GULF OF FINLAND
Narva
Narva Lake
RUSSIAN FEDERATION
Peipsi Lake
PANDIVERE UPLANDS
HAANJA UPLANDS
Tallinn
BALTIC SEA
GULF OF RIGA
LATVIA
0
20
40
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		632	mm/yr
		28.5	km^3/yr
Internal renewable water resources		12.712	km^3/yr
Total (actual) renewable water resources	1997	12.808	km^3/yr
Dependency ratio	1997	0.75	%
Total (actual) renewable water resources per inhabitant	1996	8 707	m^3/yr
Total dam capacity	1995	0.012	$10^6\ m^3$
Water withdrawal:			
- agricultural	1995	8.2	$10^6\ m^3/yr$
- domestic	1995	88.0	$10^6\ m^3/yr$
- industrial	1995	61.8	$10^6\ m^3/yr$
Total water withdrawal		158.0	$10^6\ m^3/yr$
per inhabitant	1995	103	m^3/yr
as % of total (actual) renewable water resources		1.2	%
Other water withdrawal	1995	1 408.7	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1995	396	$10^6\ m^3/yr$
- treated wastewater	1995	378	$10^6\ m^3/yr$
- re-used treated wastewater		-	$10^6\ m^3/yr$
Agricultural drainage water		-	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

'scattered' villages, in which houses are far apart. The average population density is 33 inhabitants/km^2, varying from 12 inhabitants/km^2 on Hiiumaa Island to 127 inhabitants/km^2 in Harjumaa county, where the capital is located. During the last two years, Estonia has had a negative population growth rate, about -1% per year. In 1996, 13% of the economically active population was engaged in agriculture. In 1993, agriculture accounted for an estimated 10% of GDP.

CLIMATE AND WATER RESOURCES

Climate

The sea has an impact on the climate throughout the country. Winters are mild, springs are short, summers are warm and sunny, and autumns are long and windy. The average precipitation is 632 mm/year, but is somewhat lower on the islands and in the coastal areas while being somewhat higher in the uplands.

The climatological conditions allow the cultivation of one crop per year during summer with irrigation possibly needed in May and June. In dry years, it is necessary to irrigate in July and August as well. However, more important than irrigation is drainage. It is estimated, that without drainage about two-thirds of the land for agricultural production would suffer from waterlogging.

River basins and surface water resources

Estonia can be divided into five hydrological basins: the Lake Peipus-Narva basin in the east; the Gulf of Finland basin in the north; the Gulf of Riga basin, including the Salaca River, in the southwest; the Muhu Sound basin, including the Gauja River, in the southeast; and the Islands.

TABLE 3
Irrigation and drainage

Irrigation potential		1995	150 000	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1995	3 680	ha
- surface irrigation		1995	-	ha
- sprinkler irrigation		1995	3 680	ha
- micro-irrigation		1995	-	ha
% of area irrigated from groundwater		1995	0	%
% of area irrigated from surface water		1995	100	%
% of area irrigated from non-conventional sources		1995	0	%
% of equipped area actually irrigated		1995	44	%
2. Equipped wetland and inland valley bottoms (i.v.b.)			-	ha
3. Spate irrigation			-	ha
Total irrigation (1+2+3)		**1995**	**3 680**	**ha**
- as % of cultivated area			0.4	%
- increase over last 10 years		1985-95	minus 65	%
- power irrigated area as % of irrigated area		1995	100	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 100 ha	1995	2 551	ha
Medium-scale schemes		1995	1 094	ha
Small-scale schemes	< 10 ha	1995	35	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production			-	t
as % of total grain production			-	%
Harvested crops under irrigation			-	**ha**
- permanent crops: total			-	ha
- annual crops: total			-	ha
. pastures and fodder			-	ha
. vegetables			-	ha
. other annual crops			-	ha
Drainage - Environment:				
Drained area		1995	732 359	ha
- drained area in full or partial control irrigated areas			-	ha
- drained area in equipped wetland and i.v.b.			-	ha
- other drained area			-	ha
- area with subsurface drains		1995	650 835	ha
- area with surface drains		1995	81 524	ha
Drained area as % of cultivated area			84.8	%
Power drained area as % of total drained area		1995	1.4	%
Area salinized by irrigation			-	ha
Population affected by water-borne diseases			-	inhabitants

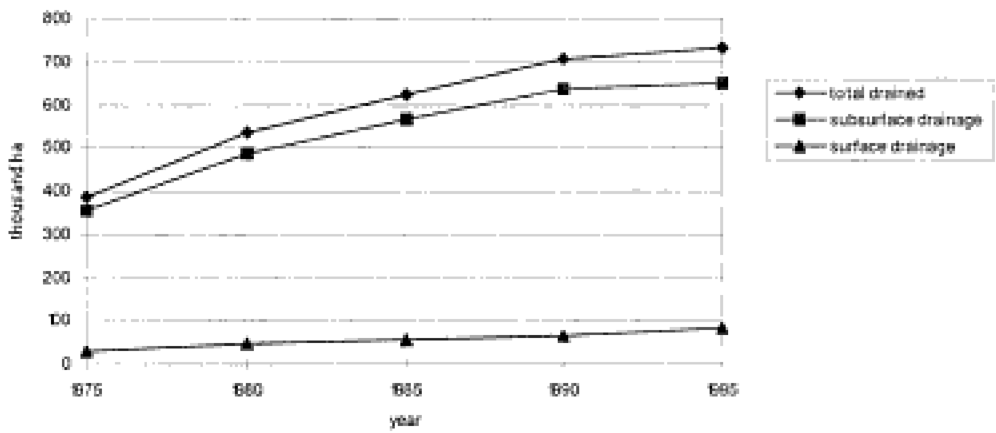
The IRSWR are estimated at 11 712 million m^3/year (Figure 1). A total quantity of about 96 million m^3/year is estimated to flow from Latvia and the Russian Federation into Estonia, while an estimated 406 million m^3/year flow from Estonia into Latvia and the Russian Federation.

Renewable surface water resources (RSWR) by river basin group

River basin group	IRSWR million m^3/yr	Inflow million m^3/yr	Inflow from:	Total RSWR million m^3/yr	Outflow to:
Lake Peipus-Narva	3 853	63+25	Russian F. + Latvia	3 941	Russian Fed. (7) + Sea
Gulf of Finland	2 730	-		2 730	Sea
Gulf of Riga	3 677	8	Latvia	3 685	Latvia (89) + Sea
Muhu Sound	310	-		310	Latvia
Islands	1 142	-		1 142	Sea
Total	11 712	96		11 808	

1897 and the first Baltic Marsh Improvement Society in 1906. By 1939, there were 779 land reclamation societies for the operation and maintenance of the drainage canals. In 1957, Land Improvement Bureaux were established to expand, operate and maintain the drainage systems. During the 1970s, around 40 000 ha/year were equipped with subsurface drains. In 1975, about 390 000 ha of agricultural land were drained. At present about 732 000 ha, or almost 85% of the cultivated land, are drained, of which 650 000 ha, or 89%, are equipped with subsurface drainage systems (Figure 3). In addition, an estimated 560 600 ha of forests, or 13% of the total forest area, are said to be drained.

FIGURE 3
Evolution of the drained area



The cost of drainage development (1995) varies between $US 1 620 and 2 000/ha for open drainage systems and between $US 2 150 and 2 800/ha for subsurface drainage systems.

Irrigation development

Summer runoff constitutes around 10% of the annual runoff. In order to preserve the aquatic environment, it is estimated that not more than 0.5 litres/s per km^2 should be taken from the dry season discharge. Considering these water resources, the irrigation potential is estimated at 150 000 ha. In the coastal areas it is not possible to irrigate without the construction of reservoirs.

All irrigation is sprinkler irrigation. Different types of sprinkler irrigation systems have been constructed during the last 20 years, depending on the scheme size and technological improvements. The large irrigation systems were generally of poor quality and were soon abandoned. During the 1980s, only drag hose irrigation systems were used. The area equipped for irrigation reached almost 14 000 ha by the end of the 1970s, but was reduced to 3 680 ha in 1995 due to the liquidation of the *kolkhoz* and *sovkhoz* (Figure 4). More than 50% of the area equipped is reported to need rehabilitation. The irrigation areas are mainly located in the north and east of the country. All the area is irrigated by surface water, of which 80% by pumping in rivers and 20% from reservoirs (Figure 5). The main irrigated crops are pasture and vegetables.

Almost 70% of the irrigated areas are found in large-scale schemes, with areas between 100 and 300 ha each, while under 1% of the irrigated areas are in schemes of less than 10 ha each (Figure 6). The cost of the development of sprinkler irrigation schemes varies from $US 500/ha for large-scale schemes to $US 810/ha for small-scale schemes, while the average costs of O&M are estimated at $US 160/ha for large-scale schemes and $US 200/ha for small-scale schemes.

FIGURE 4
Evolution of irrigation

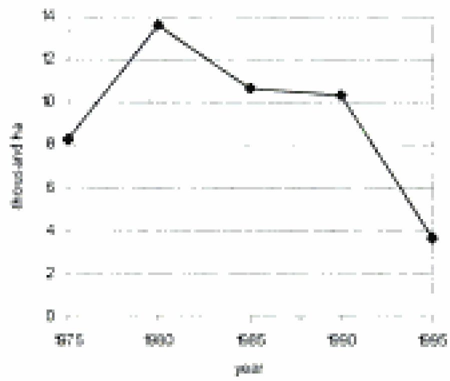


FIGURE 5
Origin of irrigation water
Total: 3 680 ha in 1995

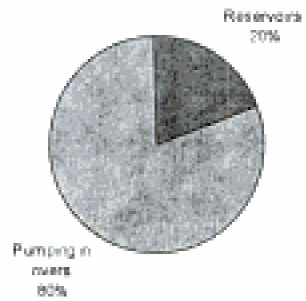
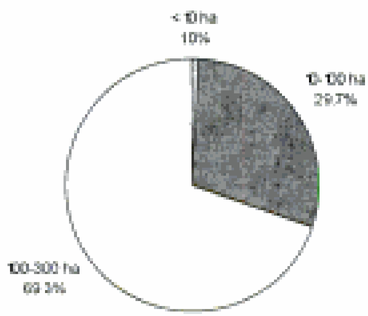


FIGURE 6
Irrigation scheme size
Total: 3 680 ha in 1995



INSTITUTIONAL ENVIRONMENT

The main institutions involved in water resources management are:

- The Ministry of Environment, with the Water Department, is responsible for the development of water legislation, the setting of water quality standards, the development of groundwater and surface water resources, and the management of water resources and water use.
- The Regional Environmental Departments are responsible for the implementation of the water management policy in close cooperation with the municipalities.
- The Ministry of Agriculture, with the Land Improvement Bureau, is responsible for land improvement and related problems.
- The land and water associations are responsible for the operation, maintenance and management of the drainage systems.

TRENDS IN WATER RESOURCES MANAGEMENT

The restoration of Estonia's independence has brought with it significant changes in ownership and in the institutional framework of the economy. The transition process in the economy has caused changes in landownership. The large drainage systems have to be shared among new landowners, and land and water associations need to be established to oversee the operation, maintenance and management of the drainage systems.

A clearly defined government agricultural policy does not yet exist. As part of the agrarian reform, the former *kolkhoz* and *sovkhoz* were liquidated after 1 April 1993. They were replaced by around 1 200 joint stock companies, 700 cooperatives and private farms. In 1995, there were about 11 000 new private farms. It was expected that in 1995 the downward trend in agricultural production of the last few years would come to an end.

Only small-scale irrigation schemes (5-10 ha) with drag hose equipment are expected to be profitable. At present, farmers lack the large investment resources needed for new irrigation systems.

Intensive agriculture has led to an increase in nitrogen concentration in groundwater through the intensive use of fertilizers. A decline in the use of fertilizers in recent years seems to have already resulted in a decrease in the nitrogen concentration in groundwater wells. While deeper groundwater layers meet the existing drinking water standards, upper groundwater layers in many regions are still polluted with nitrogen components. Close to former military bases, groundwater is often polluted with oil products. The drastic reduction in economic activity since 1989 and the construction of new wastewater treatment plants have already reduced pollution considerably.

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Georgia

GEOGRAPHY AND POPULATION

Georgia, with a total area of 69 700 km², is located in the Caucasus region in the southeast of Europe. It is bordered by the Russian Federation in the north, Azerbaijan in the southeast, Armenia and Turkey in the south, and the Black Sea in the west. For administrative purposes, the country is divided into 11 regions (comprising some 67 districts) plus the capital city Tbilisi. It declared its independence from the Soviet Union in April 1991.

The country can be divided into three physiographic regions: mountains covering about 54% of the total area, highlands about 33%, and valleys some 13%. The northern boundary consists of the Caucasus mountains, whose highest peak stands at some 5 000 m above sea level. About 70% of the territory lies below 1 700 m above sea level. Cropping is possible throughout the country up to 2 000 m. At higher elevations, only pastures are reported.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	6 970 000	ha
Cultivable area	1996	2 987 473	ha
Cultivated area	1996	1 065 755	ha
- annual crops	1996	758 990	ha
- permanent crops	1996	306 765	ha
Population:			
Total population	1996	5 442 000	inhab.
Population density	1996	78	inhab./km²
Rural population	1996	41	%
Economically active population engaged in agriculture	1996	25	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population	1991	33	%
Rural population	1988	30	%

Since the end of the Soviet period, a process of land privatization has been undertaken. Of the total agricultural land of 3 million ha, some 0.7 million ha are now owned and cultivated by private farmers; 0.3 million ha have been leased to farmers for short-term (3-5 years), medium-term (25 years) or long-term (49 years) periods; while 2 million ha are still owned by the state (Figure 1). Except for some seed-breeding farms, most of the state-owned land, which is no longer managed by *sovkhoz* (state farms) or *kolkhoz* (collective farms), is not cultivated.

The total cultivable area, which according to Georgian statistics is equal to the agricultural area, was estimated in 1996 at some 3 million ha, or 43% of the territory. About 2.2 million ha are forest, which, under the Forest Code of 1978, cannot be transformed into agricultural cropped areas. The cultivated land is estimated at 1.06 million ha, of which 29% of permanent crops and 71% of annual crops.

The total population is estimated at 5.4 million (1996), of which 41% is rural. The average population density is 78 inhabitants/km², but varies from 25 inhabitants/km² in the mountainous areas to 250 inhabitants/km² in the valleys. Before independence, the annual population growth was about 1% per year, but since 1991, the growth has been negative. In

GEORGIA

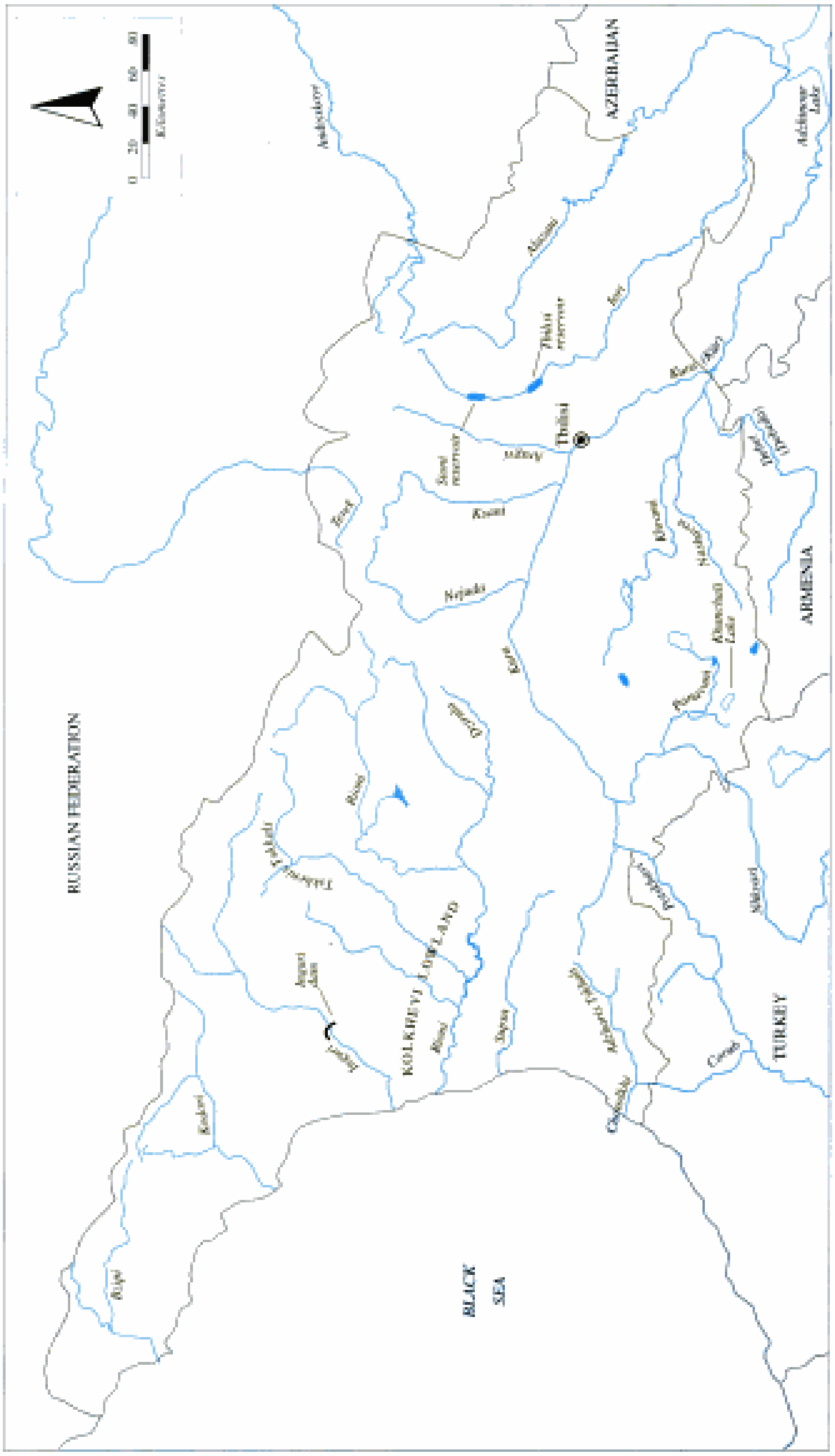
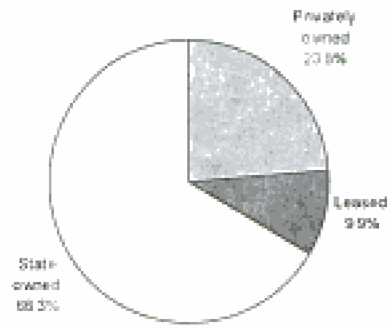

0 20 40 60 80
Kilometres
RUSSIAN FEDERATION
AZERBAIJAN
ARMENIA
TURKEY
BLACK SEA
KOLKHETI LOWLAND
Tbilisi
Kura

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		1 065	mm/yr
		74.23	km^3/yr
Internal renewable water resources		58.13	km^3/yr
Total (actual) renewable water resources	1997	63.33	km^3/yr
Dependency ratio	1997	8.2	%
Total (actual) renewable water resources per inhabitant	1996	11 637	m^3/yr
Total dam capacity	1996	3 175	$10^6\ m^3$
Water withdrawal:			
- agricultural	1990	2 043	$10^6\ m^3/yr$
- domestic	1990	728	$10^6\ m^3/yr$
- industrial	1990	697	$10^6\ m^3/yr$
Total water withdrawal		3 468	$10^6\ m^3/yr$
per inhabitant	1992	634	m^3/yr
as % of total (actual) renewable water resources		5.5	%
Other water withdrawal		-	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1985	614	$10^6\ m^3/yr$
- treated wastewater	1985	279	$10^6\ m^3/yr$
- re-used treated wastewater		-	$10^6\ m^3/yr$
Agricultural drainage water		-	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

1995, the population was estimated to be 1% less than in 1991. Agriculture employs some 25% of the economically active population. Due to the shrinking of the industrial sector since 1990, the contribution of agriculture to GDP reached 38% in 1995, a share much higher than in the 1980s.

FIGURE 1
Land categories
Total: 2 987 473 ha in 1996



CLIMATE AND WATER RESOURCES

Climate

Georgia, with an average rainfall of 1 065 mm/year, can be divided into two climatic regions:

- West Georgia, where the climate is subtropical humid. The average precipitation is estimated to vary between 1 100 and 1 700 mm/year. Drainage of excess water is one of the main problems for agriculture in this part of the country. Average temperatures vary between 5°C in January and 22°C in July.

- East Georgia, where the climate is subtropical dry. The average precipitation varies between 500 and 1 100 mm/year. About 80% of the rainfall occurs from March to October, while the longest dry period is about 50-60 days. Drought years are common. Hail occurs in spring and autumn. There is a need for irrigation in the areas where precipitation is less than 800 mm/year. Average temperatures vary between -1°C in January and 22°C in July.

TABLE 3
Irrigation and drainage

Irrigation potential		1989	725 000	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1996	437 500	ha
- surface irrigation		1996	366 600	ha
- sprinkler irrigation		1996	70 900	ha
- micro-irrigation		1996	0	ha
% of area irrigated from groundwater		1996	0	%
% of area irrigated from surface water		1996	100	%
% of area irrigated from non-conventional sources		1996	0	%
% of equipped area actually irrigated		1996	63	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		1996	31 500	ha
3. Spate irrigation			-	ha
Total irrigation (1+2+3)		**1996**	**469 000**	**ha**
- as % of cultivated area			44	%
- increase over last 10 years			-	%
- power irrigated area as % of irrigated area		1996	30	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 1 000 ha	1996	359 604	ha
Medium-scale schemes		1996	44 281	ha
Small-scale schemes	< 500 ha	1996	33 615	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production		1986	153 250	t
as % of total grain production		1986	32	%
Harvested crops under irrigation		**1986**	**307 511**	**ha**
- permanent crops: total		1986	104 970	ha
- annual crops: total		1986	202 541	ha
. Pasture and fodder		1986	66 269	ha
. Vegetables and potatoes		1986	37 813	ha
. Wheat		1986	27 680	ha
. Maize		1986	11 647	ha
. other annual crops		1986	59 132	ha
Drainage - Environment:				
Drained area		1996	164 740	ha
- drained area in full or partial control irrigated areas		1996	31 800	ha
- drained area in equipped wetland and i.v.b.		1996	31 500	ha
- other drained area		1996	101 440	ha
- area with subsurface drains		1996	44 200	ha
- area with surface drains		1996	120 540	ha
Drained area as % of cultivated area			15	%
Power drained area as % of total drained area		1996	19	%
Area salinized by irrigation			-	ha
Population affected by water-borne diseases			-	inhabitants

River basins and water resources

The country can be divided into two main river basin groups:

- The Black Sea basin, in the west of the country. The RSWR generated in this basin are estimated at 42.5 km³/year. The main rivers are, from north to south, the Inguri, Rioni and Chorokhi. The main stream of the Chorokhi rises in Turkey (the Corub River), and the inflow from Turkey is estimated at 6.3 km³/year.

- The Caspian Sea basin, in the east of the country. The RSWR generated in this basin are estimated at 14.4 km³/year. The main rivers are, from north to south: the Terek and Andiyskoye rivers, which rise in the north of the country and flow northeast to the Russian Federation before entering the Caspian Sea; the Alazani, Iori and Kura rivers, which rise in Georgia and flow into Azerbaijan in Lake Adzhinour, and then flow southeast in Azerbaijan before entering the Caspian Sea. Two tributaries of the Kura River rise in Turkey: the Mktvari, with an inflow from Turkey estimated at 0.91 km³/year; and the Potskhovi, with an inflow from Turkey estimated at 0.25 km³/year. The inflow of the Debet River, a southern tributary of the Kura River, is estimated at 0.89 km³/year from Armenia.

The renewable groundwater resources are estimated at 17.23 km³/year, of which, however, 16 km³/year are considered to be drained by the surface water network (overlap). In 1990, the total water abstraction was estimated at 3 km³/year from some 1 700 tube-wells. A further 7 km³/year could be abstracted in the future according to a recent assessment. Groundwater use was not greatly developed during the Soviet period, due to the emphasis on large-scale state-run surface irrigation schemes.

The IRWR are estimated at 58.13 km³/year and the ARWR at 63.33 km³/year.

International agreements and actual water resources

In 1925, an agreement with Turkey was reached on the use of water of the Chorokhi River, allocating half of the average surface water flow to each country. This agreement dealt only with water flow and did not consider the sediment flow estimated at 5 million m³/year. About 46% of these sediments form the sand beach and are an important resource, as tourism is of prime importance to Georgia's earnings. Turkey is presently planning to construct a cascade of 11 dams on the Chorokhi River, which will affect the sediment flow and thus the beaches on the Georgian shore. Georgia is pressing for a reconsideration of the agreement, which should not only deal with the allocation of water but also address the issue of sediment flow.

Armenia and Georgia are now working on agreements about the use of the Lake Khanchali and Debet River waters.

Lakes and dams

There are about 43 dams in Georgia, and their total reservoir capacity is estimated at about 3.2 km³. The largest dam, for hydropower, is the Inguri dam, with a reservoir capacity of 1.092 km³. In 1995, hydropower supplied 89% of electricity. For irrigation purposes, some 31 dams have been built, with a total reservoir capacity of 1 km³, of which 782 million m³ is active. The three largest irrigation reservoirs are all on the Iori River: the Sioni reservoir upstream (325 million m³), the Tbilisi reservoir (308 million m³) and the Dalimta reservoir downstream (180 million m³).

Water withdrawal and wastewater

The total water withdrawal was estimated at 3.5 km³/year in 1990 (Figure 2), less than in 1985 (4.6 km³). The main reason for this decrease has been the industrial decline since the end of the Soviet Union. This decline resulted in a 50% reduction in industrial water withdrawal between 1985 and 1990.

FIGURE 2
Water withdrawal
Total: 3 468 million m³ in 1990

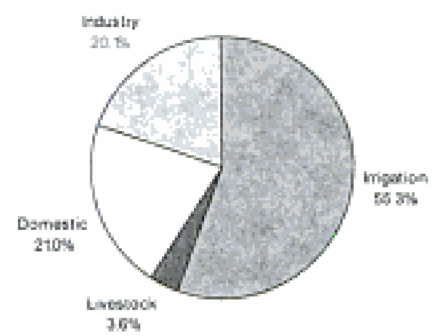


FIGURE 3
Distribution of the area under irrigation
Total: 469 000 ha in 1996

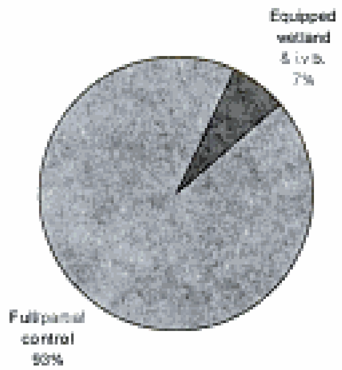
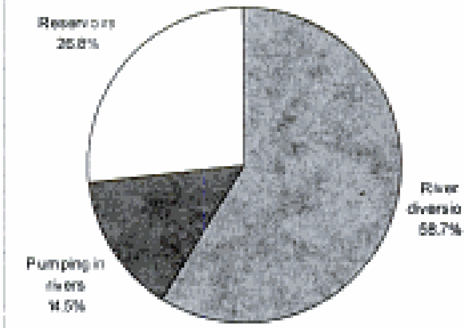


FIGURE 4
Origin of irrigation water
Total: 469 000 ha in 1996



In 1985, the total produced wastewater was estimated at 614 million m³, of which 279 million m³ (45%) was treated. There is no tradition of treated wastewater re-use in Georgia.

IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

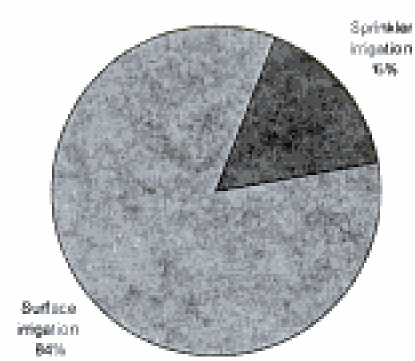
The irrigation potential in Georgia is estimated at 725 000 ha.

There is a tradition of land improvement through irrigation and drainage in Georgia. At the beginning of the twentieth century, the total irrigated area in Georgia was about 112 000 ha. Major investments were made in the irrigation sector during the Soviet period. This resulted in a total area of about 500 000 ha equipped for irrigation at the beginning of the 1980s.

In 1996, irrigation covered 469 000 ha, of which 31 500 ha of equipped wetland and inland valley bottoms and 437 500 ha of full or partial control irrigated areas (Figure 3). River diversion is the main source of water for irrigation (Figure 4). Groundwater is not used for irrigation in Georgia.

The main irrigation technique developed on full or partial control irrigation equipped areas is surface irrigation (Figure 5). Micro-irrigation was practised on an experimental basis on 200 ha in east Georgia at the beginning of the 1990s. However, all micro-irrigated areas were destroyed between 1991 and 1994. Moreover, the high costs of micro-irrigation development have so far limited the scope for future expansion.

FIGURE 5
Irrigation techniques, full or partial control
Total: 437 500 ha in 1996

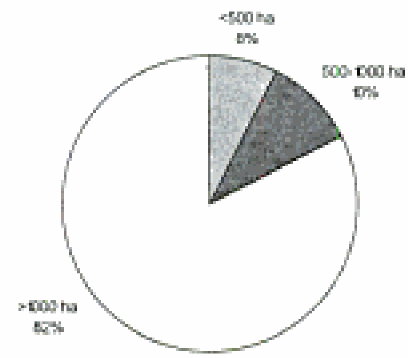


Most of the schemes are large-scale schemes (Figure 6). The largest schemes are: the upper Alazani (41 100 ha), the lower Alazani (29 200 ha), the upper Samgori (28 100 ha), and the lower Samgori (29 200 ha).

FIGURE 6

Irrigation scheme size, full or partial control

Total: 437 500 ha in 1996



The part of the equipped area which is actually irrigated is estimated as being limited to 273 769 ha, which is only 63% of the total area, mainly because of security problems for farmers, severe economic stringency and the prevailing political situation.

There is no private irrigation in Georgia. All irrigation schemes are managed by the state through its Department of Land Improvement and Water Economy. Though irrigation remains the responsibility of the state, the land irrigated might be owned either by private farmers or by the state but leased to farmers, cooperatives or agro-firms.

At the beginning of 1997, irrigation water charges were introduced in Georgia, on a basis of $US 3 per 1 000 m³. This figure is the same for all schemes in Georgia. It will probably increase in the future since it does not enable O&M costs to be fully recovered. The water charges cover about 12% of the total O&M costs, the government budget covers 15% of the total, while the remaining 73% are not covered, resulting in the degradation of the irrigation systems. In 1996, over 300 000 ha were estimated to be in need of rehabilitation. The current policy is for the government to pay for the O&M of the dams and headworks which have been constructed, while the O&M costs of the distribution and on-farm network should be paid by irrigation users through a higher water charge.

The average cost of irrigation development (1996) varies between $US 3 500 and 4 500/ha for surface irrigation, and between $US 6 500 and 7 200/ha for sprinkler irrigation. Average O&M costs vary between $US 55 and 70/ha per year respectively.

In 1986, the major crops cultivated under full or partial control irrigation were fruit trees and grapes, pasture and fodder crops, vegetables, potatoes, wheat, maize and sunflower (Figure 7). Irrigated crop yields compared relatively favourably with rainfed crop yields, although the average difference is very low due to the good climatic conditions in the areas where rainfed agriculture is practised. In 1986, in the full or partial control irrigation schemes, the average irrigated crop yields were 3.0 t/ha for winter wheat, 2.9 t/ha for maize, 4.8 t/ha for grapes, 5.0 t/ha for fruits and 12 t/ha for potatoes.

Drainage development

In 1996, the total drained area was estimated at 164 740 ha, consisting mainly of surface drainage (Figure 8).

Drainage has been developed mainly in the high rainfall region of western Georgia (Kolkhety lowland), on 132 940 ha out of a total of 164 740 ha for the whole country. The total area of

FIGURE 7
Irrigated crops, full or partial control irrigation

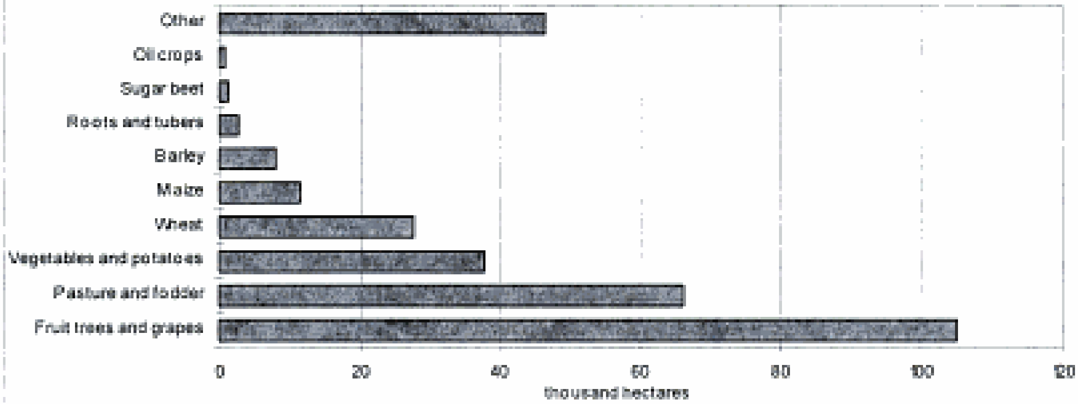


FIGURE 8
Drainage techniques
Total: 164 740 ha in 1996

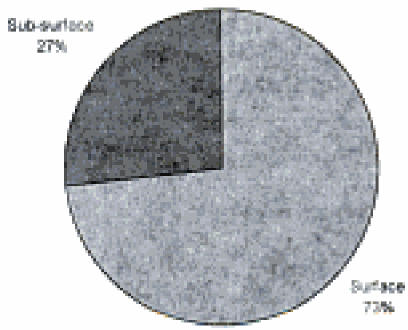
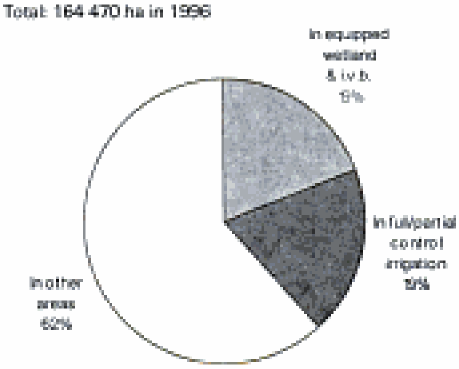


FIGURE 9
Distribution of the drained areas
Total: 164 470 ha in 1996



Kolkhety lowland, where drainage infrastructure could be developed in the future, is about 800 000 ha.

About 31 800 ha of full or partial control irrigation equipped areas are also equipped with a network of surface and subsurface drains (Figure 9). About 31 100 ha of the equipped wetland and inland valley bottoms are also power drained. They are located in the coastal regions of west Georgia, in polder systems where electric pumps drain seawater and excess floodwater.

INSTITUTIONAL ENVIRONMENT

The main institutions involved in water resources management are:

- The Ministry of Agriculture and Food, with:

- the Department of Land Improvement and Water Economy, responsible for planning, monitoring, and promoting irrigated agriculture. This department defines the water requirements for irrigation and supervises the management of the irrigation schemes.
- the Hydraulic Design Institute (Saktskalproject), responsible for irrigation, drainage, flood control, land reclamation, hydroelectric and water supply schemes design.
- the Georgian Scientific Research Institute of Water Management and Engineering Ecology, responsible for research into all issues related to water.

• The Ministry of Environment and Natural Resources Planning, with:

- the Water Resources Pollution Department, which is responsible for the control and regulation of water pollution. In the future it will be the principal advisory body to the government on all matters related to the utilization of water resources.

During the Soviet period, many administrative units were involved in the management of the same irrigation scheme. With the institutional changes which have occurred in Georgia, every scheme is now directly managed by one of the 48 administrative units of the Department of Land Improvement and Water Economy.

A water law is being prepared and should be submitted to parliament in 1997.

TRENDS IN WATER RESOURCES MANAGEMENT

The irrigation and drainage schemes are in a poor condition. It is estimated that about 300 000 ha, or 68% of the whole irrigation system, need rehabilitation. However, the cost of rehabilitation is very high, and in the cases of several power irrigated schemes, rehabilitation might not be economically justified.

An important constraint is the design of the surface irrigation schemes. Most of the medium- or large-scale schemes were designed during the Soviet period, when the plots were very large. Because of the privatization process in Georgia, most farms now consist of small plots, which require a different water module. Reorganization and simplification of water distribution system in medium- and large-scale schemes is thus a priority.

Small-scale irrigation is developing without any subsidies from the government. Groundwater irrigation is likely to increase in the future for small-scale irrigation schemes, but only in western Georgia where the shallow aquifers are located.

Future irrigation development is expected to be on a very limited scale, particularly for large-scale and medium-scale schemes, mainly because of the high opportunity cost and the shortage of funds. Flow regulation through dams would be needed for these schemes, but the competition between hydropower and irrigation, which do not need water at the same periods, prevents the construction of multipurpose dams.

Although no WUAs have been established so far, farmers will be encouraged to form such associations in the near future, within the framework of the new water law currently under preparation. This law should provide a legal framework for the establishment of water charges in irrigation.

Drainage works might be carried out in the future, particularly in the Kolkhety lowland, with attention to ecological and environmental analysis. The eradication of malaria in this area would be one of the goals of these drainage works. However, opponents of this project propose the halting of land reclamation in the Kolkhety lowland and the creation of a national park.

Emphasis should be placed on drainage maintenance, since some 60% of the salt-affected areas have been equipped with drainage infrastructure, but are no longer being maintained. Salinization is therefore likely to occur in these areas.

MAIN SOURCES OF INFORMATION

Department of Land Improvement and Water Economy. 1996. Some suggestions on the rehabilitation of land improvement of Georgia. Ministry of Agriculture and Food of Georgia. Tbilisi, 11 p.

European Union: Technical Assistance for the Commonwealth of Independent States [TACIS]. 1996. Irrigation and drainage evaluation. Prepared by Anthony Zagni for Project No.FDREG9501A, Regional Agricultural Reform Programme, 1, Caucasus Region, Georgia. 60 p.

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Kazakhstan

GEOGRAPHY AND POPULATION

Kazakhstan, with a total area of 2 717 300 km², is the second largest country of the FSU after the Russian Federation. It is located in Central Asia, bordered in the northwest and north by the Russian Federation, in the east and southeast by China, in the south by the Kyrgyz Republic and Uzbekistan, and in the southwest by Turkmenistan and the Caspian Sea. For administrative purposes, the country is divided into 19 provinces (*oblasts*), one of which includes the capital city of Almaty (former Alma-Ata). It declared its independence from the Soviet Union in December 1991.

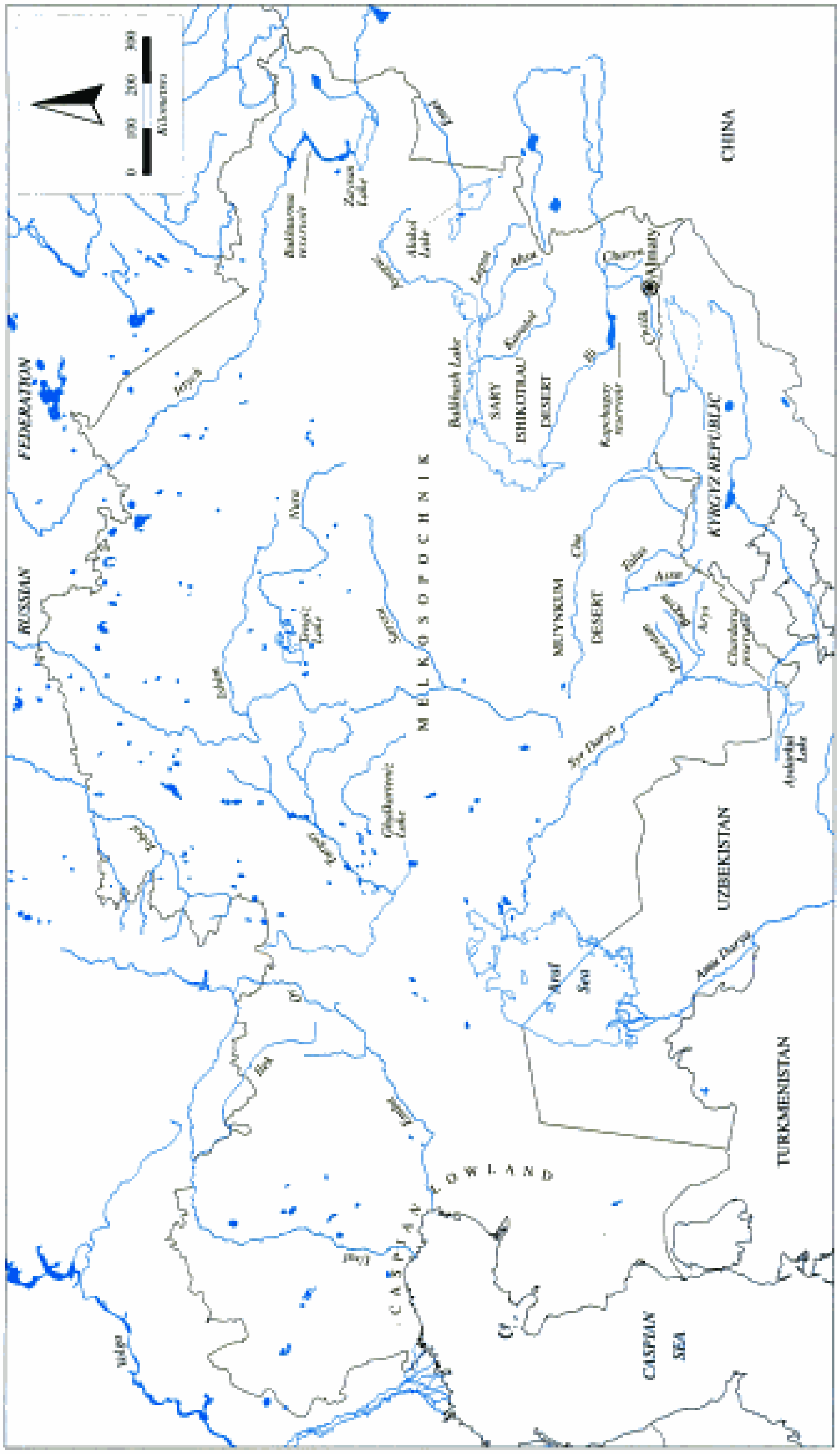
Deserts and steppes account for more than 80% of the total area. The central part of the country consists of a sandy plateau with small hills named the Kazakh Melkosopochnik, surrounded in the north and northeast by the west Siberian plain, in the south by the Turan plain, and in the west by the Caspian lowland. In the east and southeast, mountain chains (Altay, Djungar Alatau, Tien Shan) alternate with depressions (Zaisan, Balkhash-Alakol, Ili and Chu-Talas) which comprise sandy deserts (Sary-Ishikotrau and Muynkum). The country's highest peak (Khan-Tengry) stands at 6 995 m above sea level in the Tien Shan mountain range in the southeast.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	271 730 000	ha
Cultivable area	1993	222 328 500	ha
Cultivated area	1993	34 372 400	ha
- annual crops	1993	34 060 400	ha
- permanent crops	1993	312 000	ha
Population:			
Total population	1996	16 820 000	inhab.
Population density	1996	6	inhab./km²
Rural population	1996	40	%
Economically active population engaged in agriculture	1996	21	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population	1993	93	%
Rural population	1993	26	%

The cultivable area, including the area suitable for pastures/grazing and notably the steppes, is estimated at 222 million ha, or 82% of the total area. The cultivated area was estimated at 34.4 million ha in 1993, or 15% of the cultivable area, of which 99% consisted of annual crops. Fodder accounts for more than 10 million ha. There has been a dramatic increase in the cultivated area since 1950, mainly due to the political decision taken in 1950 to develop agriculture on semi-desertic land, called 'virgin land', notably in the northern and central part of the republic. From 7.8 million ha in 1950, the cultivated area increased to 28.5 million ha in 1960. In 1993, *sovkhoz* (state farms) and *kolkhoz* (collective farms) were still predominant in Kazakhstan, with private plots covering less than 1% of the cultivated area, and the joint stock companies and farmers associations less than 8% of the cultivated area (Figure 1). The land reform process was extended further after 1994, and most of the land was transferred to farmers or companies, through private ownership or long-term leases (99 years). With the possibility of selling private land, or transferring land lease, an increase in the average farm size has been

KAZAKHSTAN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KYRGYZ REPUBLIC
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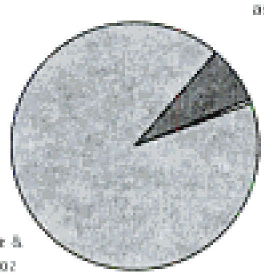
CASPIAN SEA
Aral Sea
M E L K O S O P O C H N I K
MUYUNKUM DESERT
SARY ISHIKOTRAU DESERT
C A S P I A N L O W L A N D
Almaty
Balkhash Lake
Syr Darya
Amu Darya
Irtysh
Ural
Volga

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		344	mm/yr
		934.8	km^3/yr
Internal renewable water resources		75.42	km^3/yr
Total (actual) renewable water resources	1997	109.61	km^3/yr
Dependency ratio	1997	31.2	%
Total (actual) renewable water resources per inhabitant	1996	6 517	m^3/yr
Total dam capacity	1994	88 750	10^6 m^3
Water withdrawal:			
- agricultural	1993	27 413	10^6 m^3/yr
- domestic	1993	583	10^6 m^3/yr
- industrial	1993	5 678	10^6 m^3/yr
Total water withdrawal		33 674	10^6 m^3/yr
per inhabitant	1993	2 000	m^3/yr
as % of total (actual) renewable water resources		30.7	%
Other water withdrawal	1993	452	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1993	1 833	10^6 m^3/yr
- treated wastewater	1993	274	10^6 m^3/yr
- re-used treated wastewater	1993	274	10^6 m^3/yr
Agricultural drainage water	1993	6 785	10^6 m^3/yr
Desalinated water	1993	1 328	10^6 m^3/yr

reported, up from about 5 ha to more than 7 ha per farm between 1994 and 1997.

FIGURE 1
Land categories
Total: 34 914 700 ha in 1993



The total population is 16.8 million (1996), of which 40% is rural. The average population density is 6 inhabitants/km², but varies from 2 inhabitants/km² in the central province of Jeskazgan to 20 inhabitants/km² in Almaty province. The average annual population growth rate was 1.1% between 1985 and 1990. It then decreased to 0.4% per year between 1990 and 1994, becoming negative in 1993 with a figure of -0.2%. In 1996, about 21% of the economically active population was engaged in agriculture. In 1993, agriculture accounted for an estimated 19% of GDP, 7% of which resulted from irrigated crop production, and 28% from rainfed crop production. The remainder (65%) consisted of livestock products, notably beef, mutton, dairy products and wool.

Climate and water resources

Climate

The climate of Kazakhstan is typically continental, with cold dry winters and hot dry summers. In the south, average temperatures vary from -3°C in January to 30°C in July. In the north, average temperatures vary between -18°C in January and 19°C in July, while records show temperatures of -45°C in January. The frost-free period varies between 195 and 265 days in the south and between 245 and 275 days in the north. The cropping period is limited to one season from March to October in the south and from April to September in the north.

TABLE 3
Irrigation and drainage

Irrigation potential		1990	3 768 500	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1993	2 313 100	ha
- surface irrigation		1993	1 763 500	ha
- sprinkler irrigation		1993	549 600	ha
- micro-irrigation		1993	-	ha
% of area irrigated from groundwater		1993	7.7	%
% of area irrigated from surface water		1993	90.3	%
% of area irrigated from non-conventional sources		1993	2.0	%
% of equipped area actually irrigated		1993	100	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		1993	138 700	ha
3. Spate irrigation			1 104 600	ha
Total irrigation (1 + 2 + 3)		**1993**	**3 556 400**	**ha**
- as % of cultivated area			10.3	%
- increase over last 10 years		1985-93	+15.5	%
- power irrigated area as % of irrigated area		1993	16.8	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 1 000 ha	1993	2 114 500	ha
Medium-scale schemes			-	ha
Small-scale schemes	< 1 000 ha	1993	198 600	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production		1993	1 363 000	t
as % of total grain production		1993	6.3	%
Harvested crops under irrigation		**1993**	**2 313 100**	**ha**
- permanent crops: total		1993	311 700	ha
- annual crops: total		1993	2 001 400	ha
. fodder		1993	1 006 900	ha
. cereals		1993	733 200	ha
. cotton		1993	110 600	ha
. oil crops		1993	80 000	ha
. other annual crops		1993	70 700	ha
Drainage - Environment:				
Drained area		1993	433 100	ha
- drained area in full or partial control irrigated areas		1993	433 100	ha
- drained area in equipped wetland and i.v.b.			-	ha
- other drained area			-	ha
- area with subsurface drains		1993	15 600	ha
- area with surface drains		1993	417 500	ha
Drained area as % of cultivated area			1.3	%
Power drained area as % of total drained area		1993	35.3	%
Area salinized by irrigation		1993	242 000	ha
Population affected by water-borne diseases			-	inhabitants

The average annual precipitation is estimated at 344 mm, ranging from less that 100 mm in the Balkhash-Alakol depression in the central-eastern part of the country or near the Aral Sea in the south, up to 1 600 mm in the mountain zone in the east and southeast of the country. About 70-85 % of the annual rainfall occurs during the winter season, between October and April.

The continental climate is also characterized by its high evaporation level, which, together with the low rainfall, makes irrigation a necessity in large parts of the country, notably in the south.

In the mountainous zone in the southeast, there are 2 724 glaciers with a total area of 1 963 km^2.

River basins and water resources

Four major hydrologic regions can be distinguished in Kazakhstan, depending on the final destination of water: the Arctic Ocean through the Ob River, the Caspian Sea, the Aral Sea and internal lakes, depressions or deserts.

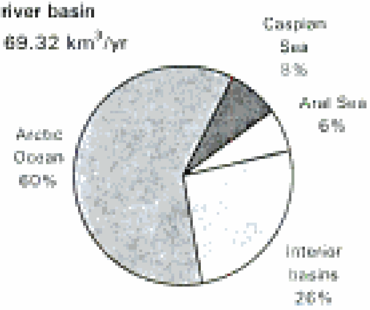
Renewable Surface Water Resources (RSWR) by major river basin

Name of the river	Region	Area of river basin		Internal RSWR	Inflow		Total Actual RSWR	Outflow to
		Total	within Kazakhstan					
		'000 km²	'000 km²	km³/yr	km³/yr	from	km³/year	
Arctic Ocean:								
Irtysh	Northeast	1 592.0	335	37	9.2	China	46.2	Russian Fed. (Ob)
Ishim	North	277.0	210	3.62	-		3.62	Russian Fed. (Irtysh)
Tobol	Northwest	394.6	114.5	1.1	0.8	Russian F.	1.9	Russian Fed. (Irtysh)
Subtotal		**2 263.6**	**659.5**	**41.72**	**10**		**51.72**	**Russian Fed. (Ob)**
Caspian Sea:								
Ural	West	231	148	4	5	Russian F.	9	Caspian Sea
Emba	West	45.8	45.8	0.47	-		0.47	Caspian lowland
Other rivers	West		116	0.8	0.5	Russian F.	1.3	Caspian lowland/Sea
Subtotal			**309.8**	**5.27**	**5.5**		**10.77**	**Caspian Sea**
Aral Sea :								
Syr Darya	South	540	344.4	4.5	10 *	Uzbekistan	14.5	Aral Sea
Subtotal		**540**	**344.4**	**4.5**	**10 ***	**Uzbekistan**	**14.5**	**Aral Sea**
Interior basins:								
Chu	South	62.5	25	0.73	1.24*	Kyrgyz Rep.	1.97	Muynkum desert
Talas (Assa)	South	52.7	42.2	0.55	0.79*	Kyrgyz Rep.	1.34	Muynkum desert
Lake Balkhash	Southeast	250	190	7.3	6	China (Ili)	13.68	Lake Balkhash
					0.36	Kyrgyz Rep.		
Emel	East	60	38	0.75	0.3	China	1.05	Lake Alakol
Lake Tengiz	Central-north	60.8	60.8	1.2	-		1.2	Lake Tengiz
Saryau	Central-south	81.6	81.6	0.9	-		0.9	Lake Ashchikol
Turgay	Central	157	157	1.2	-		1.2	Lake Ghalkarteniz
Other		600	600	5.2	-		5.2	
Subtotal		**1 324.6**	**1 194.6**	**17.83**	**8.69**		**26.52**	
Total			**2 508.3**	**69.32**	**34.19**		**103.51**	

* According to existing agreements

The total IRSWR of Kazakhstan are thus estimated at 69.32 km³/year, while the total incoming flow from neighbouring countries is estimated at 34.19 km³/year (Figure 2). The outflow to the Russian Federation is estimated at 38.8 km³/year, while the total outflow to the Aral and Caspian seas is estimated at 1.5 and 5 km³/year respectively.

FIGURE 2
Internal renewable water resources by major river basin
Total: 69.32 km³/yr



International agreements have addressed the water allocation issues between Kazakhstan and its neighbours:

- For the Syr Darya River, the existing principles governing water sharing among the Central Asian countries will remain valid (Agreement of 18 February 1992) until the adoption of a new water strategy for the Aral Sea basin, endorsed by the Interstate Commission for Water Coordination. Under the 1992 Agreement, the part of the Syr Darya surface water resources allocated to Kazakhstan has to be no less than 10 km³/year downstream of the Chardara reservoir. Considering the 4.5 km³/year of internal surface water resources generated in the Kazakh part of the Syr Darya River basin, it can be considered that the actual surface water resources in the Kazakh part of the Syr Darya basin are about 14.5 km³/year.

- For the Chu and Talas rivers, flowing in from the Kyrgyz Republic, an interstate agreement has been reached with the Kyrgyz Republic (May 1992). This agreement addresses the water allocation issues between both republics, considering the total resources generated in the basin (including surface water, groundwater and return flow) and taking into account the water evaporated from the lakes and reservoirs. On average, it can be considered that the part of the surface water resources allocated to Kazakhstan is 1.24 km³/year for the Chu basin and 0.79 km³/year for the Talas and Assa river basin.

The annual renewable groundwater resources of Kazakhstan are estimated at 35.87 km³/year (1993), of which 29.77 km³/year corresponds to the overlap with the surface water resources. The total ARWR can thus be estimated at 109.61 km³/year. In 1993, the part of groundwater resources which could be extracted from existing pumping facilities was estimated at 6.1 km³/year.

Non-conventional sources of water

About 1.3 km³ of Caspian Sea water is desalinated by the Mangistau nuclear power plant (1993), mainly for industrial purposes and to supply water to the cities of Mangistau and Novi Uzen.

In 1993, the return flow within Kazakhstan amounted to 8.62 km³/year, including 6.79 km³/year of agricultural drainage water and 1.83 km³/year of domestic and industrial wastewater. The main part of the return flow, about 6.78 km³/year, flows back to rivers. About 1.57 km³/year is directed to natural depressions, and 0.27 km³/year is directly re-used for irrigation. In the Syr Darya River basin, about 1.2 km³/year of return flow flows back to rivers while 0.7 km³/year is directed to natural depressions.

Lakes and dams

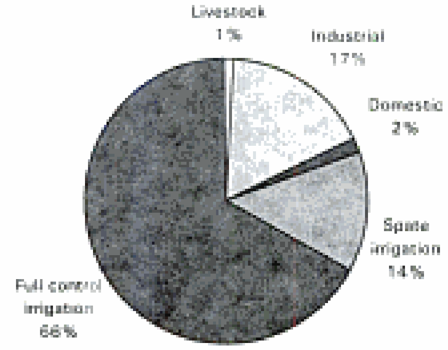
The Caspian Sea is the largest lake in the world. Its level is presently subject to important variations. In the last decade, the Caspian Sea level has risen by about 2 m, which has resulted in waterlogging in towns and villages, and the loss of agricultural land. On the other hand, the Aral Sea has been affected by a dramatic decrease in its level and volume, mainly due to irrigation development upstream. This has resulted in environmental problems, which have been tentatively addressed by the Central Asia Interstate Commission on Water Coordination.

There are more than 17 000 natural lakes in Kazakhstan, with a total area of about 45 000 km² and a total volume of water estimated at about 190 km³. Salinity varies from 0.12 g/litre in east Kazakhstan to 2.7 g/litre in the central part of the country. More than 4 000 lakes are inventoried as saline. The largest lakes are: Lake Balkhash, with an area of 18 000 km² and a volume of 112 km³; Lake Zaisan, with an area of about 5 500 km²; and Lake Tengiz, with an area of 1 590 km². Irrigation development in the last 20 years in the basin of the Ili River, which flows into Lake Balkhash, has led to ecological problems in the region, notably the drying up of small lakes. For the whole country, it is estimated that about 8 000 small lakes have dried up in the recent past due to overexploitation of water resources.

The main natural depression is the Arnasay depression where Lake Aydarkul, with a capacity of 30 km³, was created artificially with water released from the Chardara reservoir and with the return flow from the Hunger steppe irrigated land which is shared with Uzbekistan.

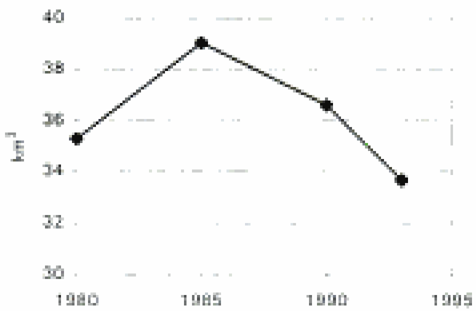
More than 180 water reservoirs have been constructed in Kazakhstan, for a total capacity of 88.75 km³. There are 19 large ones, with a capacity higher than 0.1 km³ each, accounting for 95% of the total capacity. Most of them are multipurpose: hydropower production, irrigation, and flood control. The largest reservoirs are: the Bukhtarma reservoir on the Irtysh River, with a total capacity of 49 km³; the Kapchagay reservoir on the Ili River in the Balkhash basin, with a total capacity of 28.1 km³; and the Chardara reservoir on the Syr Darya River at the border with Uzbekistan with a total capacity of 5.7 km³.

FIGURE 3
Water withdrawal
Total: 33.7 km³ in 1993



The gross theoretical hydropower potential of Kazakhstan is estimated at 110 000 GWh/year and the economically feasible potential at about 35 000 GWh/year. The total installed capacity of the hydropower plants exceeds 3 GW. Hydro-electricity represents 12% of total electricity generation of the country, which meets only 85% of the total electricity demand, the remainder being imported from neighbouring countries.

FIGURE 4
Evolution of water withdrawal



Water withdrawal and wastewater

In 1993, the total annual water withdrawal was estimated at 33.67 km³, of which more than 80% for agricultural purposes (Figure 3). After a regular increase in water withdrawal till the mid-1980s, there has been a slight decrease during the last decade, mainly in the agricultural sector due to the adoption of water conservation methods, and in the industrial sector, due to the decline in the sector since independence (Figure 4). The main source of water is surface water, which is used for agriculture, while the domestic sector is supplied by groundwater and desalinated water (Figure 5). Groundwater is mainly used in the Irtysh River basin (0.6 km³/year), in the Lake Balkhash basin (0.5 km³/year) and in the Syr Darya River basin (0.5 km³/year).

In 1993, the total produced wastewater amounted to 1.8 km³/year, of which 0.27 km³/year was treated.

IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

In 1993, irrigation covered 3.5 million ha, or over 10% of the cultivated area, and provided about 20% of the country's crop production. Irrigation in Kazakhstan consists of full control irrigation (also called 'regular irrigation') on 2 313 100 ha, followed by spate irrigation on 1 104 600 ha, and equipped wetland and inland valley bottoms of 138 700 ha (Figure 6). The evolution of the irrigated area in the last 20 years has shown a progressive and constant increase in the areas equipped for full control, while spate irrigated areas and equipped areas which could be equipped for full control irrigation at the horizon of 2010. This is estimated at an additional 1 455 400 ha, which leads to a total irrigation potential of 3 768 500 ha.

Surface irrigation is the main technique used in full control irrigation (Figure 8). Sprinkler irrigation, which is the dominant irrigation technique in the northern provinces, covers about 550 000 ha. Micro-irrigation is rare, and generally carried out on a experimental basis. There were about 20 000 ha using drip irrigation in 1990, but they have since been abandoned because of a lack of funds for maintenance.

FIGURE 8
Irrigation techniques (full control)
Total: 2 313 100 ha in 1993

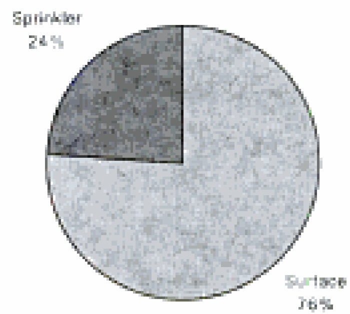
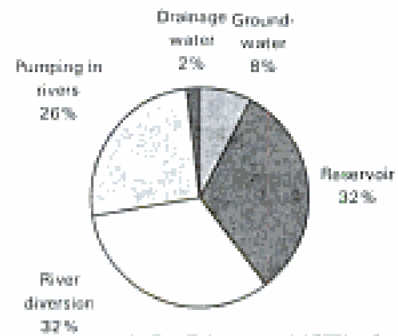
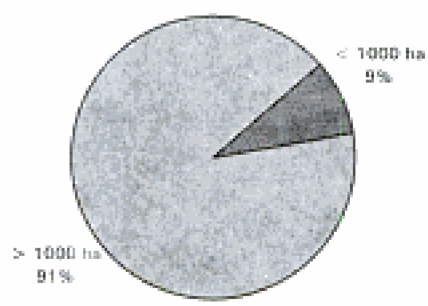


FIGURE 9
Origin of irrigation water (full control)
Total: 2 313 100 ha in 1993



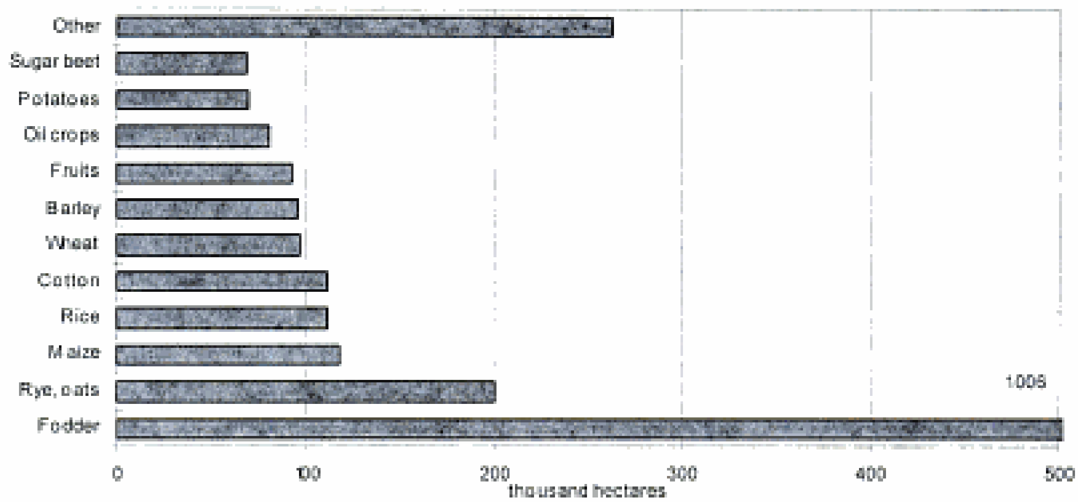
Full control irrigated areas are mainly supplied with surface water (Figure 9). On about 600 000 ha, water is provided through pumping in rivers. An important hydraulic infrastructure exists in Kazakhstan: the Kirov Interstate canal, constructed at the beginning of the century (from 1913 to 1957) to irrigate the Hunger steppe. The O&M of this canal, which has a capacity of 220 m³/s at his head and a length of 137 km, is the task of the Syr Darya River BWO. The Irtysh-Karaganda canal was constructed between 1962 and 1974 to supply the water-scarce region of Karaganda with the Irtysh waters. Its total length is about 458 km and its capacity is 76 m³/s. More than 22 pumping stations and 14 small reservoirs have been built on this canal, which raises water over a total elevation of 250 m. It is estimated that there are more than 14 000 km of inter-farm canals in Kazakhstan.

FIGURE 10
Irrigation scheme size (full control)
Total: 2 313 100 ha in 1993



There is no fully private irrigation in Kazakhstan. Large-scale schemes, with an area of more than 1 000 ha, cover 2.1 million ha (Figure 10). They are managed by state organizations. Small-scale schemes are managed by local (district) water management bodies, which are now self-supporting and financially autonomous. According to a 1996 World Bank report, maintenance is deficient and declining due to staff cuts and shortages of funds. The irrigation efficiencies are very low, due to seepage in unlined canals, resulting in water losses and waterlogging of adjacent lands. Water scheduling is quite rigid, leading in some cases to over-irrigation and a rise in the water table.

FIGURE 11
Irrigated crops (full control)
Total: 2 313 100 ha in 1993



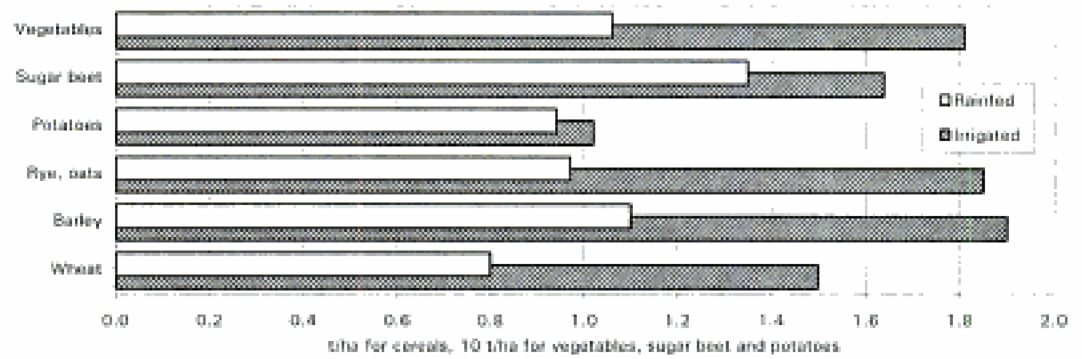
Each farm has a fixed and registered water allocation. During water shortages, water is pro-rated according to the crop water requirement norms: higher value cash crops usually have first priority.

Since 1993, a privatization process has resulted in land being leased to joint stock companies and private individuals. The first WUAs were established in 1996, but private forms of water service (delivery and management) are still not operational in Kazakhstan. In 1994, Kazakhstan was the first Central Asian country to implement water fees. The price of water, which is different for each province, was defined by volume and according to the added value irrigation could bring to agricultural production. However, the actual price was fixed well below the price which would have enabled full O&M cost recovery. For example, in 1995, in the Kyzyl Orda province, in the south in the Syr Darya basin, the actual price was fixed at \$US 0.06/m^3 although the real cost of O&M would require \$US 0.56/m^3. This low price has not stimulated farmers to adopt water saving techniques. There are few incentives for reduced water use. However, in the case of overuse of water, fines up to five times the cost of the water used above allocation are imposed on farmers.

The major irrigated crops are fodder (mainly alfalfa), cereals, cotton, fruits, potatoes and sugar beet (Figure 11). Wheat, rice, cotton and potatoes are the major Kazakh export crops. In 1993, irrigated crop yields were 1.81 t/ha for cotton, 1.5 t/ha for wheat, 4.3 t/ha for rice, 3 t/ha for maize, and 2.5 t/ha for grapes (Figure 12). Fodder crops, which are required for winter feeding of the large livestock population, are grown in many areas where salinity and poor drainage conditions prevent other crops from being grown. The fodder crop yields have declined 15-40% in the last five years.

Irrigation schemes for rice with unlined canals, which are predominant along the Syr Darya River in the south, cost about \$US 3 500-5 000/ha, but might require an additional \$US 5 000-11 000/ha if agriculture infrastructure is needed. Furrow irrigation systems in the south cost about \$US 3 700-5 800/ha. Sprinkler irrigation in the centre of the country costs about \$US 5 500-7 200/ha. Between 1985 and 1990, the average cost of irrigation

FIGURE 12
Comparison of crop yields under rainfed and irrigated conditions



development, including the cost of dams, pumping stations, main canals, infrastructures and drainage networks, was about $US 18 000/ha. Rehabilitation costs vary between $US 3 500 and 4 200/ha.

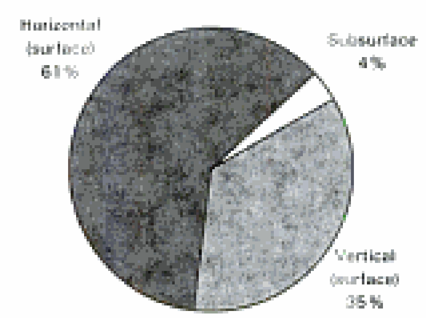
Waterlogging, salinity and drainage development

Out of the total irrigated area of 2 313 100 ha in the country, over 700 000 ha require drainage. In 1993, drainage had been developed on 433 100 ha. The area equipped with subsurface drains amounts to 15 600 ha, while vertical drainage is carried out on about 152 900 ha (Figure 13). These two drainage techniques have been developed in the newly reclaimed areas, i.e., the Hunger steppe, the Kyzylkum scheme and the Kyzyl-Orda scheme, all of them in the south of the country. Almost all the drained areas (99%) are located in the five southern provinces of the country. The average cost of drainage development is about $US 600/ha for surface drains and $US 1 400/ha for subsurface drains.

Little maintenance has been done on the drainage network since 1990. Moreover, part of the agricultural drainage system does not work properly because of deficiencies in design and construction. It is estimated that about 90% of the vertical drainage systems are not in use due to the high costs of pumping. A significant problem also exists with the disposal of highly mineralized water.

In 1993, about 242 000 ha (10.5%) of the irrigated areas were classed as saline by Central Asian standards (toxic ions exceed 0.5% of total soil weight). These areas are mainly concentrated in the south of the country.

FIGURE 13
Drainage techniques
Total: 433 100 ha in 1993



INSTITUTIONAL ENVIRONMENT

The State Committee for Water Resources of the Republic of Kazakhstan (SCWR) is responsible for maintaining and operating the existing inter-farm system for delivery of irrigation and rural drinking water through regional and district water resources committees. It is responsible for inter-sector and inter-provincial water allocation and for defining national policies on water quality and the protection of water resources. It administers international river systems with respect to water sharing. It supervises the eight national River Basin Water Organizations, which are the Aral-Syr Darya, Balkhash-Alakol, Irtysh, Ishim, Nura-Sarysu, Tobol-Turgay, Ural-Caspian and Chu-Talas BWOs.

The Ministry of Agriculture is in charge of agricultural research and extension, and on-farm agricultural and land reclamation development. This ministry is also responsible for the monitoring of drainage, waterlogging and soil salinity conditions for the major irrigation projects in the five southern provinces.

The Ministry of Municipal Affairs is in charge of domestic water supply and wastewater treatment, while the management of the main water supply network at the provincial and inter-provincial levels falls within the mandate of the SCWR.

The Ministry of Geology and Protection of Underground Resources, the Ministry of Ecology and Biological resources, and the Hydrometeorological Service are also involved in the water sector.

The Water Code, adopted on 31 March 1993, provides the framework for the regulation of domestic, industrial and agricultural water use, ensuring the respecting of environmental water requirements. It also opens the way for the introduction of a market economy in irrigated agriculture, since it allows the creation of WUAs at the inter-farm level and the privatization of the district water organizations. Irrigation infrastructure (on-farm network, inter-farm secondary network, and equipment/machinery) may also be privatized.

TRENDS IN WATER RESOURCES MANAGEMENT

Kazakhstan is very much concerned about water quality. At international level, Kazakhstan collaborates with the Russian Federation on this issue for the Irtysh, Ishim, Tobol and Ural rivers. Kazakhstan is also working with Azerbaijan, Iran and the Russian Federation on the Caspian Sea waters. Here the issues include oil extraction, boundary definitions, fisheries and the proposal for a programme to address the rising level of the Caspian Sea.

Kazakhstan's Caspian lowland is directly affected by the rising level of the Caspian Sea. The economic and environmental consequences of this rise are numerous. Kazakhstan is asking its neighbours and the international community to take or finance mitigating measures in view of protecting coastal areas, agricultural areas and human settlements from flooding. The creation of levees, dams and polders are among the measures envisaged. On the other hand, Kazakhstan is also concerned about the drying up of the Aral Sea.

The national water strategy, which has been prepared recently within the framework of the regional water strategy, has defined the main objectives of the country which are:

- improvement of the water quality,
- supply of clean drinking water to the population,
- optimization of the flow regime for the transboundary resources;

- implementation of measures to stop the drying up of the Aral Sea, particularly its northern part.

This last objective comprises: the rehabilitation of the Syr Darya delta in order to stabilize the coastal zone; increasing the Syr Darya River capacity, notably downstream of the Chardarya reservoir where the capacity is a constraint; construction of a dam (Berg Strait) to stabilize and increase the level of the northern part of the Aral Sea.

The government is interested in privatizing the O&M of the inter-farm systems. Although the on-farm system of O&M was the responsibility of the farm, the funds were previously provided by the state. Because these funds are no longer available, maintenance of on-farm facilities has been neglected. Sprinkler irrigation, covering about 667 000 ha in 1990, fell to about 550 000 ha in 1993. According to a World Bank report, almost 680 000 ha of irrigated land are out of use because of: soil salinization; waterlogging; incomplete distribution systems; improper farming practices; limited inputs such as fertilizers and fuel; and in some instances, lack of water. To address this problem, the government has initiated, on a pilot basis, the transfer of the responsibility for water management to WUAs, which are semi-autonomous. This process will be implemented with the privatization of the irrigated land. The World Bank and the Asian Development Bank will assist the government in this initiative.

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Kyrgyz Republic

GEOGRAPHY AND POPULATION

The Kyrgyz Republic is a landlocked country in Central Asia with a total area of 198 500 km^2. It is bordered in the north by Kazakhstan, in the east and southeast by China, in the southwest by Tajikistan and in the west by Uzbekistan. It became independent from the Soviet Union in August 1991. The country is divided into six provinces (*oblasts*).

The country is largely mountainous, dominated by the western reaches of the Tien Shan range in the northeast and the Pamir-Alay in the southwest. The highest mountain is the Victory Peak (Tomur Feng, 7 439 m above sea level) at the eastern tip of the country, on the border with China. The mountain stands in the Mustag massif, one of the world's largest glaciers, covering 1 579 km^2. About 94% of the country is located at more than 1 000 m above sea level, and 40% above 3 000 m. Much of the mountain region is permanently covered with ice and snow, and there are many glaciers (covering about 4% of the territory) The Fergana mountain range, running from the northwest across the country to the central-southern border region, separates the eastern and central mountain areas from the Fergana valley in the west and southwest. Other lowland areas include the Chu and Talas valleys near the northern border with Kazakhstan. The world's second largest crater lake, Lake Issyk-Kul, lies in the northeast of the country.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	19 850 000	ha
Cultivable area	1994	10 100 000	ha
Cultivated area	1994	1 343 000	ha
- annual crops	1994	1 306 800	ha
- permanent crops	1994	36 200	ha
Population:			
Total population	1996	4 469 000	inhab.
Population density	1996	23	inhab./km^2
Rural population	1996	61	%
Economically active population engaged in agriculture	1996	31	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population	1994	86	%
Rural population	1994	75	%

The cultivable land is estimated at 10.1 million ha. In 1994, the cultivated area was estimated at 1.34 million ha, which was about 13% of the cultivable area. About 97% consisted of annual crops and 3% of permanent crops. A major programme of land reform is well advanced. Most of the land formerly controlled by the 195 *kolkhoz* (collective farms) and 275 *sovkhoz* (state farms) is being distributed to their employees and dependants in the form of certificates extending 99 years of land-use rights. This process is still underway with only 63% of all agricultural land reported as fully privatized and de-collectivized. Agricultural land is estimated at 9.34 million ha, including at least 7.8 million ha of permanent pasture. The latest statistics available (1994) show that out of these 9.34 million ha, *kolkhoz* cover 2.56 million ha, *sovkhoz* 0.89 million ha, private farms 1.71 million ha, and associations of farmers (agricultural stock companies) 4.18 million ha (Figure 1).

KYRGYZ REPUBLIC

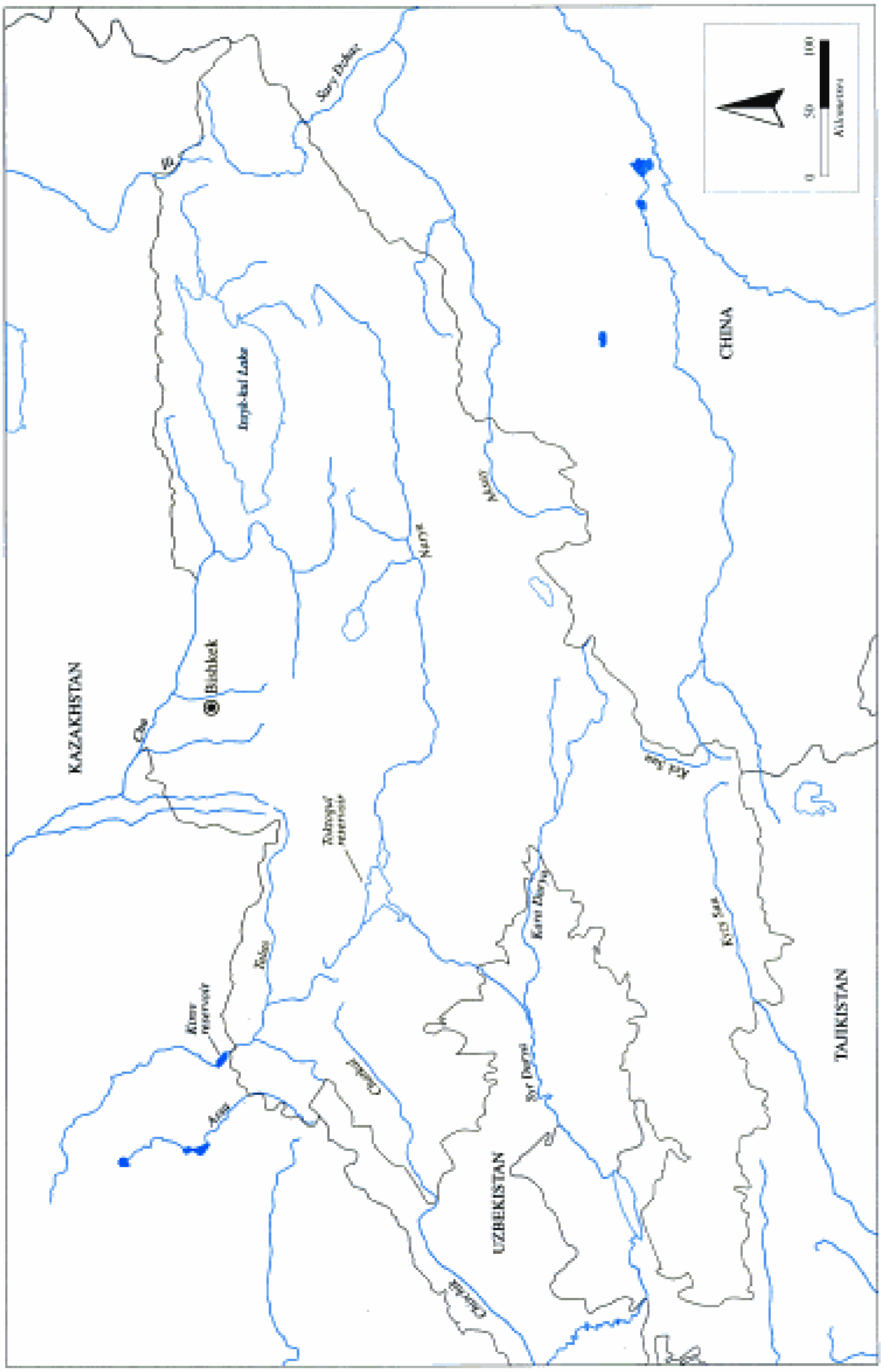
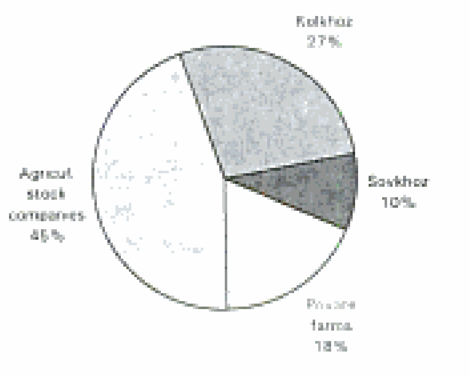


TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		553	mm/yr
		105.8	km^3/yr
Internal renewable water resources		46.45	km^3/yr
Total (actual) renewable water resources	1997	20.58	km^3/yr
Dependency ratio	1997	0	%
Total (actual) renewable water resources per inhabitant	1996	4 605	m^3/yr
Total dam capacity	1994	21 500	10^6 m^3
Water withdrawal:			
- agricultural	1994	9 496	10^6 m^3/yr
- domestic	1994	301	10^6 m^3/yr
- industrial	1994	289	10^6 m^3/yr
Total water withdrawal		10 086	10^6 m^3/yr
per inhabitant	1994	2 264	m^3/yr
as % of total (actual) renewable water resources		49.0	%
Other water withdrawal	1994	9	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1994	380	10^6 m^3/yr
- treated wastewater	1994	0.19	10^6 m^3/yr
- re-used treated wastewater	1994	0.14	10^6 m^3/yr
Agricultural drainage water	1994	1 720	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

The total population is about 4.5 million (1996), of which 61% is rural. The average population density varies from 6 inhabitants/ km² in the eastern mountainous zone to about 70 inhabitants/km² in the north of the country. The annual population growth rate fell from 2.2% in 1989 to 1.8% in 1995, mainly because of the difficult economic situation prevailing since independence and the migration of part of the population away from the Kyrgyz Republic. In 1996, 31% of the economically active population was engaged in agriculture. In 1994, agriculture accounted for about 33% of the country's GDP, and the contribution of crop production to the agri-cultural product was about 57%, of which 80% were irrigated crops and 20% rainfed crops.

FIGURE 1
Land categories
Total: 9341 000 ha in 1994



CLIMATE AND WATER RESOURCES

Climate

The climate in the Kyrgyz Republic is continental with hot summers and cold winters, during which frost occurs all over the country. The frost-free period is 185 days per year in the Chu valley, 120-140 days per year in the Naryn valley and 240 days per year in the Fergana valley. Double cropping is therefore limited to vegetables. Average temperatures in the valleys vary from -18°C in January to 28°C in July. Absolute temperatures vary from -54°C in winter to 43°C in summer. The average annual precipitation is estimated at 533 mm, varying from 150 mm in the plains (Fergana valley) to over 1 000 mm in the mountains. Precipitation occurs during the winter season, mainly between October and April, when temperatures are low.

TABLE 3
Irrigation and drainage

Irrigation potential		1990	2 247 300	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1994	1 077 100	ha
- surface irrigation		1994	1 040 100	ha
- sprinkler irrigation		1994	37 000	ha
- micro-irrigation		1994	0	ha
% of area irrigated from groundwater		1994	0.6	%
% of area irrigated from surface water		1994	99.4	%
% of area irrigated from non-conventional sources			-	%
% of equipped area actually irrigated		1994	100	%
2. Equipped wetland and inland valley bottoms (i.v.b.)			-	ha
3. Spate irrigation			-	ha
Total irrigation (1+2+3)		**1994**	**1 077 100**	**ha**
- as % of cultivated area			80.2	%
- increase over last 10 years		1983-94	+7.4	%
- power irrigated area as % of irrigated area		1994	5.6	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 5 000 ha	1990	643 200	ha
Medium-scale schemes		1990	229 400	ha
Small-scale schemes	< 1 000 ha	1990	200 000	ha
Total number of households in irrigation		1990	705 825	
Irrigated crops:				
Total irrigated grain production		1994	924 000	t
as % of total grain production		1994	60	%
Harvested crops under irrigation		**1994**	**1 077 100**	**ha**
- permanent crops: total		1994	36 200	ha
- annual crops: total		1994	1 040 900	ha
. fodder		1994	541 100	ha
. wheat		1994	229 000	ha
. barley		1994	75 200	ha
. sesame and sunflower		1994	58 400	ha
. other annual crops		1994	137 200	ha
Drainage - Environment:				
Drained area		1994	149 000	ha
- drained area in full or partial control irrigated areas		1994	149 000	ha
- drained area in equipped wetland and i.v.b.			-	ha
- other drained area			-	ha
- area with subsurface drains		1994	65 300	ha
- area with surface drains		1994	83 700	ha
Drained area as % of cultivated area			11	%
Power drained area as % of total drained area			-	%
Area salinized by irrigation		1994	60 000	ha
Population affected by water-borne diseases			-	inhabitants

Rainfed agriculture is therefore very limited. Snowfall constitutes an important part of the total precipitation. About 10% of the territory, situated at the lowest altitude, is classed as arid.

River basins and water resources

The country can be divided into two hydrological zones: the flow generation zone (mountains), covering 171 800 km^2, or 87% of the territory; and the flow dissipation zone of 26 700 km^2, which is 13% of the territory. Most of the rivers are fed by glaciers and/or snow melt. Peak flows occur from April to July, with 80-90% of the flow in the period of about 120-180 days extending to August or September.

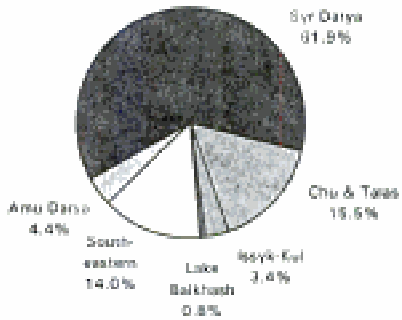
There are six main river basin groups in the country. No rivers flow into the Kyrgyz Republic. The river basins are, from the largest to the smallest (Figure 2):

- The Syr Darya River basin. Called the Naryn River before it reaches the Fergana valley, the Syr Darya flows to Tajikistan and Uzbekistan. In Uzbekistan, the Syr Darya receives the Chatkal, a tributary which rises in the Kyrgyz Republic.
- The Chu, Talas and Assa river basin. All three rivers flow to Kazakhstan, where the part not withdrawn is lost in the desert.
- The southeastern river basins. These consist of small catchment areas draining to China. The main rivers are the Aksay, Sary Dzhaz and Kek Suu, and are situated at high elevations.

FIGURE 2

Internal renewable surface water resources by river basin

Total: 44.05 km³/yr.



- The Lake Issyk-Kul interior basin. The lake is low-saline and it is estimated that all the flow which is not evaporated is used for irrigation or domestic purposes.
- The Amu Darya River basin. The Amu Darya rises mainly in Tajikistan, but receives the contribution of a Kyrgyz tributary, the Kyzyl Suu, in the southwest of the country.
- The Lake Balkhash basin. It consists of the small catchment of the Ili River, which rises in the Kyrgyz Republic and flows to this Kazakh lake.

Renewable Surface Water Resources (RSWR) by major river basin

River basin	Region	Part of territory	Internal RSWR	Outflow to:	Part to be reserved by treaties	Actual RSWR
		%	km³/year		km³/year	km³/year
Syr Darya	West	55.3	27.25	Tajikistan and Uzbekistan	22.33	4.92
Chu, Talas and Assa	North	21.1	6.83	Kazakhstan	2.03	4.80
Southeastern	Southeast	12.9	6.18	China	-	6.18
Lake Issyk-Kul	Northeast	6.5	1.50	Interior basin	-	1.50
Amu Darya	Southwest	3.9	1.93	Tajikistan	1.51	0.42
Lake Balkhash	Northeast	0.3	0.36	Kazakhstan	-	0.36
Total		**100**	**44.05**		**25.87**	**18.18**

The average natural surface water flow is estimated at 44.05 km³/year, all internally produced. The FSU allocated about 25% of these water resources to the Kyrgyz Republic, with the rest going to the neighbouring republics of Kazakhstan, Uzbekistan and Tajikistan. This rule did not concern the resources generated in the southeastern basins, since they flow towards China, and the very limited resources generated in the Lake Balkhash basin. This allocation has been re-endorsed by the five states of Central Asia, until a new water strategy for the Aral Sea basin, which is being prepared by the Interstate Commission for Water Coordination, proposes another sharing. The surface water resources allocated to the Kyrgyz Republic are calculated every year, depending on the existing flows. However, on average, it can be considered that they represent a volume of 11.64 km³/year. In addition, the 6.18 km³/year of the southeastern basin and the 0.36 km³/year of the Lake Balkhash basin are available for use, giving a total of 18.18 km³/year of ARSWR.

The annual renewable groundwater resources have been estimated at 13.6 km³/year, of which about 11.2 km³/year is common to surface water resources. The groundwater resources for which abstraction equipment exists (1991) have been estimated at 3.39 km³/year, mainly in the Chu River basin (2.02 km^3/year or 60% of the total), the Syr Darya River basin (0.73 km^3/year or 22%) and the Issyk-Kul depression (0.52 km^3/year or 15%).

The ARWR of the Kyrgyz Republic can thus be estimated at 20.58 km^3/year.

Non-conventional sources of water

In 1994, the return flow on the territory of the Kyrgyz Republic was estimated at 2.1 km^3/year, of which 30% in the Chu River basin and 70% in the Syr Darya River basin. This total consists of 1.72 km^3/year of agricultural drainage water collected through the collector-drainage canals, and about 0.38 km^3/year of municipal and industrial untreated wastewater. Most of the return flow (1.8 km^3/year) flows back to the rivers (0.3 km^3/year in the Chu River and 1.5 km^3/year in the Syr Darya), and might be re-used by downstream countries, while 0.3 km^3/year is directly re-used for irrigation, after a natural desalting treatment (phytomelioration).

Lakes and dams

The total number of natural lakes in the Kyrgyz Republic is 1 923, with a total surface area of 6 800 km^2. The largest lake is Lake Issyk-Kul with a total area of 6 236 km^2.

Due to the glacier and snow origin of most of the rivers, low and unreliable flows are often the rule in the months of August and September, which correspond to the latter part of the growing season. Regulation of these flows is thus needed to ensure that adequate water supplies are available over the whole cropping period.

In 1995, the total capacity of reservoirs was estimated at 23.5 km^3. There were 18 reservoirs: 6 in the Chu River basin, with a total capacity of 0.6 km^3; 3 in the Talas River basin, with a total capacity of 0.6 km^3; and 9 in the Syr Darya River basin, with a total capacity of 22.3 km^3. The Toktogul dam, with a reservoir capacity of 19.5 km^3, is situated on the Naryn River, a northern tributary of the Syr Darya. It is a multipurpose dam for irrigation, hydropower production and flood protection/regulation. However, due to its location near the border with Uzbekistan, it does not play an important role in the irrigation of areas within the Kyrgyz Republic. The same applies to the Kirov dam, which has a capacity of 0.55 km^3 and is located on the Talas River near the border with Kazakhstan.

The gross theoretical hydropower potential in the Kyrgyz Republic has been estimated in 1985 at about 162 500 Gwh/year, and the economically feasible potential is estimated at about 55 000 GWh/year. The hydropower installed capacity is estimated at about 3 GW, a number of hydropowerplants being part of the Naryn-Syr Darya cascade, controlled by the Toktogul dam. Hydropower plays a key role in the Kyrgyz Republic and is the country's main source of energy (about 90% of electricity generation in 1995), given its limited gas, oil and coal resources. However, hydropower production releases water mainly in winter, while the downstream countries would need water for the summer cropping season. At regional level, competition between irrigation and hydropower appears to be a major issue. An agreement was reached with Uzbekistan and Kazakhstan in 1996. These two countries will transfer energy, coal or gas to the Kyrgyz Republic in the period of power deficit, to compensate for the non-use of water for hydropower in the winter period.

Water withdrawal and wastewater

In 1994, the total water withdrawal was estimated at 10.1 km^3 (Figure 3), including the re-use of drainage waters. The total water withdrawal increased progressively from 1970 to 1990 (Figure 4). The average annual surface water availability for irrigation in the period 1985-1992 was about 10.77 km^3, although the water requirement had been evaluated at 10.83 km^3, leading to an overall irrigation water deficit for the country of 0.06 km^3. In some basins (Syr Darya, Chu, Talas) there was a fairly severe water shortage, while in other basins (Amu Darya, Issyk-Kul, southeastern) there was a surplus.

In 1994, more than 0.6 km^3 of water was withdrawn from groundwater (Figure 5). Other water needs, mainly for fisheries, were estimated at 9 million m^3/year in 1994. A prospective analysis shows that in 2010 the water demand might be 13.07 km^3/year, which exceeds the current allocation.

FIGURE 3
Water withdrawal
Total: 10.086 km^3 in 1994

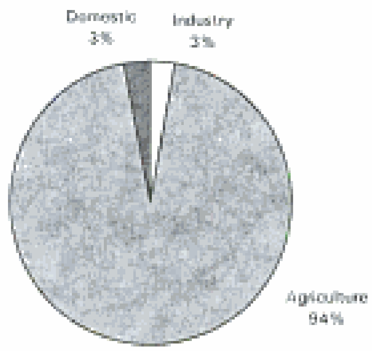
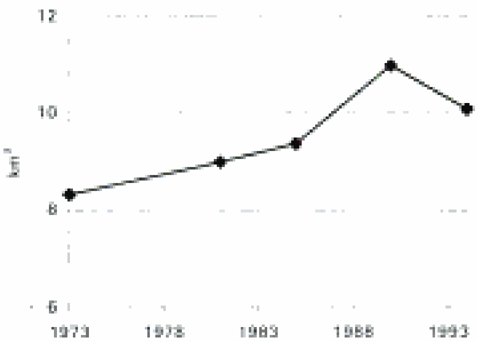


FIGURE 4
Evolution of water withdrawal

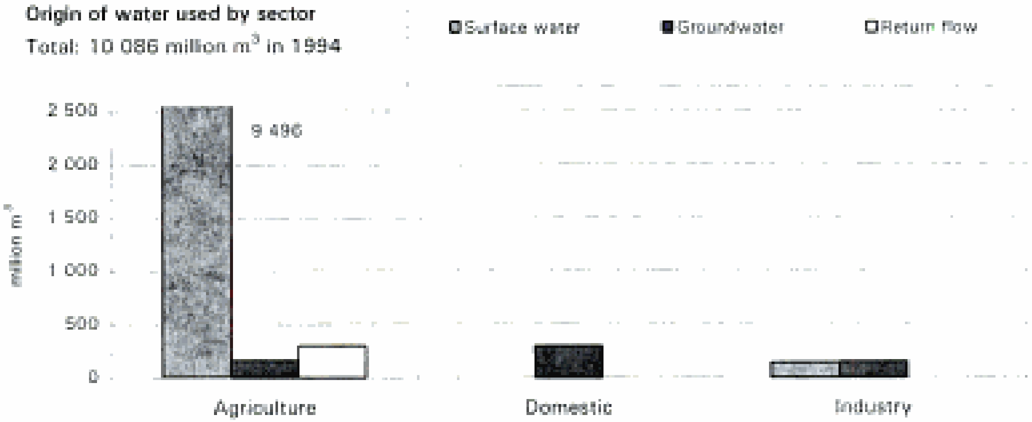


Irrigation and drainage development

Irrigation development

Irrigation is of key importance to the agricultural sector of the Kyrgyz Republic and covers 80% of the cultivated area. The irrigation potential has been estimated at about 2.25 million ha.

FIGURE 5
Origin of water used by sector
Total: 10 086 million m^3 in 1994



Characteristics of the irrigation schemes (1990)

Size	Number of schemes	Total area of schemes (ha)	Average area of scheme (ha)	Number of beneficiaries	Number of benefic./ha
Small (< 1 000 ha)	1 174	204 500	170	486 400	2.4
Medium (1 000-5 000 ha)	101	229 400	2 270	648 400	2.8
Large (> 5 000 ha)	71	643 200	9 060	1 688 500	2.6
Total	1 346	1 077 100	800	2 823 300	2.6

The inter-farm irrigation network is generally well maintained, particularly the main canals downstream of the large storage dams. The distribution network within the *kolkhoz* and *sovkhoz* is generally poorly designed, built and maintained. Seepage and leakage losses in the distribution system are considerable, resulting in a conveyance/distribution efficiency estimated at 55%.

FIGURE 9
Typology of irrigation canals
Total: 12 835 km in 1994

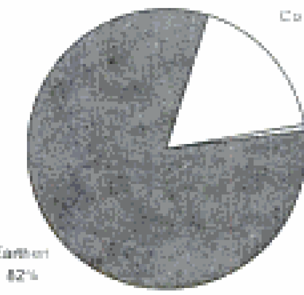
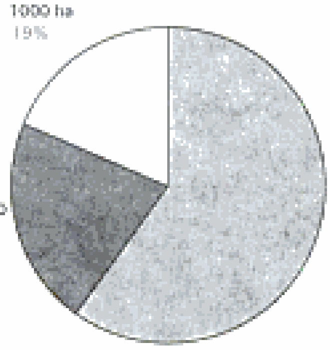


FIGURE 10
Irrigation scheme size
Total: 1 072 600 in 1990



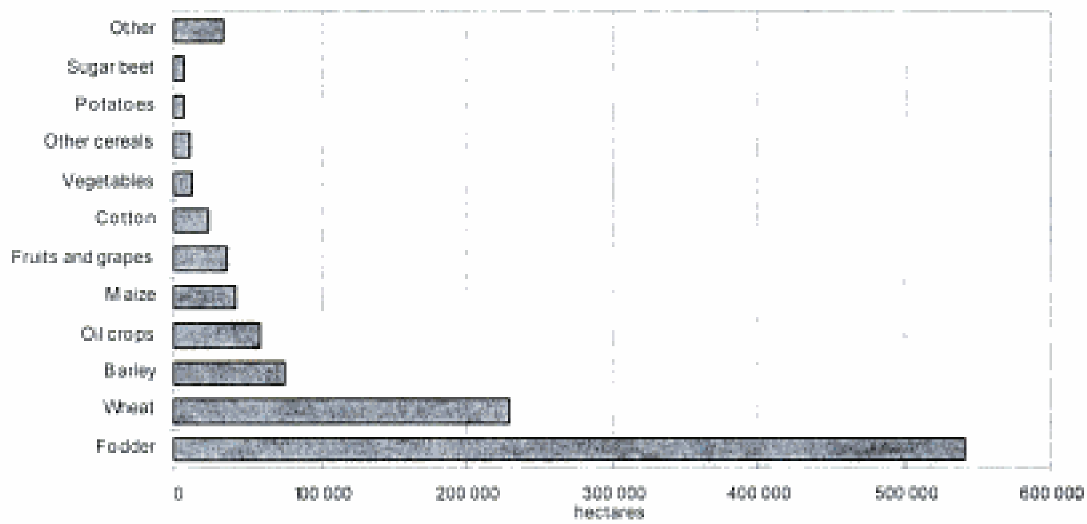
The average cost of surface irrigation development (1995) varies from $US 5 800/ha for small schemes to $US 8 500/ha for medium schemes and $US 11 600/ha for large schemes. The respective costs for sprinkler irrigation are $US 6 900, 10 400 and 14 200/ha. However, these costs vary substantially depending on the physiographic conditions. In general, the costs are lower in the Chu valley and the Issyk-Kul depression and higher in the Syr Darya valley, which is more mountainous. Rehabilitation costs vary between $US 2 400 and 5 000/ha.

The annual O&M cost which would enable full cost recovery is estimated at $US 350/ha, but the actual operational costs have not exceeded $US 60/ha in the last four years. In the past, farmers were not charged for water, although the land tax was two or three times higher on irrigated land than on non-irrigated land of similar quality. However, the financial situation has changed dramatically and the Ministry of Water Resources is no longer able to cover irrigation costs from general tax revenues. In 1992-93, a water fee was imposed on the *kolkhoz* and *sovkhoz*.

In 1995, the Ministry of Water Resources proposed a water charge equivalent to $US 0.6/1 000 m^3, to cover the O&M costs. Parliament approved the equivalent of $US 0.1/1 000 m^3, an amount which was divided by three for supplementary irrigation during autumn and winter seasons. In 1995, only 29% of the charges due were collected.

The major irrigated crops are fodder crops and cereals, mainly wheat (Figure 11). Other figures show that only 732 000 ha, instead of 1 077 100 ha, might have been harvested on irrigated areas in 1993. Although the yields for irrigated land are generally low by world

FIGURE 11
Irrigated crops
Total: 1 077 100 ha in 1994



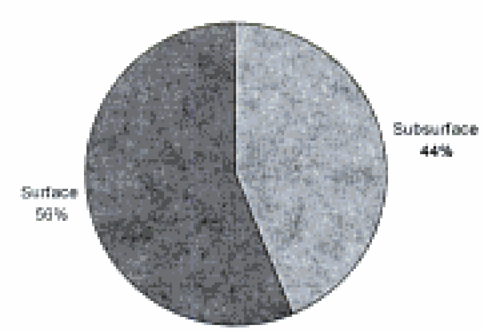
standards, they are about two to five times higher than yields on non-irrigated areas. The average yields for wheat, barley and rye are, respectively, 2.2, 2.2 and 1.9 t/ha on irrigated land and 1.1, 0.9 and 1.0 t/ha on rainfed land.

Waterlogging, salinity and drainage development

In 1994, about 60 000 ha were saline by Central Asia standards (toxic ions exceed 0.5% of total soil weight). In addition to this area, which can be distinguished into 34 200 ha moderately saline and 25 800 ha highly saline, a further 63 400 ha were slightly saline. In the Chu River basin, about 15% of the irrigated area is considered saline, while this figure falls to 5% in the Syr Darya River basin. The waterlogged area was estimated at 89 200 ha in 1990.

It is estimated that 750 000 ha of irrigated land would need drainage. At present only 149 000 ha have been equipped for drainage. Subsurface drainage has been developed mainly on newly reclaimed areas in the north and southwest (Figure 12). With the very restricted budget of the Ministry of Agriculture and Water Resources, it is unlikely that the state will be able to maintain and operate the existing drainage system effectively, or to improve or extend it. For this reason, salinity and drainage problems are likely to worsen in the near future.

FIGURE 12
Drainage techniques
Total: 149 000 ha in 1994



Institutional environment

The Ministry of Agriculture and Water Resources (formerly there were two separate ministries) is in charge of water resources research, planning, development and distribution, and undertakes the construction, operation and maintenance of the irrigation and drainage networks at the inter-farm level of the country. Water allocations are regularly reduced in order to promote savings and to satisfy the demand from new users. In the case of the Syr Darya River basin, one of the objectives is also to increase the flow to the Aral Sea.

In the past, irrigation systems were designed and operated to deliver water to the large *sovkhoz* and *kolkhoz* and it was a relatively easy task for the Ministry of Water Resources to deliver water to each farm. However, with the increasing number of small farms that has resulted from the privatization programme, there is a need for institutions which provide technical support to farmers, and which are in an intermediate position between the Ministry of Agriculture and Water Resources and the farmers.

Article 18 of the new water law (14 January 1994) includes specific provisions for the establishment of WUAs which would receive water from the Ministry of Agriculture and Water Resources and allocate it among their members. They would have legal status, be independent of the government, be able to collect taxes from their members, borrow funds, and take appropriate action to maintain and upgrade 'their' parts of the irrigation system, which are the on-farm systems formerly operated by the *sovkhoz* and *kolkhoz*.

The Ministry of Municipal Affairs is responsible for domestic water supply and wastewater treatment.

Monitoring of surface water quantity and quality is carried out by the Kyrgyz Hydrometeorological Agency, while the systematic exploration, investigation and monitoring of groundwater is carried out by the State Committee for Geology and Hydrogeological Expedition.

At international level, the Kyrgyz Republic is a member of the Syr Darya River BWO, ICWC and IFAS.

Trends in water resources management

The Kyrgyz Republic is endowed with sufficient quantities of water of excellent quality for domestic and industrial use for the foreseeable future. Due to commitments towards downstream countries, water availability is likely to become a constraint on expanding irrigation, extending land reclamation, and improving productivity of irrigated areas, unless there are significant improvements in efficiency, and a major effort made to increase water conservation.

The main environmental problems in the country are related to: the water pollution, due to the poor quality of the existing plants for wastewater treatment; the absence of treatment for saline return flow from agricultural land; and possible contamination from the radioactive refuse inherited from the Soviet period.

Other environmental problems are related to: the observed reduction of glaciers, which might lead to a reduction in flow; to soil erosion and the resulting siltation of reservoirs, which limit the possibility of flow regulation; and to the increase of soil salinity, which might become a constraint on farming.

According to the agricultural sector review of the World Bank (1995), the following three key issues need immediate attention to secure the sustainability of irrigation in the Kyrgyz Republic:

- New institutional arrangements must be made at farm level to manage and maintain the distribution of water within the former *sovkhoz* and *kolkhoz* as farming units are privatized. For this, the need to create WUAs has been felt. The new water law already provides a framework for this, but the establishment of such WUAs will require further attention.

- The financing of O&M of the existing systems must be secured and obtained largely from water users. The new water law has a section devoted to water fees and taxes. There are charges for water use, for the service of providing water (collection, transport, distribution and purification) and for the discharge of polluting substances into water. There are also provisions for increased fees if water consumption rates exceed forecast levels. There are also fee exemptions for the use of water-saving technologies and other water conservation measures.

- Environmental degradation of the irrigation systems and the irrigated lands must be guarded against through increased efforts to improve drainage and to reduce salinity and soil erosion. For this, a programme to improve irrigation efficiency and reduce water applications, especially in the higher lands, is needed. The steep slopes of the irrigated lands in the mountain areas with shallow soils should enable the conversion to sprinkler or micro-irrigation methods, especially where water under pressure can be provided.

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Latvia

GEOGRAPHY AND POPULATION

Latvia is one of the three Baltic states. It is bordered in the northeast by Estonia, in the east by the Russian Federation, in the southeast by Belarus, in the south by Lithuania and in the west and northwest by the Baltic Sea and the Gulf of Riga. Its total area is 64 600 km^2. The country became independent from the Soviet Union in May 1990. Administratively, it is divided into 26 districts and 7 district towns.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	6 460 000	ha
Cultivable area	1994	2 540 300	ha
Cultivated area	1994	1 213 900	ha
- annual crops	1994	1 192 000	ha
- permanent crops	1994	21 900	ha
Population:			
Total population	1996	2 504 000	inhab.
Population density	1996	39	inhab./km^2
Rural population	1996	27	%
Economically active population engaged in agriculture	1996	14	%
of which: - men	1995	65	%
- women	1995	35	%
Water supply coverage:			
Urban population	1994	90	%
Rural population		-	%

Latvia consists of a continental part in the east and the Kurzeme peninsula (Kurland) in the west. The continental consists of morainic uplands that are crossed by several rivers flowing to the lowlands, of which the main ones are the Daugava, Gauja and Salaca rivers. The highest point of the country is in the Vidzeme uplands with an altitude of almost 312 m above sea level. The continental part is separated from the peninsula in the west by the Lielupe River, which flows through the Zemgales plain. In the peninsula are the Kurzeme uplands, which are lower than the continental uplands and crossed by several rivers, of which the Venta River is the most important. The highest point in these uplands is at 184 m above sea level. About 57% of the country lies below 100 m above sea level and only 2.5% lies above 200 m.

The cultivable area is estimated at over 2.5 million ha, which is 39% of the total area of the country. In 1994, the cultivated land was estimated at 1.2 million ha, of which over 98% was covered by annual crops. The soils in Latvia are generally not very fertile. Around 230 000 ha are threatened by wind erosion and around 380 000 ha by water erosion. According to various estimates, marshes cover 5-10% of the total area of the country. Some swamps of peat ground reach a depth of 5 m. The fertile marshy black soils can be found only in the Zemgales plain.

Until 1989, 60% of the area was cultivated by *kolkhoz* (collective farms) and 40% by *sovkhoz* (state farms). In 1989, as a result of the proclamation of the 'Act on Land Reform in Rural Areas', private farms started developing. In 1994, the private sector, including peasant farms, household plots, private auxiliary farms and private fruit gardens, cultivated over 1 million ha (Figure 1). The average size of private farms does not exceed 20 ha.

LATVIA

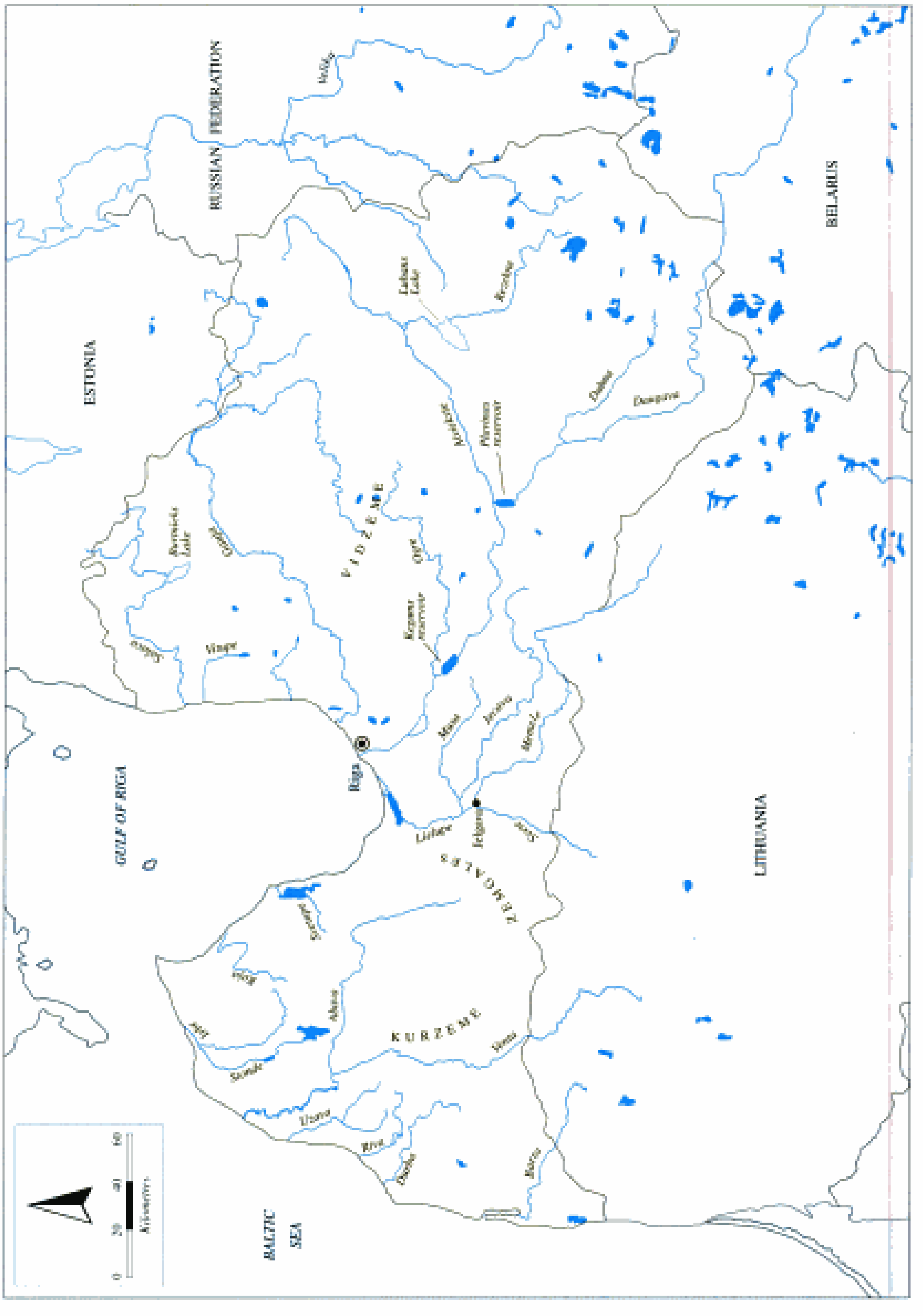
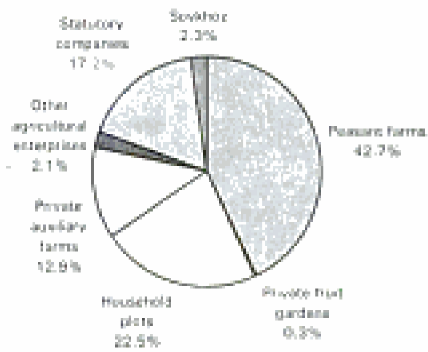

ESTONIA
RUSSIAN FEDERATION
BELARUS
LITHUANIA
GULF OF RIGA
BALTIC SEA
VIDZEME
KURZEME
ZEMGALE
Riga

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		743	mm/yr
		48.0	km^3/yr
Internal renewable water resources		16.740	km^3/yr
Total (actual) renewable water resources	1997	35.449	km^3/yr
Dependency ratio	1997	52.8	%
Total (actual) renewable water resources per inhabitant	1996	14 157	m^3/yr
Total dam capacity	1988	1 050	$10^6\ m^3$
Water withdrawal:			
- agricultural	1994	36.3	$10^6\ m^3/yr$
- domestic	1994	157.1	$10^6\ m^3/yr$
- industrial	1994	91.8	$10^6\ m^3/yr$
Total water withdrawal		285.2	$10^6\ m^3/yr$
per inhabitant	1994	111	m^3/yr
as % of total (actual) renewable water resources		0.8	%
Other water withdrawal	1994	149.1	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1994	215.8	$10^6\ m^3/yr$
- treated wastewater	1994	66.7	$10^6\ m^3/yr$
- re-used treated wastewater	1994	11.8	$10^6\ m^3/yr$
Agricultural drainage water		-	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

The total population is 2.5 million (1996), of which 27% is rural. The population density is 39 inhabitants/km^2. In 1994, about 1.3 million people lived in the seven district towns, 857 000 of them in the capital Riga. During the 1980s, the annual population growth averaged 0.3%. In 1990, it was only 0.1%, while it 1994 it was negative, -0.7%. This decrease is related, on the one hand, to a reduced natural population growth, and on the other, to the fact that people of other nationalities (in particular Russians, but also people from Belarus and Ukraine) have been leaving Latvia. In 1996, 14% of the economically active population was engaged in agriculture, with women making up 35% of the agricultural labour force. About 13% of all employed women and 24% of all employed men were engaged in agriculture. Agriculture, including fishery, forestry and hunting, accounted for almost 8% of GDP in 1995.

FIGURE 1
Land categories
Total: 1 348 600 ha in 1994



CLIMATE AND WATER RESOURCES

Climate

The average annual precipitation, including snowfall, has been estimated at 743 mm. Four climatological regions can be distinguished in Latvia:

TABLE 3
Irrigation and drainage

Irrigation potential		-	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1995	20 000	ha
- surface irrigation	1995	-	ha
- sprinkler irrigation	1995	20 000	ha
- micro-irrigation	1995	-	ha
% of area irrigated from groundwater	1995	0	%
% of area irrigated from surface water	1995	100	%
% of area irrigated from non-conventional sources	1995	0	%
% of equipped area actually irrigated	1995	100	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1 + 2 + 3)	**1995**	**20 000**	**ha**
- as % of cultivated area		1.6	%
- increase over last 10 years	1985-95	17.6	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production		-	t
as % of total grain production		-	%
Harvested crops under irrigation	**1995**	**20 000**	**ha**
- permanent crops: total	1995	0	ha
- annual crops: total	1995	20 000	ha
. potatoes and vegetables		-	ha
. sugar beet		-	ha
. other annual crops		-	ha
Drainage - Environment:			
Drained area	1995	1 583 400	ha
- drained area in full or partial control irrigated areas		-	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1995	1 490 300	ha
- area with surface drains	1995	93 100	ha
Drained area as % of cultivated area		130	%
Power drained area as % of total drained area		-	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

- The coastal region, covering 25% of the country, includes the Zemgales plain and the whole coastal region from Lithuania to Estonia. The average annual precipitation is 600 mm. The average temperature varies from -3°C in January to 16.5°C in July. Humidity is low.

- The Latgales region, covering 28% of the country, includes the southeast of the country. The average annual precipitation is 700 mm. The average temperature varies from -7°C in January to 17°C in July. Humidity is high.

- The Vidzeme region, covering 30% of the country, includes the northeastern inland part of the country. The average annual precipitation is 700-850 mm. The average temperature varies from -7°C in January to 16.5°C in July. Humidity is high.

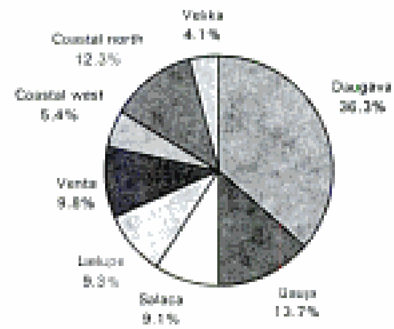
- The Kurzeme region, covering 17% of the country, includes the inland part of the Kurzeme peninsula. The average annual precipitation is 700-850 mm. The average temperature varies from -4°C in January to 16.5°C in July. There is medium humidity.

For agriculture, drainage is more important than irrigation. Over 90% of the agricultural land in Latvia can be intensively cultivated only if drained. Irrigation is generally supplementary irrigation.

River basins and surface water resources

Depending on the physical and geographical conditions, a large part of the river discharge comes from either snow melt, groundwater or direct surface runoff. About 50-55% of the waters of the Daugava, Venta, Lielupe and Musa rivers is melted snow, while for the Gauja and Amata rivers it is 35-40%. About 10-20% of the flow of some tributaries of the Lielupe (Memele and Svete) and the Aiviekste tributary of the Daugava is fed by groundwater, while for the Daugava and Gauja rivers it is 35-40%. In the Kurzeme peninsula and in the middle uplands, direct surface runoff accounts for 40% of flow of the rivers, while in the Zemgales plain it represents 20-30%.

FIGURE 2
Internal renewable surface water resources by major river basin
Total: 16.54 km^3/year



The country can be divided into eight river basins (Figure 2):

- The Daugava basin. Its total area is 87 900 km^2, of which 28% is located in Latvia. The Daugava River rises in the Russian Federation, flows through Belarus (where it is called the Western Dvina), enters Latvia in the southeast and flows northwest to the Gulf of Riga. Several tributaries enter the Daugava River inside Latvian territory, including four large ones: Ogre, Aiviekste, Dubna and Rezekne.

- The Gauja basin. Its total area is 8 900 km^2, of which 88% is situated in Latvia. The Gauja River rises in the Vidzeme upland and flows east, then turns northwest, becomes the border between Latvia and Estonia for a short distance, and then flows southwest to the Gulf of Riga.

- The Salaca basin. It covers the north of the country, near the border with Estonia. Its total area is 3 600 km^2, of which 92% is located in Latvia. The Salaca River rises in Lake Burtnieks in the north and flows west to the Gulf of Riga.

- The Lielupe basin. Its total area is 17 600 km^2, of which 50% is situated in Latvia. The Lielupe River rises in Lithuania, enters Latvia in the south and flows north to the Gulf of Riga through the most fertile regions of the country. It has many tributaries, the most important being the Memela, Jecava and Svete.

- The Venta basin. Its total area is 11 800 km^2, of which 67% is situated in Latvia. The Venta River rises in Lithuania, enters Latvia in the southwest and flows north through the Kurzeme lowland to the Baltic Sea. The Venta has many tributaries, but only one of them, the Abava River, exceeds 100 km in length.

- The coastal basins between Lithuania and the Venta. Their total area is 5 100 km^2. This area includes rivers such as the Barta, Durba, Riva and Uzava, which flow to the Baltic Sea.

- The basins within the coastal lowland, on the opposite shores of the Gulf of Riga. Their combined area is 3 800 km^2. This area includes rivers such as the Irbe, Stonde, Roja, Svetupe and Vitupe.

- The Velika basin. This basin consists of a number of smaller rivers flowing into the Velika in the Russian Federation. Its area within Latvia is 3 200 km^2. The total discharge of the Velika amounts to 4.2 km^3/year, of which 16% is generated within Latvia.

The total IRSWR are estimated at 16.540 km^3/year, incoming surface water resources at 18.709 km^3/year.

Renewable Surface Water Resources (RSWR) by major river basin

Name of river basin	Area within Latvia		IRSWR	Inflow		Total RSWR	Outflow
	km^2	% of total	km^3/year	km^3/year	from	km^3/year	to
Daugava	24 700	38.2	6.000	14.800	Bel.(14.3); Lith.(0.5)	20.300	Sea
Gauja	7 800	12.1	2.270	0.310	Estonia	2.580	Sea
Salaca	3 300	5.1	1.510	0.089	Estonia	1.599	Sea
Lielupe	8 800	13.6	1.540	2.000	Lithuania	3.540	Sea
Venta	7 900	12.2	1.620	1.300	Lithuania	2.920	Sea
Coastal west	5 100	7.9	0.890	0.210	Lithuania	1.100	Sea
Coastal north	3 800	5.9	2.040	-		2.040	Sea
Velika	3 200	5.0	0.670	-		0.670	Russian Fed.
Total	64 600	100.0	16.540	18.709		35.249	

Groundwater resources

The internal renewable groundwater resources are estimated at 2.2 km^3/year. Part of the groundwater flows to the sea or is withdrawn by wells, and part is drained by the surface network. That part of the groundwater flow which does not contribute to the total IRWR (overlap) is estimated at 2 km^3/year. Groundwater use is estimated at about 800 000 m^3/day. In some regions, rapid depletion of the water table is observed. Quite a large quantity is used by cities. In the Jūrmala area, close to the capital Riga, the groundwater is famed for its medicinal qualities (thermal baths).

International agreements

Under Soviet administration, no agreements existed with neighbouring republics. Being independent, agreements are now recognized as a necessity. An agreement with the Russian Federation and Belarus concerning the prevention of pollution of the water courses in the Daugava basin is under preparation, as is an agreement with Lithuania on the prevention of water pollution in the Lielupe, Venta and Barta rivers. No agreements on water sharing exist.

Lakes and dams

There are about 2 250 lakes with a total area of about 850 km^2. About 36% of them are located in the Latgales upland in the southeast of the country.

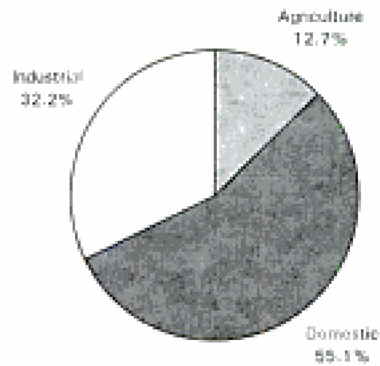
Dams have been constructed for two main reasons: to control floods and to build hydro-electric power stations. Before the Second World War, about 300 such stations had been built.

After the Second World War, the construction of another 547 small stations was planned, but only 267 were built. At present, no small power stations are functioning, though the reservoirs still exist.

Three large hydropower dams have been constructed on the Daugava River, with a total full reservoir capacity of 1.005 km^3 and a surface area of 101.9 km^2. The Kegums reservoir, with an area of 24.8 km^2 and a full capacity of 0.157 km^3, was constructed before the Second World War. Since the Second World War, the Plavinas reservoir, with an area of 34.9 km^2 and a full capacity of 0.509 km^3, and the Riga reservoir, with an area of 42.2 km^2 and a full capacity of 0.339 km^3, have been constructed. The total dam capacity in Latvia is estimated at 1.050 km^3.

Water withdrawal and wastewater

FIGURE 3
Water withdrawal
Total: 285.2 million m^3 in 1994



In 1994, the total water withdrawal for agricultural, domestic and industrial purposes was estimated at 285.2 million m^3, of which about 12.7% for agriculture (Figure 3). Other water use, including water use for hydropower, was 149.1 million m^3.

In 1994, the total quantity of produced wastewater was 215.8 million m^3, of which 119.4 million m^3 were classed as clean without treatment, while 66.7 million m^3 were treated to meet the quality standards. The remaining 29.7 million m^3 were not treated. The largest quantity of untreated wastewater flows into the Daugava and Lielupe river basins. In 1994, the total quantity of re-used treated wastewater amounted to 11.8 million m^3.

According to hydrobiological and hydrochemical data, 85% of all surface water is slightly polluted or polluted. Eutrophication is the main problem, caused by untreated municipal wastewater and runoff from agricultural lands.

IRRIGATION AND DRAINAGE DEVELOPMENT

Drainage development

The more important works connected with land drainage started in the eighteenth century in the east of the country. At the beginning of the nineteenth century, large-scale hydraulic works were carried out on the Bera, Auce, Riva and Lielupe rivers; dikes were built along the Roja, Abava, Riva and Pededza rivers; and the Starpinupe canal connecting Lake Kanaris with the Gulf of Riga was constructed. In the middle of the nineteenth century, a canal connecting Lake Lubans with the Aiviekste River was constructed. Subsurface drainage started in 1850. Until 1924, all hydraulic works were carried out without the use of any machinery. In 1924, machines and excavators were purchased, which facilitated the excavation of cross-cuts, made it possible to straighten riverbeds and to shape new ones. The first land improvement act was passed in 1937.

By 1995, almost 1.6 million ha, including agricultural land, meadows, pastures and land used for construction, had been drained (Figure 4). The area has not increased during the last five years because of financial problems. Most of this area, almost 1.5 million ha, has been provided with subsurface drains, using ceramic or polymer pipes (Figure 5). The state only finances improvements and maintenance of the system. For 1996 and 1997, $US 3.3 million has been earmarked for these purposes. In spite of financial difficulties, there are two or three specialized companies functioning in each district. These companies carry out improvements and undertake maintenance work on individual commissions on private farms.

FIGURE 4
Evolution of the drained area

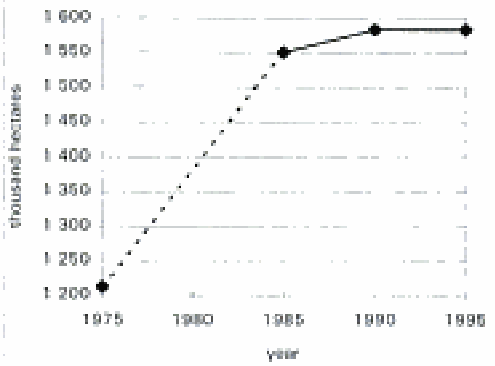
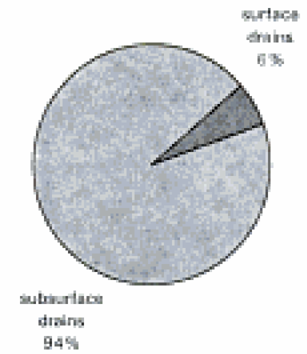
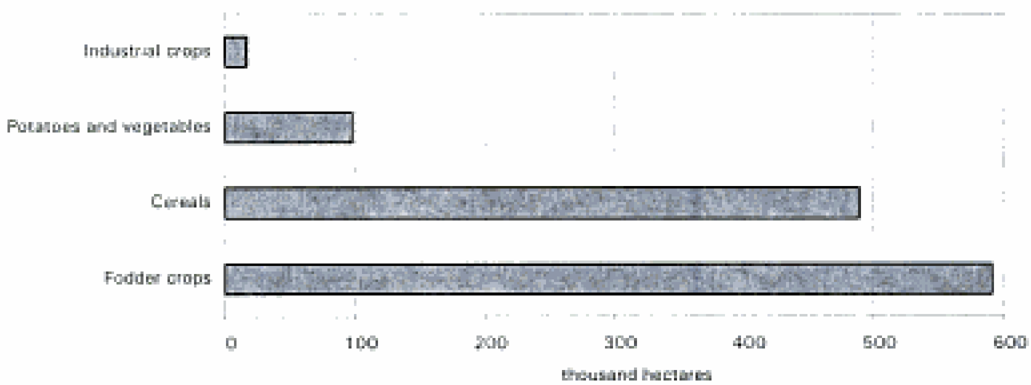


FIGURE 5
Drainage techniques
Total: 1 583 400 ha in 1995



In 1994, fodder crops covered a large part of the drained area (49.5%), followed by cereals (40.9%), vegetables and potatoes (8.2%) and industrial plants (1.4%) (Figure 6). The drained lands produce 80% of all vegetable production. It is assumed that, generally, crop yields on drained land are 20-25% higher than those on undrained land. In 1992, the yield of cereals on drained lands was 2.7-3.0 t/ha and exceeded those on undrained lands by 1.0-1.5 t/ha. Calculations by the Land Improvement Administration at the Ministry of Agriculture reveal that, in order to fully cover the country's demand for cereals, a further 150 000-200 000 ha should be drained and 200 000 ha manured with lime every year.

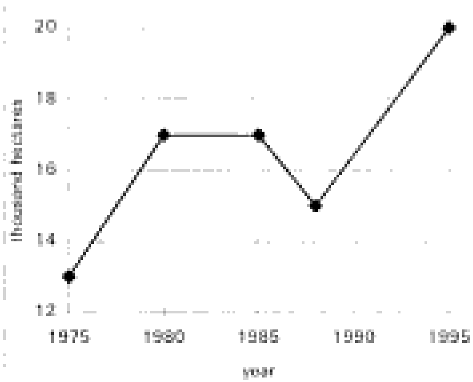
FIGURE 6
Main crops on drained areas
Total: 1 194 600 ha in 1994



Irrigation development

In order to increase yields, improve quality and secure production, experiments with sprinkler irrigation on vegetable plantations, early potatoes and sugar beet started in the 1970s. The first sprinkler systems were installed on the 'Peternicki' experimental farm in the Jelgava district and then on the 'Uzvara' *kolkhoz* in the Bauska district and on the 'Kekava' *kolkhoz* in the Riga district, all in the Zemgales plain. At present, the irrigated area covers about 20 000 ha (Figure 7). All irrigation is sprinkler irrigation, and irrigation in general is supplementary irrigation. The main irrigated crops are potatoes, vegetables and sugar beet.

FIGURE 7
Evolution of irrigation



INSTITUTIONAL ENVIRONMENT

The following institutions are involved in water resources management:

- The Ministry of Agriculture is responsible for water management. It includes the Department of Land Reclamation in Riga and local departments in every district. On behalf of the local departments, a land improvement specialist supervises the drainage networks of two or three communes. The funds allocated for the reconstruction and maintenance of the networks are managed by district departments and are allotted after consultations with farmers' organizations (mainly the Latvian Farmers Federation).

- The Ministry of Environmental Protection and Regional Development, with the Environmental Protection Department, collects information on the quantity and quality of water, and is responsible for preventing pollution of water, agricultural land and air.

- The Ministry of Power Engineering is responsible for the hydroelectric power stations.

- The Latvian Hydrometeorological Agency deals with recording the water quantities of the rivers, lakes and reservoirs.

- The Melioprojects Company VU in Riga keeps all the records concerning the process of land improvement. There are detailed maps, to a scale of 1:50 000 and 1:100 000, of particular districts, with newly drained areas.

- The Latvian University of Agriculture in Jelgava carries out large-scale scientific research on irrigation and land reclamation.

- The Latvian State Research Institute, Agriculture Polymers and Water Management in Jelgava deals with matters of land reclamation, protection of the water against natural and anthropogenic pollution, and hydraulic modelling.

- The University of Latvia in Riga conducts research on hydrology, climate, geography of water resources (Faculty of Geography) and in environmental sciences (Faculty of Geography, Centre for Environmental Studies). It collects statistics and information on water management, agriculture and irrigation.

TRENDS IN WATER RESOURCES MANAGEMENT

A top priority for the 1995 National Environment Policy Plan for Latvia is the environmental protection of water courses in the Baltic Sea basin, since 85% of the surface water resources are classed as either slightly polluted or polluted. Eutrophication is the most important problem.

Another task is to extend the agricultural period through faster draining during spring. Since 1991, there has been no drainage development at all in Latvia. Over 66 000 km of drainage ditches (almost all the existing ditches) require rehabilitation. During the next ten years, it is planned to drain an additional 150 000-200 000 ha in order to achieve self-sufficiency in cereals.

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Lithuania

GEOGRAPHY AND POPULATION

Lithuania, with a total area of 65 200 km^2, is one of the three Baltic states. It is bordered in the west by the Baltic Sea, in the north by Latvia, in the east and southeast by Belarus, in the southwest by Poland and the Russian Federation. It declared its independence from the Soviet Union in March 1990. For administrative purposes, Lithuania is divided into ten districts.

Lithuania is part of the east European plain. Within the country, lowland plains alternate with hilly uplands. From west to east, three lowland plains can be distinguished: the Pajuris, middle lowland and eastern lowland. Similarly, there are three uplands: the Zemaiciai (or Baltic), Aukstaiciai and eastern upland. The peak of the highest hill is at 293 m above sea level.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	6 520 000	ha
Cultivable area	1995	3 925 766	ha
Cultivated area	1994	2 573 512	ha
- annual crops	1994	2 514 712	ha
- permanent crops	1994	58 800	ha
Population:			
Total population	1996	3 728 000	inhab.
Population density	1996	57	inhab./km^2
Rural population	1996	27	%
Economically active population engaged in agriculture	1996	18	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population		-	%
Rural population		-	%

The cultivable area is estimated at about 3.9 million ha, which is 60% of the total area of the country. In 1994, the cultivated area was estimated at almost 2.6 million ha, of which 98% was covered by annual crops. The central and western parts of Lithuania are the best regions for crop production, especially the middle lowland. This region was almost entirely exploited before 1989-1991, in order to supply cities such as Moscow and Saint Petersburg with agricultural products.

In the Soviet era, agriculture was collectivized and organized in large-scale farms. After independence, agriculture was restructured and the land returned to its former owners. The structure of Lithuanian agriculture is now characterized by three different types of farming. In 1995, private commercial farms occupied some 33% of the farmland. Collective commercial farms occupied some 20% of the farmland. Smallholdings, with an average size of 2 ha, occupied another 21%. The remaining 26% was under state ownership, rented out to various types of farms (Figure 1). The restructuring process has not yet been completed and legal titles for most of the land are still not settled.

The total population is 3.7 million (1996), of which 27% is rural. The average population density is 57 inhabitants/km^2, but varies from 28 inhabitants/km^2 in the Utena district to almost 95 inhabitants/km^2 in the Vilnius district, where the capital Vilnius is located. The

LITHUANIA

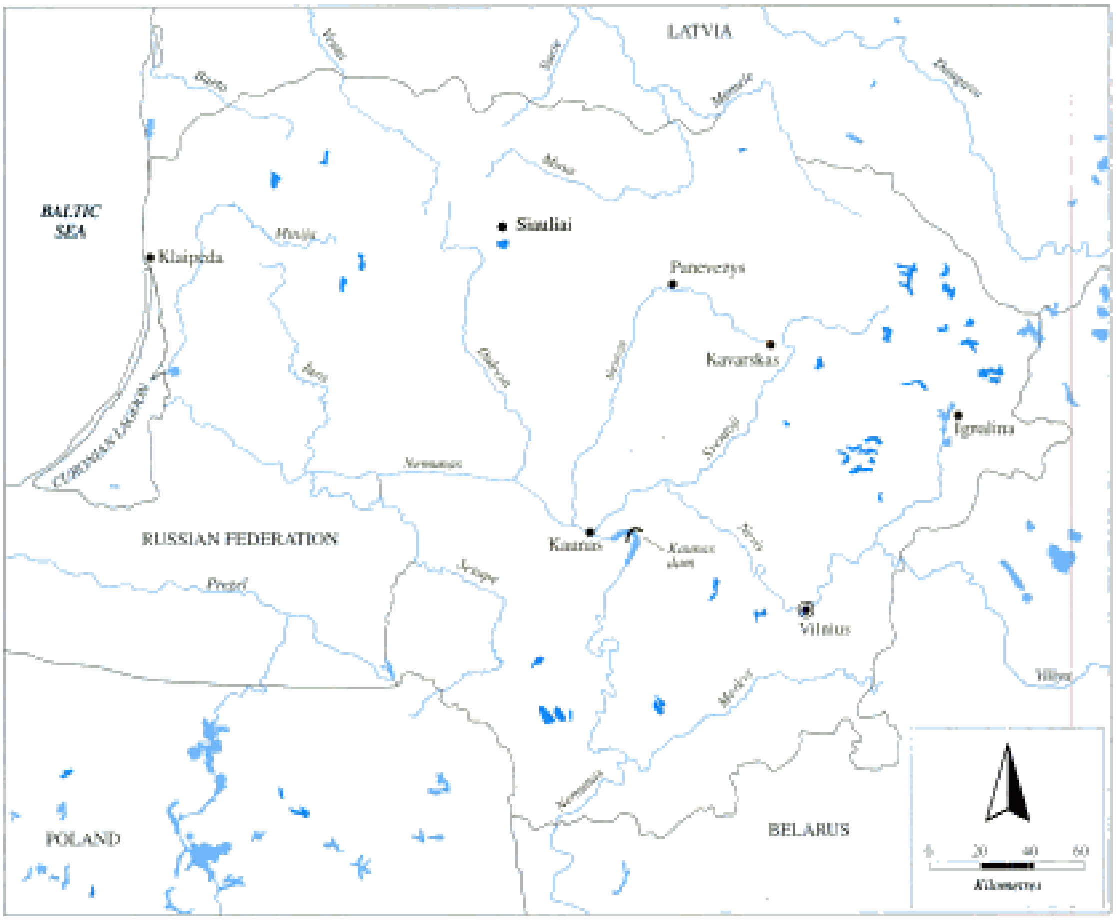
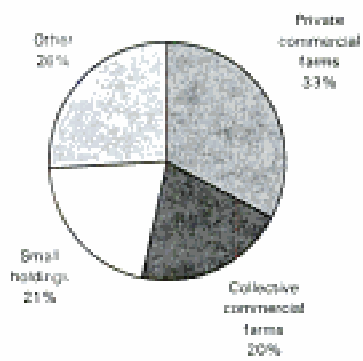

LATVIA
BALTIC SEA
Klaipeda
Siauliai
Panevezys
Kavarskas
Ignalina
CURONIAN LAGOON
Nemunas
RUSSIAN FEDERATION
Kaunas
Kaunas dam
Vilnius
POLAND
BELARUS
0 20 40 60
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		748	mm/yr
		48.77	km^3/yr
Internal renewable water resources		15.56	km^3/yr
Total (actual) renewable water resources	1997	24.90	km^3/yr
Dependency ratio	1997	37.5	%
Total (actual) renewable water resources per inhabitant	1996	6 679	m^3/yr
Total dam capacity	1991	1 820	10^6 m^3
Water withdrawal:			
- agricultural	1995	8.1	10^6 m^3/yr
- domestic	1995	205.2	10^6 m^3/yr
- industrial	1995	40.3	10^6 m^3/yr
Total water withdrawal		253.6	10^6 m^3/yr
per inhabitant	1995	68	m^3/yr
as % of total (actual) renewable water resources		1	%
Other water withdrawal	1995	4 215.9	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1995	303.8	10^6 m^3/yr
- treated wastewater	1995	77.9	10^6 m^3/yr
- re-used treated wastewater	1995	4.8	10^6 m^3/yr
Agricultural drainage water		-	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

annual population growth was 0.2% in 1993. It decreased to -1% in 1994 and 1995. In 1996, about 18% of the economically active population was engaged in agriculture. In 1994, agriculture accounted for an estimated 7% of GDP.

FIGURE 1
Land categories
Total: 3 344 046 ha in 1995



CLIMATE AND WATER RESOURCES

Climate

Lithuania is a semi-humid country. The climate is transitional between maritime and continental. In the 12-15 km-wide coastal zone it is maritime, and in the east of the country it is continental. The average annual precipitation is 748 mm, ranging from less than 550 mm in the north to a maximum of more than 846 mm in the Zemaiciai hills. Over two-thirds of the precipitation occurs during the warm period, from April to October. The main issue in relation to agriculture is thus the removal of excess water to enable cropping.

River basins and water resources

Rivers and lakes have long been used as waterways, although, with the exception of the Nemunas River in the south of the country, they are not very suitable for navigation. Within the country, there are 722 rivers over 10 km long and 21 of them are more than 100 km long. Most of the rivers flow across the middle lowland and the western part of the Zemaiciai upland.

Six major river basins can be distinguished in Lithuania (Figure 2):

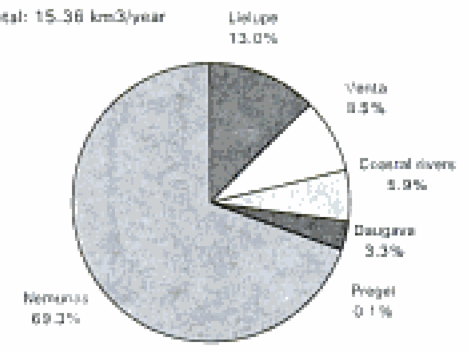
TABLE 3
Irrigation and drainage

Irrigation potential		-	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1995	9 247	ha
- surface irrigation	1995	-	ha
- sprinkler irrigation	1995	9 247	ha
- micro-irrigation	1995	-	ha
% of area irrigated from groundwater	1995	0	%
% of area irrigated from surface water		-	%
% of area irrigated from non-conventional sources		-	%
% of equipped area actually irrigated		-	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1+2+3)	**1995**	**9 247**	**ha**
- as % of cultivated area		0.4	%
- increase over last 10 years	1985-95	minus 75	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production	1990	12 422	t
as % of total grain production	1990	0.4	%
Harvested crops under irrigation	**1990**	**38 400**	**ha**
- permanent crops: total	1990	29 900	ha
- annual crops: total	1990	8 500	ha
. fodder crops	1990	2 900	ha
. barley (spring crop)	1990	2 800	ha
. vegetables	1990	1 900	ha
. winter and summer wheat	1990	900	ha
Drainage - Environment:			
Drained area	1995	3 042 742	ha
- drained area in full or partial control irrigated areas	1995	8 469	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area	1995	3 034 273	ha
- area with subsurface drains	1995	2 619 512	ha
- area with surface drains	1995	423 230	ha
Drained area as % of cultivated area		118	%
Power drained area as % of total drained area	1995	1.6	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

- The Nemunas basin. It is by far the largest river basin in the country, covering 65.9% of the country. The Nemunas River rises in Belarus and enters Lithuania in the south. It flows first north and then turns to the west. It becomes the border between Lithuania and the Russian Federation before flowing into the Baltic Sea. Its major tributaries are the Neris River, rising in Belarus, and the Sesupe River, rising in Poland.
- The Lielupe basin. It covers 16.4% of the country. Several rivers, such as the Svete, Musa and Memele, rise in the north of

FIGURE 2
Internal renewable surface water resources by major basin

Total: 15.36 km3/year



Lithuania. They flow into Latvia and become the Lielupe River after their confluence.

- The Venta basin. It covers 9.1% of the country. The Venta River rises in the northwest of Lithuania and flows into Latvia.
- The group of coastal basins. They cover 4.4% of the country.
- The Daugava basin. It covers 4.1% of the country in the northeast. The Daugava River itself does not flow in Lithuania. Some tributaries, rising in Lithuania, flow northeast into Latvia, where they flow into the Daugava River.
- The Pregel basin. It covers less than 0.1% of the country in the southwest. It drains west into the Russian Federation.

The total IRSWR are estimated at 15.36 km^3/year; incoming surface water resources at 9.34 km^3/year. The outflow into the Russian Federation is estimated at 0.85 km^3/year; the outflow into Latvia at 4.01 km^3/year.

Renewable Surface Water Resources (RSWR) by major river basin

Name of	Area within Lithuania		IRSWR	Inflow		Total RSWR	Outflow
river basin	km^2	% of total	km^3/year	km^3/year	from	km^3/year	to
Nemunas	42 970	65.9	10.65	9.34	Belarus (9.30); Poland (0.04)	19.99	Russian Fed. + Sea
Lielupe	10 690	16.4	2.00	-		2.00	Latvia
Venta	5 930	9.1	1.30	-		1.30	Latvia
Coast	2 870	4.4	0.90	-		0.90	Latvia + Sea
Daugava	2 670	4.1	0.50	-		0.50	Latvia
Pregel	70	0.1	0.01	-		0.01	Russian Fed.
Total	65 200	100.0	15.36	9.34		24.70	

Groundwater resources

The internal renewable groundwater resources are estimated at 1.2 km^3/year. It is considered that most of the flow is drained out by the river system and does not contribute to the total RWR. However, that part of the groundwater which is withdrawn through wells can be added to the surface flow to make up the total IRWR. The overlap has been estimated at 1 km^3/year.

International agreements

No international agreements or treaties on the sharing of water of international rivers exist between Lithuania and its neighbours. An agreement has been signed with Belarus on the exchange of information in the event of accidental pollution in the transboundary rivers. An agreement has been signed with Poland on the monitoring and protection of the transboundary Sesupe River and Lake Galadusis. An agreement with the Russian Federation on the protection and monitoring of the Nemunas River and the Curonian Lagoon might be signed in the future.

Lake and dams

There are over natural 3 000 lakes in Lithuania, 25 of them with areas of more than 10 km^2. They cover 1.5% of the total area of the country. Most lakes are concentrated in the Aukstaiciai uplands in the east of the country.

One large dam, the Kaunas dam, has been built on the Nemunas River for hydropower generation. Its total capacity is 0.46 km^3 and its useful capacity is 0.22 km^3. About 376 dams have been built for water storage for irrigation and flood control. Their total capacity is

1.36 km^3 and their useful capacity is 0.23 km^3. The reservoirs could also be useful for fishery and recreation. At present, the possible use of these dams for hydropower generation, by constructing small power stations, is under discussion. A nuclear power station has been built in Ignalina, in the east of the country.

FIGURE 3

Water withdrawal

Total: 253.6 million m^3 in 1995

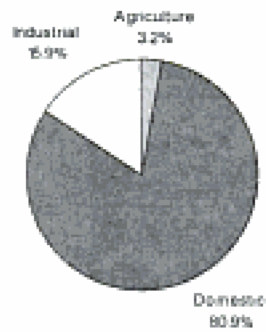
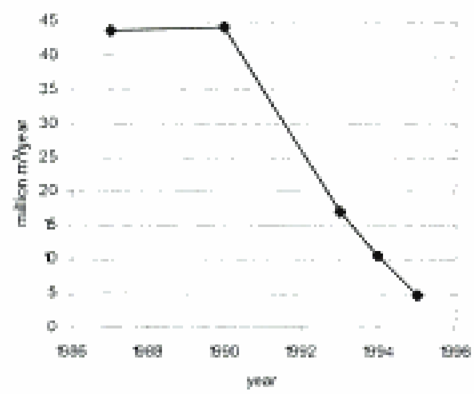


FIGURE 4

Re-used treated wastewater for irrigation



Water use and wastewater

In 1995, the total water withdrawal for agricultural, domestic and industrial purposes was 253.6 million m^3, of which only 3.2% was for agricultural purposes (Figure 3). Livestock watering in rural settlements with centralized water supply is included in domestic water withdrawal. In addition, the nuclear power station used 4 099.2 million m^3 of water for cooling; while 115.7 million m^3 was considered necessary for fisheries and 1 million m^3 for other non-consumptive uses.

The total quantity of produced wastewater in 1995 was 303.8 million m^3, compared with 446.1 million m^3 in 1990. This fall was mainly the result of reduced industrial production. Of this quantity, 77.9 million m^3, or 26% (22% in 1990), was treated to reach the quality standards, 171.8 million m^3, or 56%, was inadequately treated, and 54.1 million m^3, or 18%, was not treated at all. In 1995, 4.8 million m^3 of wastewater, partly treated in accumulating reservoirs, was re-used for irrigation compared with 44.3 million m^3 in 1990 (Figure 4). The remaining wastewater, both treated and untreated, was not re-used directly but discharged to the rivers.

In recent years, many farmers have no longer been able to afford fertilizers and pesticides. This has led to a significant decrease in their use and their leaching from the soil surface, resulting in a reduction in groundwater pollution.

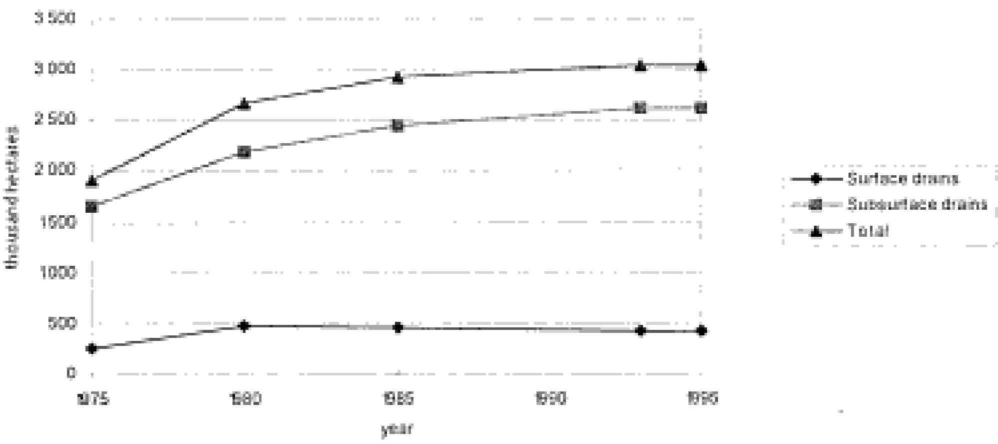
In 1990, the total groundwater abstraction from some 12 000 tube-wells was 497.2 million m^3. In 1995, it fell to 205.2 million m^3 due to reduced industrial consumption and a decrease in domestic water withdrawal. As a result of the increased price of water for domestic purposes, many water consumers have installed water meters and started saving water. This downward trend is expected to be reversed in the near future, when an expected industrial recovery and a rise in living standards should lead to an increase in industrial and domestic water withdrawal.

IRRIGATION AND DRAINAGE DEVELOPMENT

Drainage development

In ancient times, Lithuanians removed excess moisture from fields by furrowing them, using a special way of ploughing, or by making ditches. The first subsurface drainage systems are said to have been installed in 1855. Drainage works increased significantly at the beginning of the twentieth century, starting with the beginning of cultivation in the Nemunas River delta. In 1918, about 5 900 ha were known to be drained. In 1939, 14 800 ha of land were intensively drained, including 11 800 ha by subsurface drainage. In addition, 457 700 ha of land were drained extensively. Around 1 million ha of wetland had been drained by 1970 and 2 million ha by 1978. In 1995, the total drained area was estimated at about 3 million ha, of which 2.6 million ha, or 86%, were equipped with subsurface drainage systems (Figure 5). The total length of subsurface drainage lines is almost 1.6 million km. It is calculated that drainage systems have been installed on 90% of the area needing drainage, which is estimated at almost 3.4 million ha.

FIGURE 5
Evolution of the drained areas



The present cost of drainage installation is $US 1 700-2 000/ha. The additional grain crop harvest on drained lands is about 0.8-0.9 t/ha, or 25-30%.

Drainage is usually carried out in conjunction with specific cultural practices: removing shrubs and stumps, gathering stones, ploughing drained swamps and fallow lands. However, sometimes too many shrubs are removed, resulting in an increase in soil erosion. For this reason, serious attention is now being paid to environmental protection. The construction of new drainage systems has been suspended, and efforts are being made to maintain earlier installed drainage systems in a proper condition.

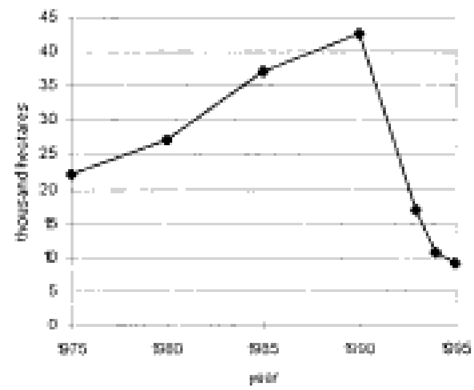
Irrigation development

In the Nemunas River delta, about 40 000 ha of meadows in polders are protected by dams against flooding. About 100 pumping stations have been installed to remove excess water in periods of flood. However, initially this led to moisture deficit in dry periods. This problem was solved by the installation of sluices in the polders, enabling both the water level in the ditches to be regulated and irrigation in the driest periods. In 1976, 2 200 such systems, called sluice systems, were exploited. However, these systems were not used for long as sprinkler irrigation soon proved to be a more effective system of irrigation under Lithuanian conditions.

Since 1965, a lot of research on sprinkler irrigation has been carried out in the country. The first sprinkler irrigation systems were installed in 1965 in the Kaunas and Kėdainiai districts in the centre of the country, where for some time domestic wastewater was used for irrigation. However, after an outbreak of cholera in the region in about 1970, the use of domestic wastewater for irrigation was forbidden.

In the period 1973-1985, 33 industrial pig complexes were built in the country. Irrigation systems were installed on 6 600 ha close to these complexes, using the dung as fertilizer.

FIGURE 6
Evolution of irrigation



The construction of irrigation systems is rather expensive, on average $US 7 500/ha, because of the need for reservoir construction. The average cost of O&M is estimated at $US 250/ha per year. Nevertheless, irrigation systems have increased rapidly. By the end of 1970, irrigation covered 5 100 ha; in 1975 and in 1990 it was 22 300 and 42 700 ha respectively.

During the Soviet period, large irrigation systems were installed (100-200 ha) on *kolkhoz* (collective farms) and *sovkhoz* (state farms). After they were broken up, private owners started working on small plots (8-20 ha) and many of the large irrigation systems stopped functioning. This is the reason for the rapid decrease in irrigation in recent years. While 42 700 ha were equipped for irrigation in 1990, only 9 247 ha were left equipped for irrigation in 1995 (Figure 6). The rest of the system has largely been destroyed, as farmers have not been interested in using large, costly irrigation schemes.

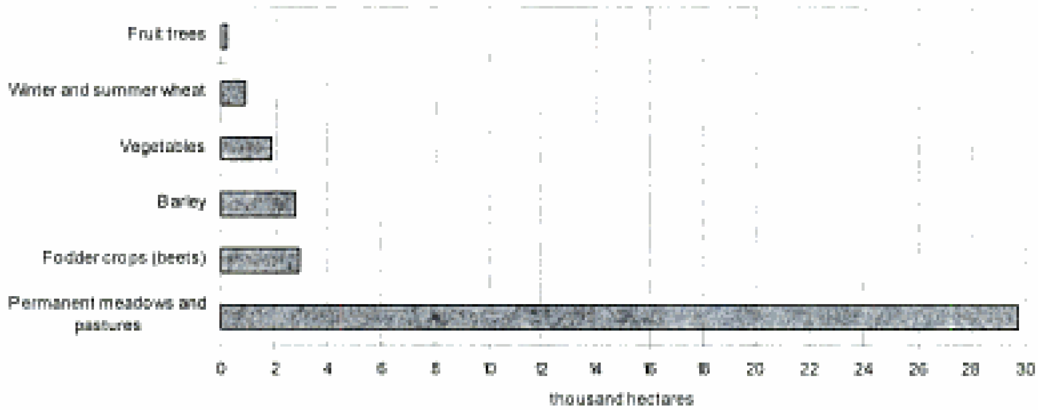
Of the total actually irrigated area of 38 400 ha in 1990, 29 700 ha (77%) consisted of meadows and pastures. The remaining part was covered by fodder crops (beets), barley (spring crop), vegetables and wheat. Some 200 ha of gardens were irrigated (Figure 7). In 1994, the main rainfed crops were cereals (46%); fodder crops, including grasses (46%); and potatoes (5%).

INSTITUTIONAL ENVIRONMENT

The main institutions involved in water resources management are:

- The Ministry of Agriculture and Forestry. It is responsible for land reclamation and irrigation. The Land Reclamation Division within the Ministry is responsible for design, equipment, maintenance, land reclamation planning and research.

FIGURE 7
Irrigated crops
Total: 38 400 ha in 1990



- The Water Division within the Ministry of Environmental Protection. It is responsible for monitoring design, construction, equipment, maintenance, water planning, water research, sewerage and sanitation.
- The Association of Land Reclamation Enterprises. This is an independent association of most of the land reclamation companies which has indirect links with the Ministry of Agriculture and Forestry. It is the principal public advisory body to the government on all issues related to the activities of land reclamation enterprises.
- The Ministry of Government Reforms and Local Administrations, the Ministry of Building and Urban Development and the local municipalities. They regulate issues on water supply, sewerage and sanitation.
- The Association of Land and Water Management Engineers. This is a non-governmental organization for water management engineers. It is the principal public advisory body to the government on all matters related to land and water management.

The following laws relating to land and water are in force or under preparation:

- Land Reform Law of 1991;
- Land Reclamation Law of 1994;
- Water law (under preparation), containing sections on: general regulations; water use; water protection and prevention of harmful influences; state registration and planning of use of water sources; responsibility for water law violations.

TRENDS IN WATER RESOURCES MANAGEMENT

Because of the prevailing economic situation, the state can no longer bear the cost of constructing new drainage and irrigation systems, and can only partly cover the maintenance costs of the existing drainage systems. The new farms, which have replaced the *kolkhoz*, are also in a very precarious situation. This means there is a real danger of the progressive destruction of drainage systems. The future of the remaining irrigation systems is also unclear and, moreover, the cost of irrigation has increased due to the rising energy prices. Furthermore, the advisory service that organized the irrigation no longer exists. The state has referred the question of irrigation to the private initiative of farmers and agricultural companies. The Ministry of Agriculture and Forestry limits its activities to the collection of basic data about irrigation systems.

In the future, small-scale irrigation will probably take place more spontaneously under market forces, without government promotion. At present, some farmers are already showing initiative by buying foreign irrigation equipment. Irrigation water charges do not exist, but farmers must obtain an authorization from the Ministry of Environmental Protection to ensure that no damage to the environment will result.

Several wastewater treatment plants have been, or are being, built or reconstructed. In 1996, biological wastewater treatment plants were due to start operating in the city of Vilnius. The primary wastewater treatment plant in Kaunas is almost complete and it should become operational in 1997. The Klaipeda wastewater treatment plant is under reconstruction.

At present, the worst ecological situation exists in the Kulpe River in the north (Lielupe basin), to which wastewater from Siauliai city is discharged, and in the Nevezis River below Panevezys (Nemunas basin). The minimal summer discharges of these rivers are very low and therefore the wastewater has to be carefully treated. Part of the Sventoji river flow in the northeast of the Nemunas basin (from 1 to 4 m^3/s) is used to maintain good sanitary conditions in the Nevezis River. For this purpose, a pumping station has been installed near Kavarskas in the Anyksciai district. The Siauliai wastewater treatment plant needs to be reconstructed and water cleaning efficiency needs to be improved. However, in view of the current economic situation, it is unlikely that these activities will be undertaken in the near future.

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Moldova

GEOGRAPHY AND POPULATION

Moldova is a landlocked country in southeast Europe with a total area of 33 700 km^2. It is bordered in the west by Romania and in the north, east and south by Ukraine. It became independent in 1991. For administrative purposes, Moldova is divided into 42 provinces.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	3 370 000	ha
Cultivable area	1992	2 559 700	ha
Cultivated area	1992	2 201 800	ha
- annual crops	1992	1 735 400	ha
- permanent crops	1992	466 400	ha
Population:			
Total population	1996	4 444 000	inhab.
Population density	1996	132	inhab./km^2
Rural population	1996	47	%
Economically active population engaged in agriculture	1996	30	%
of which: - men	1992	68	%
- women	1992	32	%
Water supply coverage:			
Urban population	1993	100	%
Rural population	1993	100	%

The northern part of the country belongs to the Podole highland and the southern part to the Black Sea lowland. The average altitude is 147 m above sea level. The highest peak is 430 m above sea level and 75% of the country lies below an altitude of 200 m. Black soil, the world's most fertile soil, covers about 75% of Moldova's agricultural land. In the Soviet era, the country, representing only 0.15% of the total area of the Soviet Union, produced 40% of the Soviet Union's tobacco, 10% of its fruits and 5% of its vegetables. However, the country's location makes it prone to marked changes in weather conditions, resulting in fluctuating agricultural production. The agricultural potential is concentrated in two regions:

- the north, with the rich black soils and the fertile Dnestr River valley;
- the south, with its calcium soils (carbonate black soils) and warm climate, which make it particularly suitable for irrigated vineyards, as well as for peach and apricot orchards.

The cultivable area is estimated at almost 2.6 million ha, which is 76% of the total area of the country. In 1992, the cultivated area was estimated at 2.2 million ha, of which 1.7 million ha was occupied by annual crops and 0.5 million ha by permanent crops.

Although nearly 70% of the enterprises in the industrial sector (including food processing) have already been transferred to the private sector, privatization in the agricultural sector is still almost non-existent. According to the latest census (1992), *kolkhoz* (collective farms) occupy 60% of the agricultural land and *sovkhoz* (state farms) 20%. About 19% is in the hands of industrial enterprises and organizations, and only 1.5% is owned by private farms (Figure 1). In 1992, the number of registered private farms was 13 660 with an average area of 2.8 ha.

MOLDOVA

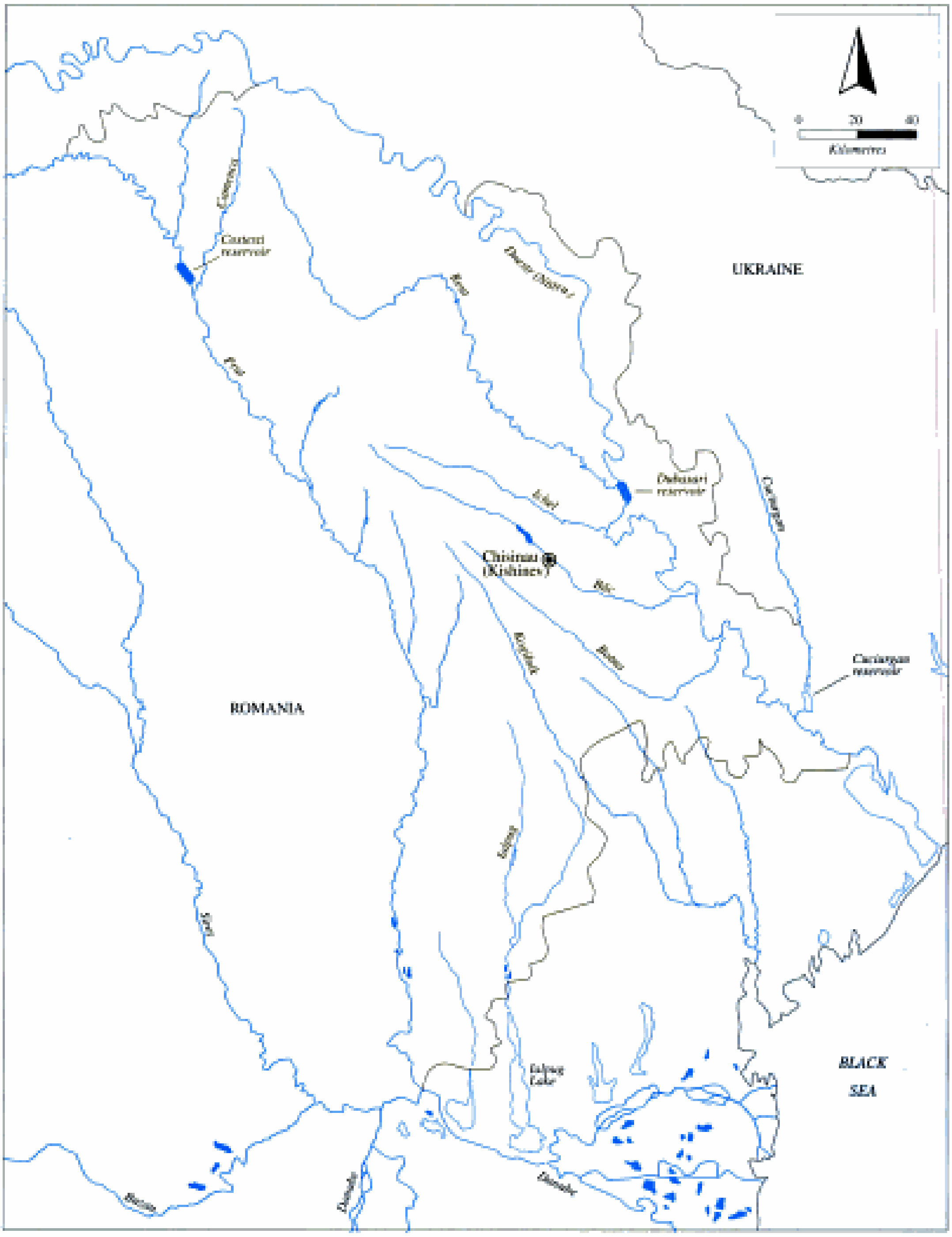
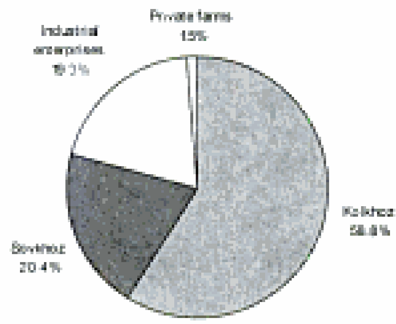

UKRAINE
ROMANIA
Chisinau
(Kishinev)
BLACK
SEA
Kilometres
0
20
40
Costesti
reservoir
Dubasari
reservoir
Cuciurgan
reservoir
Ialpug
Lake
Prut
Danube
Raut
Bic
Botna
Cuciurgan

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		450	mm/yr
		15.2	km^3/yr
Internal renewable water resources		1.0	km^3/yr
Total (actual) renewable water resources	1997	11.65	km^3/yr
Dependency ratio	1997	91.4	%
Total (actual) renewable water resources per inhabitant	1996	2 622	m^3/yr
Total dam capacity	1994	2 022	$10^6\ m^3$
Water withdrawal:			
- agricultural	1992	775	$10^6\ m^3/yr$
- domestic	1992	269	$10^6\ m^3/yr$
- industrial	1992	1 919	$10^6\ m^3/yr$
Total water withdrawal		2 963	$10^6\ m^3/yr$
per inhabitant	1992	673	m^3/yr
as % of total (actual) renewable water resources		25.4	%
Other water withdrawal		-	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater		-	$10^6\ m^3/yr$
- treated wastewater	1992	298	$10^6\ m^3/yr$
- re-used treated wastewater		-	$10^6\ m^3/yr$
Agricultural drainage water		-	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

The total population is about 4.4 million (1996), of which 47% is rural. The average population density is 132 inhabitants/km^2, which is the highest among the countries of the FSU. It ranges from 70 inhabitants/km^2 in the south to more than 200 inhabitants/km^2 in the central part of the country. Between 1988 and 1992, the population growth rate was 1.1% a year. Between 1992 and 1993, the population growth rate was negative, -0.3%, but has since risen again. In 1996, agriculture employed 30% of the economically active population. In 1992, women made up 32% of the agricultural labour force. About 25% of the total female labour force and 45% of the total male labour force are engaged in agriculture. In 1992, agriculture accounted 25% of GDP. Moldova's GDP declined by 40% between 1991 and 1994. In 1995, an increase of 0.3% was estimated, with an increase of 6% forecast for 1996.

FIGURE 1
Land categories
Total: 2.56 million ha in 1992



CLIMATE AND WATER RESOURCES

Climate

The average annual precipitation is estimated at 450 mm. Two climatological zones can be distinguished:

TABLE 3
Irrigation and drainage

Irrigation potential	1994	1 500 000	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1994	312 000	ha
- surface irrigation	1994	305 000	ha
- sprinkler irrigation	1994	3 400	ha
- micro-irrigation	1994	3 600	ha
% of area irrigated from groundwater	1994	0	%
% of area irrigated from surface water	1994	100	%
% of area irrigated from non-conventional sources	1994	0	%
% of equipped area actually irrigated		-	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1+2+3)	**1994**	**312 000**	**ha**
- as % of cultivated area		14.2	%
- increase over last 10 years	1985-94	11	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production		-	t
as % of total grain production		-	%
Harvested crops under irrigation	**1986**	**300 000**	**ha**
- permanent crops: total	1986	43 100	ha
- annual crops: total	1986	256 900	ha
. fodder crops	1986	103 200	ha
. cereals	1986	66 000	ha
. potatoes and vegetables	1986	66 000	ha
. sugar beet and sunflower	1986	18 300	ha
. other annual crops	1986	3 400	ha
Drainage - Environment:			
Drained area	1992	42 000	ha
- drained area in full or partial control irrigated areas	1992	29 400	ha
- drained area in equipped wetland and i.v.b.	1992	0	ha
- other drained area	1992	12 600	ha
- area with subsurface drains	1992	290 400	ha
- area with surface drains	1992	12 600	ha
Drained area as % of cultivated area		1.9	%
Power drained area as % of total drained area		-	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

- The semi-arid and warm zone of steppe, covering the south of the country (45%). The average annual precipitation varies from 370 mm in the extreme south to 450 mm in the southern part of the Dnestr valley, concentrated between May and October. Average temperatures vary between -3°C in January and 22°C in July.

- The moderately warm zone of forested steppe, covering the northern and central parts of the country (55%). The average annual precipitation varies from 420 mm in the central part to 550 mm in the north, concentrated between May and October with the peak in June or July. Average temperatures vary between -4.5°C in January and 20.5°C in July.

River basins and water resources

The country can be divided into three main river basins:

- The Dnestr (called 'Nistru' in Moldova) basin. It covers about 57% of the country. The Dnestr rises in Ukraine and forms the border between Ukraine and Moldova in parts of the north, northeast and southeast before flowing back into Ukraine, where it continues for some 20 km before reaching the Black Sea with an average annual discharge of 10 km^3.

- The Danube basin. It covers about 35% of the country. The Prut River, a tributary of the Danube, rises in Ukraine and forms the border between Moldova and Romania before flowing into the Danube just after crossing the border into Ukraine. The Danube River then continues for about 125 km before flowing into the Black Sea. Where the Prut River becomes the border between Romania and Moldova, its average annual flow is estimated at 2.9 km^3. Its average discharge into the Danube is also estimated at 2.9 km^3/year, which would mean that all the water generated between the northern and southern parts within Moldova and Romania is used. There are a number of small seasonal tributaries of the Danube in southern Moldova that flow into the Danube after having crossed the border to Ukraine.

- The southern basins. In the south of the country, between the Dnestr and the Danube basins, several other rivers rise and flow across the border into Ukraine and then into the Black Sea. Their basins cover about 8% of the country.

Renewable Surface Water Resources (RSWR) by river basin

Name of basin	Part of total area (%)	Internal RSWR km^3/year	Inflow		Total RSWR km^3/year	Outflow to
			km^3/year	from		
Dnestr	57	0.65	9.2	Ukraine	9.85	Ukraine
Danube:	35	0.29	1.45		1.74	
of which: - Prut		0.24	1.45	Border with Romania	1.69	Ukraine
- Other		0.05	-		0.05	Ukraine
Southern basins	8	0.06	-		0.06	Ukraine
Total	100	1.00	10.65		11.65	

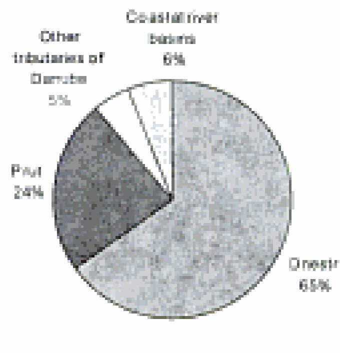
The total IRSWR are estimated at 1.00 km^3/year (Figure 2). The total ARSWR are estimated at 11.65 km^3/year. About 45% of the discharge of the Dnestr and Prut rivers takes place during the spring season due to snow melt in their upper catchment areas in Ukraine.

The average annual renewable groundwater resources are estimated at 0.4 km^3, but the water is often too mineralized to be used for domestic or irrigation purposes. The groundwater flow is estimated to be drained out into the river system (overlap) and therefore does not contribute to the IRWR.

FIGURE 2

Internal renewable surface water resources by major basin

Total: 1 km^3/year



International agreements

The legislation of the FSU on water sharing issues still applies. This concerns the agreement with Romania of the 1960s on a 50-50% share of the water of the bordering Prut River and the former internal regulations between the Soviet republics. Under these regulations, Moldova has the right to use the water stored in the Cuciurgan reservoir on the border with Ukraine and in the Costesti reservoir on the Prut, as well as to construct tanks on the tributaries of the border rivers.

Lakes and dams

There are few natural lakes in Moldova. The largest one is Lake Beleu in the Prut valley with a surface area of 6.3 km^2.

There are 2 519 artificial tanks in Moldova, constructed for irrigation purposes, flow regulation and fishing pools. Most are small tanks for local use with a surface area of up to 3 ha. Their total storage capacity is 2.02 km^3, which is equal to more than twice the IRWR of the country.

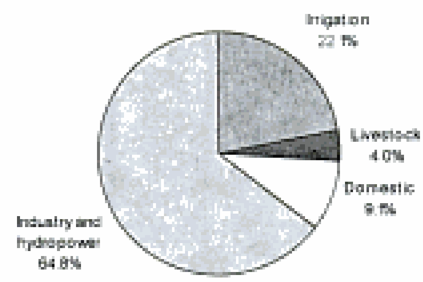
Artificial tanks in Moldova

Name of basin	Number of tanks	Total capacity million m^3	Year of construction
Dnestr	1 219	626	
of which:			
- Dubasari reservoir		485	1954
- Cuciurgan reservoir		88	1964
Danube (mainly Prut)	1 175	1 355	
of which:			
- Costesti reservoir		1085	1976
Southern basins	125	41	
Total	2 519	2 022	

Water use and wastewater

In 1992, the total water use was estimated at 2 963 million m^3. This includes the use of water for hydropower. Of this total, 22% was used for irrigation purposes (Figure 3). The quantity of treated wastewater amounted to 296 million m^3 in 1992.

FIGURE 3
Water use
Total, incl. hydropower: 2 963 million m^3 in 1992



IRRIGATION AND DRAINAGE DEVELOPMENT

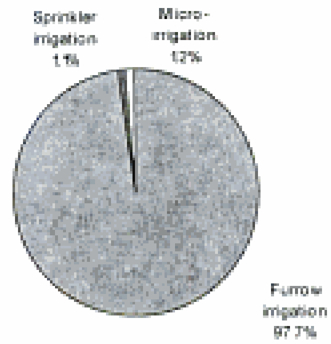
Irrigation development

Between 1918 and 1940, when the part of Moldova to the west of the Dnestr River was part of Romania, the first tanks were constructed in the Prut basin. Large-scale water resources development started after the Second World War when the country was part of the Soviet Union.

In 1994, irrigation was estimated to cover 312 000 ha. The irrigation water is stored in reservoirs and tanks, built on the rivers, and pumped into the main irrigation canals. The three largest schemes are: the Rabnita in the Dnestr valley, with a total area of 24 000 ha; and the Suklei and Etuliy irrigation schemes, with an area of 10 000 ha each.

Furrow irrigation is practised on about 98% of the area equipped for irrigation (305 000 ha). Micro-irrigation is used on 3 600 ha of orchards and vineyards. On the remaining area, sprinkler irrigation is used for some vegetables and on some permanent meadows (Figure 4). However, other sources indicate that most of the irrigated land is equipped with sprinkler irrigation, a large part of the equipment being out of use. No groundwater is used for irrigation due to its unsuitable quality.

FIGURE 4
Irrigation techniques
Total: 312 000 ha in 1994

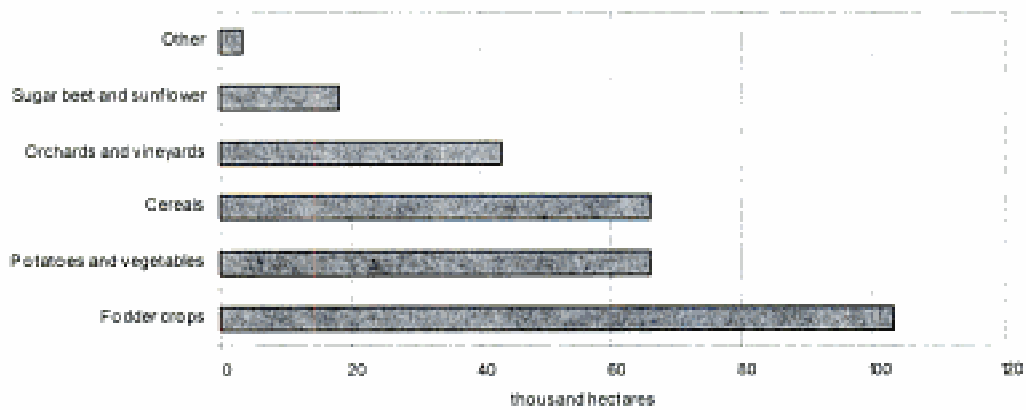


Irrigation is mainly concentrated in the central and southern parts of the country, in the Dnestr and Prut valleys. Between 1985 and 1992, an average of 2 500 ha/year were equipped for irrigation.

The irrigation potential has been estimated at 1.5 million ha. About 30% of this irrigation potential, or 500 000 ha, is located in the Dnestr basin, 200 000 ha in the area surrounding the Costesti reservoir on the Prut River, and another 200 000 ha in the extreme south, if using water stored in the Ukrainian Ialpug and Cahul lakes close to the border. The remaining areas consist of extension possibilities of the existing schemes (mainly in the Dnestr basin) and of areas scattered all over the country. On most of these lands, rainfed agriculture is currently practised or they are used as pastures. The anticipated water requirements for the development of the irrigation potential are estimated at 4.5-5 km^3/year. The problem in general is the low water quality: soil analyses have revealed that after 10-15 years of irrigation some soils have become highly alkaline.

In 1986, about 34% of the irrigated land was used for the production of fodder crops, 22% for potatoes and vegetables (mainly tomatoes), and 22% for cereal production (mainly winter wheat and maize). Orchards and vineyards occupied another 15% of the irrigated area (Figure 5). About 70% of the country's vegetable production, 28% of its potato production and 30% of the production of fodder crops comes from irrigated land. In 1982, the yield of irrigated wheat reached 4.0-4.2 t/ha and the yield of irrigated maize over 5 t/ha, while on rainfed land the yields were 3.3 and 3.6 t/ha respectively.

FIGURE 5
Irrigated crops
Total: 300 000 ha in 1986

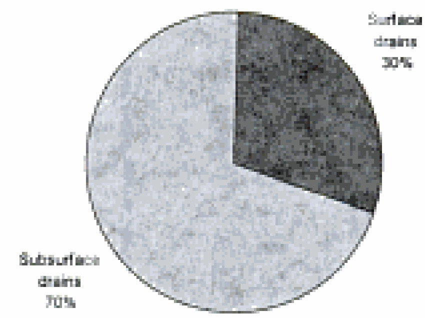


Water charges were introduced in the Soviet Union in 1982, varying from one region to another, but never actually collected. It is expected that they will be enforced in Moldova, in connection with land privatization.

Drainage development

In 1992, the drained area was estimated at 42 000 ha. About 70% was equipped with subsurface drains, usually pipes, located in the area equipped for irrigation (Figure 6). Drainage is mainly concentrated in the central and southern parts of the country. It is planned to reclaim and drain about 200 000 ha in the river valleys in the south.

FIGURE 6
Drainage techniques
Total: 42 000 ha in 1992



INSTITUTIONAL ENVIRONMENT

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

- The Ministry of Agriculture and Food. In the early 1990s its Department of Water Resources was replaced by the state consortium 'AQUA', which is associated to the Ministry and responsible for the planning of and investment in irrigation and drainage.

- The Ministry of Communal Services and Exploitation of Natural Resources, with its Department of Water Supply for Domestic Use and Wastewater Treatment.

- The State Office of Protection of Natural Resources, an independent government institution. Its Department of Licensing of Use of Natural Resources authorizes irrigation and drainage projects.

- Several scientific institutions:

  The Agrarian University in Chisinau with its Faculty of Hydraulics;
  The Research Institute of Irrigated Cultures in Balti, in the north of the country;
  The A. N. Dimo Memorial Agricultural Institute in Chisinau;
  The Agrarian Section of the Academy of Sciences in Chisinau.

TRENDS IN WATER RESOURCES MANAGEMENT

At present, the government of Moldova's main interest is the extension of the irrigation of plantations (orchards and vineyards). Under the 1996-2000 Five Year Plan, irrigation development on 25 000 ha of new plantations is planned. The following two five year plans, envisage irrigation development on 28 000 ha and 30 000 ha respectively. This corresponds to an average annual development of 5 000, 5 600 and 6 000 ha respectively. In the period 1985-1992, an average of 2 500 ha/year were developed for irrigation.

Another target is the replacement of the outdated irrigation and drainage equipment on about 10 000 ha within the next few years.

While there are plans to privatize the agricultural sector, so far privatization has mainly been limited to the industrial sector.

The two main rivers of Moldova, the Dnestr and Prut, are fairly polluted. An international programme exists for the protection of the Danube, especially its delta, and the Prut River is part of this programme. An environmental protection campaign is being conducted through the media. This includes reports on the dangers of the pollution of the Dnestr and Prut rivers.

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Russian Federation

GEOGRAPHY AND POPULATION

With a total area of over 17 million km^2, the Russian Federation is the largest country in the world. It covers the eastern part of Europe and the northern part of Asia. It has access to the Arctic Ocean in the north, the Pacific Ocean in the east, the Black Sea and the Caspian Sea in the southwest, and the Baltic Sea in the northwest. It borders 14 countries: Korea DPR, China, Mongolia, Kazakhstan, Azerbaijan, Georgia, Ukraine, Belarus, Latvia, Estonia, Finland, Norway and, with the province (*oblast*) of Kaliningrad, Poland and Lithuania.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	1994	1 707 540 000	ha
Cultivable area	1994	686 900 000	ha
Cultivated area	1994	116 900 000	ha
- annual crops	1994	114 900 000	ha
- permanent crops	1994	2 000 000	ha
Population:			
Total population	1996	148 126 000	inhab.
Population density	1996	9	inhab./km^2
Rural population	1996	24	%
Economically active population engaged in agriculture	1996	12	%
of which: - men	1994	62	%
- women	1994	38	%
Water supply coverage:			
Urban population	1994	84	%
Rural population	1994	33	%

The Soviet Union came to an end in late 1991 and the Russian Federation emerged as one of the 15 newly independent former Soviet republics. Administratively, the Russian Federation is divided into 89 units, which are autonomous and self-governing members of the Russian Federation. Each unit has a separate agreement with the Russian Federation and, usually, a differing degree of autonomy. The Russian Federation is also divided into 11 economic regions, plus Kaliningrad, presently considered as the twelfth region and which previously formed one economic region with the Soviet republics of Lithuania, Latvia and Estonia.

The Russian Federation is exceptionally rich in natural resources. It is a major producer of most types of minerals and for many of them it is the world's leading producer and exporter. In particular, the Russian Federation has vast reserves of fuels and metal ores, including significant deposits of gold-bearing ore. The agricultural production potential is distributed extremely unevenly and is limited mainly to the south of the European part and small areas on the southern fringes of Siberia as well as areas in the far east region. This distribution reflects the zonal diversification of the natural environment, from ice deserts in the north, through tundra, coniferous woods (*taiga*), mixed woods, to the fragments of steppes and semi-deserts in the south.

The Russian Federation is formed of three vast, low plains: the east European plain and the west Siberian plain, divided by the Ural mountains, and the Caspian plain in the south. In the northern part of the lowlands there are young glacial formations and swamps, especially in the west Siberian plain. South of the lowlands there is a belt of loess with fertile black soils. In the European part, there are poor semi-desert and desert soils south of the loess belt. In central and southern Siberia and in the far east, mountains of medium height predominate,

RUSSIAN FEDERATION

TABLE 2
Water: sources and use

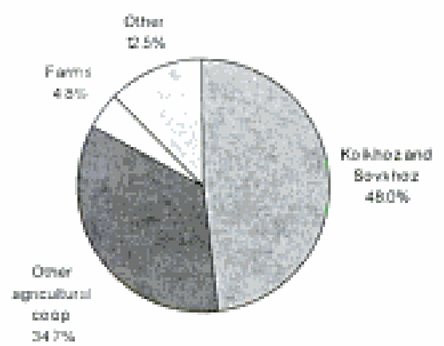
Renewable water resources:			
Average precipitation		589	mm/yr
		10 057	km^3/yr
Internal renewable water resources		4 312.70	km^3/yr
Total (actual) renewable water resources	1997	4 498.24	km^3/yr
Dependency ratio	1997	4.1	%
Total (actual) renewable water resources per inhabitant	1996	30 368	m^3/yr
Total dam capacity	1992	360 000	10^6 m^3
Water withdrawal:			
- agricultural	1994	15 300	10^6 m^3/yr
- domestic	1994	14 300	10^6 m^3/yr
- industrial	1994	47 500	10^6 m^3/yr
Total water withdrawal		77 100	10^6 m^3/yr
per inhabitant	1994	518	m^3/yr
as % of total (actual) renewable water resources		1.7	%
Other water withdrawal	1992	7 430	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1990	33 880	10^6 m^3/yr
- treated wastewater	1990	5 080	10^6 m^3/yr
- re-used treated wastewater		-	10^6 m^3/yr
Agricultural drainage water		-	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

with a peak of 4 506 m above sea level (Bielukha in Altay). The highest mountains are situated in the Caucasus (up to 5 642 m above sea level).

Russian statistics consider the area of lands belonging to all kinds of agricultural farms as an equivalent to cultivable land. In 1994, this area amounted to almost 687 million ha, which is 40% of the total area of the country. The cultivated area was estimated at almost 117 million ha, including almost 115 million ha of annual crops and 2 million ha of permanent crops.

Beginning in late 1990, a set of laws, decrees and resolutions opened the way for land reform in the Russian Federation. This legislation established the right to private ownership of land, restructured *sovkhoz* (state farms) and *kolkhoz* (collective farms), and laid the legal basis for the establishment and operation of private family farms. However, in 1995, less than 5% of the agricultural land was occupied by family farms (Figure 1).

FIGURE 1
Land categories
Total: 686.9 million ha in 1995



The total population is about 148 million (1996), of which 24% is rural. The population growth was low in the 1980s, falling to -0.6% in 1994. The average population density is about 9 inhabitants/km^2. The most densely populated area is the central region, where the capital Moscow is located, with 62 inhabitants/km^2, followed by Kaliningrad with 61 inhabitants/km^2. The least densely populated regions are eastern Siberia and the far east with 2 and 1 inhabitants/km^2 respectively. About 76% of the total population is urban and it is estimated that about 74% of the population lives in cities and large towns.

TABLE 3
Irrigation and drainage

Irrigation potential	1990	29 000 000	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1990	6 124 000	ha
- surface irrigation	1990	245 000	ha
- sprinkler irrigation	1990	5 879 000	ha
- micro-irrigation	1990	0	ha
% of area irrigated from groundwater		-	%
% of area irrigated from surface water		-	%
% of area irrigated from non-conventional sources		-	%
% of equipped area actually irrigated	1994	79	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1 + 2 + 3)	**1994**	**5 158 000**	**ha**
- as % of cultivated area		4.4	%
- increase over last 10 years	1985-94	minus 11	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production		-	t
as % of total grain production		-	%
Harvested crops under irrigation	**1994**	**4 095 000**	**ha**
- permanent crops: total	1994	0	ha
- annual crops: total	1994	4 095 000	ha
. fodder crops	1994	2 553 000	ha
. cereals and pulses	1994	1 217 000	ha
. potatoes and vegetables	1994	208 000	ha
. industrial plants (mainly sugar beet)	1994	117 000	ha
Drainage - Environment:			
Drained area	1994	5 027 000	ha
- drained area in full or partial control irrigated areas	1990	1 286 000	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1990	3 238 000	ha
- area with surface drains	1990	4 161 000	ha
Drained area as % of cultivated area		-	%
Power drained area as % of total drained area		-	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

The largest city is Moscow with 8.8 million inhabitants, followed by Saint Petersburg with 4.9 million inhabitants and 11 cities of 1-2 million inhabitants.

In 1996, agriculture employed 12% of the economically active population. In 1994, women made up 51% of the total labour force. In 1994, 38% of the total labour force was engaged in agriculture, down from 42% in 1980. About 11% of the total female labour force and 18% of the total male labour force is engaged in agriculture. In 1993, agriculture accounted for 16% of GDP. Inflation reached 880% in 1993, 320% in 1994 and 150% in 1995.

CLIMATE AND WATER RESOURCES

Climate

Seven climatic zones can be distinguished within the Russian Federation. Their main features are presented in the table below. In large regions, temperature is a major constraint on cropping.

Climatic zones in the Russian Federation

Climate type	% of area of country	Region	Temperatures (°C)	
			warmest month	coldest month
Polar	5%	far north	0	
Subpolar	10%	north	10	
Moderately cool	50%	half of country, with continental features increasing towards east	20	-20
Moderately cool, maritime	2%	the coast near Japan	16	-10 to -16
Moderately warm	18%	Moscow region (continental) and near the Baltic Sea (transitional)	16 to 20	0 to -16
Moderately warm, semi-dry	10%	at the shore of the Sea of Azov, in the Volga region and in the southern fringes of Siberia	20	-10
Moderately warm, dry	5%	northeastern foot of Caucasus up to the Volga mouth	20 to 25	0 to -10

Precipitation in the Russian Federation ranges from less than 200 mm/year at the mouth of the Volga River in the southwest of the country, in the central part of the far east (Yakutsk), and on the Arctic Ocean coast east of the mouth of the Lena River; up to 1 000 mm in the mountains of the far east. The annual precipitation ranges from 400 to 500 mm in most areas of the European part and western Siberia, and from 300 to 400 mm in central and eastern Siberia. The average annual precipitation for the country as a whole is 589 mm.

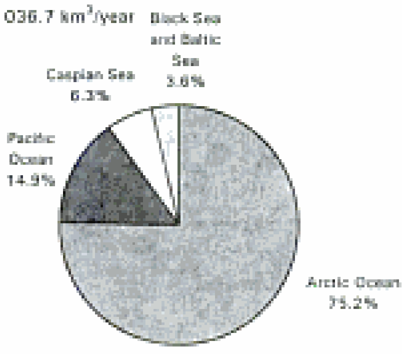
River basins and surface water resources

Most of the freshwater resources of the Russian Federation are contained in the permafrost which covers the north of the European part and western Siberia, all central and eastern Siberia and almost all the far east region. These resources, as well as the glaciers in the Arctic islands, in the Ural mountains and in the mountains of southern Siberia, are of no practical use.

FIGURE 2

Internal renewable surface water resources by major basin group

Total: 4 036.7 km^3/year



It is only possible to use the resources of rivers, lakes and groundwater. There are 120 000 rivers over 10 km long. Their total length within the Russian Federation equals 2.3 million km, their total discharge to the sea is estimated at almost 4 202 km^3/year and to other countries at 20.4 km^3/year. About 12.2 million km^2, or 71% of the total area of the country, drain towards the north into the Arctic Ocean; 2.4 million km^2, or 14%, drain towards the east into the Pacific Ocean; and 1.6 million km^2, or 10%, drain towards the south into the Caspian Sea. The remaining 5% drain towards the southwest into the Black Sea and the Sea of Azov and towards the west into the Baltic Sea.

Of the total annual RSWR, estimated at 4 222.24 km^3, 185.54 km^3 come from neighbouring countries, the remaining 4 036.7 km^3 being generated inside the country (Figure 2).

The rivers of the Russian Federation freeze for from one month in the southwest between the Caspian and the Black Sea, up to 8 months and longer in the northern part of Siberia and the far east region.

Renewable Surface Water Resources (RSWR) by major river basin

Name of river	Major region within The Russian Fed.	Area of basin total 1000 km²	Area of basin Rus.Fed. 1000 km²	Internal RSWR km³/year	Inflow km³/yr	Inflow from:	Total RSWR km³/year	Outflow to:
Arctic Ocean:								
Severnaya Dvina	Northern	358	358	148.0	-		148.0	White Sea
Pechora	Northern	322	322	129.0	-		129.0	Barents Sea
Ob	Ural, W.Siberia	2 990	2 330	364.0	38.0	Kazakhstan	402.0	Kara Sea
Yenisey	Siberia	2 580	2 180	605.0	25.0	Mongolia	630.0	Kara Sea
Pyasina	Eastern Siberia	182	182	82.0	-		82.0	Kara Sea
Lena	E.Siberia, F.East	2 470	2 470	532.0	-		532.0	Laptev Sea
Khatanga	Eastern Siberia	422	422	88.0	-		88.0	Laptev Sea
Olenek	Far East	219	219	34.0	-		34.0	Laptev Sea
Indigirka	Far East	360	360	55.0	-		55.0	East Siberia Sea
Kolyma	Far East	647	647	128.0	-		128.0	East Siberia Sea
Other rivers		2 660	2 660	872.0	-		872.0	
Subtotal		**13 210**	**12 150**	**3 035.0**	**63.0**	**Subtotal**	**3 098.0**	**Subtotal**
Pacific Ocean:								
Amur	E.Siberia, F.East	1 855	780	225.0	100.0	Mongolia, China	325.0	Sea of Okhotsk
Kamchatka	Far East	56	56	33.0	-		33.0	Pacific
Anadyr	Far East	191	191	53.0	-		53.0	Bering Sea
Other rivers		1 412	1 412	290.0	-		290.0	
Subtotal		**3 514**	**2 439**	**601.0**	**100.0**	**Subtotal**	**701.0**	**Subtotal**
Caspian Sea:								
Volga	Volga	1 360	1 360	230.0	-		230.0	Caspian Sea
Ural	Ural	270	110	5.0	-		5.0	Kazakhstan
Other rivers		160	160	20.0	-		20.0	
Subtotal		**1 790**	**1 630**	**255.0**	**0.0**	**Subtotal**	**255.0**	**Subtotal**
Black/Baltic:								
Dnepr	Central	558	135	8.2	-		8.2	Belarus
Don	N.Cauc., C.Tche.	422	400	34.3	2.7	Ukraine	37.0	Black Sea
Kuban	N.Caucasus	58	58	13.0	-		13.0	Black Sea
Western Dvina	Central	88	8	7.2	-		7.2	Belarus
Neva	Northern	281	220	66.0	16.0	Finland	82.0	Baltic Sea
Pregel	Kaliningrad	15	12	1.0	2.0	Lithuania, Poland	3.0	Baltic Sea
Nemunas	Kaliningrad	98	2	1.0	0.84	Lith, Belar, Poland	1.84	Baltic Sea
Other rivers		23	21	15.0	1.0	Estonia/Latvia/other	16.0	Black/Baltic/other
Subtotal		**1 543**	**856**	**145.7**	**22.54**		**168.24**	**Subtotal**
TOTAL RUSSIAN FEDERATION		**20 057**	**17 075**	**4 036.7**	**185.54**		**4 222.24**	**TOTAL RUSSIAN FEDERATION**

Groundwater resources

The renewable groundwater resources are estimated at 788 km³/year. This figure, however, does not include resources in the form of inland ice, glaciers and pergelisol (permafrost). For the regions of western and eastern Siberia alone, the quantity of ice of the arctic islands is estimated at 5 000 km³ and that of the mountain glaciers at 170 km³. The resources in the form of pergelisol are even larger. The overlap between surface water and groundwater resources has been estimated at 512 km³/year.

Water resources distribution

Water resources in the Russian Federation are very unevenly distributed in relation to the population. The European part, where 80% of the total population lives, has 360 km³ of surface water resources, which is about 8% of the total river runoff, and 23 km³ of groundwater resources, which is 10% of the total renewable annual groundwater resources. In the Terek basin draining into the Caspian Sea in the southwest (northern Caucasus region) and in the Western Dvina basin in the west (central region), the annual river discharge is about 2 000-3 000 m³ per inhabitant, while in the Siberian and far east basins it reaches 120 000-190 000 m³ per inhabitant. The water resources in the densely populated Povolze (Volga region) with its rich soils and in the black soils region (central Tchernozem) in the European part are estimated at around 2 000 m³/inhabitant per year. The huge distances between the Siberian and European basins make it practically impossible to transfer water from Siberia to Europe. Transfer projects were considered in the past but encountered several problems, including environmental ones.

International agreements

During the Soviet period, an agreement concerning the use of water of the Amur River was concluded with China. Renegotiated and modified since 1991, the latest agreement was signed in 1996. There are also agreements with other neighbours (Poland, Finland). These are general agreements, fixing the borders, including texts on crime issues, fishery, the prevention of pollution in river courses, etc. There have been no new international agreements on water sharing with the other countries of the FSU, and the inter-republic arrangements from the Soviet period are still in force.

Lakes and dams

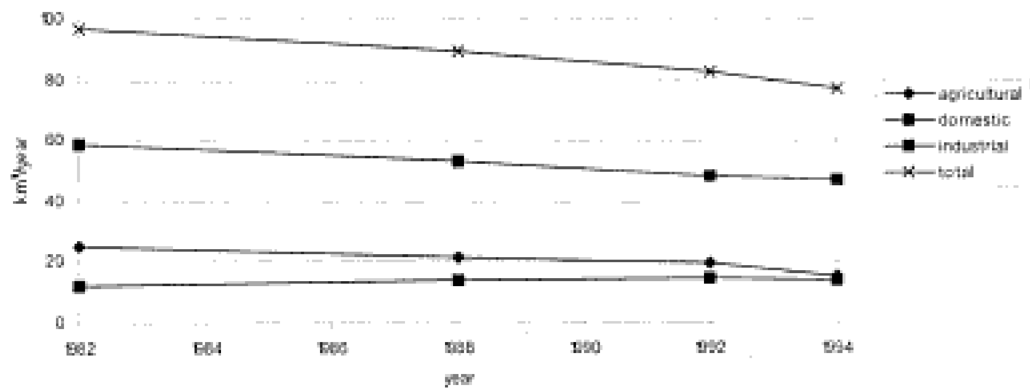
There are about two million fresh- and saltwater lakes in the Russian Federation. The largest saltwater lake is the Caspian Sea, surrounded by the Russian Federation, Kazakhstan, Turkmenistan, Iran and Azerbaijan. The largest freshwater lake is Lake Baikal, located entirely within the Russian Federation in the southeast of eastern Siberia.

Dams have been constructed on most large rivers in the Russian Federation, mainly for electrical energy production, but also for irrigation. There are 330 large reservoirs in use at present, with a capacity of more than 200 million m^3 each. Their total capacity is 360 km^3. There are about 3 000 medium-sized reservoirs. The gross theoretical hydropower potential is estimated at 2 900 000 GWh/year and the economically feasible potential is estimated at 852 000 Gwh/yea. The hydropower installed capacity is estimated at 40 GW.

Water withdrawal and wastewater

In 1982, the water withdrawal was 97.8 km^3, while in 1994 it had dropped to 77.1 km^3 (Figure 3). This reduction in water consumption, which concerns industrial and irrigation water withdrawal, has been related to the difficult economic situation in the Russian Federation, which worsened in 1990. Of the total water withdrawal of 77.1 km^3 in 1994 for domestic, agricultural and industrial purposes, almost 20% was used for irrigation (Figure 4).

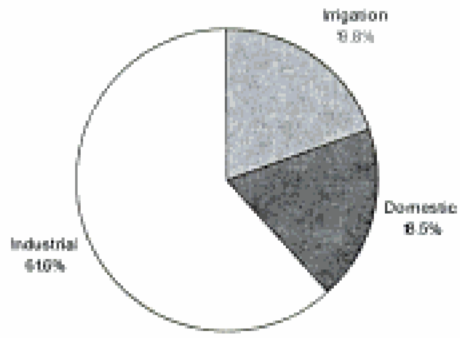
FIGURE 3
Evolution of water withdrawal



Only a small quantity of wastewater undergoes treatment. In 1990, the quantity of produced wastewater was estimated at about 33.9 km^3, of which only 5.1 km^3, or 15%, was partly or fully treated.

Pollution in most industrial centres has reached dangerous levels and rivers have been severely polluted. The country has a long history of serious environmental accidents, especially in the fuel and chemical industries.

FIGURE 4
Water withdrawal
Total: 77.1 km^3 in 1994



IRRIGATION AND DRAINAGE DEVELOPMENT

Larger scale irrigation and drainage works started at the beginning of the eighteenth century. The main goal of the water works was not the development of agriculture, but to use the water to generate power for the mines and steelworks of the southern Urals, and to drain areas near the then capital, Saint Petersburg. However, the damming up of water in the neighbourhood of the Urals also enabled the development of irrigation, while the drainage works turned some of the swamps into cultivable land. During the nineteenth century, irrigation developed slowly, mainly outside the territory of today's Russian Federation. In 1894, the first government land improvement institution was established, called the Department of Land Improvement, and water legislation was introduced in 1902. In 1916, about 214 000 ha of irrigated land and 890 000 ha of drained land were used for agriculture within the territory of the present Russian Federation. A sudden acceleration in drainage and irrigation work took place between 1920 and 1931, in connection with the great electrification programme (GOELRO). Initially, electrification always had priority over irrigation and drainage. Only in the 1950s, during the construction of the Volga cascade reservoirs, did irrigation become as important as hydro-electricity in water development design. In 1967, the irrigated area was 1.62 million ha, which was eight times the irrigated area of 1916, while the drained area of 1.64 million ha was almost twice that of 1916. By the end of the 1980s, every year, up to 200 000 ha of newly irrigated areas and 160 000 ha of newly drained areas were given for agricultural use. However, the scale of the negative effects resulting from the drying up of swamps and from the salinization of irrigated areas was increasing. The rhythm of development of irrigation and drainage work slowed down at the beginning of the 1990s.

Irrigation development

Based on climate and soil conditions, it is estimated that 15-20% of the cultivable area needs irrigation in the moderately warm dry semi-desert zone, 5-8% in the moderately warm semi-dry steppe zone, 2-5% in the moderately warm semi-dry forested steppe zone, and 1-2% in the moderately warm forest zone. Figures for irrigation potential are estimated at almost 29 million ha under permanent irrigation. Other sources give a potential of more than 74 million ha of complementary irrigation.

In 1990, irrigation covered 6.12 million ha. In 1994, however, it had fallen to 5.16 million ha, which was equal to about 4.4% of the cultivated area (Figure 5). One reason for the decrease has been the economic recession. The sprinkler systems (accounting for almost 96%

of the area equipped for irrigation in 1990) are overused, and there is no maintenance and operation system. This progressively results in the complete destruction and subsequent abandonment of the schemes. Another reason might be that in the past the statistics were overestimated; the figures for more recent years seem to be more reliable. The largest irrigation development has taken place in the north Caucasian and Volga regions.

Irrigation was undertaken mainly on huge *sovkhoz* and, to a smaller extent, on *kolkhoz*. Water fees were formally introduced in 1982, but the charge was quite insignificant and never actually collected. Until 1996, there existed no organizational forms of water administration for the newly created farms.

Most of the land under irrigation is commanded by reservoirs, and open canals convey the water to the irrigation schemes. The largest canals are: Saratovski, Donski, Magistral, Great Stavropolski, Tersko-Kumski and Kumo-Manycki. Within the schemes, underground pipes convey the water to the emitters (rain guns). Sprinkler irrigation is the most widely used technique (96% of the area), surface irrigation being used on the remainder (Figure 6). In 1990, only 21% of the irrigated land was equipped with a drainage system.

FIGURE 5
Evolution of irrigation

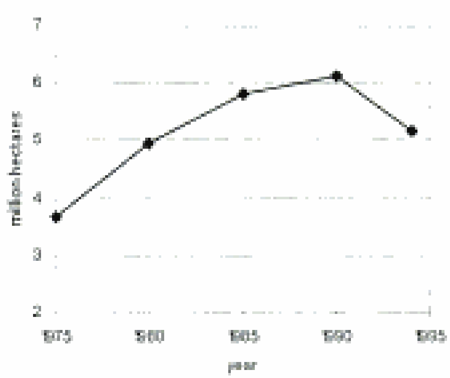
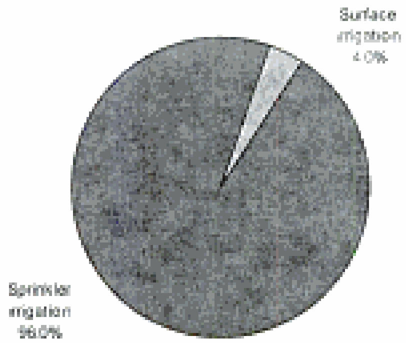


FIGURE 6
Irrigation techniques
Total: 6 124 000 ha in 1990

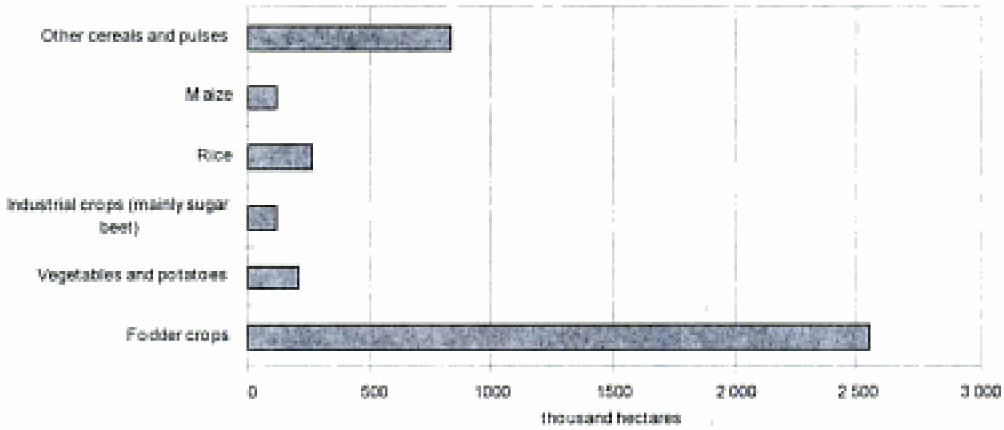


In 1994, irrigated crops covered almost 4.1 million ha, equal to 79% of the equipped area. Fodder represented the largest irrigated crop area with almost 2.6 million ha, 62% of the total. It was followed by cereals and pulses (Figure 7). Yields of irrigated crops are higher than those of rainfed crops. Irrigated maize yields are about 2.7 t/ha compared with 1.7 t/ha for rainfed maize. For barley, the respective figures are 2.25 and 1.65 t/ha.

Drainage development

In 1990, the drained area was 7.4 million ha, of which almost 44% was equipped with subsurface drainage systems (Figure 8). However, in 1994 the drained area had dropped to about 5 million ha. This fall was due either to the breakdown of the infrastructure because of overexploitation without proper maintenance, or to the theft of pipes or the destruction of drains (Figure 9). In 1994, crops were grown on 2.45 million ha of drained land, the major crops being fodder crops followed by cereals (Figure 10). Yields of drained crops are somewhat lower than those of rainfed crops. This might be explained by the fact that drained land is already of marginal quality. Soils are very poor with a low pH and are not really suitable for cultivation. Another reason for the low yields might be the advanced state of degradation of large parts of the drained land.

FIGURE 7
Irrigated crops
Total: 4 095 000 ha in 1994



In 1994, about 25.6 million ha were estimated to be excessively humid and marshy areas needing drainage. Over 15 million ha were estimated to be salinized and 24.3 million ha to have saline soils (solontchak).

INSTITUTIONAL ENVIRONMENT

Under the Soviet Union, the Ministry of Water Administration (Minvodkhoz) functioned at the level of the Soviet Union, and the Ministry of Land Improvement at the Russian Federation level. After the ending of the Soviet Union, both ministries were dissolved. The 89 administrative units of the Russian Federation are now entitled to develop their own water administration policy and establish suitable organs. At federation level, two ministries are responsible for water administration:

- The Ministry of Nature Protection, responsible for water resources protection and water quality;
- The Ministry of Agriculture, whose activity during recent years has concentrated on structural transformations in the agricultural sector.

FIGURE 8
Drainage techniques
Total: 7 399 000 ha in 1990

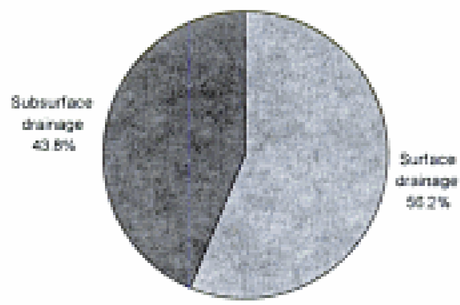


FIGURE 9
Evolution of the drained area

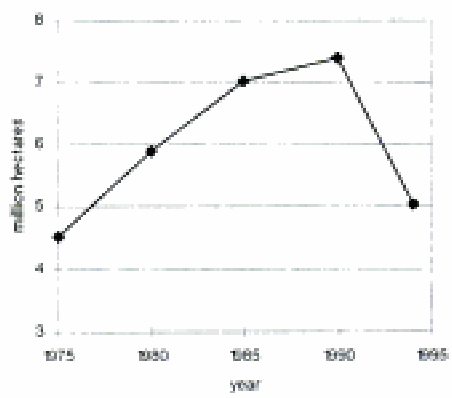
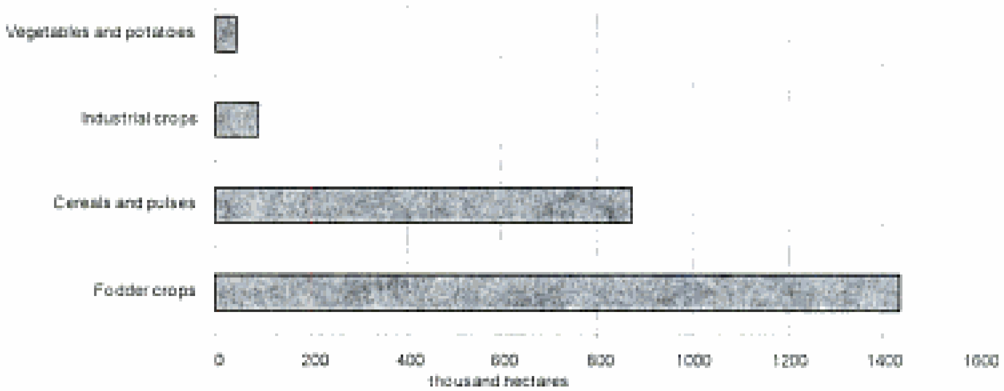


FIGURE 10
Crops grown on drained areas
Total: 2 447 000 ha in 1994



Irrigation and drainage activities are the responsibility of the Russian Water Committee (Roskomvod), reporting to the Ministry of Agriculture, and also of joint stock companies, carrying out irrigation and drainage works, subordinate to the ministry.

The State Hydrological Institute in Saint Petersburg is an independent unit, reporting directly to the government. It focuses not only on scientific research and estimation of water resources, but also prepares plans for water resources utilization and supervises their execution with regard to resources protection.

The institutes of the Russian Academy of Sciences involved in soil and water research programmes are: the Institute of Water Resources (Institut Vodnych Problemov RAN) and the Institute of Geography (Institut Geografii RAN). Irrigation and drainage techniques, land cultivation within improved areas and similar problems are the concern of the scientific institutions reporting to the Academy of Agricultural Sciences.

The main information centre concerning water resources and their utilization is the 'Vodinform' Agency in Moscow.

Trends in water resources management

After a period of rapid irrigation development, there was a slow-down and the area equipped for irrigation even decreased by 16% between 1990 and 1994. Even faster was the process of degradation of irrigation equipment. During the same period the drained area decreased by 22%. However, in this case it can be assumed that the official data from 1990 were overstated and that the actual drop was a little slower. The declining trend persisted in the period 1994-96. During this period, there was practically no new irrigation or drainage development and part of the formerly cultivated lands was excluded from use. The reasons have been the general difficult situation in Russian agriculture and the low yields on irrigated and drained lands.

Large irrigated and drained areas are used for growing unprofitable crops like fodder crops, grain and potatoes. On irrigated areas, crop yields are higher than on rainfed land, but the difference is not always significant. On drained areas, yields are often even lower than those of rainfed crops.

During the last few years, there has been a decrease in crop yields on irrigated and drained areas. One of the reasons for this has been the rise of the Caspian Sea level. In the Povolzhe region (Volga), this has caused groundwater levels to rise and the flooding of fields. This process has affected 719 000 ha of irrigated land and 563 000 ha of drained land in the districts of Astrakhan, Volgograd, Saratov and Samara. The causes of the rise of the Caspian Sea level have not yet been explained.

Though water management policies can be decided by the 89 administrative units themselves, most of them have not yet prepared their future programmes. The exception is Kalmykia, located between the mouth of the Volga River and the Caucasus mountains. This is one of the richest parts of the Russian Federation and large irrigation projects have been planned for the period 1998-2003, to be irrigated mostly from groundwater.

The Volga River is the river worst affected by pollution, as it receives 45% of all the sewage water of the Russian Federation. However, due to the recession, industrial activity has decreased in recent years, resulting in less sewage water.

MAIN SOURCES OF INFORMATION

The most complete information on the present state of irrigation and drainage in the Russian Federation is available in statistical yearbooks in Russian (which contain more information than the English versions) and in the publications: Melioratsia i Vodnoe Chozaystvo (Drainage and Water Management) and Vodnye Resursy (Water Resources), published by the Russian Academy of Sciences in cooperation with the Ministry of Agriculture, Publishing House: Agropromizdat.

Kopytny, L.M. 1996. Water resources of Siberia (Vodnyye resursy Sibirii). Scholar Geography (*Geografia v shkole*), No 1, pp. 15-20. Ministry of Education, Moscow. (in Russian)

Murray Fackbakh (ed.). 1995. Environmental and health atlas of Russia. Paims, Moscow. 320 p.

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Ministry of Natural Environment and Resources Protection. 1994. The state of the environment and environment protection on the ex-USSR territory (Sostoyanie okruzayushtchey sredy i prirorookhronnaya deyatel'nost na territorii byvshego SSSR). Moscow. 160 p. (in Russian).

Tcherneyev, A.M. *et al.* 1992. Water resources and water management in Russia (Vodnyye resursy i vodnoye khozaystvo Rosii). Drainage and Water Management (*Melioratsia i Vodnoye Khozaystvo*), No 9-12, pp. 2-5, Agropromizdat/Ministry of Agriculture, Moscow. (in Russian).

Tajikistan

GEOGRAPHY AND POPULATION

Tajikistan is a mountainous, landlocked country in the southeastern part of the Central Asia. It has a total area of 143 100 km². It is bordered in the west and northwest by Uzbekistan, in the northeast by the Kyrgyz Republic, in the east by China and in the south by Afghanistan. It became independent in September 1991. Administratively, the country is divided into four provinces.

TABLE 1
Basic statistics and population

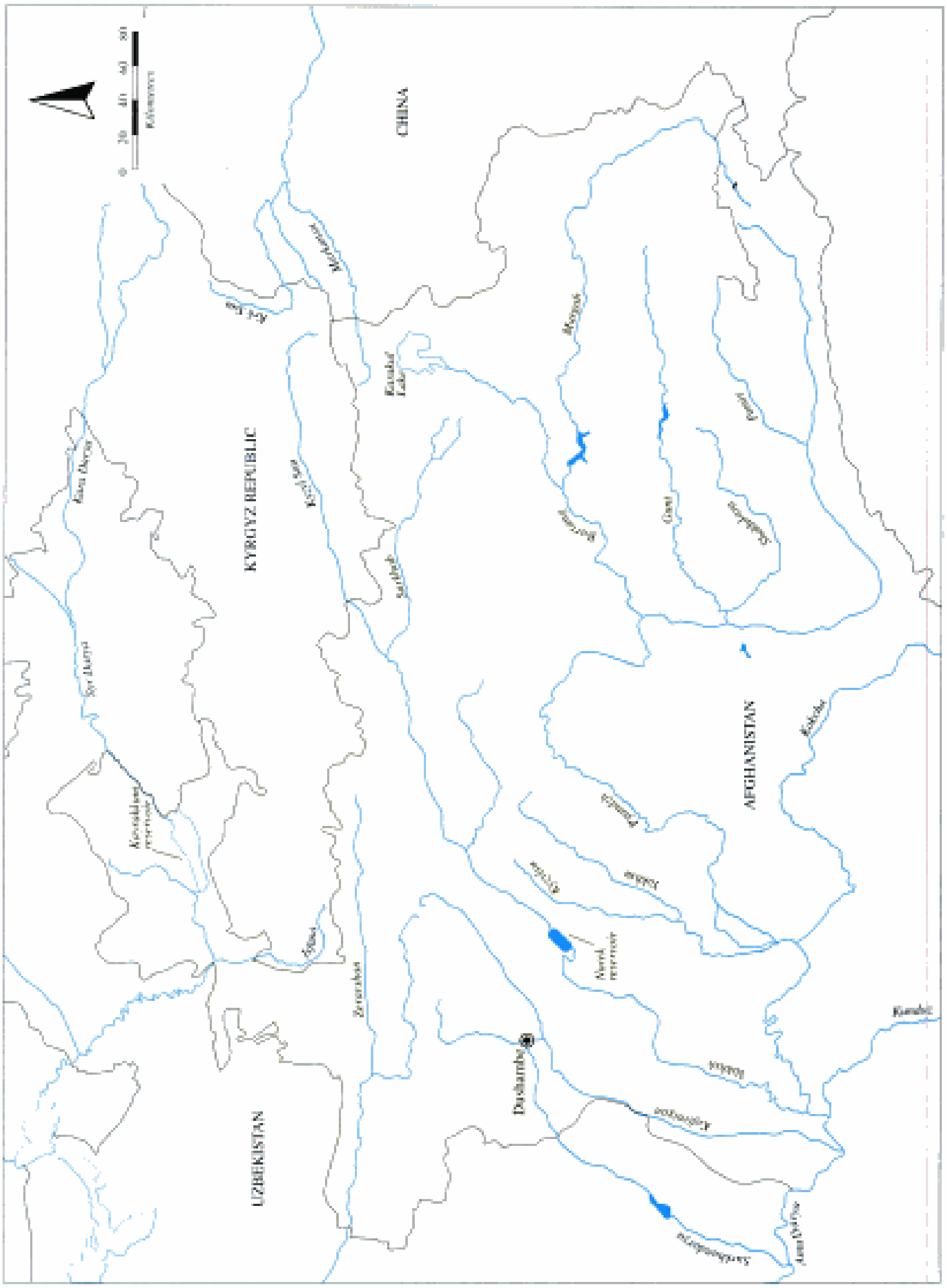
Physical areas:			
Area of the country	1994	14 310 000	ha
Cultivable area	1994	1 571 000	ha
Cultivated area	1994	769 900	ha
- annual crops	1994	689 400	ha
- permanent crops	1994	80 500	ha
Population:			
Total population	1996	5 935 000	inhab.
Population density	1996	41	inhab./km²
Rural population	1996	68	%
Economically active population engaged in agriculture	1996	37	%
of which: - men		-	%
- women		-	%
Water supply coverage:			
Urban population	1994	90	%
Rural population	1994	20	%

The different regions of the country are separated by high mountain ranges and are often isolated during the winter months. The north of the country covers part of the Fergana valley, which is a major agricultural area in the region. A few valleys in the central part of the country are situated between several mountain chains. Most of the country lies at over 3 000 m above sea level. In the east of the country are the Pamir mountains, which are part of the Himalayan mountain chain and are among the highest and most inaccessible mountains in the world. The highest mountain in the country, as well as in the whole of the FSU, the Peak of Communism with an altitude of 7 495 m, is situated in this region.

The cultivable area has been estimated at 1.57 million ha, which is about 11% of the total area of the country. In 1994, the total cultivated area was estimated at 769 900 ha, which is almost half of the cultivable area. About 689 400 ha consisted of annual crops and 80 500 ha of permanent crops, of which more than half were vineyards.

In 1994, there were 297 000 households in 262 *kolkhoz* (collective farms), occupying 48.4% of the cultivated area, and 199 700 households in 393 *sovkhoz* (state farms), occupying 44.3% of cultivated area. Private plots and land leased to state farm employees (about 33 000 households) totalled only about 7.3% of cultivated area (Figure 1).

The total population is 5.9 million (1996), of which 68% is rural. The average population density is about 41 inhabitants/km². The southeast of the country has the lowest population density with fewer than 3 inhabitants/km². The highest population density is in the southwest with 77 inhabitants/km². Between 1990 and 1994, the average annual population growth rate was 1.9%, while during the 1980s it had been 3.3%. The main reasons for the decline have



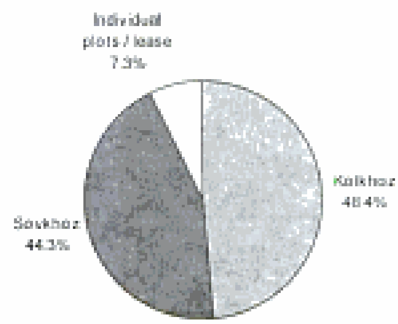
TAJIKISTAN

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		691	mm/yr
		98.88	km^3/yr
Internal renewable water resources		66.30	km^3/yr
Total (actual) renewable water resources	1997	15.98	km^3/yr
Dependency ratio	1997	16.7	%
Total (actual) renewable water resources per inhabitant	1996	2 693	m^3/yr
Total dam capacity	1994	28 970	$10^6\ m^3$
Water withdrawal:			
- agricultural	1994	10 961	$10^6\ m^3/yr$
- domestic	1994	412	$10^6\ m^3/yr$
- industrial	1994	501	$10^6\ m^3/yr$
Total water withdrawal		11 874	$10^6\ m^3/yr$
per inhabitant	1994	2 074	m^3/yr
as % of total (actual) renewable water resources		74.3	%
Other water withdrawal		-	$10^6\ m^3/yr$
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1994	0.577	$10^6\ m^3/yr$
- treated wastewater		-	$10^6\ m^3/yr$
- re-used treated wastewater		-	$10^6\ m^3/yr$
Agricultural drainage water	1994	3 780	$10^6\ m^3/yr$
Desalinated water		-	$10^6\ m^3/yr$

been emigration and lower birth rates resulting from deteriorating socio-economic conditions. In 1996, agriculture employed 37% of the economically active population. In 1992, agriculture contributed some 17% of GDP. The contribution of crop production to the gross agricultural production was about 64%, while animal husbandry contributed 36%. About 94% of crop production comes from irrigated lands.

FIGURE 1
Land categories
Total: 769 900 ha in 1994



CLIMATE AND WATER RESOURCES

Climate

The climate of Tajikistan is classed as continental, but its mountainous terrain gives rise to wide variations. In those areas where cultivation takes place, which is mainly in the floodplains of the rivers, the climate consists of hot, dry summers and mild, warm winters. The average annual precipitation is 691 mm, ranging from less that 100 mm in the southeast up to 2 400 mm on the Fedchenko glacier in the central part of the country. Precipitation occurs during the winter season, mainly between September and April. The average temperature is about 16°-17°C. The absolute maximum temperature recorded is 48°C in July, the absolute minimum temperature -49°C in January. The daily temperature range is about 7°C in winter and 18°C in summer.

River basins and water resources

Tajikistan can be divided into four major river basins:

TABLE 3
Irrigation and drainage

Irrigation potential		1994	755 200	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1994	719 200	ha
- surface irrigation		1994	719 200	ha
- sprinkler irrigation		1994	-	ha
- micro-irrigation		1994	0	ha
% of area irrigated from groundwater		1994	9.5	%
% of area irrigated from surface water		1994	87.0	%
% of area irrigated from non-conventional sources		1994	3.5	%
% of equipped area actually irrigated			100	%
2. Equipped wetland and inland valley bottoms (i.v.b.)			-	ha
3. Spate irrigation			-	ha
Total irrigation (1 + 2 + 3)		**1994**	**719 200**	**ha**
- as % of cultivated area			93.4	%
- increase over last 10 years		1985-94	10	%
- power irrigated area as % of irrigated area		1994	44.2	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 5 000 ha	1994	670 000	ha
Medium-scale schemes		1994	0	ha
Small-scale schemes	< 5 000 ha	1994	49 200	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production		1994	192 100	t
as % of total grain production		1994	84.5	%
Harvested crops under irrigation		**1994**	**719 200**	**ha**
- permanent crops: total		1994	80 500	ha
- annual crops: total		1994	638 700	ha
. cotton		1994	282 740	ha
. fodder crops		1994	117 300	ha
. cereals		1994	145 570	ha
. vegetables		1994	23 060	ha
. other annual crops		1994	70 030	ha
Drainage - Environment:				
Drained area		1994	328 600	ha
- drained area in full or partial control irrigated areas		1994	328 600	ha
- drained area in equipped wetland and i.v.b.			-	ha
- other drained area			-	ha
- area with subsurface drains		1994	137 600	ha
- area with surface drains		1994	191 000	ha
Drained area as % of cultivated area			42.7	%
Power drained area as % of total drained area		1990	30.5	%
Area salinized by irrigation		1994	115 000	ha
Population affected by water-borne diseases			-	inhabitants

- The Syr Darya basin. The northwest of the country forms part of the Syr Darya basin. About 78% of the flow of the Syr Darya River is generated on the territory of the Kyrgyz Republic. Only 1% of the total flow of the Syr Darya River is generated within Tajikistan by the shallow rivers Khodzhabakirgan, Aksu, Isfara and Isfana, with a total flow of 0.4 km^3/year.

- The Amu Darya basin. About 82.5% of the flow of the Amu Darya River is generated on the territory of Tajikistan by the Vakhsh, Pyandzh and Kafirnigan rivers. The Vakhsh River is the largest river in Tajikistan, crossing it from the northeast to the southwest. It rises in the Kyrgyz Republic, where it is called the Kyzyl Suu, and its catchment area lies in the highest part of Tajikistan at over 3 500 m. The Pyandzh River forms the border between Tajikistan and Afghanistan for almost its entire length. After the confluence with the Vakhsh River, it becomes the Amu Darya River and about 100 km further downstream it leaves Tajikistan to become the border between Afghanistan and Uzbekistan. The Kafirnigan River is another large tributary of the Amu Darya River. It rises in Tajikistan and flows into the Amu Darya River about 36 km downstream of the confluence of the Pyandzh and Vakhsh rivers.

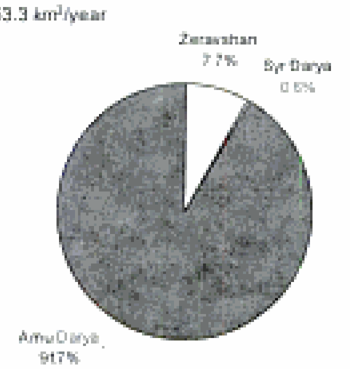
- The Zeravshan basin. The Zeravshan River, rising in Tajikistan, was once the largest tributary of the Amu Darya River. At present its flow is almost fully used, mainly for irrigation.

- The basin draining to China. In the extreme northeast of the country, a small area drains towards China. No figures on flows are available.

Renewable Surface Water Resources (RSWR) by river basin

River basin	Part of total area of country	Internal RSWR	Inflow secured by treaties		Outflow to be reserved		Actual RSWR
	(%)	(km^3/year)	(km^3/year)	from:	(km^3/year)	to:	(km^3/year)
Syr Darya	11	0.40	11.80	Uzbekistan	11.54	Uzbekistan	0.66
Amu Darya	84	58.03	1.51	Kyrgyz Rep.	49.00	Uzbekistan	10.54
Zeravshan	4	4.87	-		3.09	Uzbekistan	1.78
Northeast	1	-	-		-	China	-
Total	100	63.30	13.31		63.63		12.98

FIGURE 2
Internal renewable surface water resources by major river basin
Total: 63.3 km^3/year



The total IRSWR of Tajikistan are estimated at 63.3 km^3/year (Figure 2). During the Soviet period, the sharing of water resources among the five Central Asia republics was on the basis of master plans for the water resources development in the Amu Darya and Syr Darya river basins. With the establishment of the Interstate Commission for Water Coordination in 1992, the newly independent states decided to prepare a regional water strategy (Agreement of 18 February 1992), but to continue to respect the existing principles until the adoption of a new water sharing agreement to be proposed by this new water strategy. The surface water resources allocated to Tajikistan are thus calculated every year, depending on the existing flows. However, on average, it can be considered that the surface water resources available for Tajikistan are 12.98 km^3/year.

The internally generated renewable groundwater resources are estimated at 6 km^3/year, of which 3 km^3/year overlap with surface water resources. The part of groundwater resources for which abstraction equipment exists has been estimated at 2.2 km^3/year.

The ARWR of Tajikistan can thus be estimated at 15.98 km^3/year.

Non-conventional sources of water

In 1994, the return flow within Tajikistan amounted to 4.36 km^3/year, including 3.78 km^3/year of collector-drainage flow from irrigation and about 0.58 km^3/year of domestic and industrial wastewater. The main part of the return flow, about 3.94 km^3/year, flows back to rivers, of which 2.85 km^3 into the Amu Darya River and 1.09 km^3 into the Syr Darya River. More than 0.35 km^3/year (8% of total return water) are re-used for irrigation. The remaining 0.06 km^3/year of return flow are directed to natural depressions.

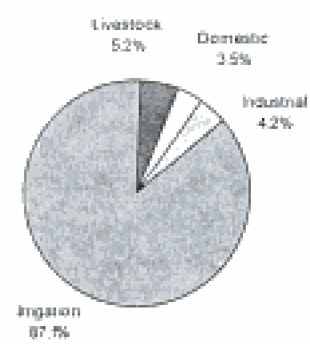
Lakes and dams

There are 1 300 natural lakes in Tajikistan with a total water surface area of 705 km^2 and a total capacity of about 50 km^3. About 78% of the lakes are situated in the mountain zone above 3 500 m above sea level. The largest lake in the country is Lake Karakul in the northeast at an altitude of 3 914 m, with a surface area of 380 km^2 and a capacity of 26.5 km^3.

In 1994, there were 19 dams in Tajikistan: 5 in the Syr Darya River basin and 14 in the Amu Darya River basin (7 on the Vakhsh River, 4 on the Pyandzh River and 3 on the Kafirnigan River). Their total reservoir capacity is about 29 km^3 and the reservoir area 934 km^2. There are nine large reservoirs (capacity more than 500 million m^3 each) with a total capacity of 25.34 km^3 and an area of 690 km^2. The largest reservoirs are: the Nurek on the Vakhsh River (10.5 km^3), the Kayrakkum on the Syr Darya River (4.16 km^3), and the Lower Kafirnigan on the Kafirnigan River (0.9 km^3). The Nurek headwork incorporates a unique rock-fill dam with a central core, 310 m in height, a power plant with a capacity of 2 700 MW and a reservoir with a capacity of 10.5 km^3. The Rogun reservoir on the Vakhsh River (8.6 km^3) has been planned, but not yet constructed. The main purposes of the reservoirs are hydropower production and irrigation.

The gross theoretically hydropower potential of Tajikistan is estimated at 527 000 Gwh/year, about half of which would be economically feasible. In 1994, the total installed capacity was about 4 GWh, generating about 98% of the country's electricity. Tajikistan ranks third in the world for hydropower development, after the United States and the Russian Federation.

FIGURE 3
Water withdrawal
Total: 11.874 km^3 in 1994



Water withdrawal and wastewater

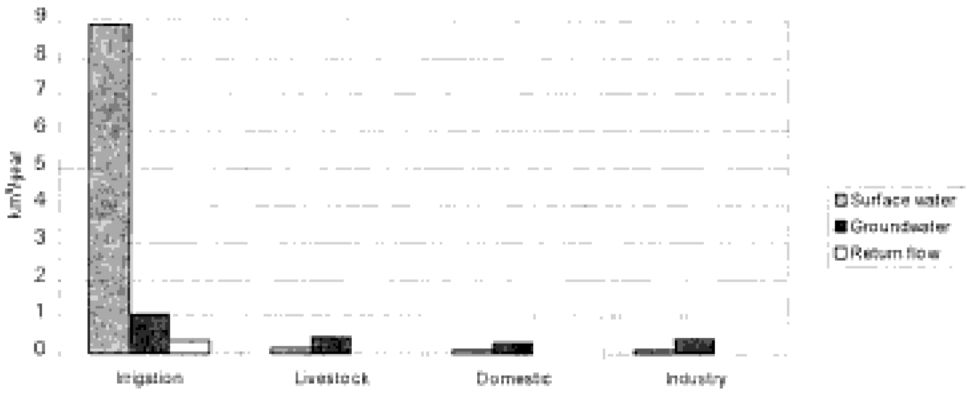
In 1994, the total annual water withdrawal was estimated at 11.87 km^3, of which over 92% for irrigation purposes (Figure 3). About 2.26 km^3 was groundwater, an esti-mated 0.35 km^3 re-used collector-drainage water and wastewater for irrigation, and the remainder was surface water (Figure 4). In 1995, the total water demand for all sectors was estimated at 12.955 km^3.

IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

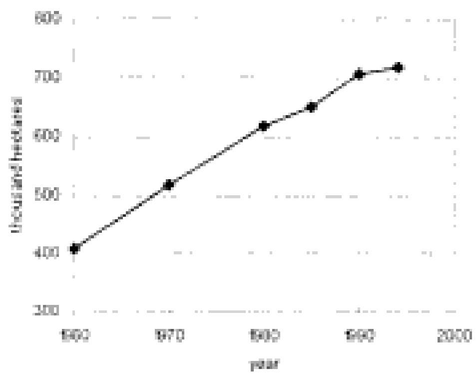
Irrigation in Tajikistan is important for the development of agriculture and the national economy. In 1960, the total area equipped for irrigation was estimated at about 408 000 ha. In 1994 it was 719 200 ha, which was 93.4% of the total cultivated area (Figure 5). About

FIGURE 4
Origin of water used by sector
Total: 11.874 km³ in 1994



33% of the total irrigated area (240 200 ha) is situated in the Syr Darya River basin and 67% (479 000 ha) in the Amu Darya River basin, of which 20 000 ha in the Zeravshan basin, 49 000 ha in the Kafirnigan basin, 18 000 ha in the Pyandzh basin and 392 000 ha in the Vakhsh basin. Considering that a further 36 000 ha are potentially suitable for irrigation development up to 2010, the total potential for irrigation development has been estimated at 755 200 ha.

FIGURE 5
Evolution of irrigation



In northern Tajikistan, irrigation is mainly based on the water resources of the Syr Darya River, whose water is delivered by pumping stations. The Tajik part of the Hunger steppe is bordered in the northwest by Uzbekistan. This region belongs to a semi-desert zone and the irrigated area is about 39 000 ha, mainly used for cotton. Water is taken from the diversion canal of the Farkhad power plant in two stages by remote-controlled pumping stations, which lift the water to an elevation of 170 m. In 1994, the total power irrigated area was estimated at 318 000 ha.

Large-scale irrigation development in southern Tajikistan started in 1931 with the construction of the Vakhsh main canal in the Vakhsh valley. This canal is 11.7 km long with a capacity of 150 m³/s, diverting water from the Vakhsh River for the irrigation of 120 000 ha. The Vakhsh main canal was later reconstructed, its capacity increased to 200 m³/s and the canal extended to irrigate also the Akgazin plateau.

During the Soviet period, important irrigation development took place in the Kafirnigan River basin, located in southern Tajikistan. Together with Uzbekistan, Tajikistan built the Large Gissar canal in 1940, which carries water from the Dushanbe River into the basin of the Surkhandarya River (situated in Uzbekistan). The irrigated area in this part of Tajikistan is about 29 000 ha.

Further irrigation development in southern Tajikistan took place with the construction of the Nurek and Baipaza dams on the Vakhsh River. Water is provided for the irrigation of 76 000 ha in the Dangarin area. In the Vakhsh basin, a large irrigation system (40 000 ha) is located in the Yavan and Obikiik valleys, which are extremely short of water. At present, the valleys are supplied with water from the Baipaza reservoir through a tunnel 7.3 km long.

Surface irrigation is the only irrigation technique used in Tajikistan. In 1994, furrow irrigation was practised on over 96% of the area equipped and borderstrip irrigation on about 2%. On the hill slopes the delivery network for the irrigation of gardens and grapes consists of pipes, but the irrigation technique used on the field is also surface irrigation (Figure 6). Micro-irrigation was developed on an experimental basis on 110 ha in 1990, but at present is no longer used.

All irrigation is full control irrigation. About 68 000 ha are irrigated from groundwater and about 25 000 ha from re-used drainage water and wastewater (Figure 7). To some 250 000 ha, or 34.8% of total area equipped for irrigation, water is provided through pumping in rivers, while elsewhere the water is gravity fed from river diversion or reservoirs.

FIGURE 6
Irrigation techniques
Total: 719 200 ha in 1994

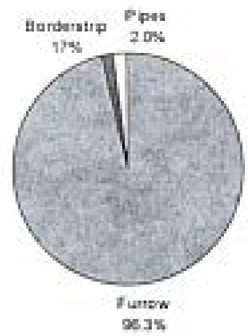
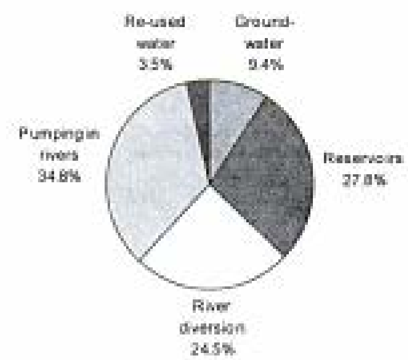


FIGURE 7
Origin of irrigation water
Total: 719 200 ha in 1994

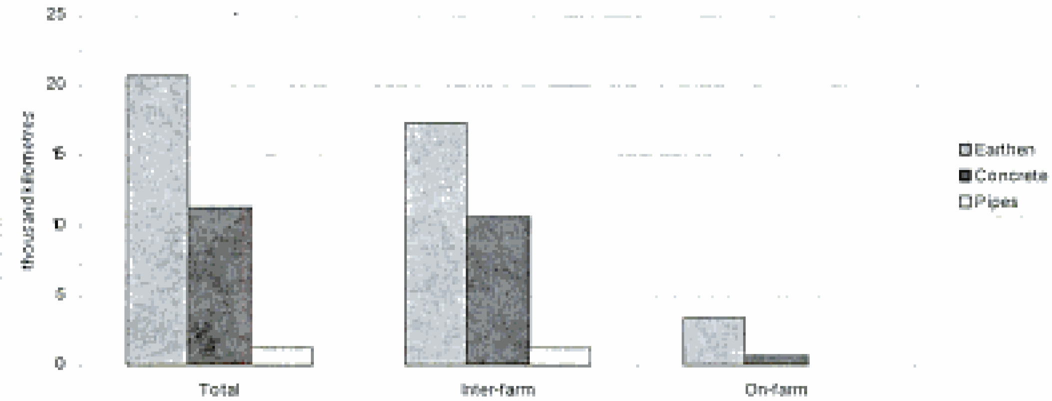


In 1994, the total length of the irrigation canal network was about 33 250 km. The length of the main canals and the inter-farm network was 27 991 km, of which 38% consisted of concrete canals. The on-farm canal network totalled 5 259 km, with 13.3% concrete canals, 21.9% pipes and the remaining 64.8% unlined earthen canals (Figure 8). In 1994, the irrigation efficiency, considering losses between the source and the irrigated field, was estimated at 72%.

Large-scale schemes, with an area of more than 5 000 ha, cover 670 000 ha, while small-scale schemes, with an area of less than 5 000 ha, cover the remaining 49 200 ha (Figure 9). No private irrigation systems exist in Tajikistan.

The major irrigated crops are cotton, fodder, fruits and grapes, cereals and vegetables (Figure 10). Cotton, fruits and grapes are the most important export crops. In 1994, irrigated crop yields were 1.91 t/ha for cotton, 0.85 t/ha for wheat, 1.71 t/ha for rice and 3.01 t/ha for grapes.

FIGURE 8
Typology of irrigation canals
Total: 33 250 km in 1994



The costs of irrigation development and rehabilitation are higher in Tajikistan than in downstream countries, mainly because of the need for pumping and erosion control. The average cost of irrigation development is estimated at $US 10 000-18 000/ha for large-scale surface irrigation schemes using standard modern technologies, including agricultural development. If micro-irrigation were to be developed on the existing irrigated lands, its estimated implementation cost would be $US 2 300-3 500/ha. Annual O&M costs which would enable full cost recovery are estimated at about $US 550/ha for gravity

FIGURE 9
Irrigation scheme size
Total: 719 200 ha in 1994

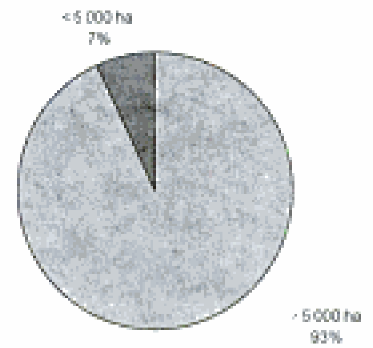
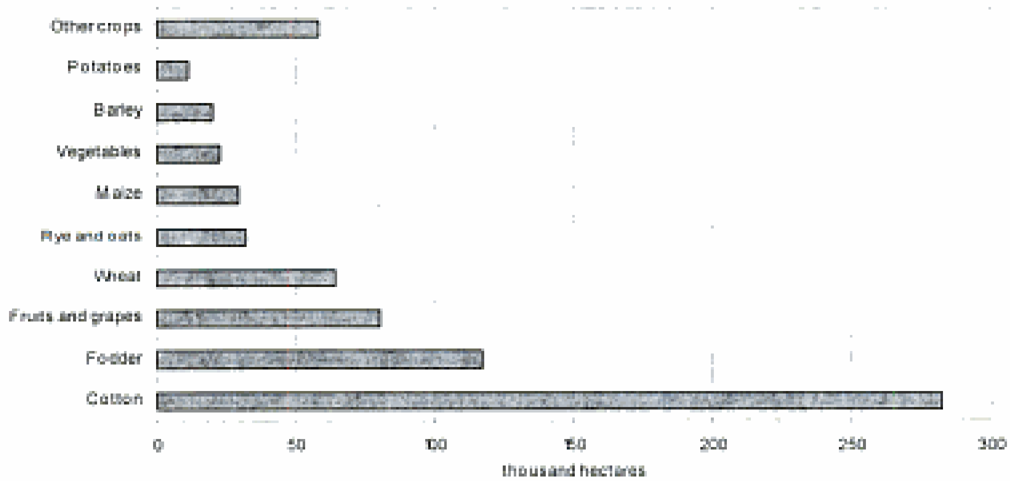


FIGURE 10
Irrigated crops
Total: 719 200 ha in 1994

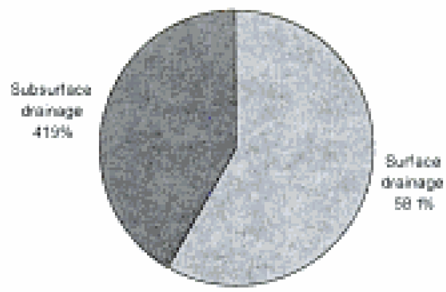


surface irrigation systems, $US 600/ha for micro-irrigation and $US 750/ha for pump systems. However, in recent years the actual operational cost has not exceeded $US 120-136/ha.

Waterlogging, salinity and drainage development

Out of the total irrigated area of 719 200 ha, over 600 000 ha require drainage. However, in 1994, drainage systems had been constructed on only 328 600 ha. Approximately 58% is surface drainage, and 42% is subsurface drainage (Figure 11). The average cost of surface drainage development is estimated at $US 500-600/ha, and that of subsurface drainage development at $US 1 400/ha. The total length of the existing drainage network is about 11 500 km.

FIGURE 11
Drainage techniques
Total: 328 600 ha in 1994



The two major land quality problems in the country are the interrelated issues of salinity and waterlogging, caused by high groundwater levels. In 1994, about 115 000 ha, or 16% of the irrigated land, were classed as saline by Central Asian standards (toxic ions exceed 0.5% of total soil weight).

INSTITUTIONAL ENVIRONMENT

The Ministry of Water Resources (MWR) is in charge of water resources research, planning, development and distribution. It also undertakes the construction, operation and maintenance of the irrigation and drainage networks at inter-farm level. Water distribution is based on a strict limitation of water withdrawal. Water allocations are regularly reduced to promote water savings and to satisfy the demand from new users. Institutionally, water management follows a hierarchy: state, province, district, farm (or WUA). The first three levels come under the MWR and are responsible for water distribution and delivery to the farm inlet, for assistance to the water users in implementing advanced technology, and for the control of water use and water quality. The special reclamation services at provincial level are the responsibility of the MWR. They monitor the irrigated lands (groundwater level, drainage discharge, soil salinity) and plan measures for the maintenance and improvement of soil conditions, including leaching, repair and cleaning of collectors and drainage network, and rehabilitation.

The Ministry of Agriculture is in charge of agricultural research and extension, agricultural and land reclamation development at farm level, and operation and maintenance of the irrigation network at farm level.

The state enterprise 'Tajikjilkomkhoz' is responsible for domestic water supply and the treatment of wastewater. The Ministry of the Environment is responsible for the protection of water resources.

The water law and water rights are defined by the special 'Water Code of Tajikistan', which was confirmed on 12 December 1993.

Tajikistan is a member of IFAS and ICWC. Within Tajikistan are the Leninabad board of the Syr Darya BWO and the Kurgan Tube board of the Amu Darya BWO.

TRENDS IN WATER RESOURCES MANAGEMENT

Tajikistan has developed two alternative scenarios in its national water strategy, the main objective of which is water conservation.

Under the first scenario, the irrigated area in 2000 will be the same as in 1994, 719 200 ha, while in 2010 it will be 743 000 ha. The main goal during the next 15 years will be the rehabilitation of the existing irrigated land and a reduction in irrigation water demand from 11.23 km^3/year in 1995 to 9.81 km^3/year in 2010. The irrigated area per caput is expected to fall from 0.12 ha to 0.08 ha, which will not be able to satisfy the growing demand for food. In the other sectors, water consumption is expected to increase: municipal demand from 0.48 km^3 in 1995 to 0.60 km^3 in 2010, industrial water demand from 0.5 km^3 to 1.5 km^3. The total water withdrawal is assumed to remain more or less stable, or even to decrease slightly during the next 15 years.

Under the second scenario, the irrigated area will be 755 200 ha in 2010, while water withdrawal will fall from 11.23 km^3/year at present to 10.38 km^3/year in 2010. The total water withdrawal is assumed to increase by about 0.7-0.8 km^3/year.

The environmental problems in Tajikistan are the result of its climate and natural conditions (steep slopes) and the structure of the national economy. The irrigated area is subject to substantial erosion, land slides, sagging and deformation. The area affected is estimated to be about 45 000 ha. Irrigation development in the foothill zone, especially in the more stony areas, induces increasing groundwater recharge, intensifying waterlogging and salinization of the lower areas, and increasing the sediment loaded drainage water runoff. Collector-drainage water is the principal water polluter (common mineralization, pesticides and some other waste ingredients). Environmental pollution is also increasing as a consequence of industrial production.

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Turkmenistan

GEOGRAPHY AND POPULATION

Turkmenistan, located in Central Asia, is bordered in the west by the Caspian Sea, in the northwest by Kazakhstan, in the north and northeast by Uzbekistan, in the southeast by Afghanistan and in the south and southwest by Iran. The total area of the country is 488 100 km². It formally declared its independence from the Soviet Union in October 1991. For administrative purposes, the country is divided into five vilayats, one of which includes the capital city of Ashkhabad.

The Kara Kum Desert covers 80% of the total area of the country. In the southwest, along the border with Iran, lies the Kopetdag mountain chain with the Shakhshakh peak at 2 912 m above sea level. The highest point of the country is the Airybaba peak at 3 137 m, in the Kougitantau mountain range in the east on the border with Uzbekistan.

TABLE 1
Basic statistics and population

Physical areas:		
Area of the country	1996	48 810 000 ha
Cultivable area	1995	7 013 000 ha
Cultivated area	1994	1 755 200 ha
- annual crops	1994	1 511 200 ha
- permanent crops	1994	244 000 ha
Population:		
Total population	1996	4 155 000 inhab.
Population density	1996	9 inhab./km²
Rural population	1996	55 %
Economically active population engaged in agriculture	1996	36 %
of which: - men		- %
- women		- %
Water supply coverage:		
Urban population	1994	80 %
Rural population	1994	23 %

The cultivable area is estimated at 7 million ha, or 14% of the total area of the country. In 1994, the total cultivated area was estimated at 1.75 million ha, of which 1.51 million ha consisted of annual crops, and 0.24 million ha of permanent crops, mostly vineyards, pistachio nuts, figs and olives. In 1994, the cultivated area was divided into: *kolkhoz* (collective farms) and *sovkhoz* (state farms) which covered a combined area of 1 596 400 ha; the 'land of citizens' on 109 900 ha (this corresponds to gardens and individual plots); and 48 900 ha of private farms owned by 4 500 households. In May 1994, a land reform was approved by the government. This reform should eventually result in the privatization of agricultural land. The *sovkhoz* and *kolkhoz* lands are to be distributed to their employees under a lease contract of 99 years. At the end of 1994, about 720 000 ha of this land had already been distributed to some 260 000 farmers (Figure 1).

The total population is estimated at 4.16 million inhabitants (1996), of which 55% is rural. The average population density is about 9 inhabitants/km². The annual population growth rate was estimated at almost 2% in 1995, compared with 2.5% during the 1980s. The decline has mainly been due to the prevailing difficult post-independence economic situation.

TURKMENISTAN

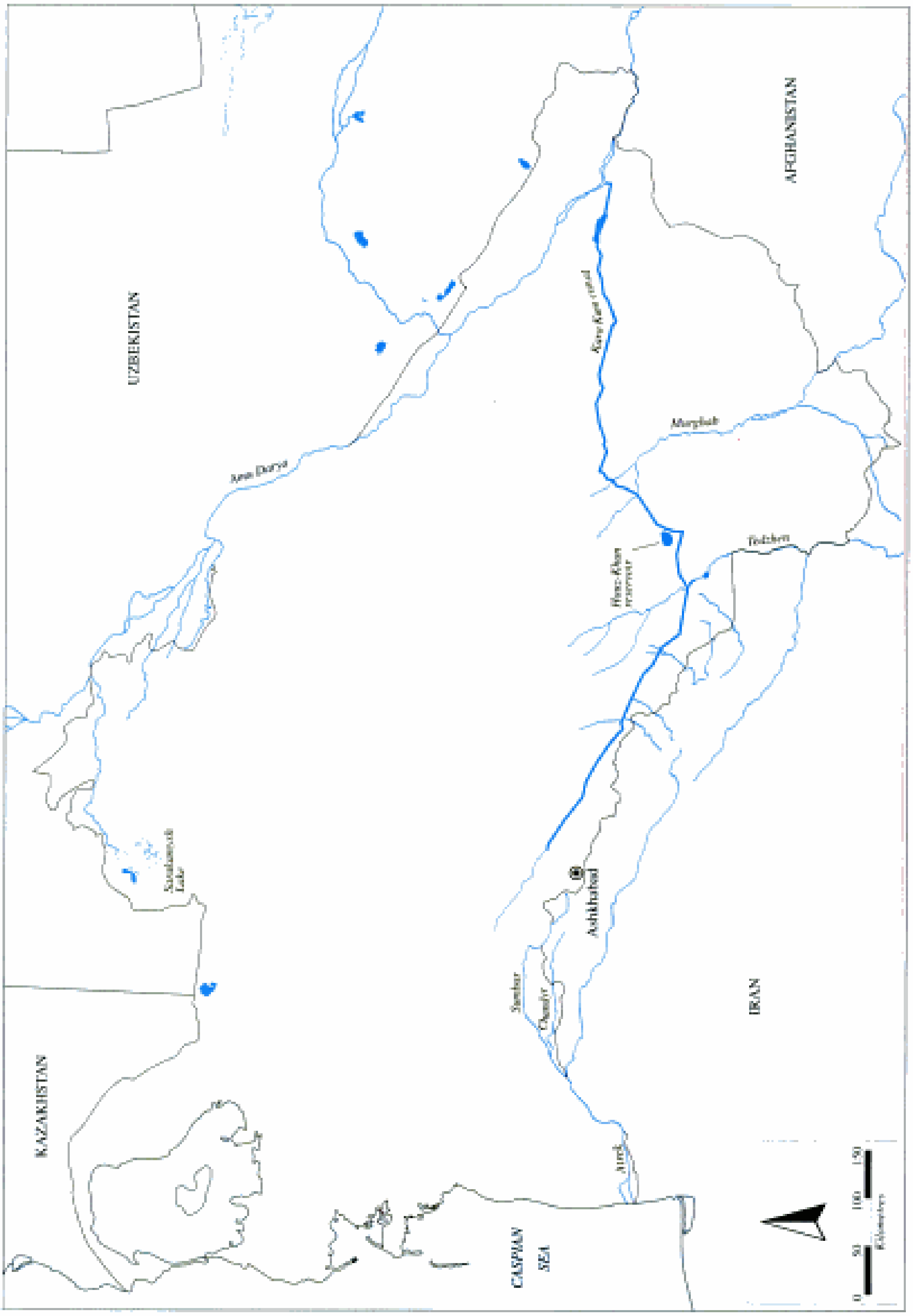
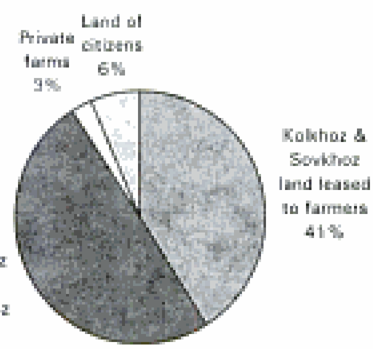


TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		191	mm/yr
		93.2	km^3/yr
Internal renewable water resources		1.36	km^3/yr
Total (actual) renewable water resources	1997	24.72	km^3/yr
Dependency ratio	1997	97.1	%
Total (actual) renewable water resources per inhabitant	1996	5 949	m^3/yr
Total dam capacity	1995	2 890	10^6 m^3
Water withdrawal:			
- agricultural	1994	23 291	10^6 m^3/yr
- domestic	1994	349	10^6 m^3/yr
- industrial	1994	139	10^6 m^3/yr
Total water withdrawal		23 779	10^6 m^3/yr
per inhabitant	1994	5 952	m^3/yr
as % of total (actual) renewable water resources		96.2	%
Other water withdrawal	1994	42	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater		-	10^6 m^3/yr
- treated wastewater	1994	25	10^6 m^3/yr
- re-used treated wastewater		-	10^6 m^3/yr
Agricultural drainage water	1994	5 400	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

In 1995, the agricultural sector contributed almost 50% to GDP and in 1996 it employed about 36% of the total economically active population. Animal husbandry contributes 14% to the gross agricultural production, and crop production contributes 86%, mainly through irrigated crops (95% of the gross crop product).

FIGURE 1
Land categories
Total: 1 755 200 ha in 1994



CLIMATE AND WATER RESOURCES

Climate

The climate of Turkmenistan is subtropical desertic. The average annual precipitation is about 191 mm, ranging from less that 80 mm in the northeast to 300 mm in the Kopetdag mountain zone in the southwest. Precipitation occurs during the winter season, mainly between October and April. The average temperature in January is about -4°C in most of the country, except in the southwest where the climate is milder with an average temperature of 4°C in the coldest month. In July, average temperatures exceed 30°C throughout the country.

River basins and water resources

The river runoff originating in the country is estimated at 1.0 km³/year (Figure 2). Several rivers are found in Turkmenistan, most of them flowing into the country from its neighbours.

TABLE 3
Irrigation and drainage

Irrigation potential	1996	2 353 000	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1994	1 744 100	ha
- surface irrigation	1994	1 743 700	ha
- sprinkler irrigation		-	ha
- micro-irrigation	1994	400	ha
% of area irrigated from groundwater	1994	2.5	%
% of area irrigated from surface water	1994	97.5	%
% of area irrigated from non-conventional sources		-	%
% of equipped area actually irrigated	1994	100	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1+2+3)	**1994**	**1 744 100**	**ha**
- as % of cultivated area		99.4	%
- increase over last 10 years	1985-94	+ 37	%
- power irrigated area as % of irrigated area	1994	16.3	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production	1994	1 002 500	t
as % of total grain production	1994	100	%
Harvested crops under irrigation	**1994**	**1 794 200**	**ha**
- permanent crops: total	1994	232 900	ha
- annual crops: total	1994	1 561 300	ha
. Wheat	1994	570 900	ha
. Cotton	1994	557 500	ha
. Fodder	1994	248 200	ha
. Rice	1994	47 700	ha
. other annual crops	1994	137 000	ha
Drainage - Environment:			
Drained area	1995	1 022 126	ha
- drained area in full or partial control irrigated areas	1995	1 022 126	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1995	322 962	ha
- area with surface drains	1995	699 164	ha
Drained area as % of cultivated area		58.2	%
Power drained area as % of total drained area	1994	8	%
Area salinized by irrigation	1994	652 290	ha
Population affected by water-borne diseases		-	inhabitants

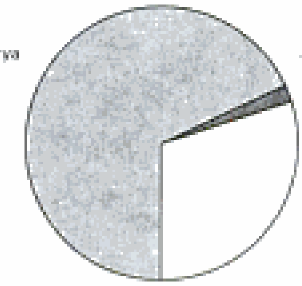
Renewable Surface Water Resources (RSWR) by major river basin

River basin	Location	Part of territory	Internal RSWR	Inflow			Outflow: to	Total actual RSWR
					from	secured through agreements		
		%	km³/yr.	km³/yr.		km³/yr.		km³/yr.
Amu Darya	Northeast	73.7	0.68	57.08	Uzbekistan	43.32*	Uzbekistan (Aral Sea)	44*
Atrek	South-west	4.4	0.02 (Sumbar & Chandyr)	0.10	Iran	0.04	Caspian Sea	0.06
Murghab	Southeast	9.6	-	1.25	Afghanistan	-	Desert	1.25
Tedzhen	South	11.3	-	1.07	Iran and Afghanistan	0.75	Desert	0.75
Other	South	1.0	0.30	-	Iran	-	Desert	0.3
Total		100	1.00	59.50		44.11		24.36

* The agreement among the five Central Asian republics stipulates that on average 22 km³/year are to be reserved for Turkmenistan (of which 0.68 km³/year are IRWR) and 22 km³/year for Uzbekistan. It has been considered that the latter comes into Turkmenistan before being used downstream in Uzbekistan.

During the Soviet period, water resources sharing among the five Central Asian republics was on the basis of master plans for water resources development in the Amu Darya and Syr Darya basins. In 1992, with the establishment of the Interstate Commission for Water Coordination, the newly independent republics agreed (18 February 1992) to prepare a regional water strategy, and to continue to respect the existing principles until the adoption of a new water sharing agreement to be proposed by this new water strategy.

FIGURE 2
Internal renewable surface water resources by major river basin
Total: 1.0 km^3/year



The part of the Amu Darya flow allocated to Turkmenistan is 50% of the actual river flow at the Kerki gauging station, the other 50% being allocated to Uzbekistan. The Turkmen allocation corresponds to 42.27% of the part of the Amu Darya surface water resources on which agreements have been concluded. The agreements are calculated on the basis of about 67% of the total amount of flow produced in the Amu Darya basin (78.46 km^3/year on average). The surface water resources allocated to Turkmenistan are thus calculated every year, depending on the importance of the current flows. On average, it can be considered that the water resources allocated to Turkmenistan in the Amu Darya basin are about 22 km^3/year.

As far as the Tedzhen and Atrek waters are concerned, the treaty signed in February 1926 between Iran and Turkmenistan remains in force. This treaty stipulates that Turkmenistan receives each year a quantity equal to 70% of the total Tedzhen average runoff, and 50% of the total Atrek average runoff. This corresponds to an average of 0.75 km^3/year for the Tedzhen River and 0.06 km^3/year for the Atrek River.

The largest and most important waterway in Turkmenistan is the Kara Kum canal. This canal was constructed in the 1950s and is, with its some 1 300 km, the longest canal in the world. The canal capacity is estimated at 630 m^3/s. Its inlet at the Amu Darya River is located just after the river enters Turkmenistan from Uzbekistan. It brings water to Ashkhabad and to the oases in the south.

The renewable groundwater resources are estimated at 3.36 km^3/year, of which about 3 km^3/year are estimated to be infiltration from rivers, including surface water resources generated in upstream countries. In 1994, the existing equipment enabled a groundwater abstraction of 1.22 km^3/year.

The total IRWR are thus estimated at 1.36 km^3/year, and the total ARWR at 24.72 km^3/year.

Non-conventional sources of water

The volume of treated industrial and domestic wastewater is estimated at 0.025 km^3/year. For the period 1990-94, agricultural drainage water was estimated at about 5.4 km^3/year on average. Water from both sources is mixed in the collector-drainage canals. About 2.35 km^3/year, or 44% of the total, return to rivers, mainly the Amu Darya River. About

2.97 km³/year, or 55% of the total, go to natural depressions, mainly Lake Sarakamysh in the north of the country on the border with Uzbekistan. The remainder, about 0.08 km³/year (1% of the total), is directly re-used for irrigation.

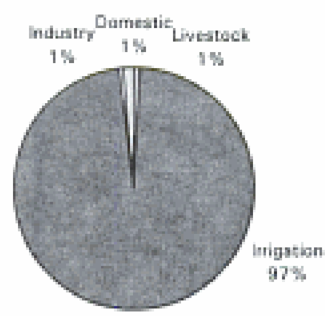
Lakes and dams

There are 18 artificial reservoirs with a total capacity of about 2.89 km³: 8 on the Murghab River, 3 on the Tedzhen River, 3 on the Atrek River and 4 on the Kara Kum canal. The largest reservoir is the Hauz-Khan reservoir on the Kara Kum canal with a total capacity of 0.875 km³. All the reservoirs were been designed and constructed mainly for irrigation purposes, and are affected by heavy siltation.

The gross hydropower potential of the country is estimated at 5.8 GWh, while the total installed capacity was about 0.7 GWh in 1993. The construction of the Puli Hatum reservoir on the Tedzhen River on the border between Iran and Turkmenistan has been planned but is awaiting agreement between the two countries. Its total capacity would be 1.3 km³, and it has been designed for flood control, hydropower generation and flow regulation purposes.

The outflow of drainage water has led to the creation of artificial lakes in natural depressions. The largest one is Lake Sarakamysh with a storage of about 8 km³. A major environmental issue in Turkmenistan is the permanent accumulation of pollutant salt in these lakes, as this leads to the degradation of their flora and fauna.

FIGURE 3
Water withdrawal
Total: 23.779 km³ in 1994



Water withdrawal

In 1994, the total annual water withdrawal was estimated at 23.8 km³, of which 97% for agricultural purposes (Figure 3). Recently, there has been a slight fall in the total water withdrawal, mainly because of the adoption of water saving methods in agriculture. The main source of water is surface water. Drainage water from irrigated land is also re-used and constitutes another source of water for irrigation. In 1994, 214 million m³ of groundwater was used for domestic purposes, 151 million m³ for agricultural purposes, and 36 million m³ for industry.

IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

Irrigation is the lifeblood of Turkmenistan's economy. In 1975, the total irrigated area was estimated at about 857 000 ha. In 1994 it was 1 744 100 ha, which was 99.4% of the total cultivated area (Figure 4).

FIGURE 7
Typology of irrigation canals
Total: 39 131 km

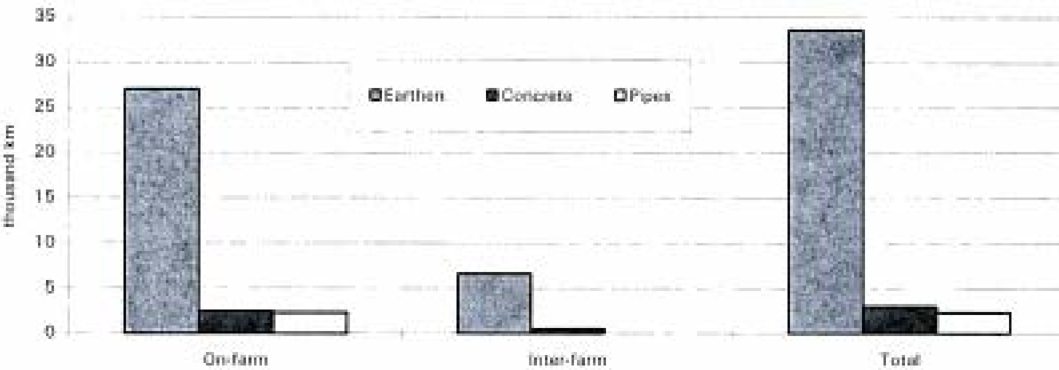
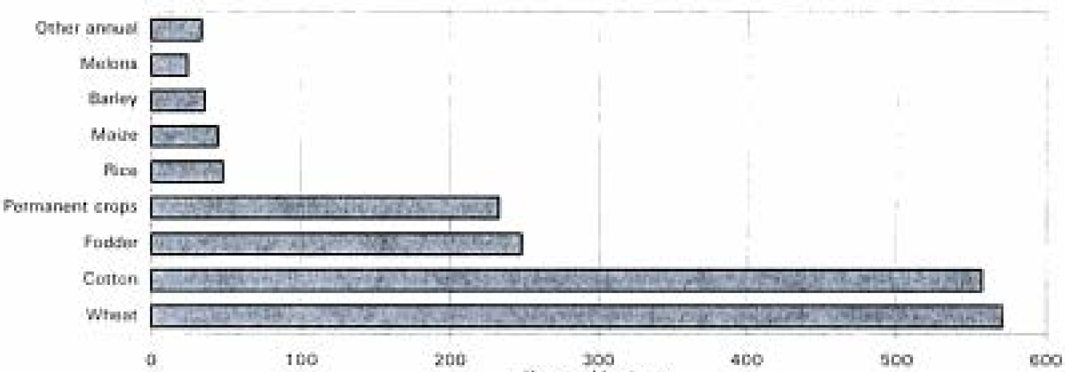


FIGURE 8
Main irrigated crops
Total: 1 794 200 ha in 1994



No private irrigation schemes exist in Turkmenistan. All the schemes are managed by a state agency. Most of the schemes are larger than 10 000 ha. Water is allocated to each farm on the basis of standard crop water requirements. When a farm exceeds its allocation, a fine is applied, based on the extra volume of water. In 1995, the rate was manat 0.503/m³, or $US 0.2/1000 m³. This measure has been introduced to encourage farmers to reduce water consumption.

The major irrigated crops are cereals (mainly wheat), cotton and fodder (Figure 8). Cotton and vegetables are the most important export crops. In 1994, irrigated crop yields were 2.3 t/ha for cotton, 1.65 t/ha for wheat, 1.78 t/ha for barley, 2.38 t/ha for rice, 8.77 t/ha for melons and 6.55 t/ha for grapes.

The average cost of irrigation development is estimated at $US 4 000-10 000/ha for large-scale surface irrigation schemes using modern technologies, including agricultural infrastructures. If micro-irrigation were to be developed on existing irrigated areas, its estimated implementation cost would be $US 3 500-5 000/ha. The annual O&M cost which would enable full cost recovery is estimated at $US 250/ha for surface irrigation systems, and at about $US 450/ha for pump systems. However, the actual cost has not exceeded $US

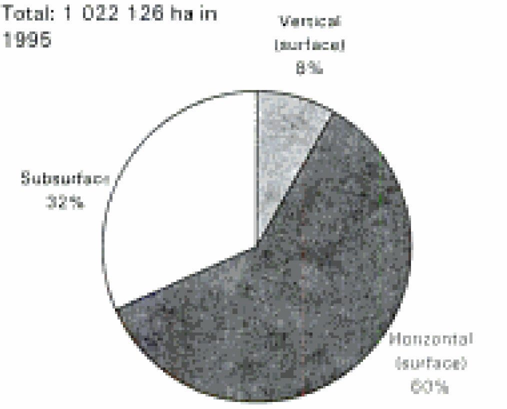
100/ha in recent years, resulting in poor maintenance of the system. It is estimated that about 653 000 ha of irrigation schemes need rehabilitation.

Waterlogging, salinity and drainage development

The water loss from the Kara Kum canal, whose banks are unprotected, is estimated at 18% of the total flow. This has caused massive waterlogging and salinization of the surrounding land. In 1994, about 652 000 ha, or 37% of the irrigated area, were classed as saline by Central Asian standards (toxic ions exceed 0.5% of total soil weight).

Out of a total irrigated area of 1 744 100 ha, over 1 222 000 ha require drainage. In 1995, drainage infrastructures had been constructed on about 1 022 126 ha. Approximately 32% is subsurface drainage, mainly on newly reclaimed areas. Surface drainage can be divided into horizontal drainage, on 614 445 ha, and vertical drainage, on 84 719 ha (Figure 9). In total, about 72 million m³ of water is pumped by vertical drainage, and discharged into the collector-drainage canals. The total length of the collector-drainage network is estimated at 35 km at on-farm level and 140 km at inter-farm level.

FIGURE 9
Drainage techniques
Total: 1 022 126 ha in 1995



INSTITUTIONAL ENVIRONMENT

The Ministry of Water Resources (MWR) is in charge of water resources research, planning, development and distribution. It also undertakes the construction, operation and maintenance of the irrigation and drainage networks at inter-farm level. Water allocations are regularly reduced in order to promote savings and to satisfy the demand from new users and to increase the water flow to the Aral Sea. The institutional structure of water management follows various hierarchical levels: state, vilayat, district, farm (or WUA). The first three, come under the MWR and are responsible for the distribution and delivery of water up to the farm inlet, for assistance to the water users in implementing modern technologies, and for the control of water use and water quality. The special reclamation services, at all levels, are also the responsibility of the MWR. They monitor groundwater level, drainage discharge and soil salinity, and plan measures for the maintenance and improvement of soil conditions, including leaching, repair and cleaning of collector-drainage network, rehabilitation, etc.

The 'Water Code of Turkmenistan', was issued on 27 December 1972. This code is currently under review, and new water legislation is planned for the near future.

The Ministry of Agriculture is in charge of agricultural research and extension, land reclamation and agricultural development at farm level, and the operation and maintenance of the irrigation network at farm level.

The Ministry of Municipal Affairs is responsible for domestic water supply and wastewater treatment.

Turkmenistan is a member of IFAS, ICWC and the Amu Darya River BWO.

TRENDS IN WATER RESOURCES MANAGEMENT

Increasing food production is one of the major goals of the national agricultural policy. Irrigation development and agricultural intensification have to be achieved in a general context of limited water resources. Increased re-use of wastewater and of agricultural drainage water is seen as one of the solutions for increasing the water availability needed to enable further irrigation expansion. At the same time, research is being carried out on water saving techniques, and new measures are expected to be adopted on a large scale to increase irrigation efficiency. Rehabilitation of drainage and irrigation networks is also envisaged to reduce water losses and to limit the expansion of salinization.

All these measures have been proposed in the national water strategy, part of the regional water strategy. They should make it possible to contain the irrigation water withdrawal at around 25 km^3/year between 2000 and 2010, compared with 23.2 km^3/year in 1994, while the irrigated area is expected to increase from 1 744 100 ha in 1994 to 2 353 000 ha in 2010.

Environmental issues are particularly acute in Turkmenistan. Water in the rivers and in the drainage networks is of very poor quality, containing high concentrations of salts and pesticides coming from upstream countries. This also affects the Aral Sea area where some of the main collector-drainage canals discharge. A trans-desert collector running for a total length of about 800 km from the northeast to the Caspian Sea in the far west is under construction. It is intended to collect the agricultural drainage waters from the Murghab, the Tedzhen oases, and from the other irrigated areas located along the Kara Kum canal.

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Ukraine

GEOGRAPHY AND POPULATION

Ukraine, located in eastern Europe, has a total area of 603 700 km² making it the third largest country of the FSU after the Russian Federation and Kazakhstan. It is bordered in the southwest by Romania and Moldova, in the west by Hungary, the Slovak Republic and Poland, in the north by Belarus, in the east by the Russian Federation, and in the south by the Black Sea, where the Crimea peninsula is located. Administratively, Ukraine is divided into 24 provinces *(oblasts)* plus the autonomous Republic of Crimea and the two large cities of Sevastopol and the capital Kiev, which are special districts.

The predominant lowland is interrupted by several regions of modest elevation, such as the Volyn-Podolsk plateau (also called the Podolian plateau) in the west, the Dnepr ridge in the centre, and the Donets ridge in the southeast. The Carpathian mountains (with their highest peak at 2 061 m above sea level) and their foothills in the southwest, together with the Crimean mountains (1 545 m above sea level) along the southern coast of the Crimean peninsula, constitute the only mountainous sections of Ukraine.

TABLE 1
Basic statistics and population

Physical areas:		
Area of the country	1994	60 370 000 ha
Cultivable area	1993	44 830 000 ha
Cultivated area	1993	31 174 000 ha
- annual crops	1993	30 173 700 ha
- permanent crops	1993	1 000 300 ha
Population:		
Total population	1996	51 608 000 inhab.
Population density	1996	85 inhab./km²
Rural population	1996	29 %
Economically active population engaged in agriculture	1996	18 %
of which: - men		- %
- women		- %
Water supply coverage:		
Urban population	1995	100 %
Rural population	1995	100 %

The cultivable area is estimated at 44.8 million ha, or 74% of the total area of the country. The cultivated area was estimated at about 31.2 million ha in 1993, of which about 30.2 million ha, or 97%, consisted of annual crops and 1 million ha, or 3%, of permanent crops. The potential for agricultural production is rather evenly spread throughout the country, with two distinguishable centres: the western region characterized by a moderate climate; and the southern region with its fertile black soils where irrigation plays an important role. The Chernobyl nuclear accident has contaminated about 4.1 million ha. About 92 settlements around Chernobyl have been evacuated. The State has provided financial support to 835 settlements for people wanting to move away. A strict radiological control has been applied over a larger zone, covering an additional 1 288 settlements. Due to the prevailing winds, most of the radioactivity fell on Belarus.

Due to the market-oriented transformation of the economy, agricultural land ownership is undergoing many changes as land privatization progresses. The previously dominant collective sector is shrinking, giving way to the development of the private sector. According to the latest occicial data of 1 January 1993, a few months after the announcement of the land

UKRAINE

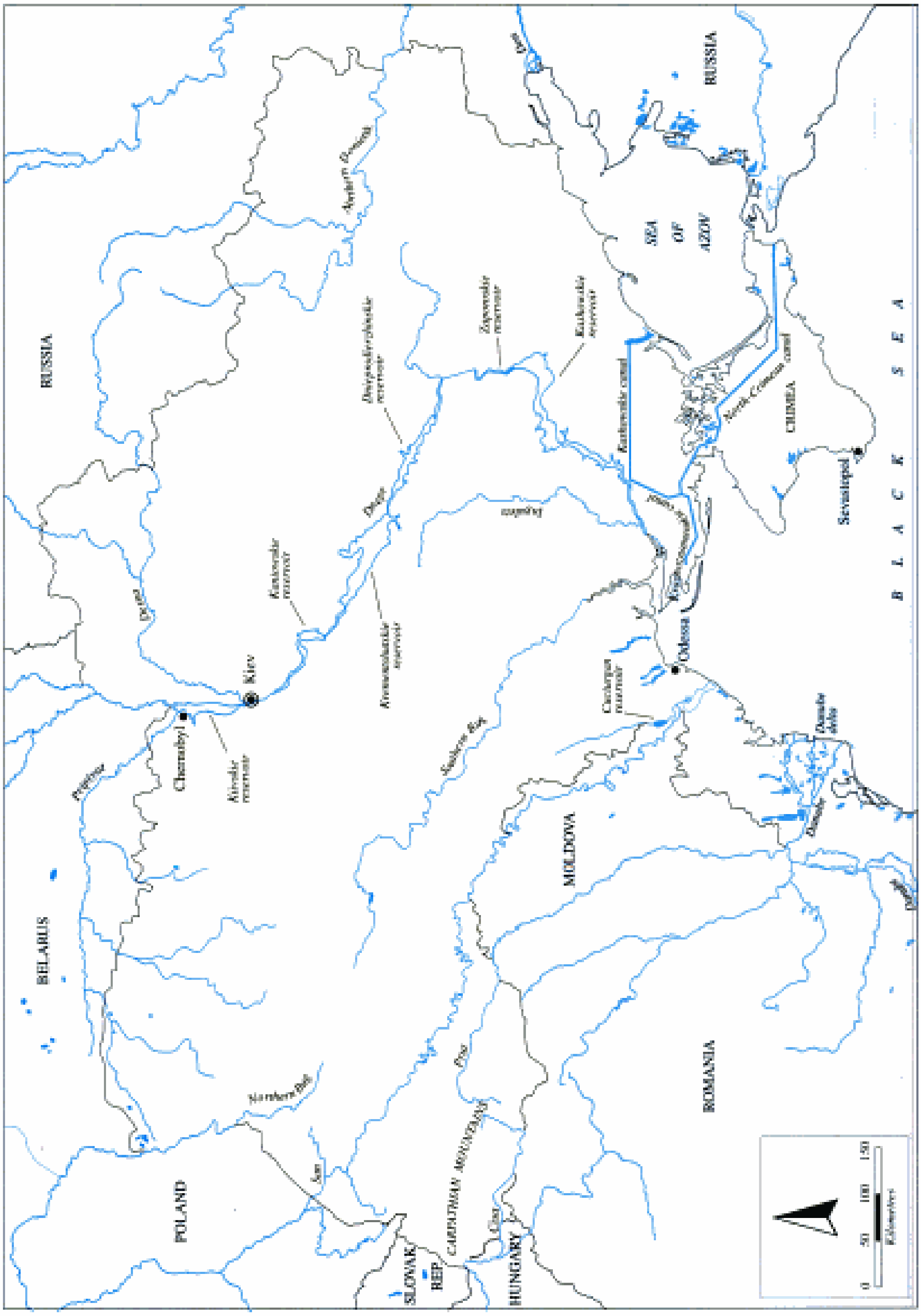
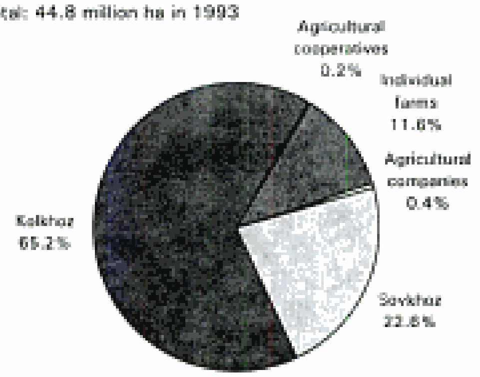

RUSSIA
BELARUS
POLAND
SLOVAK REP
HUNGARY
ROMANIA
MOLDOVA
CRIMEA
SEA OF AZOV
BLACK SEA
Kiev
Chernobyl
Odessa
Sevastopol
Desna
Southern Bug
Northern Bug
San
Prut
Tisa
Danube
Danube delta
CARPATHIAN MOUNTAINS
Kievskoe reservoir
Kanevskoe reservoir
Kremenchugskoe reservoir
Dneprodzerzhinskoe reservoir
Zaporozhskoe reservoir
Kakhovskoe reservoir
Kakhovskoe canal
North Crimean canal
Northern Donets
0 50 100 150
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		500	mm/yr
		301.8	km³/yr
Internal renewable water resources		53.1	km³/yr
Total (actual) renewable water resources	1997	139.55	km³/yr
Dependency ratio	1997	62.0	%
Total (actual) renewable water resources per inhabitant	1996	2 704	m³/yr
Total dam capacity	1967	2 700	10^6 m³
Water withdrawal:			
- agricultural	1992	7 855	10^6 m³/yr
- domestic	1992	4 637	10^6 m³/yr
- industrial	1992	13 499	10^6 m³/yr
Total water withdrawal		25 991	10^6 m³/yr
per inhabitant	1992	499	m³/yr
as % of total (actual) renewable water resources		18.6	%
Other water withdrawal	1992	933	10^6 m³/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1989	6 660	10^6 m³/yr
- treated wastewater	1989	3 800	10^6 m³/yr
- re-used treated wastewater		-	10^6 m³/yr
Agricultural drainage water		-	10^6 m³/yr
Desalinated water		-	10^6 m³/yr

privatization decree, the private sector, consisting of individual farms, agricultural companies and agricultural cooperatives, owned 5.5 million ha, or about 12% of the total cultivable area (Figure 1). The public sector *kolkhoz* (collective farms) and *sovkhoz* (state farms) occupied 29.2 million ha and 10.1 million ha respectively.

FIGURE 1
Land categories
Total: 44.8 million ha in 1993



The total population is estimated at 51.6 million inhabitants (1996), of which 29% is rural. The annual population growth rate averaged 0.3% in the period 1980-1992, but in the last few years there has been a slight decrease in the total population of the country. The average population density is 85 inhabitants/km², and ranges from 40 inhabitants/km² in the south and northwest (Volyn, Kherson) to more than 200 inhabitants/km² in the most industrialized regions (Kiev, Donietsk, Lviv). Women make up 54% of the total population, and are also the majority in the rural population (55%), unlike in other East European countries. Agriculture employs about 18% of the economically active population, far behind industry. Agriculture contributes 14% to the GDP, which declined by 33% between 1993 and 1995. Agricultural exports, consisting mainly of meat and animal products, account for about 40% of total exports.

CLIMATE AND WATER RESOURCES

Climate

There are four agro-climatological zones in Ukraine:

TABLE 3
Irrigation and drainage

Irrigation potential	1994	5 500 000	ha
Irrigation:			
1. Full or partial control irrigation: equipped area	1994	2 605 000	ha
- surface irrigation		-	ha
- sprinkler irrigation	1985	2 080 000	ha
- micro-irrigation		-	ha
% of area irrigated from groundwater	1994	0	%
% of area irrigated from surface water	1994	100	%
% of area irrigated from non-conventional sources	1994	0	%
% of equipped area actually irrigated		-	%
2. Equipped wetland and inland valley bottoms (i.v.b.)		-	ha
3. Spate irrigation		-	ha
Total irrigation (1 + 2 + 3)	**1994**	**2 605 000**	**ha**
- as % of cultivated area		8.4	%
- increase over last 10 years	1985-94	+ 8.7	%
- power irrigated area as % of irrigated area		-	%
Full or partial control irrigation schemes:			
Large-scale schemes		-	ha
Medium-scale schemes		-	ha
Small-scale schemes		-	ha
Total number of households in irrigation		-	
Irrigated crops:			
Total irrigated grain production	1990	3 693 000	t
as % of total grain production	1990	7	%
Harvested crops under irrigation	**1990**	**2 413 000**	**ha**
- permanent crops: total		-	ha
- annual crops: total	1990	2 413 000	ha
. Fodder	1990	1 254 000	ha
. Cereals	1990	803 000	ha
. Vegetables and potatoes	1990	211 000	ha
. Industrial crops (Sunflower, Sugarbeet)	1990	145 000	ha
. other annual crops	1990	0	ha
Drainage - Environment:			
Drained area	1994	3 281 000	ha
- drained area in full or partial control irrigated areas	1994	1 800 000	ha
- drained area in equipped wetland and i.v.b.		-	ha
- other drained area		-	ha
- area with subsurface drains	1994	2 058 000	ha
- area with surface drains	1994	1 223 000	ha
Drained area as % of cultivated area		10.5	%
Power drained area as % of total drained area		-	%
Area salinized by irrigation		-	ha
Population affected by water-borne diseases		-	inhabitants

- The humid zone. This zone covers 35% of the country in the northwest. It is moderately warm in summer and cold in winter. The average annual precipitation is 600 mm, concentrated between May and October, but can reach 1 600 mm in the highest part of the Carpathian mountains, with to up 300 mm falling as snow. In these areas, the snow cover generally lies for 70-90 days, from early or mid-December to the end of February, but can last until April and even mid-May. Average temperatures vary between -4°C in January and 17°C in July.
- The warm zone. This zone comprises the eastern and central forested steppe (25% of the country). The average annual precipitation is 500 mm, concentrated between February and April. Average temperatures vary between -6°C in January and 21°C in July.
- The semi-arid zone. This zone covers 25% of the country and comprises the so-called northern steppe (central part of the country) and the far east of the country (Donietsk high

plain). The average annual precipitation is 450 mm, concentrated between April and October. Average temperatures vary between -6°C in January and 21°C in July.

- The arid zone. This area in the south covers 15% of the country, including the Crimean peninsula. It is characterized by mild winters, with an average annual precipitation of about 360 mm, concentrated between December and May. Average temperatures vary between 0°C in January and 23°C in July.

The average annual precipitation over the country is estimated at 500 mm. This figure includes snowfall, which is an important source of water, particularly in the west.

River basins and water resources

The country can be divided into seven major river basins, all of them discharging into the Black Sea except the Northern Bug which flows towards the Baltic Sea:

- The Dnepr basin, covering about 65% of the country. The Dnepr River rises in the Russian Federation, then flows into Belarus before entering Ukraine. Its main affluents in Ukraine are: on the left bank, the Desna River, which rises in the Russian Federation; and on its right bank, the Pripyat River, which comes from Belarus and the Ingulets.
- The Dnestr basin, covering 12% of the country. It flows into Moldova before re-entering Ukraine some 50 km before its mouth in the Black Sea.
- The Danube basin, covering 7% of the country. The final 120 km of the Danube River before it reaches the Black Sea form the border between Ukraine and Romania. The Danube is the river with the largest number of riparian countries in the world. Some affluents of the Danube rise in Ukraine, in the Carpathian mountains, flow into neighbouring countries, and join the mainstream of the Danube before its mouth in the Black Sea. In particular, the Cisa River flows out of Ukraine into Hungary, while the Prut River flows into Romania and Moldova. Ukraine contributes 7.5% to the total flow of the Danube.
- The coastal basin, covering 7% of the country. It groups all the small rivers which flow directly into the Sea of Azov and the Black Sea, including all the Crimean rivers.
- The Northern Donietsk basin, covering 4% of the country. It rises in the Russian Federation, and flows through Ukraine for about 450 km in its eastern part before re-entering the Russian Federation.
- The Southern Bug basin, covering 3% of the country. It is an internal river basin, generating about 3.4 km³/year.
- The Northern Bug basin, covering 2% of the country. The Northern Bug River rises in Ukraine and flows north, forming the border with Poland, and then the border between Poland and Belarus. Like the Northern Bug, the San River rises in Ukraine before entering Poland where it joins the Northern Bug.

The IRSWR can be estimated at 50.1 km³/year (Figure 2), while the total surface water resources can be estimated at 136.55 km³/year.

The groundwater resources are estimated at 20 km³/year. Artesian wells are found at an average depth of 100-150m in the north of the country and at 500-600m in the south. The overlap between surface and groundwater resources has been estimated at 17 km³/year.

Renewable Surface Water Resources (RSWR) by major river basin

Name of river basin	Part of country area	Internal RSWR	Inflow		Total RSWR	Outflow to
	%	km³/yr.	km³/yr.	From	km³/yr	
Dnepr	65	20.4	26.2	Belarus, Russian Fed.	46.6	Black Sea
Dnestr	12	9.2	0.64	Moldova	9.84	Black Sea
Danube	7	9.4 (Cisa + Prut)	58.3	Border with Romania	67.7	Black Sea
Coastal	7	3.1	0.11	Moldova	3.21	Black Sea
N. Donietsk	4	2.7	1.2	Russian Fed.	3.9	Russian Fed.
S. Bug	3	3.4	-		3.4	Black Sea
N. Bug + San	2	1.9	-		1.9	Poland
Total	**100**	**50.1**	**86.45**		**136.55**	

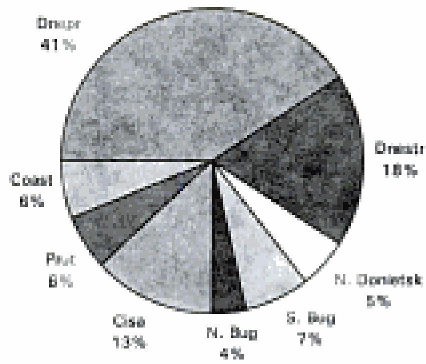
International agreements

The Soviet legislation regarding international water issues is still valid, which means that the agreements with Poland, the Slovak Republic, Hungary and Romania, as well as the internal regulations between former Soviet republics, are still in force. An agreement between Moldova and Ukraine stipulates that Moldova may use water stored in the Curciugan reservoir, located on a tributary of the Dnestr. This tributary rises in Ukraine and forms the border with Moldova before it reaches the Dnestr. Ukraine and Poland have begun discussions concerning the protection of the Northern Bug resources against pollution.

FIGURE 2

Internal renewable surface water resources by basin

Total: 50.1 km³/year



Lakes and dams

There are about 3 000 natural lakes in Ukraine, with a total area of 2 000 km². The largest freshwater lakes have an approximate area of 50 km² and are located in the central and southern parts of the country. In addition to these lakes, there are about 12 000 km² of swamp (peat soils) in the north.

About 22 000 dams have been constructed in Ukraine for flow regulation, hydropower, irrigation and fishery purposes. The largest ones, with a total capacity of 18.5 km³ and a total surface water area of 6 888 km², are located on the Dnepr: the Krementshutskie (2 252 km²), the Kachowskie (2 155 km²), the Kiivskie (922 km²), the Dnieprodierzhinskie (567 km²), the Zaporoskie (410 km²) and the Kaniowskie (582 km²). They are used for hydropower production, for supplying electricity to the main cities and industrial centres; for flood protection; and for storing irrigation water. The gross theoretical hydropower potential is estimated at 45 000 GWh/year, about 40% of which would be economically feasible. The hydropower installed capacity is estimated at 4.5 GW, generating 9% of the total electricity production.

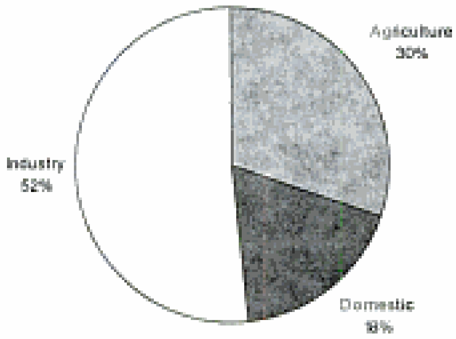
Water withdrawal and wastewater

In 1992, the total water withdrawal was estimated at 26 km³, of which 30% for agricultural purposes, and 52% for industry (Figure 3). A further 0.9 km³/year were reported to be withdrawn for other purposes.

A comparison with 1985 data shows that in the period 1985-1992 the total water withdrawn for agriculture declined by 2 km^3, and for industry by 3 km^3. This might be explained by the decrease in irrigated area due to the lack of fuel and spare parts for the pumps, the decline in animal husbandry, and the drop in industrial production caused by the prevailing difficult post-independence economic situation.

In 1989, wastewater treatment amounted to 3.8 km^3/year, which was 57% of the total produced wastewater at that time.

FIGURE 3
Water withdrawal
Total: 25.991 km^3 in 1992



IRRIGATION AND DRAINAGE DEVELOPMENT

Irrigation development

Irrigation in Ukraine has a long tradition, particularly in Crimea, where it dates back to the early centuries of the modern era. Major irrigation development also took place in the Middle Ages, during the Tatar Empire (thirteenth and fourteenth centuries), and again in the nineteenth century, when it expanded from Crimea to the steppes in the south of the country. Large irrigation schemes were built in the 1930s in eastern Soviet Ukraine, as part of the 'electrification of the socialist state' project. In 1967, the area equipped for irrigation was estimated at 667 000 ha.

The irrigation potential has been estimated at 5.5 million ha. The most suitable areas for irrigation development, from a technical and economic point of view, are: the coastal plain along the Black Sea coast between Odessa and the Danube Delta; the area between Odessa and the Southern Bug valley; central Crimea; and the coastal areas along the Sea of Azov.

In 1994, irrigation covered about 2.6 million ha. The reservoirs built on the main rivers, and particularly on the Dnepr River, provide water to the irrigated areas downstream through canals up to 500 km long. These canals also provide water to cities and industrial complexes in Crimea and in the far southwest of the country. The main irrigation canals in Ukraine are: the north Crimean (400 km), the Kachowski (130 km), the Frunzenski (120 km), the Krasnoznamenski (102 km) and the north Rohaczinski (110 km), all in the same area. There is no irrigation from groundwater in Ukraine.

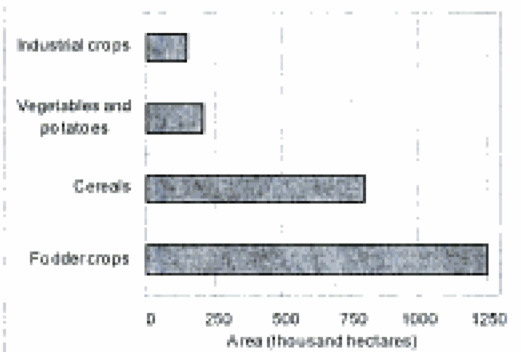
Irrigation is mainly concentrated in the south of the country. In 1984, the irrigated areas in Ukraine amounted to 2.4 million ha. More than 50% of this total was concentrated in the four districts which border the Black Sea and the Sea of Azov. Other important regions for irrigation are the valleys of the Donietsk and of the Dnepr where supplementary irrigation is practised in summer. Between 1985 and 1994, an average of a further 23 000 ha/year were equipped for irrigation.

In 1985, about 2.1 million ha were under sprinkler irrigation. The locally produced rain guns are the most widely used in Ukraine. Surface irrigation covers the rest of the area, while micro-irrigation has been introduced on an experimental basis only. Most of the irrigated areas require pumping.

Irrigation belongs to the *kolkhoz* and *sovkhoz* sector. In 1996, a small part of the irrigated land was rented by private companies. Where still operating, large irrigation projects have now turned to extensive agricultural production. Lack of fuel and capital are the main causes for the abandoning of irrigated land. Moreover, the status of irrigated land is still uncertain.

About 85% of irrigated land is used for growing fodder crops (52%) and grain (33%). About 9% is used for growing vegetables, and the remaining 6% for the production of industrial crops (Figure 4). In 1990, the average yield for cereals was 4.6 t/ha; 34% higher than the average yield for rainfed cereals. The average yields for irrigated winter wheat, sunflower seed and sugar beet were 3.9 t/ha, 1.9 t/ha and 28.4 t/ha respectively. The yields for the same crops grown on drained land in the northwest were only 2.7 t/ha, 1.7 t/ha and 27.5 t/ha respectively.

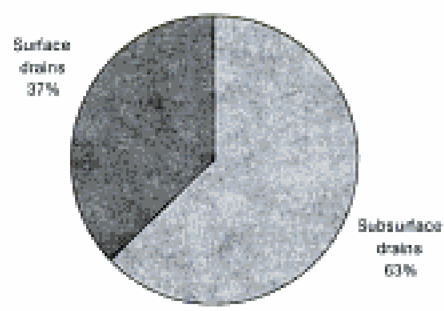
FIGURE 4
Irrigated crops
Total: 2 413 000 ha in 1990



Drainage development

The first drainage works were introduced at the end of the eighteenth century in northwest Ukraine, then part of Poland. At that time, major canals were built, mainly for communication and transport purposes, and the swamps were drained for cultivation. Drainage development has continued in the nineteenth and twentieth centuries.

FIGURE 5
Drainage techniques
Total: 3 281 000 ha in 1994



Recent studies have identified some 5.4 million ha as requiring drainage. In 1994, the drained area was estimated at 3.3 million ha, of which 63% was equipped with subsurface drains, mainly pipes (Figure 5). About 1.8 million ha of irrigated land are equipped with drainage facilities to prevent salinization. In these areas, the underground water level is kept at 1.5-3.0 m below the soil surface .

About 80-95% of the drained area is cropped every year. In 1990, the main crops on drained areas were permanent meadows (38%), cereals (27%) and fodder crops (26%) (Figure 6).

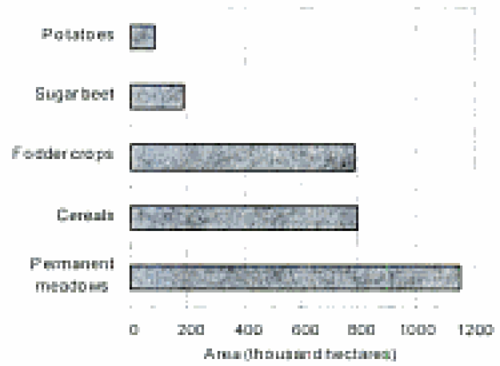
Drainage is mainly concentrated in the north and west of the country. In 1984, the drained area in Ukraine amounted to almost 3 million ha, of which 53% was in the four most northwestern districts. A further 20 000- 30 000 ha have been equipped for drainage since 1984, mainly with subsurface drainage.

Institutional Environment

FIGURE 6

Crops grown on drained areas

Total: 3 003 000 ha in 1990



Water management in Ukraine has traditionally been administered by different ministries:

- The Ministry of Land Improvement is, with the Department of New Projects, responsible for the design and execution of irrigation and drainage schemes.
- The Ministry of Agriculture is, with the Department of Water Management, responsible for operation and maintenance of the irrigated and drained areas.
- The Ministry of Power Engineering is, with the Department of Control of Water Use, responsible for water use for energy purposes,.
- The Ministry of Transport is involved in water management in view of the important role canals and rivers play in transportation and navigation.

In order to coordinate ministerial actions in the water sector, in 1992 the government established the State Committee for Water Administration. This committee is responsible for all policy issues related to water resources development, and particularly for new investments.

The Hydrometeorological Committee operates under the Council of Ministers, and maintains an extensive network of hydrological and climatological stations throughout the country.

The National Agrarian Academy of Sciences of Ukraine, established in the 1990s, supervises two affiliated institutions which deal with water resources development:
- the Institute of Hydraulic Sciences and Land Drainage, located in Kiev, in the north;
- the Institute of Irrigation in Kherson, in the south.

The main laws relating to the water sector were introduced during the Soviet era. A new law is under preparation. There are no water charges for irrigation in Ukraine.

Trends in Water Resources Management

In the water sector, the government of Ukraine is now focusing on drinking water supply. Indeed, although nearly 100% of the population has access to safe water supply (in rural areas, mostly through wells), the existing network is overexploited. For this reason, and because of energy shortages, many cities receive water only twice a day for a limited number of hours. Expenditure in this sector has increased substantially: while the five year plans of the 1980s envisaged the laying of about 60 km of pipes for the whole period, there are now some 250 km of pipes laid every year. This development should lead to an improved water supply in the near future.

In the past, the agricultural sector was a priority for the government. Indeed, in the 1960s, the Council for Dnepr River Resources Management was established with a mandate to prepare legal acts concerning the exploitation of the Dnepr, Northern Donietsk, Southern Bug, Crimea and Donbas regions. This programme was completed in the early 1980s.

Public expenditure on water resources development for agriculture has fallen substantially since 1992. This fall has been caused by a lack of capital and by the undefined status of landownership on large areas. Combined with a lack of fuel to pump water to the irrigated land, this explains the recent decrease in irrigated areas.

In the mid-1980s, the Soviet National Committee for Science and Technology launched a project concerning the automation of the Dnepr water resources management. This project reflected the prevailing needs of industry, cities and irrigated agriculture in some districts. Indeed, one of the most crucial problems is, and will be in the future, the optimal use of river water resources. At the beginning of the 1990s, some rivers of the central and southern regions were exploited in their downstream courses to such an extent that aquatic life was endangered and basic environmental requirements were not satisfied.

Salinity problems are concentrated mostly in the southern region.

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Uzbekistan

GEOGRAPHY AND POPULATION

Uzbekistan is a landlocked country in Central Asia, with a total area of 447 400 km². It is bordered in the north by Kazakhstan, in the east by the Kyrgyz Republic and Tajikistan, and in the south by Afghanistan and Turkmenistan. It became independent from the Soviet Union in August 1991. For administrative purposes, the country is divided into 12 vilayats (one of which includes the capital city of Tashkent) plus one autonomous republic: Karakalpakstan in the far west of the country near the Aral Sea.

Physiographically the country can be divided into three zones:

- the desert (Kyzylkum), steppe and semi-arid region covering 60% of the country, mainly the central and western parts;
- the fertile valleys (including the Fergana valley) that skirt the Amu Darya and Syr Darya rivers;
- the mountainous areas in the east with peaks of about 4 500 m above sea level (Tien Shan and Gissaro-Alay mountain ranges).

The cultivated land is estimated at 5.2 million ha, of which 87% under annual crops and 13% under perm-anent crops. Mainly because of water shortage, the cultivated area is only 20% of the cultivable area, estimated at 25.4 million ha. In 1994, the agricultural area could be divided into:

- *kolkhoz* (collective farms) and *sovkhoz* (state farms), for a combined area of 22 million ha;
- land leased to farmers for agricultural production on a long-term period (*arenda*), 76 800 ha;
- 'land of citizens', corresponding to gardens and individual plots cultivated by their owners, 477 500 ha;
- land managed by forest enterprises, about 1.97 million ha (Figure 1).

TABLE 1

Basic statistics and population

Physical areas:		
Area of the country	1994	44 740 000 ha
Cultivable area	1993	25 447 700 ha
Cultivated area	1993	5 207 800 ha
- annual crops	1993	4 529 700 ha
- permanent crops	1993	678 100 ha
Population:		
Total population	1996	23 209 000 inhab.
Population density	1996	52 inhab./km²
Rural population	1996	58 %
Economically active population engaged in agriculture	1996	33 %
of which: - men		- %
- women		- %
Water supply coverage:		
Urban population	1994	89 %
Rural population	1994	60 %

The total population is estimated at 23.2 million (1996), of which about 58% is rural. The average population density is about 52 inhabitants/km², which is the highest of the five Central Asian republics. It ranges from more than 464 inhabitants/km² in Andijan province (in the Fergana valley, in the east of the country) to only 8 inhabitants/ km² in

UZBEKISTAN

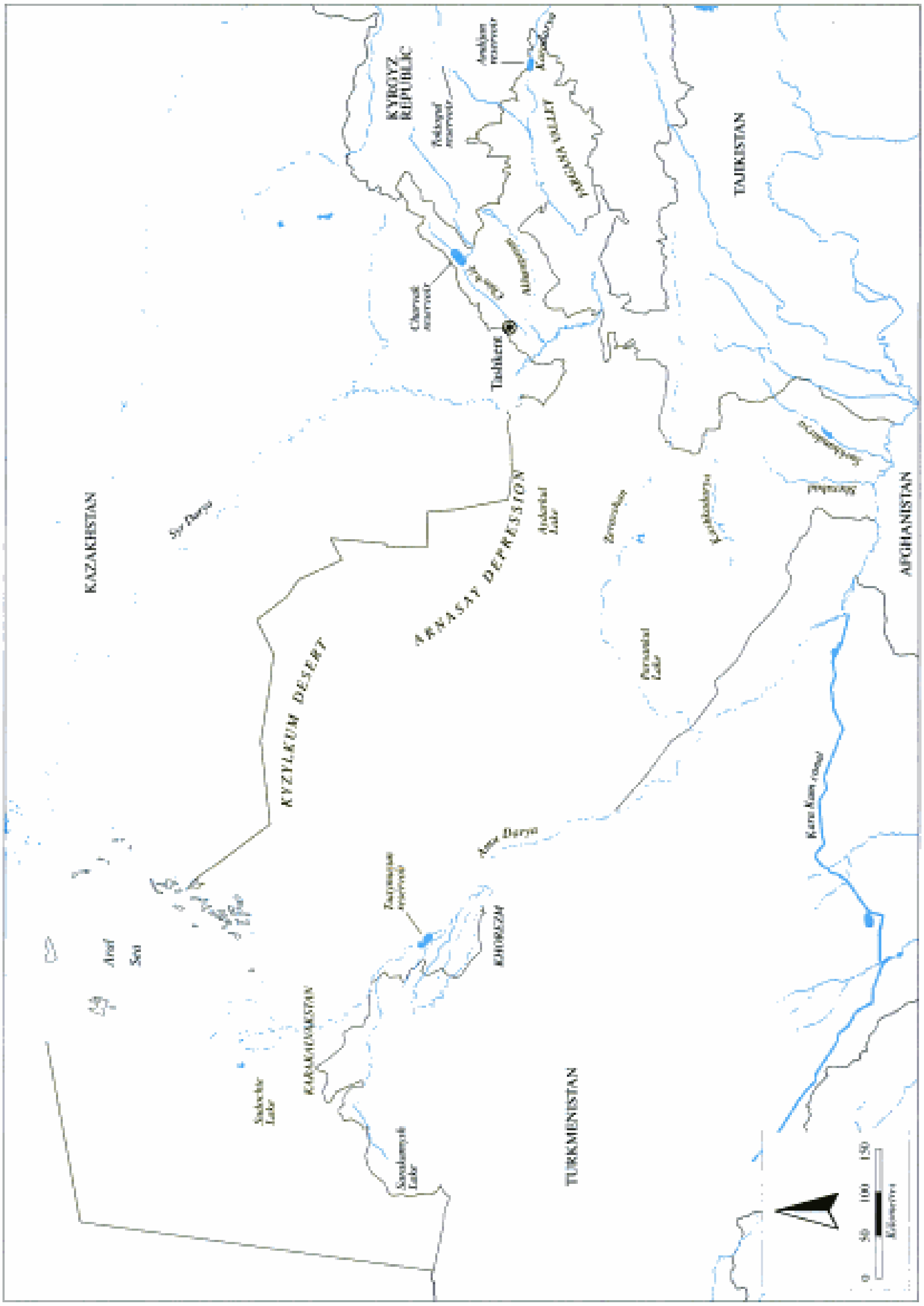
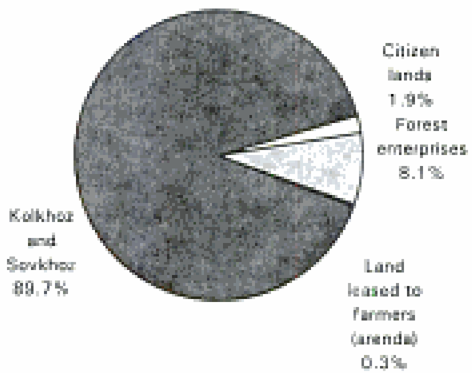

KAZAKHSTAN
KYRGYZ REPUBLIC
TAJIKISTAN
AFGHANISTAN
TURKMENISTAN
Tashkent
FERGANA VALLEY
Syr Darya
ARNASAY DEPRESSION
KYZYLKUM DESERT
Aral Sea
Amu Darya
KHOREZM
KARAKALPAKSTAN
0 50 100 150
Kilometres

TABLE 2
Water: sources and use

Renewable water resources:			
Average precipitation		264	mm/yr
		118.1	km^3/yr
Internal renewable water resources		16.34	km^3/yr
Total (actual) renewable water resources	1997	50.41	km^3/yr
Dependency ratio	1997	77.4	%
Total (actual) renewable water resources per inhabitant	1996	2 172	m^3/yr
Total dam capacity	1994	19 000	10^6 m^3
Water withdrawal:			
- agricultural	1994	54 366	10^6 m^3/yr
- domestic	1994	2 582	10^6 m^3/yr
- industrial	1994	1 103	10^6 m^3/yr
Total water withdrawal		58 051	10^6 m^3/yr
per inhabitant	1994	2 601	m^3/yr
as % of total (actual) renewable water resources		115.2	%
Other water withdrawal	1994	530	10^6 m^3/yr
Wastewater - Non-conventional sources of water:			
Wastewater:			
- produced wastewater	1994	1 492	10^6 m^3/yr
- treated wastewater		-	10^6 m^3/yr
- re-used treated wastewater		-	10^6 m^3/yr
Agricultural drainage water	1994	30 900	10^6 m^3/yr
Desalinated water		-	10^6 m^3/yr

Karakalpakstan. The annual population growth rate was stable at about 2.8-3.2% in the 1970s and 1980s, but fell to an average of 2.2% between 1990 and 1994. This fall has mainly been due to the prevailing difficult post-independence economic situation and the migration of a part of the population to other countries (the Russian Federation, Germany, Israel, etc.).

FIGURE 1
Land categories
Total: 24 530 000 ha in 1994



In 1994, the agricultural sector contributed some 36% to GDP. In 1996, it employed about 33% of the total economically active population. The contribution of crop production to GDP was about 20% from irrigated crops and 2% from rainfed crops. Cotton, called 'white gold' in Uzbekistan, vegetables and fruits are the country's principal exports. Uzbekistan is one of the world's largest cotton exporters.

CLIMATE AND WATER RESOURCES

Climate

The climate of Uzbekistan is continental, even arid/desertic over 60% of the territory. The average annual rainfall is 264 mm, ranging from less that 97 mm in the northwest to 425 mm in the mountainous zone in the middle and southern parts of country. In the Fergana valley, the average annual rainfall varies between 98 and 502 mm, while in the Tashkent vilayat, it varies between 295 and 878 mm. Rainfall occurs during the winter season, mainly between

TABLE 3
Irrigation and drainage

Irrigation potential		1990	4 915 000	ha
Irrigation:				
1. Full or partial control irrigation: equipped area		1994	4 280 600	ha
- surface irrigation		1994	4 276 090	ha
- sprinkler irrigation		1994	0	ha
- micro-irrigation		1994	4 510	ha
% of area irrigated from groundwater		1994	6.4	%
% of area irrigated from surface water		1994	93.6	%
% of area irrigated from non-conventional sources			-	%
% of equipped area actually irrigated		1994	98	%
2. Equipped wetland and inland valley bottoms (i.v.b.)			-	ha
3. Spate irrigation			-	ha
Total irrigation (1 + 2 + 3)		**1994**	**4 280 600**	**ha**
- as % of cultivated area			82	%
- increase over last 10 years		1986-94	+ 8.7	%
- power irrigated area as % of irrigated area		1994	27.4	%
Full or partial control irrigation schemes:	Criteria			
Large-scale schemes	> 10 000 ha	1994	3 639 600	ha
Medium-scale schemes			-	ha
Small-scale schemes	< 10 000 ha	1994	641 000	ha
Total number of households in irrigation			-	
Irrigated crops:				
Total irrigated grain production		1993	2 243 000	t
as % of total grain production		1993	61.5	%
Harvested crops under irrigation		**1993**	**4 308 800**	**ha**
- permanent crops: total		1993	678 100	ha
- annual crops: total		1993	3 630 700	ha
. Cotton		1993	1 694 000	ha
. Fodder		1993	967 800	ha
. Wheat		1993	457 700	ha
. Vegetables and melons		1993	207 500	ha
. other annual crops		1993	303 700	ha
Drainage - Environment:				
Drained area		1994	2 840 000	ha
- drained area in full or partial control irrigated areas		1994	2 840 000	ha
- drained area in equipped wetland and i.v.b.			-	ha
- other drained area			-	ha
- area with subsurface drains		1994	698 300	ha
- area with surface drains		1994	2 141 700	ha
Drained area as % of cultivated area			55	%
Power drained area as % of total drained area		1994	14	%
Area salinized by irrigation		1994	2 140 550	ha
Population affected by water-borne diseases		1994	271 800	inhabitants

October and April. The climate is characterized by high temperatures in summer (42-47°C in the plains and 25-30°C in the mountainous zone in July) and low temperatures in winter (-11°C in the north and 2-3°C in the south in January). Because of frequent frosts between late September and April, only one crop a year can be grown. However, double cropping of vegetables which have a short growing period is possible in favourable years.

River basins and surface water resources

Two river basins are found in Uzbekistan. These basins form the Aral Sea basin:

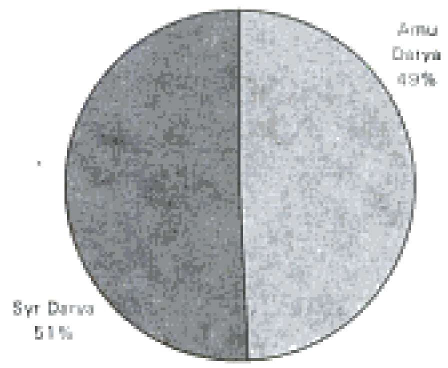
- The Amu Darya basin in the south, covering 86.5% of Uzbekistan. The main Amu Darya River can be divided into three reaches: the upper reach bordering Afghanistan and Tajikistan, and where most of the water flow is generated; the middle reach which first borders Uzbekistan and Afghanistan and then enters Turkmenistan; and the lower reach in

Uzbekistan, before it discharges into the Aral Sea. The main tributaries within Uzbekistan are the Sherabad, Kashkadarya, Surkhandarya and Zeravshan rivers. These last two rise in Tajikistan. The total amount of flow produced in the Amu Darya basin is estimated at 78.46 km^3/year; the 5% and 95% probabilities are estimated at 108.4 and 46.9 km^3/year respectively. Because of important losses in the desertic part of its course, and because of major water withdrawal by agriculture, the flow reaching the Aral Sea is limited to a small percentage of this figure (less than 10% in the driest years). About 4.7 km^3/year, or 6% of the average total surface water resources of the Amu Darya River basin, are generated within Uzbekistan.

- The Syr Darya basin in the north, covering 13.5% of the territory. The main Syr Darya River can be divided into three reaches: the upper reach in the Kyrgyz Republic, where most of the water flow is generated; the middle reach in Uzbekistan and Tajikistan; and the lower reach in Kazakhstan, before it discharges into the Aral Sea. The main tributaries within Uzbekistan are the Chirchik and Akhangaran rivers, which rise in the Kyrgyz Republic. The total amount of flow produced in the Syr Darya basin is estimated at 37.14 km^3/year; the 5% and 95% probabilities are estimated at 54.1 and 21.4 km^3/year respectively. Because of important losses in the desertic part of its course, and because of major water withdrawal by agriculture, the flow reaching the Aral Sea is limited to a small percentage of this figure (less than 5% in the driest years). About 4.84 km^3/year, or 13% of the average surface water resources of the Syr Darya river basin, are generated within Uzbekistan.

The total river flow generated inside Uzbekistan is thus estimated at 9.54 km^3/year (Figure 2).

FIGURE 2
Internal renewable surface water resources by major river basin
Total: 9.54 km^3/year



During the Soviet period, the sharing of water resources among the five Central Asian republics was on the basis of the master plans for water resources development in the Amu Darya (1987) and Syr Darya (1984) basins. In 1992, with the establishment of the Interstate Commission for Water Coordination, the newly independent republics decided, with the Agreement of 18 February 1992, to prepare a regional water strategy, but to continue to respect the existing principles until the adoption of a new water sharing agreement to be proposed by this new water strategy.

The surface water resources allocated to Uzbekistan are calculated every year, depending on the climatic situation and the existing flows. However, on average, it can be considered that the estimated average surface runoff which comes from the upstream countries is:

- 22.33 km^3/year for the Syr Darya River basin at the border between the Kyrgyz Republic and Uzbekistan, of which 11.8 km^3/year is transit flow to Tajikistan;
- 11.54 km^3/year for the Syr Darya River basin at the border between Tajikistan and Uzbekistan, of which 10 km^3/year is transit flow to Kazakhstan;
- 22 km^3/year for the Amu Darya River basin.

Groundwater resources

There are 94 major aquifers in Uzbekistan. The renewable groundwater resources are estimated at 19.68 km^3/year, of which 12.88 km^3/year are considered to be overlap with surface resources. The ARWR can thus be estimated at 50.41 km^3/year.

Limits to groundwater abstraction for each aquifer in Central Asia have been established. It is permitted to use only such a quantity of groundwater that does not cause surface flow reduction. This quantity is estimated at 6.8 km^3/year for Uzbekistan. However, the actual groundwater abstraction is estimated at 7.5 km^3/year, which thus leads to surface flow reduction.

Non-conventional sources of water

Between 1990 and 1994, the return flow on the territory of Uzbekistan was estimated at about 32.4 km^3/year, of which 21.5 km^3/year formed in the Amu Darya River basin and 10.9 km^3/year in the Syr Darya River basin. This total consists of 30.9 km^3/year of drainage flow from irrigated areas (of which 2.55 km^3/year is the result of vertical drainage by pumping) and about 1.5 km^3/year of untreated domestic and industrial wastewater.

The main part of the return flow, 15.9 km^3/year, returns to rivers: 9.5 km^3/year in the Amu Darya basin and 6.4 km^3/year in the Syr Darya basin. About 12.0 km^3/year end up in natural depressions (Arnasay, Parsankul, Sarakamish and Lake Sudochie) from which water evaporates. More than 4.5 km^3/year (about 15% of total return waters) are re-used for irrigation :

- 2.9 km^3/year being re-used without any treatment, mainly for cotton on light soils.
- 1.6 km^3/year being re-used after an *in situ* desalting treatment ('phytomelioration').

Lakes and dams

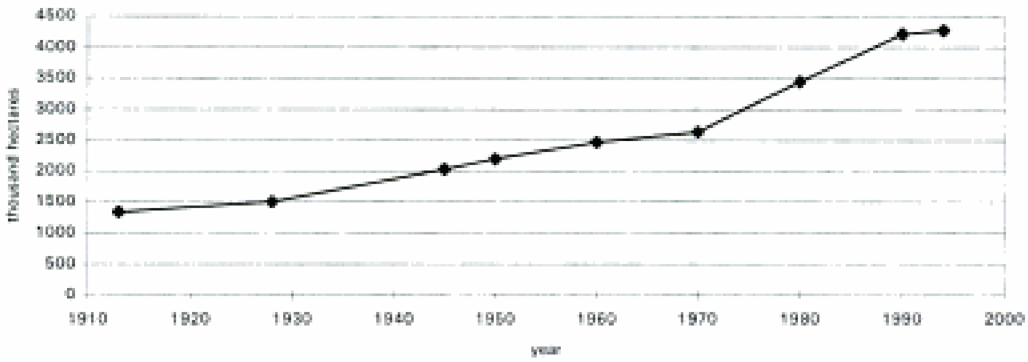
The collector-drainage water outflow has led to the creation of artificial lakes in natural depressions. The largest lakes are: Lake Aydarkul, in the Arnasay depression in the middle reach of Syr Darya, storing about 30 km^3 in 1995; the Sarykamish and Sudochie lakes, both located in the lower reach of the Amu Darya, storing 8 and 2 km^3 respectively. Several lakes have also been formed in the central part of the country in the Amu Darya basin, the largest being Lake Parsankul storing about 2 km^3, close to the Zeravshan River.

There are 50 reservoirs in Uzbekistan with a total capacity of about 19 km^3; 21 of them with a total capacity of 5 km^3 in the Syr Darya basin, and 29 with a total capacity of 14 km^3 in the Amu Darya basin. The largest reservoirs are multipurpose dams, used for irrigation, flood control and hydropower production.

In the Syr Darya basin, the largest reservoirs are the Charvak reservoir, with a capacity of 1.99 km^3, on the Chirchik River near the capital Tashkent, and the Andijan reservoir, with a capacity of 1.9 km^3, on the Karadarya River in the Fergana valley.

In the Amu Darya basin, the largest reservoir is the Tuaymuyun, in the Khorezm vilayat, with a storage capacity of 7.8 km^3, consisting of four separate reservoirs. It is expected that in the future one reservoir of this system (Kaparas) will be used to provide drinking water for Karakalpakstan. This area is experiencing severe environmental problems as a result of the

FIGURE 5
Evolution of irrigation



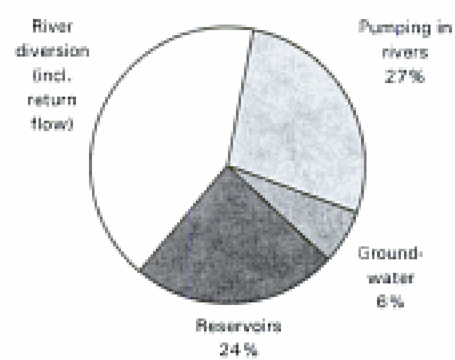
southeast; (5) Surkhandarya in the southeast; (6) Khorezm in the west-central part; (7) Karakalpakstan in the northwest.

At the beginning of twentieth century, about 1.2 million ha were irrigated in Uzbekistan. Large-scale development started in the late 1950s, when the Soviet Union decided to specialize Uzbekistan in the production of cotton. Modern irrigation techniques were then developed in the Hunger steppe in the central part of the country, in the Syr Darya basin, and in the Karshi steppe in the southeast of the country in the Amu Darya basin. In 1994, irrigation covered almost 4.3 million ha, or about 82% of the cultivated land (Figure 5).

Irrigated land produces more than 90% of crop production. About 44% of the total irrigated area is in the Syr Darya basin and 56% in the Amu Darya basin. Considering that about 634 400 ha are suitable for irrigation and that water saving would enable a further limited expansion of the irrigated area, the irrigation potential can be estimated at 4.9 million ha.

All irrigation is full control irrigation, mainly using surface water (Figure 6). Wastewater and drainage water are mixed with surface water before being re-used for irrigation. Thus, it is not possible to count them separately.

FIGURE 6
Origin of irrigation water
Total: 4 280 600 ha in 1994



Irrigation in Uzbekistan relies on a system of pumps and canals which is among the most complex in the world. Water is lifted by electric pumps for the irrigation of 1.17 million ha. In 1994, there were about 1 500 pumps. To give some examples: the Karshi system lifts 350 m^3/s of water from the Amu Darya over an elevation of 170 m; the Amubukhara pump system discharges 270 m^3/s from the Amu Darya to a canal situated 57 m above the river; the Amu Zang pump system discharges 20 m^3/s from the Surkhandarya to a canal 75 m above the river. The total length of the irrigation network is about 196 000 km. The main canals and inter-farm network extend for a length of about 28 000 km, of which some 33% is lined. The on-farm network is about 168 000 km, most of it consisting of unlined earthen canals (Figure 7).

In 1994, surface irrigation was practised on 99.9% of the total area, mainly furrow. Drip irrigation covered 4 510 ha in 1994, or only 0.1% of the total area. Sprinkler irrigation was no longer practised in 1994, although it had covered some 5 000 ha in 1990. Greatly increased energy costs and a lack of spare parts mean that this technique is not economically viable (Figure 8).

The average weighted efficiency of the irrigation network, which shows the water losses along the distance between the source and the irrigated field, is 63% (1994). The average annual water withdrawal for irrigation was estimated at 12 477 m^3/ha in 1994, and it is estimated that irrigation water requirements were covered at 80-90%. Major differences can be observed between old and new irrigated areas. New irrigated areas have been developed since 1960 with lined canals, pipes and flumes in the on-farm network, and a subsurface drainage system, which together enable an efficiency of 75-78%. Rehabilitation and modernization of the old irrigated areas would concern 2.3 million ha with an average cost of about $US 4 500/ha. The two main elements of such works would be laser land levelling and the introduction of modern irrigation techniques (drip, surge).

FIGURE 7
Typology of on-farm irrigation canals
Total: 168 000 km in 1994

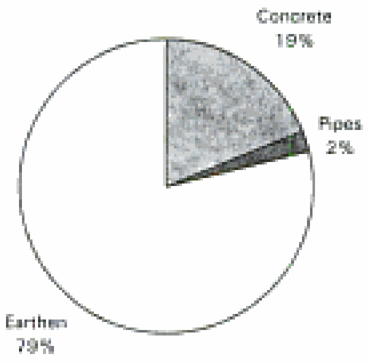
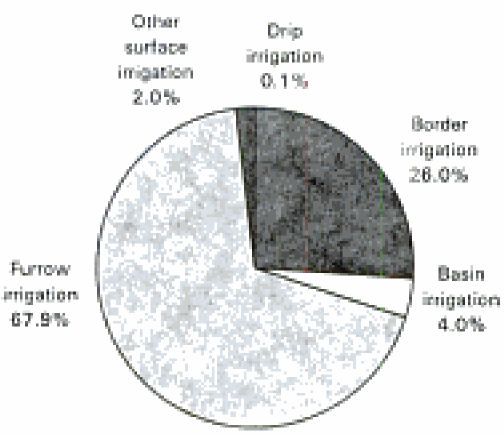


FIGURE 8
Irrigation techniques
Total: 4 280 600 ha in 1994



The average cost of irrigation development is about $US 11 200/ha, for surface irrigation schemes using standard modern technologies, including agricultural infrastructure. Drip or surge irrigation equipment adds $US 2 300/ha to this total. The cost of drip irrigation development on existing irrigated areas varies between $US 2 300 and 3 500/ha.

There are no private irrigation schemes in Uzbekistan. Each large scheme (Hunger steppe, Karshi steppe, etc.) is managed by a state agency. Small schemes are managed by district water management agencies, which often manage several schemes at once. Operation and maintenance charges are covered by the government for *kolkhoz* and *sovkhoz*, and by farmers when land is leased to them, although they are heavily subsidized by the government. The average annual O&M cost which enables full recovery is about $US 450/ha for standard systems, and more than $US 640/ha for drip irrigation or $US 680/ha for pump systems, while in recent years the actual cost has varied between $US 60 and 150/ha.

About 3.3 million ha of irrigated land would require man-made drainage. Only 2.8 million ha are currently equipped with drainage infrastructure. Most of the drainage systems are open drains (Figure 10). Vertical pumping drainage is carried out on 401 000 ha, mainly on clay soils. In the newly reclaimed areas (Hunger and Djizak steppes in the Syr Darya basin, Surkhan-Sherabad and Karshi steppes in the Amu Darya basin), drainage is mainly subsurface drainage. The total length of main and inter-farm collectors is about 30 000 km, while the on-farm collector-drainage network extends for about 110 000 km.

INSTITUTIONAL ENVIRONMENT

The Water Resources Department of the Ministry of Agriculture and Water Resources Management, established in 1996 after the merger of the Ministry of Agriculture and the Ministry of Water Resources, is in charge of water resources research, planning, development and distribution. It also undertakes the construction, operation and maintenance of the irrigation and drainage networks at the inter-farm level in the country. Water allocations are regularly reduced in order to promote savings and to satisfy the demand from new users and to increase the water flow to the Aral Sea. Water withdrawal per year thus declined from 17 500 m^3 in 1980 to 11 600 m^3 in 1995, while irrigation efficiency increased. The total annual irrigation water withdrawal declined from 58.8 km^3 in 1990 to 53.4 km^3 in 1994.

Institutional organizations dealing with water management at state, provincial and district level come under the Water Resources Department. Such organizations are responsible for water distribution and delivery to the farm inlet, for assisting water users in implementing advanced technologies, and for water use and water quality control. The special land reclamation service, under the Water Resources Department, monitors the main reclamation indicators of irrigated lands (groundwater level, drainage discharge, soil salinity, situation of the collector-drainage network) at national, provincial and local level. It also plans the required measures for irrigation and drainage network maintenance and for the reclamation of degraded lands, including leaching, repairing and cleaning of drainage-collectors and network rehabilitation.

A water law was approved in May 1993. It introduced the notion of water rights. Within the general objective of water savings, Article 30 emphasizes the need for water pricing, although it still leaves room for subsidies to the water sector.

The Ministry of Agriculture and Water Resources Management is also in charge of agricultural research and extension, on-farm agricultural and land reclamation development, and on-farm operation and maintenance of the irrigation network.

The Ministry of Municipal Affairs is responsible for domestic water supply and wastewater treatment.

Research in the water resources development sector is undertaken by the Central Asia Scientific Research Institute of Irrigation (SANIIRI). This autonomous institute of the Ministry of Agriculture and Water Resources Management was previously responsible for all Central Asia. It also manufactures irrigation equipment.

The Goskompriroda (Environment State Committee) is in charge of water quality monitoring and control of industrial and municipal pollutants.

Uzbekistan is a member of IFAS, ICWC, the Amu Darya and Syr Darya River BWOs.

TRENDS IN WATER RESOURCES MANAGEMENT

Irrigation has created serious environmental problems in Uzbekistan, the most dramatic effect being the shrinking of the Aral Sea. According to a World Bank report, the main environmental impacts of irrigation in the Aral Sea basin include: (1) the loss of fish resources in the Aral Sea, due to an increase in salinity and chemical pollution; (2) land degradation through waterlogging and salinization of irrigated land; (3) crop diseases and pests, due especially to the cotton monoculture; (4) adverse health effects on people and animals, due to wind-blown chemicals and the poor quality of water; and (5) possible local climatic change.

Drainage water is the principal carrier of environmental pollution, since it contains the results of mineralization and residues from pesticides.

The restoration of the Aral Sea to its 1960 level is not an objective for the country, although assistance to the 'disaster' zone is seen as a priority. Actions to be taken are: the stabilization of the exposed seabed; land reclamation in the delta; improved drinking water supply, health and general actions to promote the socio-economic conditions of the population in the area.

In a context of demographic growth and higher demand for water from the industrial and domestic sectors, it is now generally accepted that the Aral Sea should be maintained at its present level. This also implies that water management has to be improved, in order to constantly reduce water withdrawal for irrigation. This could be achieved through reducing water losses from the inter- and on-farm irrigation network, and through increasing overall production in a sustainable way, notably by implementing techniques for the desalinization of irrigated land. The construction of a major collector to bring drainage water from the lower Amu Darya irrigated areas directly to the Aral Sea has been undertaken. This measure also favours the stabilization of the Aral Sea level and the improvement of water quality in the main rivers.

Water savings in irrigation should enable the development of other sectors of the economy. An important thrust of irrigation and water management improvement at the on-farm level would be to move from a state run system to privatization of irrigated agriculture, notably through the establishment of WUAs. This process is developing at a very slow pace. Implementation of water pricing in the industrial and municipal sectors, as well as agricultural water pricing, may also provide room for water savings in the future.

At international level, mechanisms to introduce water quality issues into water sharing agreements are under discussion.

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C –	Chinese	*	Out of print
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P –	Portuguese		
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The AQUASTAT programme was initiated with the view of presenting a comprehensive picture of water resources and irrigation in developing countries. This report presents the results of the survey for the countries of the former Soviet Union, carried out in 1996 and 1997. The survey relied as much as possible on country-based statistics and information contained in national strategy papers. A general summary presents a regional analysis of water resources, irrigation and drainage in the region, and a series of country profiles describes the situation in each country in more detail. A section presents the specific problems related to water management in the Aral Sea basin.

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