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39

Irrigation in Central Asia in figures

AQUASTAT Survey-2012

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AQUASTAT Survey – 2012

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Edited by
Karen FRENKEN
FAO Land and Water Division

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Units

Lenght

1 km = 1 000 m = 1 x 10^3 m

1 km = 0.64 mile

1 mile = 1.56 km = 1 560 m

Area

1 acre = 4 047 m^2 = 0.4047 ha = 4.047 x 10^{-4} x 1 000 ha

1 are = 100 m^2 = 0.01 ha = 1 x 10^{-5} x 1 000 ha

1 feddan = 4 200 m^2 = 0.42 ha = 4.2 x 10^{-4} x 1 000 ha

1 ha = = 0.01 km^2 = 10 000 m^2 = 2.47 acres = 2.38 feddan

1 m^2 = 0.0001 ha = 1 x 10^{-7} x 1 000 ha

1 km^2 = 1 000 000 m^2 = 100 ha = 1 x 10^{-1} x 1 000 ha

1 km^2 = 0.41 square mile

1 square mile = 2.43 km^2

Volume

1 dm^3 = 1 litre = 0.001 m^3 = 1 x 10^{-12} km^3

1 hm^3 = 1 million m^3 = 1 000 000 m^3 = 1 x 10^{-3} km^3

1 km^3 = 1 billion m^3 = 1 000 million m^3 = 10^9 m^3 = 10^9 m^3

1 m^3 = 10^{-9} km^3

1 UK gallon = 4.546 litres = 4.546 dm^3 = 0.004546 m^3 = 4.546 x 10^{-12} km^3

1 US gallon = 3.785 litres = 3.785 dm^3 = 0.003785 m^3 = 3.785 x 10^{-12} km^3

Power-energy

1 GW = 1 x 10^3 MW = 1 x 10^6 kW = 1 x 10^9 W

1 GWh = 1 x 10^3 MWh = 1 x 10^6 kMh

US$1 = 1 United States dollar

1 ºC = 1 degree centigrade

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.

List of abbreviations

ADB	Asian Development Bank
AEI	Area equipped for irrigation
ARSWR	Actual renewable surface water resources
ARWR	Actual renewable water resources
BAIS	Basin Authority of Irrigation Systems
BWMO	Basin Water Management Organization
BWO	Basin Water Organization
CACENA	Central Asian and Caucasus (under Global Water Partnership)
CDM	Clean Development Mechanism
CEP	Caspian Environmental Programme
CIDA	Canadian International Development Agency
CMO	Canal Management Organization
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EECCA	Eastern Europe, Caucasus and Central Asia
EIRP	Emergency irrigation and rehabilitation project
EU	European Union
EUWI	European Union Water Initiative
FAO	Food and Agriculture Organization of the United Nations
FO	Farm Organization
FSU	Former Soviet Union
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GWP	Global Water Partnership
HDI	Human Development Index
I&D	Irrigation and drainage
IBRD	International Bank for Reconstruction and Development
ICAS	Interstate Council for the Aral Sea
ICOLD	International Commission of Large Dams
ICSD	Interstate Commission on Sustainable Development
ICWC	Interstate Commission for Water Coordination
IFAS	International Fund for Saving the Aral Sea

IFI	International Financial Institution
IPM	Integrated Pest Management
IRGWR	Internal renewable groundwater resources
IRSWR	Internal renewable surface water resources
IRWR	Internal renewable water resources
ISF	Irrigation Service Fee
IWRM	Integrated water resources management
JFPR	Japan Fund for Poverty Reduction
JMP	Joint Monitoring Programme for Water Supply and Sanitation
MAC	Maximum allowable concentration
MDG	Millennium Development Goal
Meq	milli-equivalent
NGO	Non-governmental organization
O&M	Operation and maintenance
RSWR	Renewable surface water resources
SANIIRI	Central Asian Irrigation Research Institute
SAR	Sodium adsorption ratio
SIC	Sepang International Circuit (of the ICWC)
TARSW	Total actual renewable surface water resources
TARSWR	Total actual renewable surface water resources
TARWR	Total actual renewable water resources
TRSWR	Total renewable surface water resources
TRWR	Total renewable water resources
UN-SPECA	United Nations Special Programme for the Economies of Central Asia
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USSR	Union of Soviet Socialist Republics
WCA	Water Consumer Association
WHO	World Health Organization
WUA	Water user organization

SECTION I
Presentation of the survey

EXPLANATORY NOTES

This section gives a brief history of AQUASTAT, its main purpose and the methodology used to update country information. It describes the main sources of information, the collection and processing of the information as well as its reliability.

A glossary of all terms used in this report is provided, which also can be found in the AQUASTAT glossary web page (http://www.fao.org/nr/water/aquastat/data/glossary/search.html?lang=en). This glossary web page contains an explanation of all variables and indicators available in the AQUASTAT main country database (http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en) as well as other terms related to water and agriculture.

Introduction

It is in the mandate of the Food and Agriculture Organization of the United Nations (FAO), as stated in Article 1 of its constitution, "to collect, analyse, interpret and disseminate information related to nutrition, food and agriculture". Within this framework, in 1993 FAO launched a programme known as AQUASTAT, its global information system on water and agriculture (http://www.fao.org/nr/aquastat). AQUASTAT collects, analyses and disseminates data and information, by country, on water recourses and water use, with emphasis on irrigated agriculture, which is targeted at users in international institutions, national governments and development agencies. Its goal is to support agricultural and rural development through sustainable use of water and land by providing the most accurate information presented in a consistent and standard way and more specifically:

- up-to-date and reliable data by country;
- methodologies and definitions for information on the water resources and irrigation sector;
- systematic descriptions about the state of agricultural water management by country;
- predictions of future agricultural water use and irrigation developments;
- in-depth analysis based on diverse thematic studies;
- contribution to major international publications;
- answers to requests from governments, research institutions, universities, non-governmental organizations and individuals.

The AQUASTAT publication series "Irrigation in [name of region] in figures" started with Africa (FAO, 1995). The survey continued with the Near East (FAO, 1997a), the countries of the former Soviet Union (FAO, 1997b), Southern and Eastern Asia (FAO, 1999), and Latin America and the Caribbean (FAO, 2000). In 2005 the African continent was updated (FAO, 2005), in 2008 the Middle East region (FAO, 2009) and in 2011 Southern and Eastern Asia (FAO, 2012b).

More than a decade after the first publication, it appeared necessary to update the data and information and to identify the main changes in water use and irrigation that had occurred in the countries of Central Asia. The regional division of the world adopted by AQUASTAT is given in Figure 1.

In this new survey, a third objective has been added to the two objectives given in the previous publication. To:

- provide for every country the most accurate status of rural water resources management, with a special focus on irrigation, by featuring major characteristics, trends, constraints and prospective changes in irrigation and in water resources;
- support regional analysis by providing systematic, up-to-date and reliable information on the status of water resources and of agricultural water management that can serve as a tool for regional planning and predictive studies;
- prepare a series of chronological data and developments in order to highlight the major changes that have occurred in the last decade on national and regional scales.

To obtain the most reliable information possible, the survey is organized as follows:

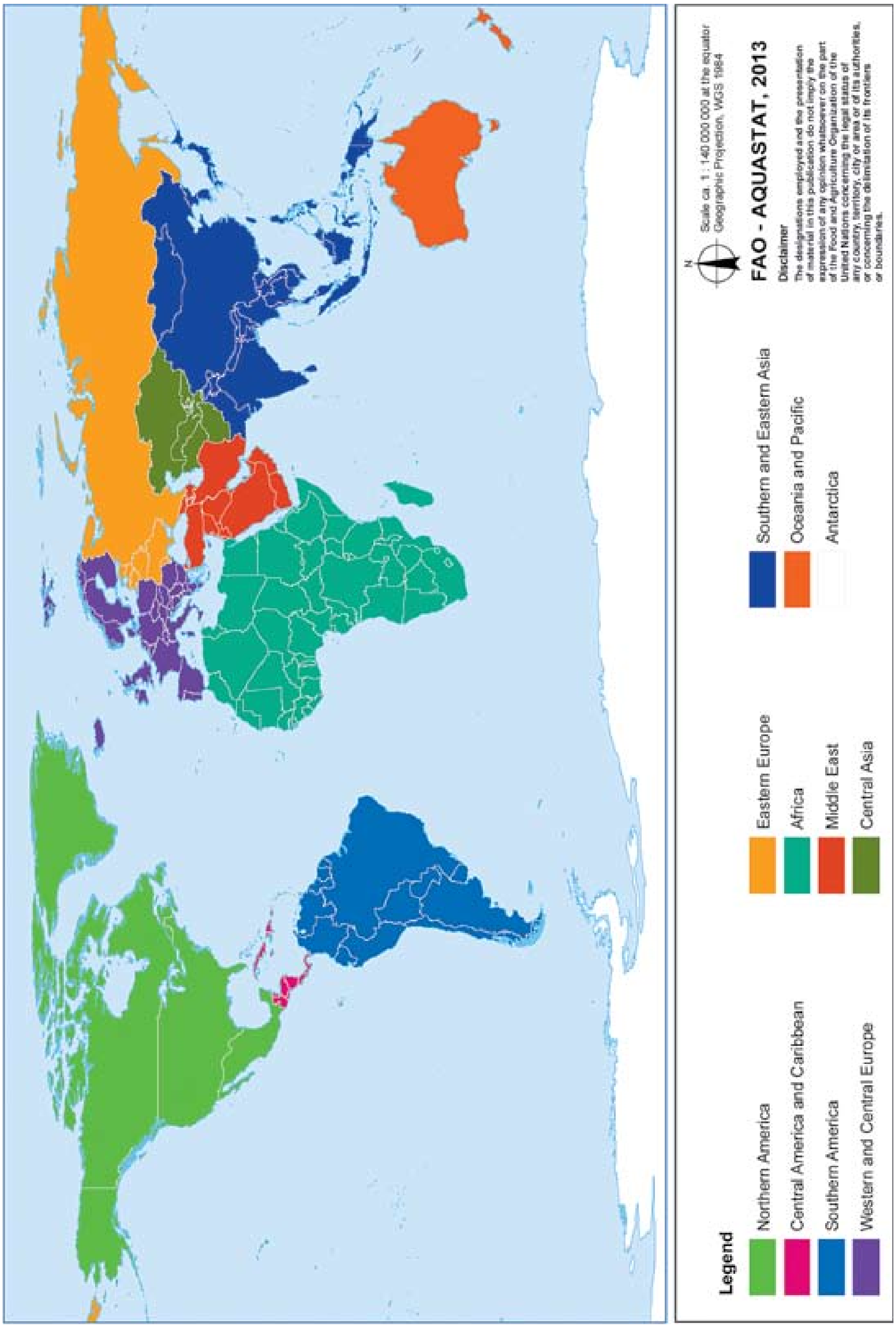
1. Review of literature and existing information at country and subcountry level.
2. Collection of information by country using a detailed questionnaire filled in by national experts, international consultants, or the AQUASTAT team at FAO.

3. Compilation and critical analysis of the information collected using data-processing software developed for this survey, and selection of the most reliable information.
4. Preparation of country profiles and submission to national authorities responsible for water resources or water management for verification, correction and approval.
5. Preparation of the final profile, the tables and the figures presenting the information by country.
6. Updating of the online database.
7. Preparation of the general regional analysis, the figures and the regional tables.

Where possible, AQUASTAT has made use of national capacity and competence. While collecting the information by country, preference was given to national experts as they have a better knowledge of their own country and easier access to national or so-called 'grey' documents, which are not available outside the country. For five of the six countries of Central Asia (all but Afghanistan), a national consultant assisted the AQUASTAT team.

FIGURE 1

Regional division of the world adopted by AQUASTAT



Country and river basin profiles

COUNTRY PROFILES

Country profiles have been prepared in English and Russian, which are the FAO official languages in the countries of the Central Asia region. They describe the state of water resources and water use in the respective countries, as well as the state of agricultural water management. The aim of the present publication is to describe the particularities of each country and the problems met in the development of the water resources and, in particular, irrigation. Irrigation trends in the country and the prospects for water management in agriculture as described in the literature are summarized. The country profiles have been standardized and organized into the following sections:

- Geography, climate and population
- Economy, agriculture and food security
- Water resources and water use
- Irrigation and drainage development
- Water management, policies and legislation related to water use in agriculture
- Environment and health
- Prospects for agricultural water management
- References and additional information

Standardized tables are used for each country. A hyphen (-) indicates that no information is available. As most information is available only for a limited number of years, the tables present the most recent reliable information and indicate the year to which it refers. In the online AQUASTAT country database, however, all available information is accessible.

The information in the country profiles is much more detailed than that in the previous AQUASTAT survey of the region. In order to establish a more complete picture of the agricultural water sector in each country, issues are addressed related to water and to irrigation that were not previously included. Some issues have been added in response to user demand.

RIVER BASIN PROFILE

In addition to country profiles, a profile has been prepared on the main transboundary river basin in the region: the Aral Sea basin. The major aim is to describe transboundary water issues and to provide a chronology of major events in the basin. The sections are organized as follows:

- Geography, population and climate
- Water resources
- Water-related developments in the basin
- Environment, water quality and health
- Transboundary water issues

Data collection, processing and reliability

The main sources of information were:

- National policies, and water resources and irrigation master plans
- National reports, yearbooks and statistics
- Reports from FAO and other projects
- International surveys
- Results and publications from national and international research centres and universities
- The Internet

Furthermore, the following sources systematically provide certain data:

- FAOSTAT (http://faostat.fao.org/). This is the only source used for variables of area (total, arable land and permanent crops) and population (total, rural, urban, female, male, and economically active). Every year countries provide the FAOSTAT data on areas through the FAO representations. It should be noted the original source for population data (total, urban and rural) is the United Nations Population Division (http://www.un.org/esa/population/), while the original source for data related to economically active population is the International Labour Organization (http://www.ilo.org/).
- World Development Indicators (http://www.worldbank.org/data/). This is the World Bank's premier annual compilation of data on development. This source provides the data on gross domestic product (GDP).
- Joint Monitoring Programme for Water Supply and Sanitation (JMP) (www.wssinfo.org/). This is a joint programme of the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), which provides access to data on improved water sources.
- Human Development Index (HDI) (http://hdr.undp.org/statistics/data/). This falls under the responsibility of the United Nations Development Programme (UNDP).

In total, more than 50 variables have been selected and these are presented in the national tables attached to the respective country profiles. They are standardized and ordered into categories that correspond to the various sections of the profile: characteristics of the country and population; water resources and use and irrigation and drainage. A detailed description of each variable is given in the *Glossary of terms*. Additional tables have been added to the country profiles where information is available, especially to specify regional or river basin data.

In most cases, a critical analysis of the information is required to ensure the general coherence of information collected for a given country. Where several sources result in divergent or contradictory information, preference is given to information collected at national or subnational level rather than at regional or world level. Moreover, except in the case of evident errors, official sources are privileged. Regarding shared water resources, the comparison of information between countries has made it possible to verify and complete the data concerning the flows of transboundary rivers and to ensure coherence at a river basin level. This information has been added in more detail in the country water resources sheets, which are available at: http://www.fao.org/nr/water/aquastat/water_res/index.stm.

In spite of these precautions, the accuracy, reliability and frequency with which information is collected vary considerably according to the region, the country and the category of information. These considerations are discussed in the profiles.

The trend tables show the period 1999–2009 as the period between the two surveys for Central Asia as a whole. The AQUASTAT team justifies this choice by virtue of the slow evolution of data for different years for each country. However, the country data show the exact year of the value.

Glossary of terms

The following definitions have been used for the variables presented in the country profiles, the tables and the database.

Access to improved drinking water sources (%)

The proportion of the population (total, urban and rural) with sustainable access to an 'improved' water source. It is the percentage of the population who use any of the following types of water supply for drinking: piped water, public tap, borehole or pump, protected well, protected spring or rainwater. Improved water sources do not include vendor-provided water, bottled water, tanker trucks or unprotected wells and springs. Figures are provided by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) website (http://www.wssinfo.org/), which defines an improved drinking-water source as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter. To allow for international comparability of estimates, JMP uses a classification to differentiate between 'improved' and 'unimproved' drinking-water sources as well as sanitation. More details can be found on the website.

Agricultural drainage water (km^3/year; million m^3/year)

This is water withdrawn for agriculture but not consumed and returned. It does not go through special treatment and therefore should be distinguished from wastewater that is treated and returned. It can be reused further downstream for irrigation, for example, and is also called secondary water. In some cases direct reuse of agricultural drainage water exists, such as is the case for example when water from rice fields flows from one terrace to the next.

Annual crops (ha)

Area of land under temporary (annual) crops, which are crops with a growing season lasting between several months and about one year and which need to be re-sown or replanted after each harvest, such as cereals and vegetables.

Arable land (ha)

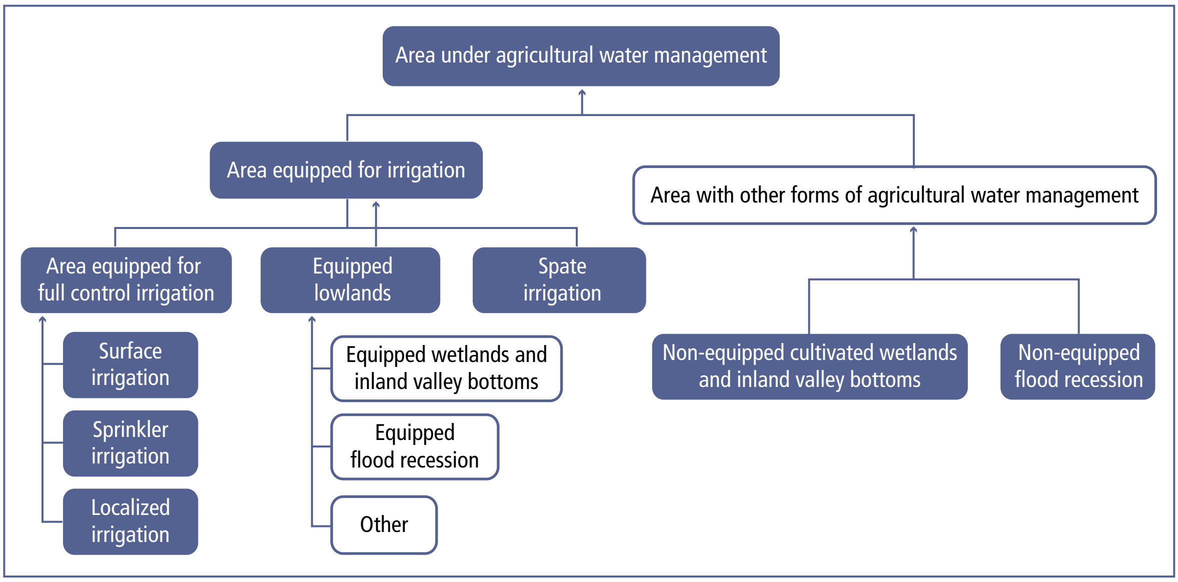
Land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included. Data for arable land is not meant to indicate the amount of land that is potentially cultivable.

Area of the country (ha)

Total area of the country, including area under inland water bodies. Possible variations in the data may be the result of updating and revisions of the country data and not necessarily to any change of area.

Area under agricultural water management (ha)

Sum of total area equipped for irrigation and areas with other forms of agricultural water management (non-equipped flood recession cropping area and non-equipped cultivated wetlands and inland valley bottoms). The classification adopted by AQUASTAT is presented in the following diagram and an explanation of each of the variables is given below. The classes in the grey boxes are not separately mentioned in the AQUASTAT database.



Average annual increase of the area equipped for irrigation (%)

This increase is calculated using the following formula: new area = $(1+i)^n$ x old area, where 'n' is the number of years in the period considered between the two AQUASTAT surveys and 'i' is the average annual increase. The percentage is equal to (100 x i).

Cropping intensity: irrigated area (%)

The number of times the same area is cropped and irrigated in one year. The area refers to full control irrigation. If available, the area actually irrigated is used for the calculation of cropping intensity. If unavailable, the equipped area is used. The calculation only refers to irrigated crops. This means that in a country with one or two wet seasons only the crops grown under irrigation are taken into consideration. When calculating cropping intensity, the crops grown on the full control equipped area during the wet season without irrigation (but using the residual soil humidity) are not included in the harvested irrigated crop area.

Cultivable area (ha)

Area of land potentially fit for cultivation. This term may or may not include part or all the forests and rangeland. Assumptions made in assessing cultivable land vary from country to country. In this survey, national figures have been used whenever available, despite possible large discrepancies in computation methods.

Cultivated area (ha)

The sum of the arable land area and the area under permanent crops.

Dam capacity (km^3 or million m^3)

Total cumulative storage capacity of all large dams. According to ICOLD (International Commission on Large Dams), a large dam is a dam with a height of 15 m or more from the foundation. If dams are 5-15 m high and have a reservoir volume of more than 3 million m^3, they are also classified as large dams. However, each country has its own definition of large dams and if information is available for other dams in a country it is also included. The value indicates the theoretical initial capacity, which does not change over time. The current or actual dam capacity is the state of the dams at a given time that can be decreased by silting. Detailed information dams in the different regions can be found in the AQUASTAT geo-referenced dam databases on http://www.fao.org/nr/water/aquastat/dams/index.stm.

Dependency ratio (%)
Indicator expressing the percent of total renewable water resources originating outside the country. This indicator may theoretically vary between 0 percent and 100 percent. A country with a dependency ratio equal to 0 percent does not receive any water from neighbouring countries. A country with a dependency ratio equal to 100 percent receives all its renewable water from upstream countries, without producing any of its own. This indicator does not consider the possible allocation of water to downstream countries.

Depletion of renewable groundwater resources: rate (km^3/year; million m^3/year)
Annual amount of water withdrawn from renewable aquifers, which is not replenished (average overexploitation of aquifers). When the action is continuous, it is a form of overdraft of rechargeable aquifers or mining. Over a long period, there is a risk of depleting the aquifer when the abstraction exceeds the recharge.

Desalinated water produced (km^3/year; million m^3/year)
Water produced annually by desalination of brackish or salt water. It is estimated annually based on the total capacity of water desalination installations.

Drained area in area equipped for irrigation (ha)
Irrigated area where drainage is used as an instrument to control salinity, pounding and waterlogging. This refers mainly to the area equipped for surface irrigation and to the equipped wetland and inland valley bottoms (the first part). Areas equipped for sprinkler irrigation and for localized irrigation do not really need a complete drainage system, except perhaps some small structures to evacuate the water in case of heavy rainfall. Flood recession cropping areas (the second part) are not considered as being drained. A distinction can be made between areas drained with surface drains (a system of drainage measures, such as natural or human-made drains meant to divert excess surface water away from an agricultural area to prevent inundation) and the area drained with subsurface drains (a human-made system that induces excess water and dissolved substances to flow through the soil to open wells, moles, pipe drains and/or open drains, from where it can be evacuated for final disposal).

Drained area in non-irrigated area (ha)
Area cultivated and not irrigated, where drainage is used to remove excess water from the land surface and/or the upper soil layer to make humid/wet land more productive. A distinction should be made between drainage in humid countries and drainage in semi-arid countries. In humid countries, it refers mainly to the areas which normally are flooded and where flood mitigation has taken place. A distinction could be made between pumped drainage, gravity drainage and tidal drainage. In semi-arid countries, it refers to the area cultivated and not irrigated where drainage is used to remove excess water from the land surface and/or upper soil layer to make humid/wet land more productive.

Drained area: total (ha)
Sum of the drained portions of area equipped for irrigation and non-irrigated land area.

Exploitable water resources regular renewable groundwater (km^3/year; million m^3/year)
Average groundwater flow that is available 90 percent of the time, and economically/ environmentally viable to extract.

Exploitable water resources: regular renewable surface water (km^3/year; million m^3/year)
Annual average quantity of surface water that is available 90 percent of the time. In practice,

it is equivalent to the low water flow of a river. It is the resource that is offered for withdrawal or diversion with a regular flow.

Exploitable water resources: irregular renewable surface water (km^3/year; million m^3/year)

Irregular surface water resources are equivalent to the variable component of water resources (e.g. floods). It includes the seasonal and inter-annual variations, i.e. seasonal flow or flow during wet years. It is the flow that needs to be regulated.

Exploitable water resources: total (km^3/year; million m^3/year)

Exploitable water resources (also called manageable water resources or water development potential) are considered to be available for development, taking into consideration factors such as: the economic and environmental feasibility of storing floodwater behind dams, extracting groundwater, the physical possibility of storing water that naturally flows out to the sea, and minimum flow requirements (navigation, environmental services, aquatic life, etc). Methods to assess exploitable water resources vary from country to country.

Flood-protected area (ha)

Area of land protected by flood control structures.

Flood-recession cropping area: non-equipped but cultivated (ha)

Areas along rivers where cultivation occurs in the areas exposed as floods recede and where nothing is undertaken to retain the receding water. The special case of floating rice is included in this category.

Fossil groundwater: abstraction (km^3/year; million m^3/year; for a given period)

Annual amount abstracted from deep aquifers with a very low rate of renewal (less than one percent per year) so considered to be non-renewable or 'fossil'.

Full control irrigation: area equipped for localized irrigation (ha)

Localized irrigation is a system where the water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or next to it. There are three main categories: drip irrigation (where drip emitters are used to apply water slowly to the soil surface), spray or micro-sprinkler irrigation (where water is sprayed to the soil near individual plants or trees) and bubbler irrigation (where a small stream is applied to flood small basins or the soil adjacent to individual trees). The following terms are sometimes used to refer to localized irrigation: micro-irrigation, trickle irrigation, daily flow irrigation, drop-irrigation, sip irrigation, diurnal irrigation.

Full control irrigation: area equipped for sprinkler irrigation (ha)

A sprinkler irrigation system consists of a pipe network, through which water moves under pressure before being delivered to the crop through sprinkler nozzles. The system basically simulates rainfall in that water is applied through overhead spraying. These systems are also known as overhead irrigation systems.

Full control irrigation: area equipped for surface irrigation (ha)

Surface irrigation systems are based on the principle of moving water over the land by simple gravity to moisten the soil. They can be subdivided into furrow, borderstrip and basin irrigation (including submersion irrigation of rice). Manual irrigation using buckets or watering cans is also included. Surface irrigation does NOT refer to the method of transporting the water from the source up to the field, which may be done by gravity or by pumping.

Full control irrigation: total area equipped (ha)
This is the sum of surface irrigation, sprinkler irrigation and localized irrigation. The text uses indifferently the expressions 'full control' and 'full/partial control'.

Full control irrigation area actually irrigated (ha)
Part of area equipped for full control irrigation that is actually irrigated in any given year. Irrigated land that is cultivated more than once a year is counted only once.

Full control irrigation: area equipped irrigated from groundwater (ha)
Portion of the full control irrigation area that is irrigated from water from wells (shallow wells and deep tube wells) or springs. The water can be primary freshwater or secondary freshwater (agricultural drainage water and wastewater returned to the system).

Full control irrigation: area equipped irrigated from surface water (ha)
Portion of the full control irrigation area that is irrigated from water from rivers or lakes (reservoirs, pumping or diversion). The water can be primary freshwater or secondary freshwater (agricultural drainage water and wastewater returned to the system).

Full control irrigation: area equipped irrigated from mixed sources of water (ha)
Portion of the full control irrigation area that is irrigated from mixed surface water and groundwater. The water can be primary freshwater or secondary freshwater (agricultural drainage water and wastewater returned to the system).

Full control irrigation schemes (ha)
Areas of irrigation schemes, usually classified as large, medium, and small schemes. Criteria used in this classification are given in the tables.

Gross domestic product (GDP)
GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current United States dollars (US$). Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. Figures provided by the World Development Indicators (WDI), the World Bank's premier annual compilation of data about development (http://data.worldbank.org/).

Harvested irrigated crop area (ha)
Total harvested irrigated crop area. It refers to the crops grown under full control irrigation. Areas under double irrigated cropping (same area cultivated and irrigated twice a year) are counted twice. Therefore the total area may be larger than the full control equipped area, which gives an indication of the cropping intensity. The total is only given if information on all irrigated crops in the country is available.

Households in irrigation
Total number of households living directly on earnings from fully controlled irrigation schemes.

Human Development Index (HDI)
This is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development:

1. a long and healthy life, as measured by life expectancy at birth;

2. knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight);
3. a decent standard of living, as measured by GDP per capita (Purchasing Power Parity US$). Figures provided by UNDP (http://hdrstats.undp.org/en/indicators/default.html).

Irrigated grain production: total (t; tons; metric tonnes)

The total quantity of cereals harvested annually in the irrigated area. Several harvests per year on the same area are counted several times.

Irrigation: area equipped (ha)

Area equipped to provide water (via irrigation) to crops. It includes areas equipped for full control irrigation, equipped lowland areas, irrigated pastures, and areas equipped for spate irrigation.

Irrigation: area equipped for irrigation actually irrigated (ha)

Part of area equipped for irrigation that is actually irrigated in any given year. It refers to the physical area. Irrigated land that is cultivated more than once a year is counted only once.

Irrigation potential (ha)

Area of potentially irrigable land. Country/regional studies assess this value according to different methods. For example, some consider only land resources, others consider land resources plus water availability, others include economical aspects in their assessments (such as distance and/or difference in elevation between the suitable land and the available water) or environmental aspects, etc. If available, this information is given in the individual country profiles. The figure includes the area already under agricultural water management.

Lowland areas: area equipped for irrigation (ha)

The land equipped for irrigation in lowland areas includes:

- cultivated wetland and inland valley bottoms (IVB) that have been equipped with water control structures for irrigation and drainage (intake, canals, etc.);
- areas along rivers where cultivation occurs making use of structures built to retain receding flood water;
- developed mangroves and equipped delta areas.

Permanent crops (ha)

Crops are divided into temporary and permanent crops. Permanent crops are sown or planted once and then occupy the land for some years and do not need to be replanted after each annual harvest, such as cocoa, coffee and rubber. This category includes flowering shrubs, fruit trees, nut trees and vines, but excludes trees grown for wood or timber.

Precipitation in depth: average (mm/year)

Long-term average (over space and time) of annual endogenous precipitation (produced in the country) in depth.

Precipitation in volume: average (km^3/year; million m^3/year)

Long-term average (over space and time) of annual endogenous precipitation (produced in the country) in volume.

Population: economically active population (inhabitants)

The number of all employed and unemployed (including those seeking work for the first time). It covers employers; self-employed workers; salaried employees; wage earners; unpaid workers assisting in a family or farm or business operation; members of producers' cooperatives; and members of the armed forces. The economically active population is also called the labour force.

Population: economically active population in agriculture (inhabitants)

Part of the economically active population engaged in or seeking work in agriculture, hunting, fishing or forestry (agricultural labour force). The economically active population refers to the number of all employed and unemployed persons (including those seeking work for the first time). It covers employers, self-employed workers, salaried employees, wage earners, unpaid workers assisting in a family or farm or business operation, members of producers' cooperatives, and members of the armed forces. The economically active population is also called the labour force.

Population: total (inhabitants)

According to the FAO definition, the total population usually refers to the present-in-area (de facto) population, which includes all persons physically present within the present geographical boundaries of countries at the mid-point of the reference period.

Population: urban, rural (inhabitants)

Usually the urban area is defined and the remainder of the total population is defined as rural. In practice, the criteria adopted for distinguishing between urban and rural areas vary from country to country. However, these criteria can be roughly divided into three major groups: classification of localities of a certain size as urban; classification of administrative centres of minor civil divisions as urban; and classification of centres of minor civil divisions on a chosen criterion which may include type of local government, number of inhabitants or proportion of population engaged in agriculture. Thus, the urban and rural population estimates in this domain are based on the varying national definitions of urban areas.

Population affected by water-related diseases (inhabitants)

Three types of water-related diseases exist:

- water-borne diseases are those diseases that arise from infected water and are transmitted when the water is used for drinking or cooking (for example cholera, typhoid);
- water-based diseases are those in which water provides the habitant for host organisms of parasites ingested (for example shistomasomiasis or bilharzia);
- water-related insect vector diseases are those in which insect vectors rely on water as habitat but transmission is not through direct contact with water (for example malaria, onchocerciasis or river blindness, elephantiasis).

Power irrigated area as percentage of total area equipped for irrigated (%)

Percent of irrigation area where pumps are used for water supply from the source to the scheme, expressed in percentage. It includes also areas where water is drained out with human- or animal-driven water lifting devices.

Renewable water resources: internal (km^3/year; million m^3/year)

Internal Renewable Water Resources (IRWR): long-term average annual flow of rivers and recharge of aquifers generated by endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources.

Renewable water resources: external (km^3/year; million m^3/year)

External Renewable Water Resources (ERWR) are that part of the country's renewable water resources that are not generated within the country. They include inflows from upstream countries (groundwater and surface water), and part of the water of border lakes or rivers.

Renewable water resources: total natural (km^3/year; million m^3/year)

Total Natural Renewable Water Resources (TRWR_natural or TNRWR): the long-term average sum of internal renewable water resources (IRWR) and external natural renewable water resources (ERWR_natural). It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment.

Renewable water resources: total actual (km^3/year; million m^3/year)

Total Actual Renewable Water Resources (TRWR_actual or TARWR): the sum of internal renewable water resources (IRWR) and external actual renewable water resources (ERWR_actual). It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment.

Return flow

That part of the water used for agricultural, municipal or industrial purposes which is returned to rivers or aquifers after use.

Safe yield of water systems (km^3/year; million m^3/year)

Amount of water (in general, the long term average amount) which can be withdrawn from the groundwater basin or surface water system without causing undesirable results. This concept concerns mostly groundwater (flow extractable without over exploitation). For the rivers, it is more common to speak of reserved flow (reservation constraint for the environment).

Salinized area by irrigation (ha)

Irrigated area affected by salinization, including formerly irrigated land abandoned because of declining productivity caused by salinization. It does not include naturally saline areas. In general, each country has its own definition of salinized area.

Soil and water conservation

A combination of in situ water conservation and soil conservation measures. Soil conservation measures comprise any set of measures intended to control or prevent soil erosion or to maintain fertility. Water conservation includes the usage of bunds to slow or stop the migration of surface water.

Spate irrigation: equipped area for irrigation (ha)

Spate irrigation, also sometimes referred to as floodwater harvesting, is a method of informal irrigation using the floodwaters of a normally dry water course or riverbed (wadi). These systems are in general characterized by a very large catchment upstream (200-5 000 ha) with a ratio of 'catchment area: cultivated area' = between 100:1 and 10 000:1. There are two types of spate irrigation:

1. floodwater harvesting within stream beds, where turbulent channel flow is collected and spread through the wadi where the crops are planted; cross-wadi dams are constructed with stones, earth, or both, often reinforced with gabions;
2. floodwater diversion, where the floods or spates from the seasonal rivers are diverted into adjacent embanked fields for direct application. A stone or concrete structure raises the water level within the wadi to be diverted to the nearby cropping areas.

Temporary crops (ha)

See Annual crops.

Wastewater: produced volume of municipal wastewater (km^3/year; million m^3/year)

Annual quantity of wastewater generated in the country from municipal use (used water from bathing, sanitation, cooking, etc.), in other words, the quantity of water that has been polluted by adding waste.

Wastewater: treated volume of municipal wastewater (km^3/year; million m^3/year)

Quantity of generated wastewater that is treated in a given year and discharged from treatment plants (effluent). Wastewater treatment is the process to render wastewater fit to meet applicable environmental standards for discharge. Three broad phases of traditional treatment can be distinguished: primary, secondary and tertiary treatment. Discharge standards vary significantly from country to country, and therefore so do the phases of treatment. For the purpose of calculating the total amount of treated wastewater, volumes and loads reported should be shown only under the 'highest' type of treatment to which it is subjected.

Wastewater: direct use of treated municipal wastewater (km^3/year; million m^3/year)

Quantity of treated wastewater, which is directly used in a given year. Wastewater treatment is the process to render wastewater fit to meet applicable environmental standards for recycling or reuse. The use refers to direct use of wastewater and can also be called non-conventional water. If the treated wastewater is returned to the river or lake, it becomes secondary freshwater.

Water harvesting area (ha)

Areas where rainwater is collected and either directly applied to the cropped area and stored in the soil profile for immediate uptake by the crop (runoff irrigation) or stored in a water reservoir for future productive use (for example used for supplementary irrigation). Rainwater harvesting includes:

- roof water harvesting is mainly used for domestic purposes and sometimes as water supply for family gardens;
- micro-catchment water harvesting is characterized by a relatively small catchment area C (< 1 000 m^2) and cropping area CA (< 100 m^2) with ratio C:CA = 1:1 to 10:1. The farmer usually has control over both the catchment area and the target area. These systems are used for the irrigation of a single tree, fodder shrubs or annual crops. The construction is mainly manual. Examples are pits, semi-circular bunds, Negarim micro-catchment, eyebrow terrace, contour bench terrace, etc.;
- macro-catchment water harvesting collects water that flows over the ground as turbulent runoff and channel flow. These systems are characterized by a large catchment area C ('external' catchment area of 1 000 m^2 – 200 ha), located outside the cultivated area CA, with a ratio C:CA = 10:1 to 100:1. The systems are mainly implemented for the production of annual crops. The construction is manual or mechanized. Examples are trapezoidal bunds, large semi-circular bunds, stone bunds, etc.

Water managed area (ha)

See Area under agricultural water management.

Water withdrawal for agriculture (km^3/year; million m^3/year)

Annual quantity of water withdrawn for irrigation, livestock and aquaculture purposes. It includes renewable primary freshwater resources as well as over-abstraction of renewable groundwater or withdrawal of fossil groundwater, secondary freshwater (agricultural drainage water and treated wastewater that was returned to the system), and non-conventional water (direct use of agricultural drainage water and treated wastewater, and desalinated water). It includes water withdrawn for irrigation purposes, aquaculture and for livestock watering, although depending on the country this last category sometimes is included in municipal water withdrawal. As far as the water withdrawn for irrigation is concerned, the value far exceeds the consumptive use of irrigation because of water lost in distribution from its source to the crops. The term 'water requirement ratio' (sometimes also called 'irrigation efficiency') is used to indicate the ratio between the net irrigation water requirements or crop water requirements, which is the volume of water needed to compensate for the deficit between potential evapotranspiration and effective precipitation over the growing period of the crop, and the amount of water withdrawn for irrigation including the losses. In the specific case of paddy rice irrigation, additional water is needed for flooding to facilitate land preparation and for plant protection. In that case, irrigation water requirements are the sum of rainfall deficit and the water needed to flood paddy fields. At scheme level, water requirement ratio values can vary from less than 20 percent to more than 95 percent. As far as livestock watering is concerned, the ratio between net consumptive use and water withdrawn is estimated at between 60 percent and 90 percent. By default, livestock water use is accounted for in agricultural water use. However, some countries include it in municipal water withdrawal.

Water withdrawal for livestock (km^3/year; million m^3/year)
Some countries include this in municipal water withdrawal, others in agricultural water withdrawal.

Water withdrawal for municipal or domestic use (km^3/year; million m^3/year)
Annual quantity of water withdrawn for municipal or domestic purposes. It includes renewable primary freshwater resources as well as over-abstraction of renewable groundwater or withdrawal of fossil groundwater, secondary freshwater (agricultural drainage water and treated wastewater that was returned to the system), and non-conventional water (direct use of agricultural drainage water and treated wastewater, and desalinated water). It is usually computed as the total water withdrawn by the public distribution network. It can include that part of the industries which is connected to the domestic network. The ratio between the net consumption and the water withdrawn can vary from 5 to 15 percent in urban areas and from 10 to 50 percent in rural areas.

Water withdrawal for industry (km^3/year; million m^3/year)
Annual quantity of water withdrawn for industrial uses. It includes renewable primary freshwater resources as well as over-abstraction of renewable groundwater or withdrawal of fossil groundwater, secondary freshwater (agricultural drainage water and treated wastewater that was returned to the system), and non-conventional water (direct use of agricultural drainage water and treated wastewater, and desalinated water). Usually, this sector refers to self-supplied industries not connected to any distribution network. It includes cooling water for energy generation (thermo-electric plants). The ratio between net consumption and withdrawal is estimated at less than 5 percent.

Water withdrawal: total (km^3/year; million m^3/year)
Annual quantity of freshwater withdrawn for agricultural, industrial and municipal purposes. It includes renewable primary freshwater resources as well as over-abstraction of renewable groundwater or withdrawal of fossil groundwater, secondary freshwater (agricultural drainage water and treated wastewater that was returned to the system), and non-conventional water (direct reuse of agricultural drainage water and treated wastewater, and desalinated water). It does not include other categories of water use, such as for mining, recreation, navigation, capture fisheries, etc., which are sectors that are characterized by a very low net consumption rate.

Waterlogged area by irrigation (ha)
Part of the land that is waterlogged because of irrigation. Waterlogging occurs on land where the water table is located at or near the surface, resulting in a decline in crop yields. Irrigation can contribute to the raising of the level of the aquifers. The non-saturated area of soils can become too small and the soils are over-saturated with water. If recharge to groundwater is greater than natural drainage, there is a need for additional drainage to avoid waterlogging.

Waterlogged area not irrigated (ha)
Part of the land in non-irrigated cultivated areas that is waterlogged. Waterlogging is the state of land in which the water table is located at or near the surface resulting in a decline of crop yields.

Wetlands and inland valley bottoms

Wetlands and inland valley bottoms (IVB) that have not been equipped with water control structures but are used for cropping. Often found in Africa, wetlands and IVB will have limited (mostly traditional) arrangements to regulate water and control drainage.

SECTION II
Regional analysis

EXPLANATORY NOTES

In this section, the water resources and irrigation situation in the six Central Asia countries – Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan – is analyzed and compared.

The analysis presents distinguishing features arising from the new data collected on a national scale for issues addressed in the six country profiles in Section III. The focus is on land use and population, water resources and use, irrigation and drainage, trends in water withdrawal and irrigation development, the legislative and institutional framework for water management, environment and health, and prospects for agricultural water management as perceived by the countries.

A hyphen (-) in the regional tables indicates that no or not sufficient information is available.

Geography, climate and population

The Central Asia region in this survey is composed of six countries. They are Afghanistan and the five Central Asia countries that were part of the Union of Soviet Socialist Republics (USSR) before their independence in 1991: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. In the previous survey *Irrigation in the countries of the Former Soviet Union in figures: AQUASTAT Survey – 1997* (FAO, 1997b) the five Central Asia countries were grouped into the Central Asia subregion. The present survey includes Afghanistan in the Central Asia region because of the important shared water resources in the Amu Darya and the Tedzhen-Murghab basins.

The total area of Central Asia is 4.66 million km^2, or 3 percent of the world's emerged landmass (Table 1 and Table 25). Out of the six countries in the region, Kazakhstan represents 59 percent, and together Afghanistan, Turkmenistan and Uzbekistan occupy 34 percent of the region's total area. The two smallest countries – Kyrgyzstan and Tajikistan – together comprise barely 7 percent of the total area (Figure 2). The region is bordered to the north by the Russian Federation, to the east by China, to the south by Pakistan and to the west by the Islamic Republic of Iran, the Caspian Sea and the Russian Federation. In 2009, the cultivated area was an estimated 40 million ha, which is 9 percent of the total area (Table 1). In Afghanistan 12 percent of the total area of the country is cultivated, falling to just over 4 percent in Turkmenistan.

Geologically the region is extremely varied. There are the Tien Shan and Pamir mountain ranges in the east. In Tajikistan, the highest mountain, Communism Peak, rises to 7 495 m above sea level (asl) in the northern Pamir range. Much of the mountainous region is permanently covered with ice and snow and there are many glaciers. Mountain ranges in the south include the earthquake prone Kopetdag range. In the northeast lies the second largest crater-lake in the world, the Issyk-Kul in Kyrgyzstan.

The main agricultural area, the Fergana valley, lies on the border between Kyrgyzstan, Tajikistan and Uzbekistan. In the southwest lies the Kara Kum or Black Sand desert, one of the largest sand deserts in the world, covering over 80 percent 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 depression of the Caspian Sea. The Aral Sea, in the central

TABLE 1
Land use

Country	Total area		Cultivated area			
	Area	in % of total area	Area	In % of country area	per inhabitant	per person economically active in agriculture
	ha	%	ha	%	ha/inhab	ha/ec.act.pop.
Afghanistan	65 223 000	14	7 910 000	12	0.2	1.3
Kazakhstan	272 490 000	59	23 480 000	9	1.4	19.9
Kyrgyzstan	19 995 000	4	1 351 000	7	0.3	2.7
Tajikistan	14 255 000	3	875 000	6	0.1	1.1
Turkmenistan	48 810 000	10	1 910 000	4	0.4	2.7
Uzbekistan	44 740 000	10	4 651 000	10	0.2	1.7
Central Asia	**465 513 000**	**100**	**40 177 000**	**9**	**0.4**	**3.3**

western part, lies on the border between Kazakhstan and Uzbekistan. This area is known as one of the world's most serious environmental disasters.

Central Asia is landlocked within the Eurasian continent, which determines its continental climate. Large daily and seasonal temperature differences are characteristic of the region, with high solar radiation and relatively low humidity. Various types of terrain and altitude range from 0 to 7 500 m asl, lead to diversified microclimates. Although this area is often struck by humid winds, the mountains trap most of the moisture, and little rain falls in the Aral Sea basin (CAWaterInfo, 2011).

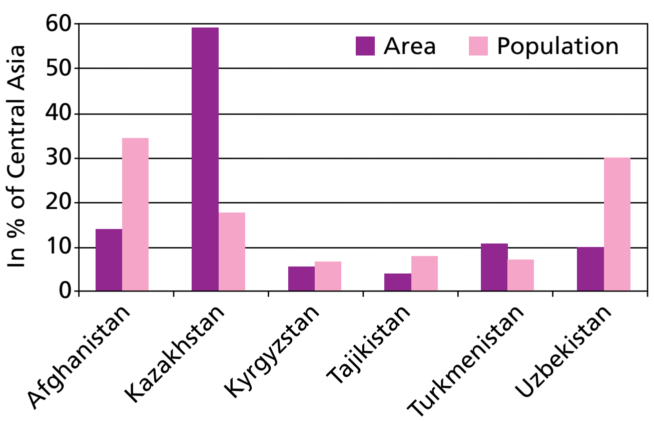
The average temperatures range from 0–4 °C in January to 28–32 °C in July. Summers in some areas, such as Kara Kum in Turkmenistan, can be as hot as 52 °C and winters can be as cold as minus 16 °C, with an absolute of minus 38 °C, making for a sharply contrasting overall climate, (Murray-Rust *et al.,* 2003).

Average annual precipitation is an estimated 273 mm, varying, from 161 mm in Turkmenistan to 691 mm in Tajikistan; from less than 70 mm on the plains and deserts to 2 400 mm in the mountains of central Tajikistan (Figure 3). Annual precipitation in the lowlands and valleys is between 80 and 200 mm, concentrated in winter and spring, while in the foothills precipitation ranges between 300 and 400 mm, and on the southern and southwestern sides of the mountain ranges it is between 600 and 800 mm (CAWaterInfo, 2011).

Because summer air humidity differs dramatically between the ancient oases and newly irrigated areas, 50–60 percent and 20–30 percent respectively. Water demands in former desert areas that are now being irrigated, are significantly greater than for the oases. Other factors that particularly affect agricultural production are unstable spring temperatures and precipitation. Late frosts may occur at the beginning of May and hail may fall in June, which sometimes destroys emerging cotton plants and vegetables over large areas (CAWaterInfo, 2011).

In 2011, the total population was an estimated 94 million inhabitants, representing 1.3 percent of the world's population (Table 2 and Table 25). Afghanistan and Uzbekistan are the most, and second most, populous countries in the region respectively, together they account for about 64 percent of the population in Central Asia. Average population density is 20 inhabitants/km^2, compared to 52 inhabitants/km^2 for the world as a whole and 178 inhabitants/km^2 for Southern and Eastern Asia, ranging from six inhabitants/km^2 in Kazakhstan to 61 inhabitants/km^2 in Uzbekistan (Figure 4). The annual demographic growth rate was an estimated 1.8 percent for the period 2010–2011, compared to 1.1 percent globally. During the period 2001–2011, annual population growth ranged from 0.8 percent in Kazakhstan and Kyrgyzstan to 3.2 percent in Afghanistan, with a regional average annual growth of 1.8 percent.

FIGURE 2
Distribution of areas and population



The population of Central Asia is predominantly rural: about 65 percent, compared to 49 percent for the world as a whole (Table 2 and Table 25). The rural population varies from more than 77 percent in Afghanistan and 74 percent in Tajikistan to 41 percent in Kazakhstan. The percentage of the economically active population engaged

FIGURE 3
Average annual precipitation

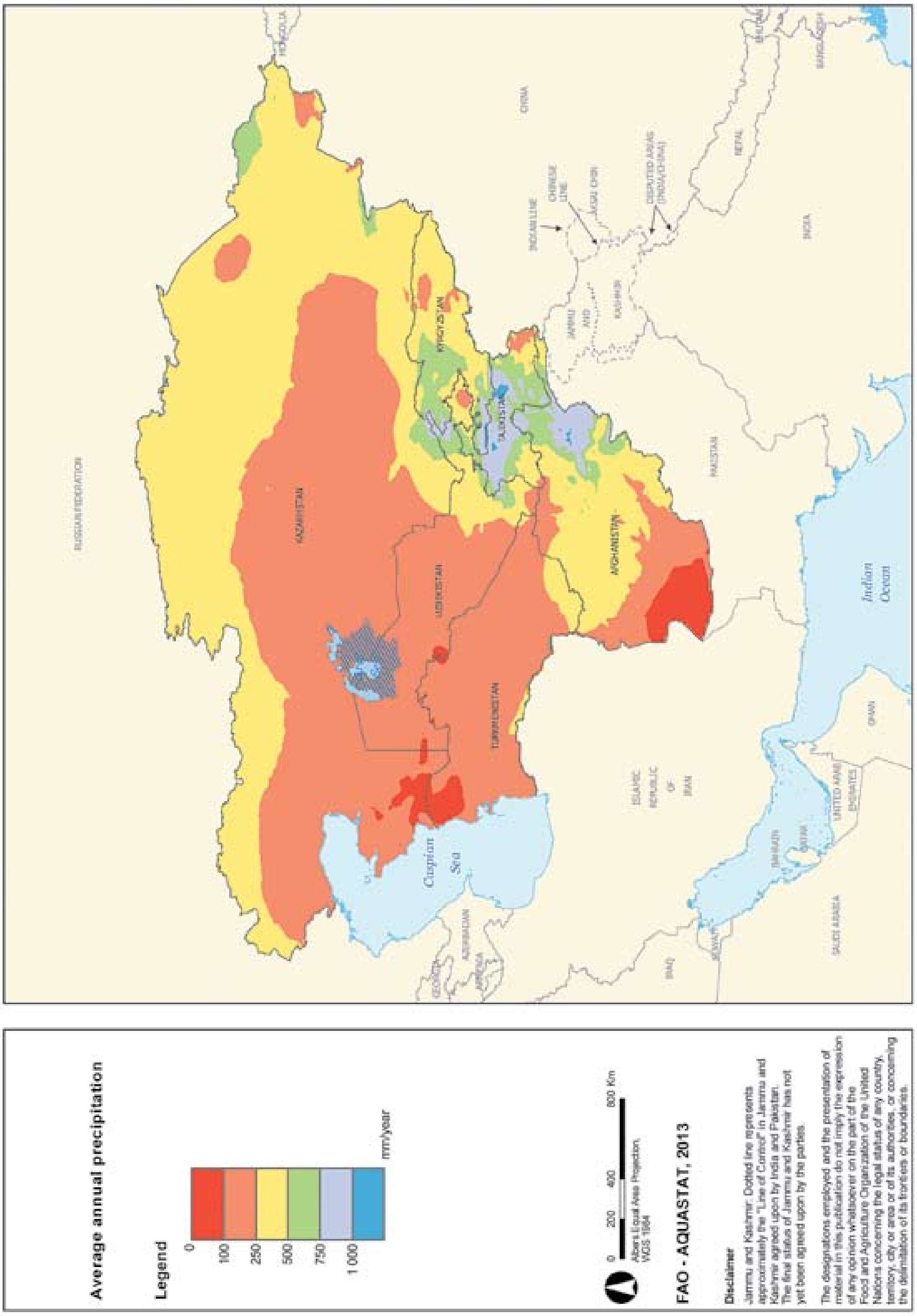
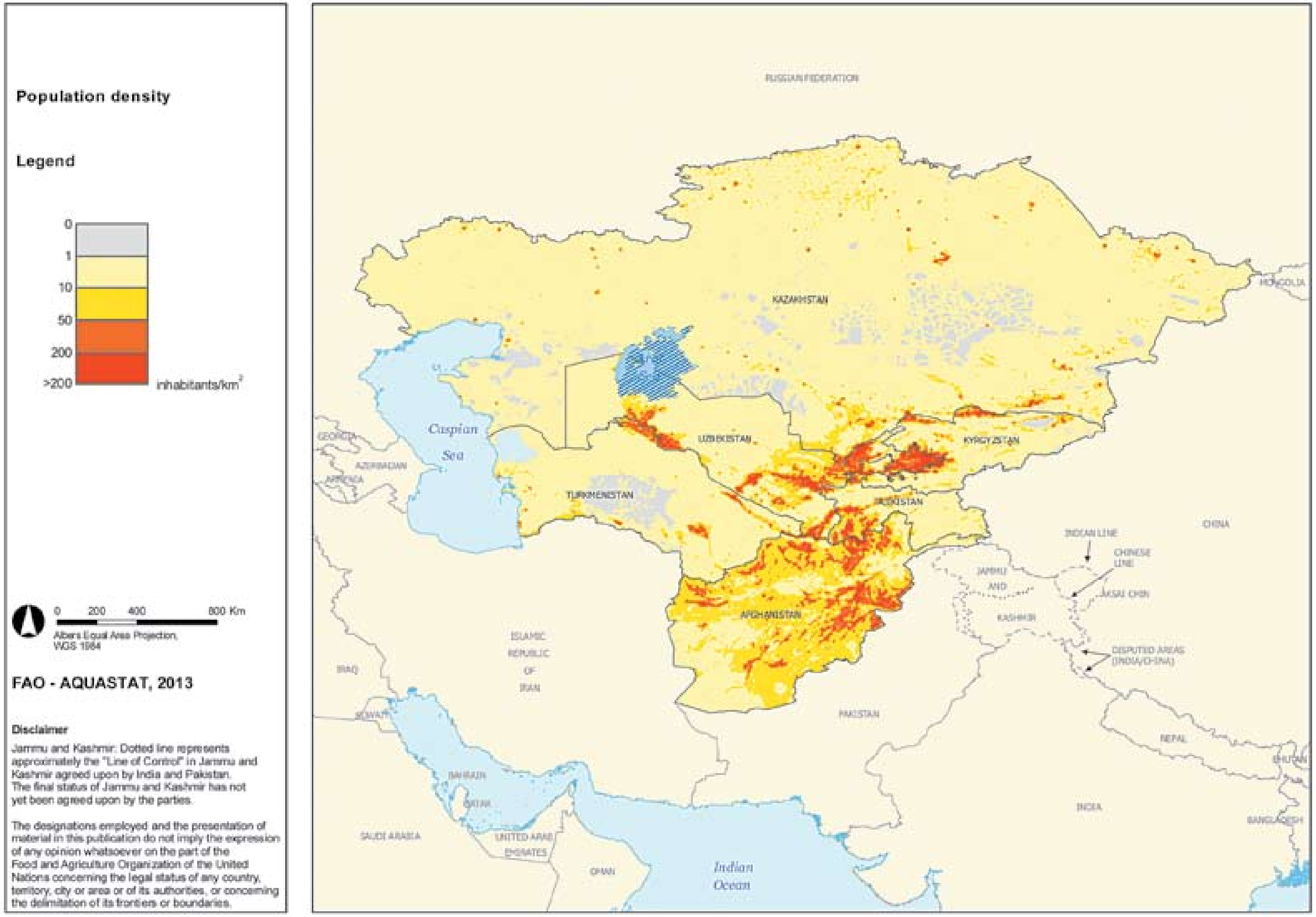


TABLE 2
Population characteristics (2011)

Country	Population				Economically active population		Economically active population in agriculture		Gross Domestic Product (2010)			Human Development Index (2011)
	Total	in % of region	% rural	Population density	Total	in % of total population	Total	in % of economically active population	Total	Value added by agriculture	GDP per inhabitant	
	inhabitants	%	%	inhabitants per km^2	inhabitants	%	inhabitants	%	Current million US$	%	Current US$/ inhabitant	(Min 0, Max 1)
Afghanistan	32 358 000	34	77	50	10 474 000	32	6 217 000	59	17 243	30	533	0.398
Kazakhstan	16 207 000	17	41	6	8 682 000	54	1 181 000	14	149 059	5	9 197	0.745
Kyrgyzstan	5 393 000	6	65	27	2 491 000	46	507 000	20	4 616	21	856	0.615
Tajikistan	6 977 000	8	74	49	2 901 000	42	778 000	27	5 640	21	808	0.607
Turkmenistan	5 105 000	5	50	10	2 431 000	48	714 000	29	20 001	12	3 918	0.686
Uzbekistan	27 760 000	30	64	62	12 916 000	47	2 695 000	21	38 982	20	1 404	0.641
Central Asia	**93 800 000**	**100**	**65**	**20**	**39 895 000**	**43**	**12 092 000**	**30**	**235 541**	**10**	**2 511**	**-**

FIGURE 4
Population density



in agriculture, at about 30 percent, is low compared to 39 percent for the world. This percentage varies from 59 percent in Afghanistan to 14 percent in Kazakhstan.

In 2010, around 74 percent of the total population of Central Asia, 94 percent of the urban and 64 percent of the rural had access to improved drinking water sources (Table 3).

TABLE 3
Access to improved water sources (Source: JMP, 2011)

Country	Access to improved water sources in 2010 (% of population)		
	National	Urban	Rural
Afghanistan	50	78	42
Kazakhstan	95	99	90
Kyrgyzstan	90	99	85
Tajikistan	64	92	54
Turkmenistan	84	97	72
Uzbekistan	87	98	81
Central Asia	**74**	**94**	**64**

Economy, agriculture and food security

Since the second half of the 1990s, Central Asia has emerged as one of the world's fastest growing regions showing notable development potential. This is significant for a region comprised largely of small landlocked economies with no access to the sea for trade. Among the advantages of the region are its high-priced commodities (oil, gas, cotton and gold), reasonable infrastructure and human capital, and its strategic location between Asia and Europe. Furthermore, several Central Asian countries have embarked on market-oriented economic reforms to boost economic performance and private sector competitiveness (Dowling and Wignaraja, 2006).

The sum of national Gross Domestic Products (GDPs) in 2010 amounted to US$235 541 million, which is 0.4 percent of world GDP. This corresponds to a GDP of about US$2 556/inhabitant, ranging from US$549/inhabitant in Afghanistan to US$9 301/inhabitant in Kazakhstan. Based on the Human Development Index (HDI) – where 1 = highest and 0 = lowest – in 2011 out of a total of 187 countries Kazakhstan holds the highest place among the Central Asia countries at 68 (0.745), Turkmenistan follows at 102 (0.686), Uzbekistan 115 (0.641), Kyrgyzstan 126 (0.615), Tajikistan 127 (0.607) and Afghanistan 172 (0.398) (Table 2).

In 2010, the added value of the primary sector (agriculture) contributed 10.4 percent to the GDP of the Central Asia region. This ranged from 5 percent in Kazakhstan to 30 percent in Afghanistan. An average of around 30 percent of the economically active population is engaged in the farming sector, ranging from 14 percent in Kazakhstan to 60 percent in Afghanistan (Table 2).

The cultivated area per person economically active in agriculture varies from a low 1.1, 1.3 and 1.7 ha/person in Tajikistan, Afghanistan, Uzbekistan respectively, 2.7 ha/person in Kyrgyzstan and Turkmenistan to almost 20 ha/person in Kazakhstan, giving an average for the region of 3.3 ha/person (Table 1).

Central Asia is rich in natural resources. Water is the most precious resource and its use is the most conflict-prone. In Kyrgyzstan and Tajikistan, large quantities of water are stored in the mountain glaciers. Kazakhstan, Turkmenistan and Uzbekistan have huge oil and gas deposits. At the same time, almost half the population in these countries lives in poverty and lacks access to sufficient natural resources to sustain livelihoods, while the countries' wealth is unevenly distributed (Perelet, 2007).

Pre-independence water allocation and irrigation system infrastructure were well maintained and operated with massive funding from the central government of the Former Soviet Union. Since independence, the situation has changed dramatically in the Central Asia countries politically, institutionally and technically. Political transition from a planned to a market economy has introduced 'new' concepts such as land tenure, water rights and different kinds of ownership. The institutional changes are described as a transition from former state collective farms – *kholkhoz* and *sovkhoz* – to smaller private farms. Many farmers, however, do not have the capacity or the resources to afford the energy required for pumping water and to irrigate land on an individual basis (Rakhmatullaev *et al.,* 2009).

Cereals (mainly wheat), cotton, fodder and pastures are the most important irrigated crops in the region.

Water resources

RENEWABLE WATER RESOURCES (PRIMARY FRESHWATER)

This survey distinguishes between internal renewable water resources (IRWR) and total renewable water resources (TRWR). IRWR is that part of a country's water resources generated by endogenous precipitation (produced in the country). Calculation of IRWR involves adding surface water flow and groundwater recharge and subtracting the overlap. TRWR is calculated by adding IRWR and external flow. This is a measure of the maximum theoretical amount of water available to a country without considering its technical, economic or environmental nature.

The methodology used in the survey also differentiates between natural and actual external flow: natural flow is the average annual amount of water that would flow at a given point in a river without any human influence, while actual flow takes into account volumes of water reserved by treaties or agreements.

Particular attention should be given to specific issues related to the calculation of water resources in Central Asian countries. In arid areas, the complex interrelation between surface water and groundwater makes it difficult to assess the overlap. In cases of extreme complexity, groundwater resources in one country may be infiltration from runoff generated in an upstream country, making it difficult to distinguish between internal and external water resources. Often, exchanges between countries are further complicated because rivers cross the same border several times. Part of the incoming water flow may originate in the same country that the river enters, making it necessary to calculate a 'net' inflow to avoid double counting of the resources.

Generally, because of the significant water withdrawals over many years, assessment of natural surface water runoff in these areas is more difficult because of the absence of a chronological series of natural flow measurements. Indeed, most of the available flow data relate to the measurement of actual runoff rather than natural flow. In addition, most figures quoted in reports correspond to the agreements covering shared water resources.

The volume of annual precipitation in Central Asia is an estimated 1 270 km^3. This volume is equal to a regional average depth of 273 mm/year, compared to a global average of 812 mm/year, but with significant disparities between and within countries. Average annual precipitation varies from less than 70 mm in the plains and deserts to more than 2 400 mm in the mountains of Central Tajikistan (Figure 3). At country-level, the driest country is Turkmenistan with 161 mm/year on average, and the wettest is Tajikistan with 691 mm/year (Table 4).

Long-term average annual IRWR in Central Asia account for 242 km^3, which represent 0.6 percent of the world's total (Table 4 and Table 25). In absolute terms Kazakhstan accounts for the largest amount of IRWR, 64 km^3/year or 27 percent of the region's water resources. This refers to 59 percent of the region's total area, thus giving a depth of only 24 mm. Tajikistan follows with 63 km^3, or 26 percent of the region's water resources, which contrary to Kazakhstan is an important value, taking into account that the country represents only 3 percent of the total area of the region, resulting in the greatest depth of 445 mm.

Kyrgyzstan and Afghanistan account for 49 km^3 and 47 km^3 respectively, each represent 20 percent of water resources in the region. Kyrgyzstan accounts for only 4 percent of the

TABLE 4
Long-term average annual renewable water resources

Country	Average annual precipitation		Annual renewable water resources					
			Internal (IRWR)			Total actual, taking into consideration agreements (TARWR)		Dependency ratio
	depth	volume	volume	depth	per inhab (2011)	volume	per inhab (2011)	
	mm	km^3	km^3	mm	m^3/inhab	km^3	m^3/inhab	%
Afghanistan	327	213	47.2	72	1 457	65.3	2 019	29
Kazakhstan	250	681	64.4	24	3 971	107.5	6 632	40
Kyrgyzstan	533	107	48.9	245	9 073	23.6	4 379	1
Tajikistan	691	99	63.5	445	9 096	21.9	3 140	17
Turkmenistan	161	79	1.4	3	275	24.8	4 851	97
Uzbekistan	206	92	16.3	37	589	48.9	1 760	80
Central Asia	**273**	**1 270**	**241.6**	**52**	**2 576**	**-**	**-**	**-**

region's total area, giving a depth of 245 mm, while Afghanistan accounts for 14 percent of the total area, giving a depth of 72 mm. Uzbekistan with 16 km^3/year accounts for 7 percent of the region's water resources, while its area covers 10 percent of the region, giving a depth of 37 mm. Turkmenistan has the least water resources with 1 km^3/year or less than 1 percent of the water resources in Central Asia. Its area represents 10 percent of the region, giving the least depth of 3 mm (Table 4, Figure 5 and Figure 6).

Population has increased by almost 18 percent since the previous survey, resulting in a decrease in annual IRWR per inhabitant from about 3 044 m^3 to 2 576 m^3 in 2011. This is less than half the global average IRWR/inhabitant of 6 097 m^3, and ranges from 275 m^3 in Turkmenistan, 589 m^3 in Uzbekistan and 1 457 m^3 in Afghanistan to 3 971 m^3 in Kazakhstan, 9 073 m^3 in Kyrgyzstan and 9 096 m^3 in Tajikistan mm (Table 4 and Table 25).

The distribution of total actual renewable water resources (TARWR) is different because of transboundary river basins. For example in Turkmenistan IRWR are 275 m^3/inhabitant, while TARWR are 4 851 m^3/inhabitant, and in Uzbekistan these figures are 589 m^3 and 1 760 m^3 respectively. Conversely, in Kyrgyzstan and Tajikistan IRWR are higher than TARWR, 9 073 and 9 096 m^3/inhabitant compared to 4 379 and 3 140 m^3/inhabitant respectively, because of the water allocation agreements between Central Asian countries.

FIGURE 5
Distribution of areas and water resources

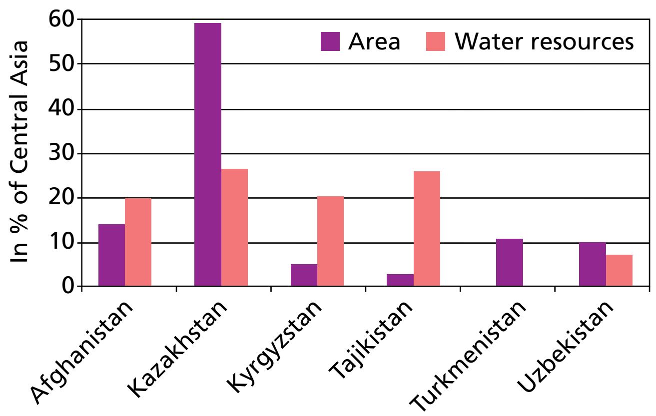


Table 5 presents those countries with an IRWR of less than 1 700 m^3/inhabitant, which is considered to be a threshold below which there are indications of water stress. Turkmenistan and Uzbekistan account for only 275 and 589 m^3/inhabitant respectively and Afghanistan accounts for 1 457 m^3/inhabitant. Looking at TARWR, all have more than 1 700 m^3/inhabitant, because they have a relatively large proportion of external renewable water resources (Figure 7).

FIGURE 6
Internal renewable water resources

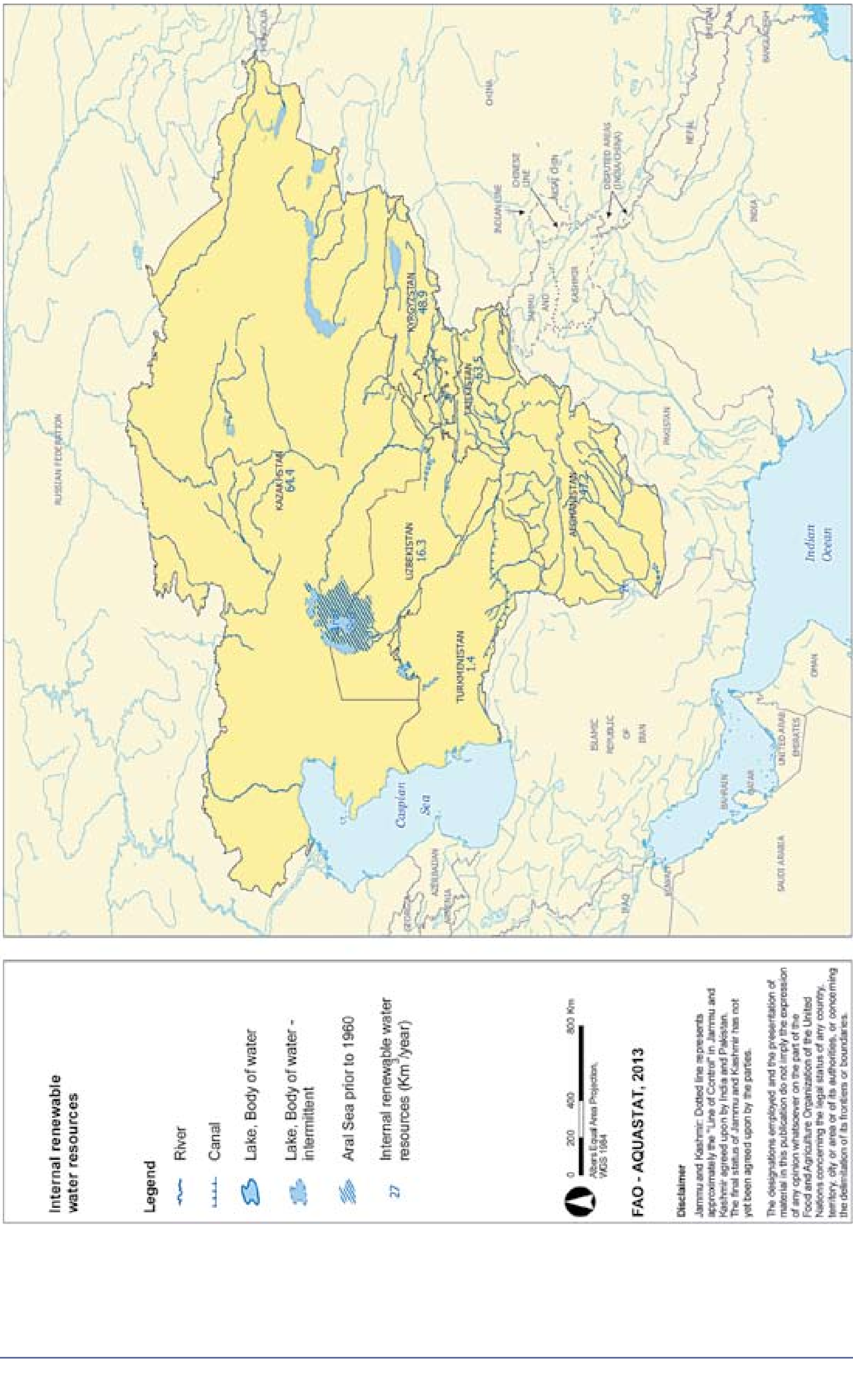


TABLE 5
Countries with annual internal renewable water resources (IRWR) of less than 1 700 m³/inhabitant

Country	Internal renewable water resources per inhabitant		Total actual renewable water resources per inhabitant	
	2001	2011	2001	2011
	(m^3)			
Afghanistan	1 991	1 457	2 759	2 019
Turkmenistan	309	275	5 442	4 851
Uzbekistan	652	589	1 951	1 760

OTHER SOURCES OF WATER

Water scarcity forces national economies to find alternative ways to satisfy the demand for water. Other sources of water may include:

- fossil groundwater;
- overexploitation of renewable groundwater;
- secondary freshwater, which includes (treated) wastewater and/or agricultural drainage water returned to the system;
- non-conventional sources of water, which include desalinated water and direct use of (treated) wastewater and/or direct use of agricultural drainage water.

No information is available on the use of fossil groundwater. Afghanistan mentions overexploitation of renewable groundwater resources meaning that withdrawal is greater than recharge, which leads to problems that include lowering of the groundwater table and groundwater pollution.

Figures on the direct use of treated wastewater are available for three out of the six countries and are often underestimated. Turkmenistan reported 336 million m^3 in 2004, Kazakhstan 194 million m^3 in 2010 and Kyrgyzstan just 0.14 million m^3 in 2006 (Table 6).

Figures on direct use of agricultural drainage water are available for five out of the six countries in the region, of which Uzbekistan is the largest user with 6 840 million m^3 in 2000. Tajikistan and Kyrgyzstan follow, each accounting for about 300 million m^3 in 2000 and 1994 respectively, while Kazakhstan accounted for 108 million m^3 in 2010 and Turkmenistan for 80 million m^3 in 2004.

TABLE 6
Produced, treated and directly used municipal wastewater

Country	Year	Municipal wastewater		
		Produced	Treated	Direct use
		million m^3		
Afghanistan	-	-	-	-
Kazakhstan *	2010	1 833	274	194
Kyrgyzstan **	2005	144	142	0.14
Tajikistan	2008	92	89	0
Turkmenistan	2004	1 275	336	336
Uzbekistan	2000	1 083	-	

* Produced and treated wastewater data refers to 1993
** Direct use of treated wastewater data refers to 2006

Of the two countries bordering the Caspian Sea, only Kazakhstan reports using desalinated water, accounting for 853 million m^3 in 2010, representing 4 percent of its total water withdrawal.

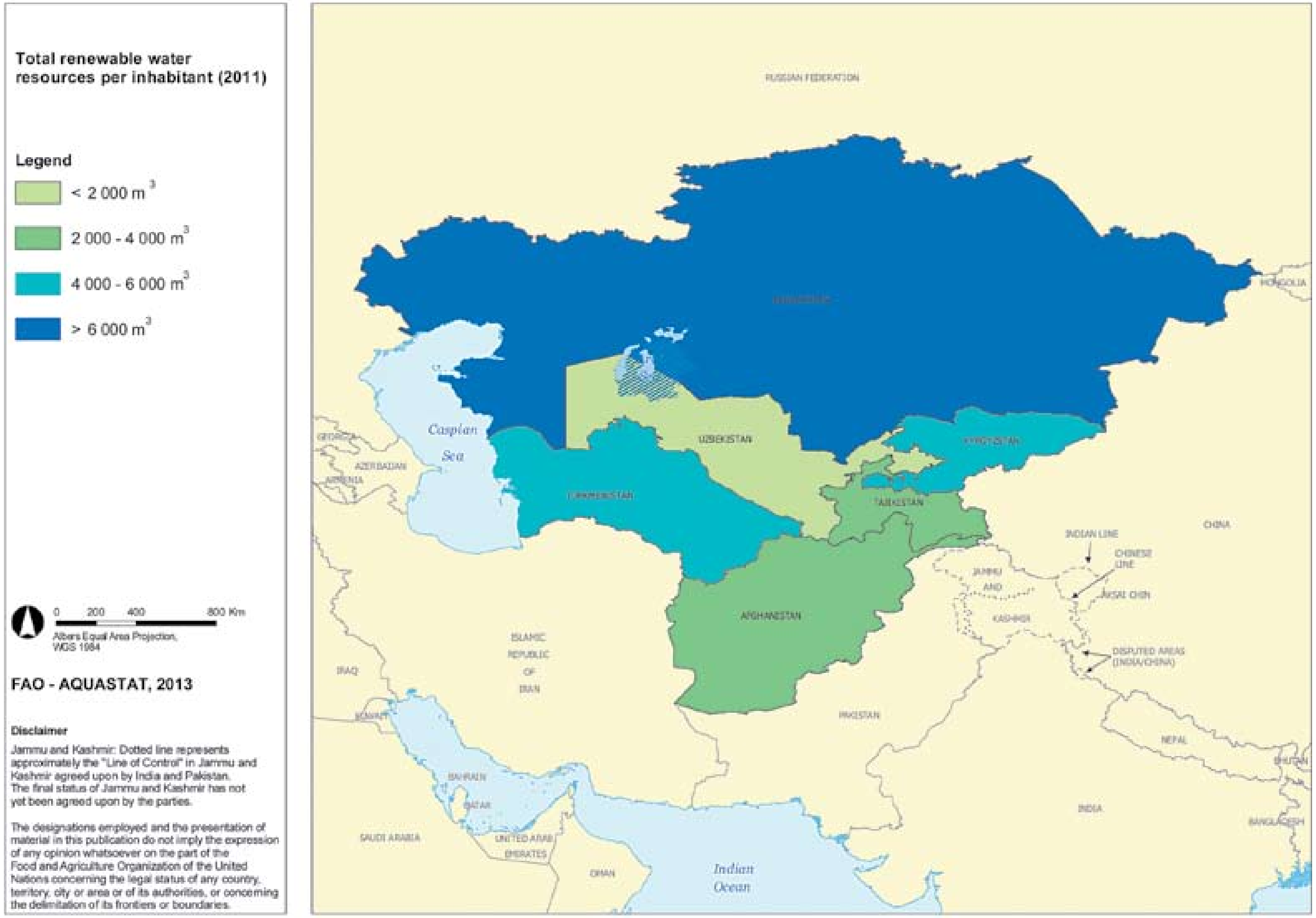
DAMS

Total dam capacity in Central Asia is 180.5 km^3, of which 53 percent is in Kazakhstan (Table 7). Sixteen dams each have a capacity greater than 1 km^3, of which six in Uzbekistan, four in Kazakhstan, two in Turkmenistan, two in Tajikistan, one in Kyrgyzstan and one in Afghanistan. Most are multipurpose dams for hydropower production, irrigation, water supply and flood control. In total these sixteen large dams account for 130.6 km^3, or 72 percent of total dam capacity in Central Asia. Bukhtarma dam in Kazakhstan, completed in 1960, has the largest capacity (50 km^3).

TABLE 7
Dams in Central Asia

Country	Dam capacity	
	km^3	% of the region
Afghanistan	3.7	2
Kazakhstan	95.5	53
Kyrgyzstan	23.5	13
Tajikistan	29.5	16
Turkmenistan	6.2	3
Uzbekistan	22.2	12
Central Asia	**180.5**	**100**

FIGURE 7
Total renewable water resources per inhabitant (2011)



The Toktogul dam in Kyrgyzstan, the Kapshagay dam in Kazakhstan and the Nurek dam in Tajikistan follow with a capacity of 20 km^3, 19 km^3 and 11 km^3 respectively. In Uzbekistan the largest dam is the Tuaymuyun dam (8 km^3), in Turkmenistan the Zeid dam (2 km^3) and in Afghanistan, the Kajaki dam (1 km^3) (Table 8).

TRANSBOUNDARY WATERS

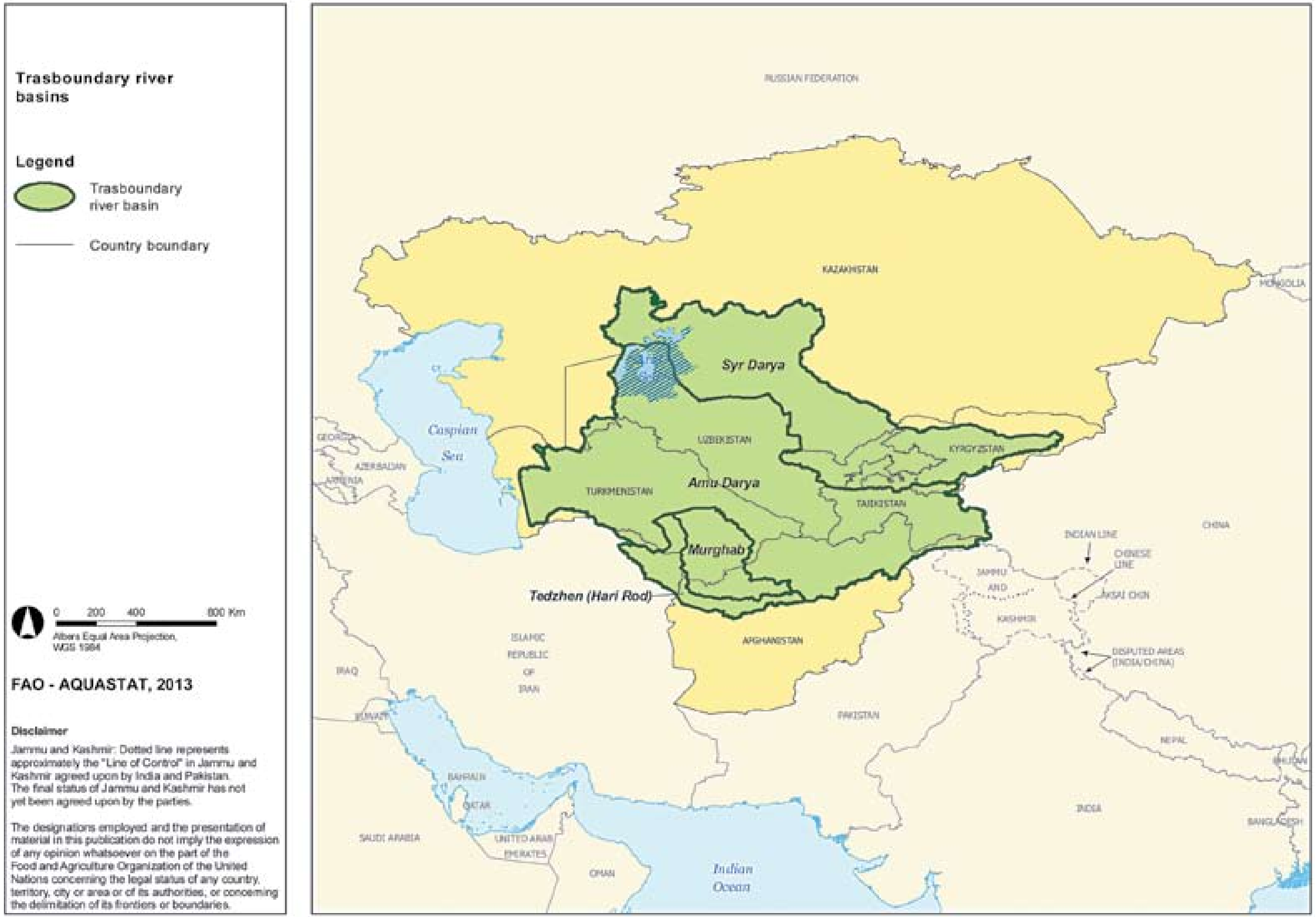
The main transboundary rivers in Central Asia are the Amu Darya and the Syr Darya, which both flow to the Aral Sea. These two transboundary river basins as well as the Tedzhen-Murghab basin form the Aral Sea basin, which covers almost 40 percent of the total area of Central Asia (Figure 8). A more detailed description of the Aral Sea basin is given in Section III.

TABLE 8
Dams with a reservoir capacity larger than 1 km^3

Dam	River	Basin	Completed (year)	Capacity (km^3)	Surface area (km^2)	Main use*	Country
Bukhtarma	Irtysh	Ob	1960	49.6	5 490	I, H, W, F	Kazakhstan
Toktogul	Naryn	Naryn	1974	19.5	-	H	Kyrgyzstan
Kapshagay	Ili	Balkhash-Alakol	1970	18.6	1 847	I, H, W	Kazakhstan
Nurek	Vakhsh	Amu Darya	1980	10.5	98	I, H, W, F	Tajikistan
Tuaymuyun**	Amu Darya	Amu Darya	1980	7.8	790	I, H, F	Uzbekistan
Chardarya	Syr Darya	Syr Darya	1968	5.2	783	I, H, W, F	Kazakhstan
Kayrakkum	Syr Darya	Syr Darya	1959	4.2	5 450	I, H	Tajikistan
Shulba	Irtysh	Ob	1988	2.4	255	I, H, W, F	Kazakhstan
Zeid	Kara Kum Canal	Amu Darya	1986	2.2	465	I, W	Turkmenistan
Charvak	Chirchik	Syr Darya	1977	2	22	I, H	Uzbekistan
Andijan	Karadarya	Syr Darya	1978	1.9	55	I	Uzbekistan
Talimarjan	Amu Darya	Amu Darya	1985	1.5	-	I	Uzbekistan
Pachkamar	Guzor	Amu Darya	1961	1.5	-	I	Uzbekistan
Dostluk	Tedzhen	Tedzhen	2004	1.3	48	I, H, W, F	Turkmenistan
Tudakul	Tudakulskaya	Amu Darya	1983	1.2	225	I	Uzbekistan
Kajaki	Upper Helmand	Helmand	1953	1.2	-	I, H	Afghanistan
Central Asia				**130.6**	**-**		

* I = Irrigation; H = Hydropower, W = Water supply; F = Flood protection
** Tuaymuyun is composed of four reservoirs: Ruslovoy, Sultansanjar, Kaparas and Koshbulak

FIGURE 8
Transboundary river basin



Water withdrawal

WATER WITHDRAWAL BY SECTOR

Data on water withdrawal by sector refer to the gross quantity of water withdrawn annually for a given use. Table 9 presents the distribution of water withdrawal by country for the three large water-consuming sectors: agriculture (irrigation, livestock cleaning and watering, aquaculture), municipalities (domestic/municipal) and industry (including water for cooling of thermoelectric plants). Although able to mobilize a significant portion of water, requirements for energy (hydroelectricity), navigation, fishing, environment and leisure activities have a low rate of net water consumption. For this reason, they are not included in the calculation of the withdrawals but they do appear in the country profiles where information is available.

For most countries, data on water withdrawal could be obtained from national statistics although there is much uncertainty about the methods of computation. Data for municipal and industrial water withdrawal in Afghanistan could not be found in national reports; estimates are based on modelled data.

Total annual water withdrawal for the Central Asia region is almost 145 km^3, which is 3.7 percent of world withdrawals (Table 9 and Table 25). Uzbekistan, with 56 km^3, has the highest withdrawal, accounting for 39 percent of the total. This is because the country has by far the largest area actually irrigated, 2–4 times the area irrigated in the other countries. Tajikistan and Kyrgyzstan have the lowest withdrawal with 8 percent and 6 percent respectively of the total withdrawals in the region. Water withdrawal per inhabitant is 1 811 m^3/year, this average however conceals significant variations between countries. The figure ranges from 937 and 1 319 m^3/inhabitant in Afghanistan and Kazakhstan respectively to 2 158 m^3/inhabitant in Uzbekistan and 5 952 m^3/inhabitant in Turkmenistan (Figure 9).

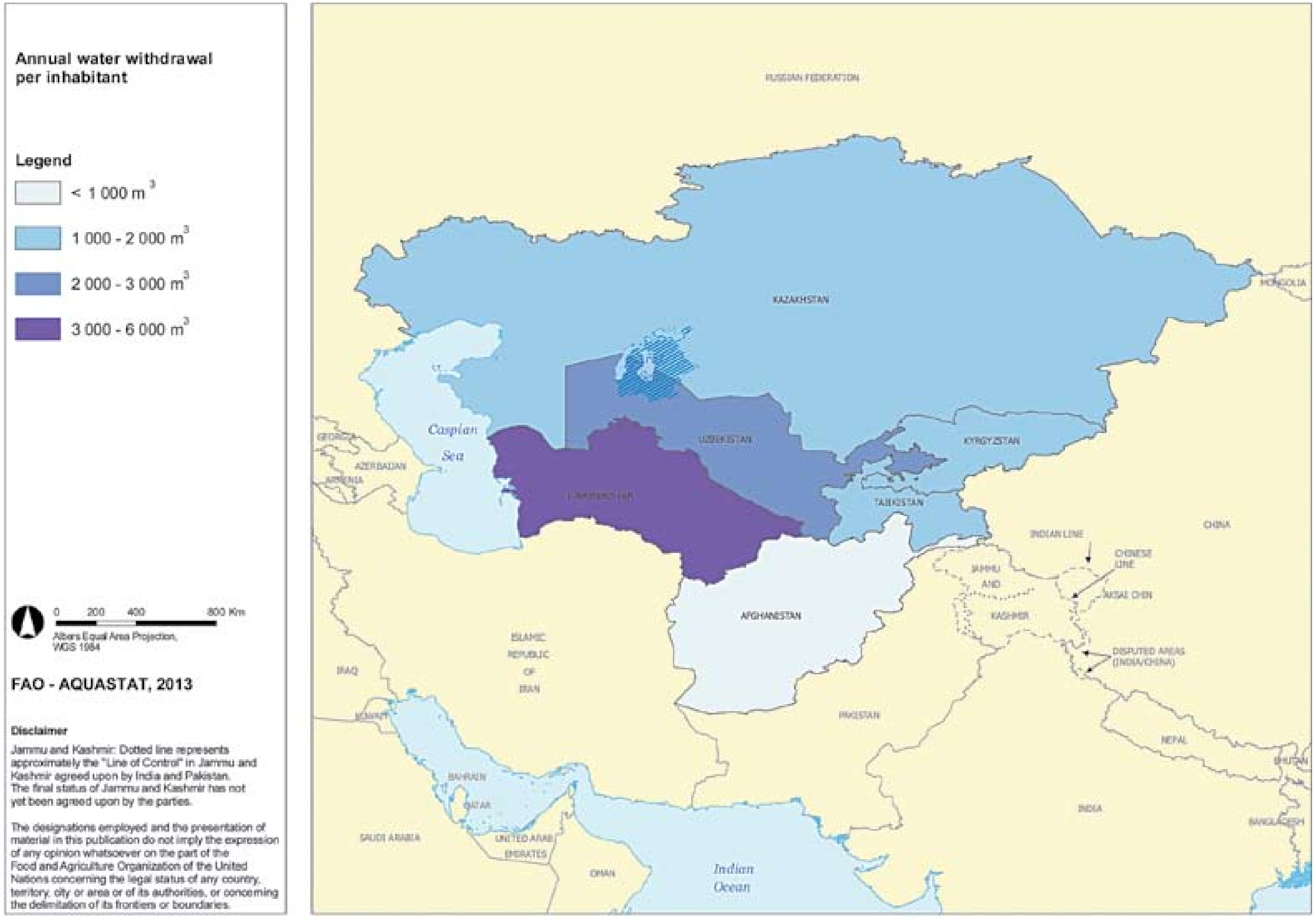
About 89 percent of inventoried withdrawal is water withdrawn by agriculture, which is higher than the value for global agricultural water withdrawal (69 percent) (Table 25). In all countries, except Kazakhstan, agricultural withdrawal accounts for more than 90 percent of total water withdrawal. In Kazakhstan it represents only 66 percent (Table 9).

TABLE 9
Water withdrawal by sector

Country	Year	Annual water withdrawal								
		Agriculture		Municipal		Industry		Total		
		Volume	% of total	Volume	% of total	Volume	% of total	Volume	% of region	per inhabitant
		million m^3	%	million m^3	%	million m^3	%	million m^3		m^3/inhab
Afghanistan*	2005	20 000	98.2	203	1.0	170	0.8	20 373	14	937
Kazakhstan	2010	14 002	66.2	878	4.2	6 263	29.6	21 143	15	1 319
Kyrgyzstan	2006	7 447	93.0	224	2.8	336	4.2	8 007	6	1 575
Tajikistan	2006	10 441	90.8	647	5.6	408	3.5	11 496	8	1 762
Turkmenistan	2004	26 364	94.3	755	2.7	839	3.0	27 958	19	5 952
Uzbekistan	2005	50 400	90.0	4 100	7.3	1 500	2.7	56 000	39	2 158
Central Asia		**128 654**	**88.7**	**6 807**	**4.7**	**9 516**	**6.6**	**144 977**	**100**	**1 811**

* Agricultural water withdrawal refers to 1998

FIGURE 9
Annual water withdrawal per inhabitant



Figures for agricultural water withdrawal, expressed in cubic meters per hectare of actually irrigated land, show large discrepancies between countries, which cannot be explained solely by differences in climatic conditions. Rather, their differences are to be found in computation methods. The gross average for the region is 12 294 m^3/ha/year. Figures for Tajikistan, Uzbekistan and Turkmenistan are 15 500, 13 600 and 13 200 m^3/ha of actually irrigated land respectively.

Kazakhstan, Afghanistan and Kyrgyzstan, however, show lower values, where agricultural water withdrawal is 11 800, 10 500 and 7 300 m^3/ha/year respectively. The scheme-level water requirement ratio is also called irrigation efficiency, which is the ratio of the estimated irrigation water requirement to the actual irrigation water withdrawal. This is around 47 percent and varies between 40 and 55 percent. However, more research and improved computation methods are needed to obtain homogenous information on agricultural water withdrawal among countries.

Municipal water withdrawal accounts for 5 percent of total water withdrawal in Central Asia, varying from 1 percent in Afghanistan to 7 percent in Uzbekistan. Municipal water withdrawal per inhabitant is 85 m^3/year or 233 litres/day for the region as a whole, with variations between countries from 9 m^3/year or 25 litres/day in Afghanistan to 161 m^3/year or 440 litres/day in Turkmenistan.

Industrial water withdrawal accounts for 7 percent of total water withdrawal in the region. At country level it is particularly significant in Kazakhstan with 6.3 km^3, accounting for 30 percent of total withdrawals in the country. In the other five countries industrial water withdrawal varies from 4 percent in Kyrgyzstan to less than 1 percent in Afghanistan (Table 9).

WATER WITHDRAWAL BY SOURCE

Data for water withdrawal by source refer to the gross quantity of water withdrawn annually from all possible sources, which are divided into primary and secondary (wastewater and agricultural drainage water returned to the system) freshwater resources, direct use of treated wastewater and agricultural drainage water and desalinated water produced. Table 10 presents the distribution of water withdrawal by country. For most countries, methods used for calculation or the measurements for obtaining the values of the withdrawal by source are not specified. For countries for which recent data were unavailable, or were considered unreliable, estimations took into account total water withdrawal by sector, given that total water withdrawal by source and total water withdrawal by sector must be equal.

Primary and secondary freshwater withdrawal accounts for 136 km^3, which is 3.6 percent of global water withdrawal (Table 10 and Table 25). This represents 93.8 percent of total water withdrawal (which is similar to the percentage in the South and East Asia region). Direct use of treated wastewater and agricultural drainage water accounts for 8 km^3 or 5.6 percent, and desalinated water accounts for 0.85 km^3 or 0.6 percent. However, while in three and five countries a figure is given for direct use of treated wastewater and direct use of agricultural drainage water respectively, the other countries could also engage in these types of water withdrawal.

In many cases it is not possible to make a distinction between the use of (un)treated wastewater and agricultural drainage water. These two sources are usually mixed before reusing. Moreover, it is not always clear from the statistics whether the agricultural drainage water is considered as secondary surface water or non-conventional water. Sometimes no distinction is made between wastewater and agricultural drainage water returned to the system and the portion that is directly used.

Considering only primary and secondary freshwater withdrawal, surface water withdrawal represents 91 percent of freshwater withdrawal and groundwater represents 9 percent, but there

TABLE 10
Water withdrawal by source of water and MDG water indicator

Country	Year	Primary and secondary freshwater withdrawal					Use of other sources of water							Total withdrawal by source	
		Surface water		Groundwater			Direct use				Desalinated water			Year	Volume
		Volume	% of total	Volume	% of total	MDG Water Indicator		Treated wastewater	Agricultural drainage water	% of total	Year	Volume	% of total		
		million m³	%	million m³	%	%	Year	million m³	million m³	%		million m³	%		million m³
Afghanistan	1998	17 317	85.0	3 056	15.0	31								1998	20 373
Kazakhstan	2010	18 959	89.7	1 029	4.9	19	2010	194	108	1.4	2010	853	4.0	2010	21 143
Kyrgyzstan	2006	7 401	92.4	306	3.8	33	1994	0.14	300	3.7				2006	8 007
Tajikistan	2006	8 936	77.7	2 260	19.7	51	2000		300	2.6				2006	11 496
Turkmenistan	2004	27 237	97.4	305	1.1	111	2004	336	80	1.5				2004	27 958
Uzbekistan	2005	44 160	78.9	5 000	8.9	101	2000		6 840	12.2				2005	56 000
Central Asia		**124 010**	**85.5**	**11 956**	**8.2**			**530**	**7 628**	**5.6**		**853**	**0.6**		**144 977**

are differences depending on the country. In Turkmenistan, Kyrgyzstan and Kazakhstan, surface water amounts to 97, 92 and 90 percent of total freshwater withdrawal respectively, while in Afghanistan, Tajikistan and Uzbekistan it accounts for 85, 80 and 79 percent respectively.

Of the two countries bordering the Caspian Sea, Kazakhstan and Turkmenistan, only Kazakhstan reports producing 0.853 km^3 of desalinated water, which represents 4 percent of total water withdrawal in the country (Table 10).

THE MILLENNIUM DEVELOPMENT GOALS – THE WATER INDICATOR

The Millennium Development Goal (MDG) water indicator, which is the total freshwater withdrawal as a percentage of total renewable freshwater resources, reflects the overall anthropogenic pressure on freshwater resources. In many areas, water use is unsustainable: withdrawal exceeds recharge rates and the water bodies are overexploited. The depletion of water resources can negatively impact aquatic ecosystems and, at the same time, undermine the basis for socio-economic development.

When relating primary and secondary freshwater withdrawal to the renewable water resources in Central Asia, three out of six countries in the region, Kazakhstan, Afghanistan and Kyrgyzstan, stand out with values of lower than 35 percent indicating that freshwater withdrawn is less than the quantity annually renewed on a long-term basis (Table 10). Tajikistan has a water indicator of 51 percent, however, there can be huge differences within countries and certain areas may be faced with serious water scarcity issues. Turkmenistan and Uzbekistan have by far the highest water indicators, 111 percent and 101 percent respectively. The figure being higher than 100 percent indicates that a large part of freshwater withdrawal is comprised of secondary freshwater withdrawal (wastewater and agricultural drainage water returned to the system and used again) (Figure 10).

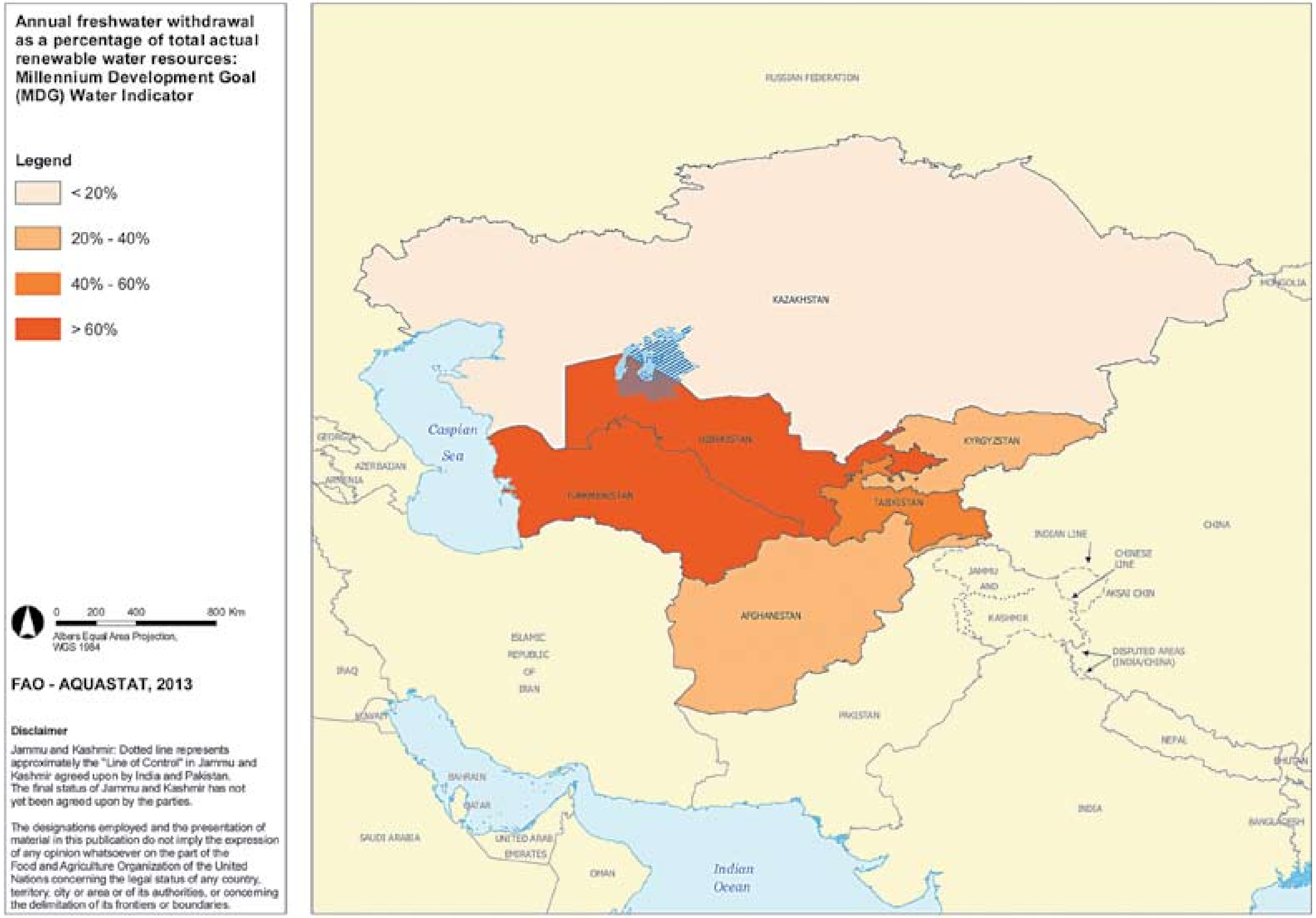
EVAPORATION LOSSES FROM ARTIFICIAL RESERVOIRS

Evaporation from artificial lakes (including evaporation ponds) and reservoirs is considered consumptive water use, since it would not occur if these had not been constructed to retain the water and thus create a surface water body from which water evaporates. This variable does not include evaporation from natural wetlands, natural lakes and rivers.

In theory this amount should be added to the data for water withdrawal, however, the information is still uncertain and a more in-depth study is needed to confirm and complete the information for the whole region.

FIGURE 10

Annual fresh water withdrawal as a percentage of total actual renewable water resources: Millennium Development Goal Water Indicator



Irrigation

IRRIGATION POTENTIAL

Methods used by countries to estimate their irrigation potential vary, which significantly influences the results. In computing water available for irrigation, some countries only consider renewable water resources, while others, especially arid countries, include the availability of fossil or non-conventional sources of water as well as the availability of secondary freshwater. Again, other countries only consider the land suitable for irrigation without considering water availability. For this reason, comparison between countries should be made with caution. In the case of transboundary rivers calculation by individual countries of their irrigation potential in the same river basin may lead to double counting of part of the shared water resources. It is therefore impossible to systematically add country figures to obtain regional estimates of irrigation potential.

The irrigation potential for Central Asia is an estimated 18 million ha. Currently the total estimated area equipped for irrigation, about 13 million ha, represents about 73 percent of the region's irrigation potential.

IRRIGATION AREAS

Irrigation plays an important role in the economies of Central Asia. In most areas crops must be irrigated because of the region's arid climate. While some areas have been irrigated for centuries, Soviet central planning created many irrigation and drainage schemes during 1950–1980. Huge schemes were constructed to irrigate desert or steppe areas and hundreds of thousands of people moved to the areas to work in agriculture. From 1970 to 1989 (the end of the Soviet period) the irrigated area expanded by factors of 150 percent and 130 percent in the Amu Darya and Syr Darya basins respectively (World Bank, 2003).

The term 'irrigation' refers to areas equipped to supply water to crops. Table 11 presents the distribution by country of the areas equipped for irrigation and the areas actually irrigated.

TABLE 11
Areas under irrigation

Country	Year	Full control irrigation area	Spate irrigation area	Total area equipped for irrigation	Area equipped as % of cultivated area	Area equipped as % of region	Area equipped for irrigation actually irrigated	Area actually irrigated as % of area equipped
		ha	ha	ha	%	%	ha	%
Afghanistan	2002	3 208 480		3 208 480	42	24	1 896 000	59
Kazakhstan	2010	1 199 600	866 300	2 065 900	9	16	1 264 970	61
Kyrgyzstan	2005	1 021 400		1 021 400	75	8	1 021 400	100
Tajikistan	2009	742 051		742 051	85	6	674 416	91
Turkmenistan*	2006	1 990 800		1 990 800	102	15	1 990 800	100
Uzbekistan	2005	4 198 000		4 198 000	89	32	3 700 000	88
Central Asia		**12 360 331**	**866 300**	**13 226 631**	**33**	**100**	**10 547 586**	**80**

* Total area equipped for irrigation is larger than the cultivated area, since the irrigation area includes irrigated permanent pasture while permanent pasture is not included in cultivated area.

The total area equipped for irrigation in the six Central Asian countries covers 13.2 million ha, accounting for 4.4 percent of the world's irrigation (Table 25, Figure 11 and Figure 12). This is almost equal to the area equipped for irrigation in all 54 countries of Africa together (13.7 million ha). More than half of the area equipped for irrigation is concentrated in Uzbekistan and Afghanistan, while Kyrgyzstan and Tajikistan together account for less than 15 percent. Most of the area equipped for irrigation – almost 9.8 million ha or 75 percent of the total – is located in the Aral Sea basin (see Section III). Not considering Afghanistan, this figure rises to 85 percent.

Full control irrigation covers 12.4 million ha and is by far the most widespread form of irrigation in Central Asia, accounting for 93 percent of the area equipped for irrigation. Only Kazakhstan reports spate irrigation, amounting to 866 300 ha. It should be noted that during the previous survey the figure reported for spate irrigation in Kazakhstan was 1 105 000 ha. It is not clear whether the previous figure was wrong or whether, maybe, much of the area that was previously reported under spate irrigation has, in the mean time, become full control irrigation.

Irrigation is practised on 33 percent of the total cultivated area in the region compared to 20 percent globally (Table 11, Table 25 and Figure 13). Turkmenistan has the highest level, with 102 percent of cultivated land under irrigation, the irrigated area is larger than the cultivated area, since the irrigation area includes irrigated permanent pasture, while permanent pasture is not included in the cultivated area, followed by Uzbekistan with 89 percent and Tajikistan with 85 percent. Kazakhstan has only 9 percent of the cultivated area under irrigation.

Irrigation in Central Asia, particularly in Uzbekistan, relies upon a system of dams, pumps and canals that is among the most complex in the world. The Tuaymuyun dam comprises nine structures and four reservoirs. Although mostly located in the territory of Turkmenistan, the ownership of the Tuaymuyun structures was recognized to Uzbekistan through the "Water Management Partnership Agreement" signed by both countries in 1996. Despite having signed an additional agreement on partnership for operation, management and repair of economic assets located in the border areas of the two countries in 2008, carrying out these activities remains cumbersome. The largest and most important waterway in Turkmenistan is the Kara Kum canal. Constructed in the 1950s this canal is 1 300 km, considered the longest in the world. The canal capacity is an estimated 630 m^3/s. Its inlet at the Amu Darya is located just after the river enters Turkmenistan from Uzbekistan. The Kara Kum canal pools the Amu Darya, Murghab and Tedzhen rivers into an integrated water management system. The canal supplies water to the densely populated south and irrigates more than 1.2 million ha, bringing water to Ashgabat and to the oases in the south. Every year the canal takes 10–12 km^3 from the Amu Darya (Orlovsky and Orlovsky, after 2002).

FULL CONTROL IRRIGATION TECHNIQUES

Table 12 presents the irrigation techniques used on areas under full control irrigation. For Afghanistan and Uzbekistan, the earlier data was provided by technique rather than for the total full control irrigation area. The percentages for each of the techniques have been retained and applied to the areas currently under full control. Therefore, these values are in order of magnitude only and are not an exact reflection of the real situation. However, it seemed worth the attempt to complete the data based on the field knowledge of the AQUASTAT team so as to form a more precise picture of the irrigation techniques used in the Central Asia region. Surface irrigation, accounting for 98.4 percent of irrigation techniques, greatly exceeds pressurized irrigation techniques, which are sprinkler irrigation (1.5 percent) and localized irrigation (0.1 percent).

FIGURE 11
Area equipped for irrigation

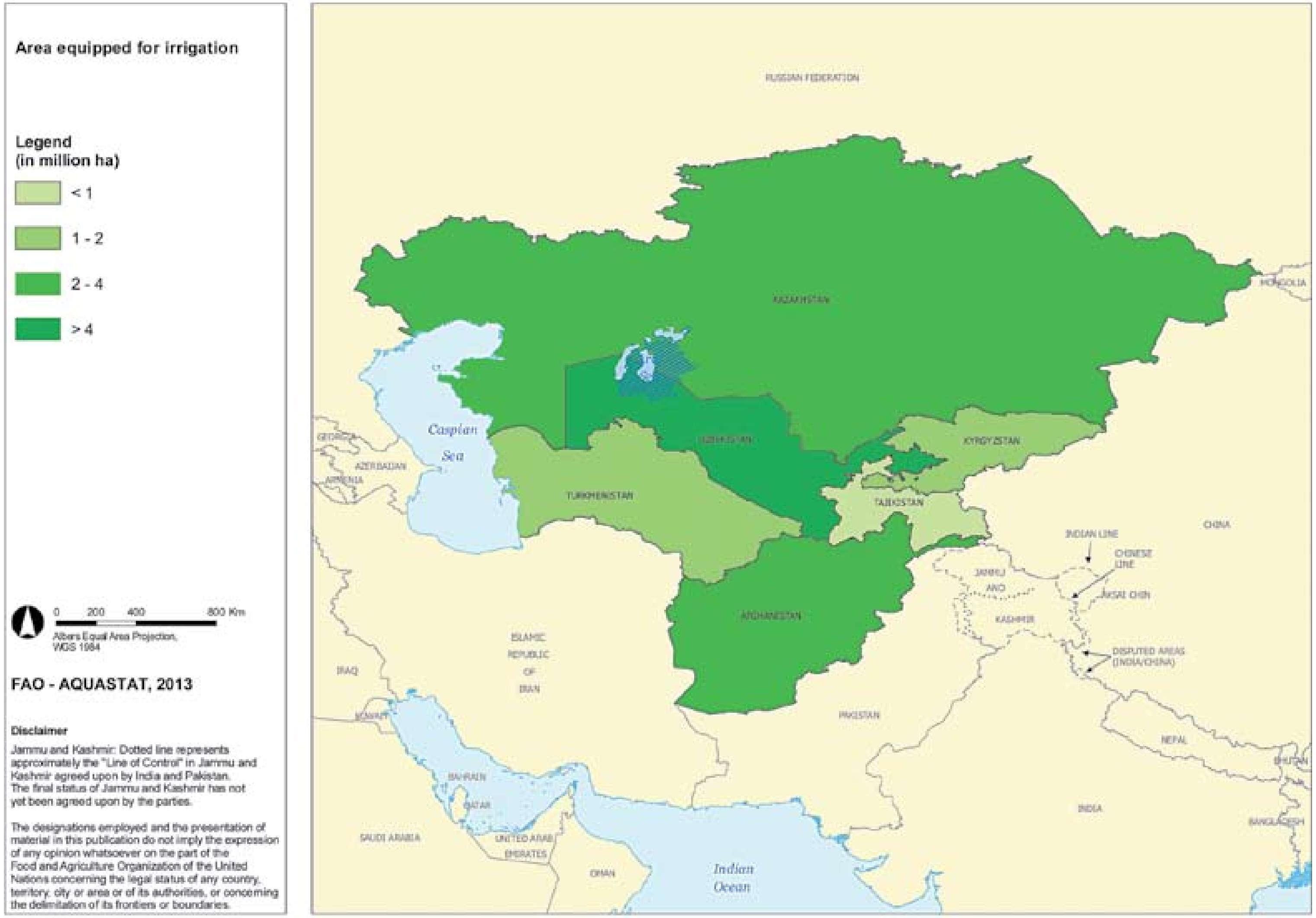


FIGURE 12
Area equipped for irrigation as percentage of country area

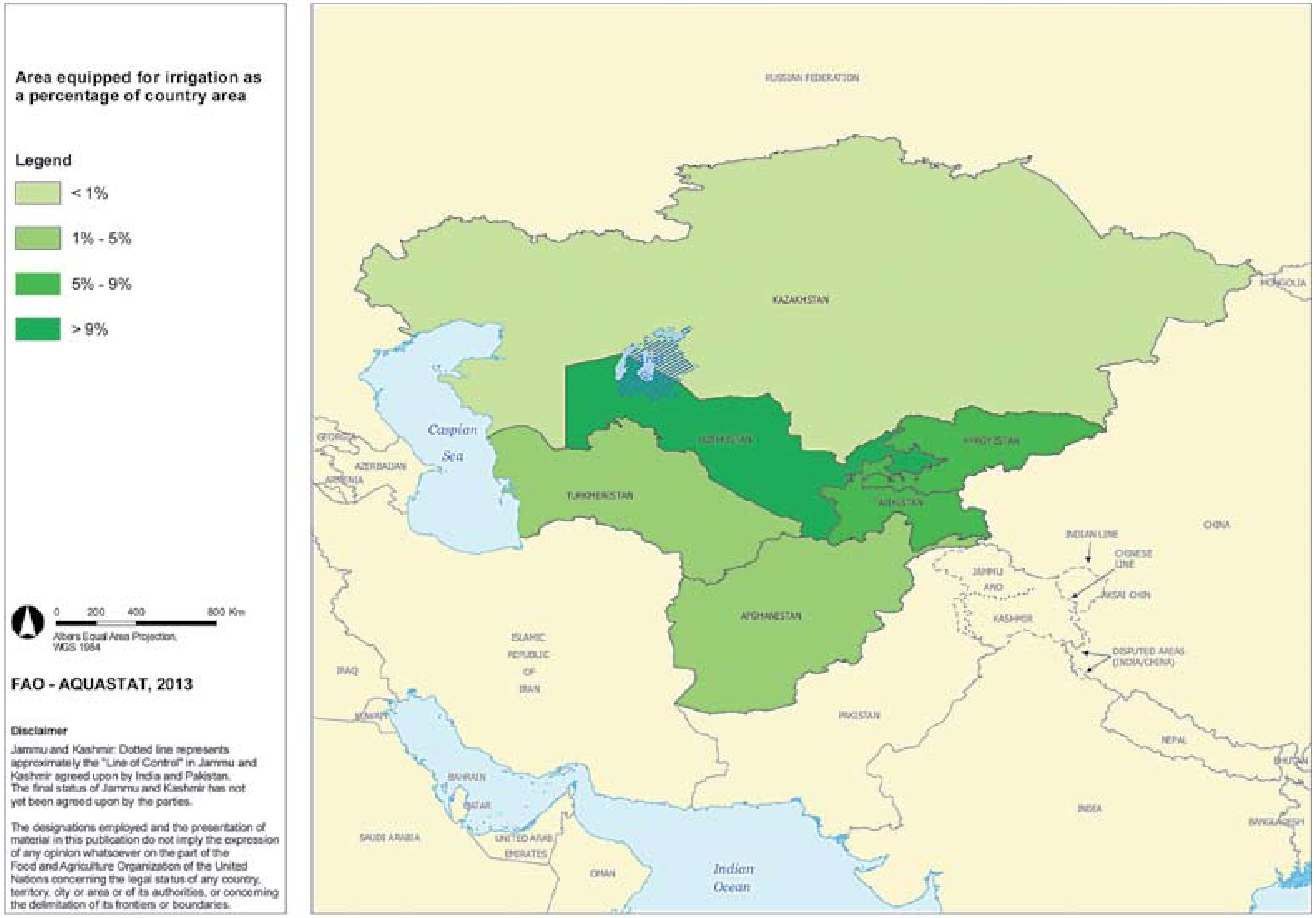
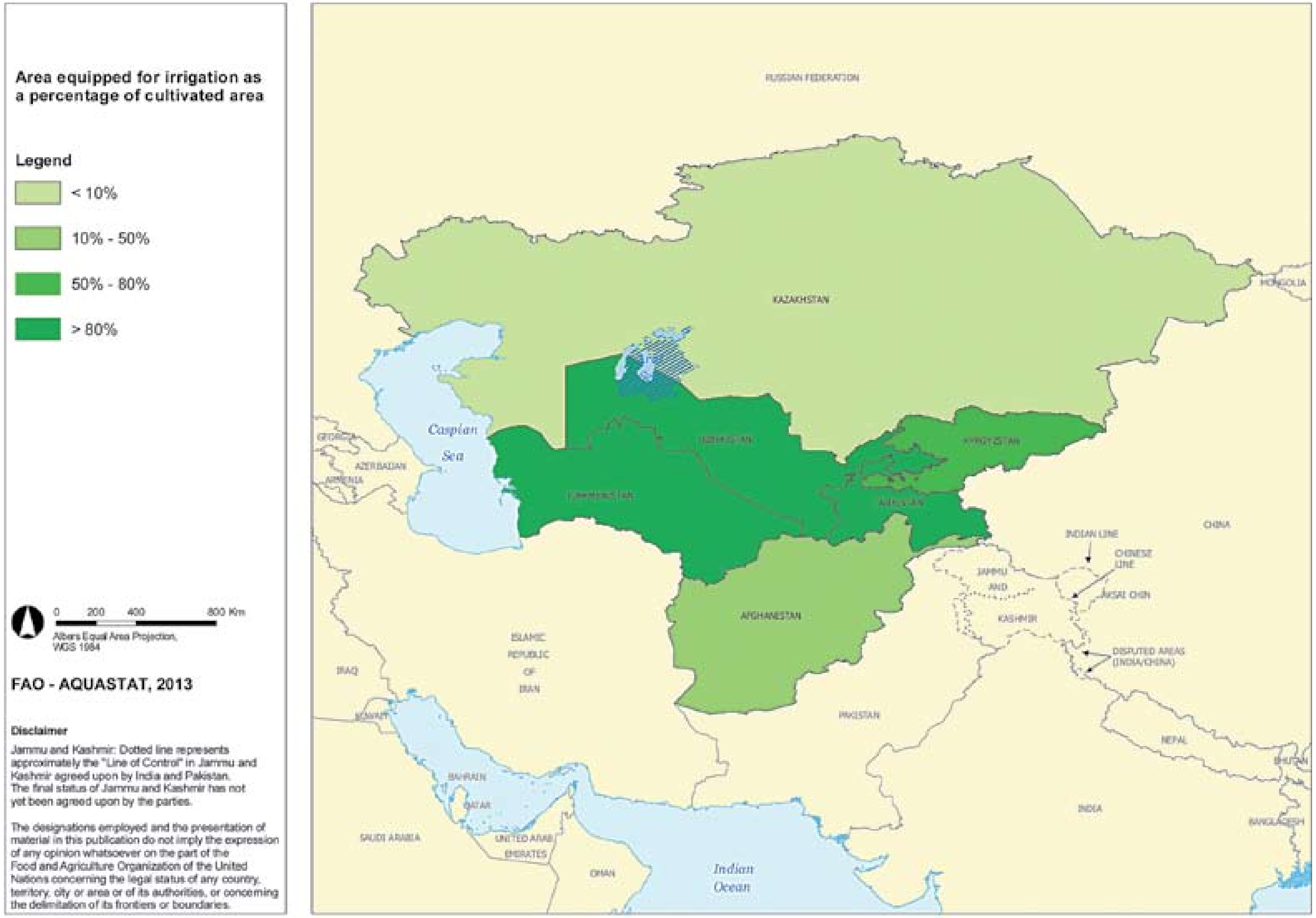


FIGURE 13
Area equipped for irrigation as percentage of cultivated area



ORIGIN OF WATER IN FULL CONTROL IRRIGATION

Table 13 presents available data concerning the origin of irrigation water in areas under full control irrigation: primary and secondary surface water, primary and secondary groundwater, and a mix of primary and secondary surface water and groundwater. While certainly several countries will directly use agricultural drainage water by irrigating from one plot to the next lower lying plot (cascade) (see Table 10), no information on this was available.

For the purpose of the analysis in Table 13, it was assumed that for those countries with data on the origin of water that refer to earlier years, rather than the total area equipped for full control irrigation, such as for Kyrgyzstan and Uzbekistan, the percentages for each of the sources have been retained and applied to the areas currently under full control irrigation. Therefore, these values are in order of magnitude only and are not an exact reflection of the real situation. However, it seemed worth the attempt to complete the data based on the AQUASTAT team field knowledge so as to form a more precise picture of the sources of water used for irrigation in the Central Asia region.

Surface water is the major source of irrigation water in Central Asia, 92.6 percent on average, varying from 82 percent to 99.8 percent.

TABLE 12
Irrigation techniques in areas equipped for full control irrigation

Country	Year	Area equipped for full control irrigation						
		Total	Surface irrigation		Sprinkler irrigation		Localized irrigation	
		ha	ha	% of total	ha	% of total	ha	% of total
Afghanistan	2002	3 208 480	3 055 166	95.22	153 314	4.78	-	-
Kazakhstan	2010	1 199 600	1 158 800	96.60	30 000	2.50	10 800	0.90
Kyrgyzstan	2005	1 021 400	1 021 000	99.96	400	0.04	-	-
Tajikistan	2009	742 051	742 051	100.00	-	-	-	-
Turkmenistan	2006	1 990 800	1 990 800	100.00	-	-	-	-
Uzbekistan	2005	4 198 000	4 193 577	99.89	-	-	4 423	0.11
Central Asia		**12 360 331**	**12 161 394**	**98.39**	**183 714**	**1.49**	**15 223**	**0.12**

TABLE 13
Origin of water used in full control irrigation (primary and secondary water)

Country	Year	Total area equipped for full control irrigation	Surface water		Groundwater		Mixed surface water and groundwater	
			Area	% of total	Area	% of total	Area	% of total
		ha	ha	%	ha	%	ha	%
Afghanistan	2002	3 208 480	2 631 324	82.0	577 156	18.0		
Kazakhstan	2010	1 199 600	1 197 600	99.8	2 000	0.2		
Kyrgyzstan	2005	1 021 400	1 011 186	99.0	10 214	1.0		
Tajikistan	2009	742 051	696 476	93.9	32 500	4.4	13 075	1.8
Turkmenistan	2006	1 990 800	1 981 190	99.5	9 610	0.5		
Uzbekistan	2005	4 198 000	3 929 282	93.6	268 718	6.4		
Central Asia		**12 360 331**	**11 447 058**	**92.6**	**900 198**	**7.3**	**13 075**	**0.1**

Note: Part of the area also must be irrigated by directly using agricultural drainage water or treated wastewater (See Table 10), but no figures are available.

Groundwater resources were not widely used for irrigated agriculture in the Central Asian Republics during the Soviet period because farmers had sufficient surface water, reliable water supply and irrigation infrastructure. Groundwater resources were used primarily for the livestock sector and for drinking water in both urban and rural areas. During the recent drought years (1998–2001) the Aral Sea basin nations started to use groundwater for vital agricultural production, because of its relatively good quality and quantity and as an alternative to the saline surface water.

In a very different situation, Afghanistan has traditionally relied on surface water and groundwater springs and *karezes* (constructed underground channels) for irrigated agriculture. The share of groundwater irrigation for the cultivated area is around 18 percent, being the highest in the region (Table 13). In Uzbekistan and Tajikistan groundwater represents 6 and 4 percent respectively, while in Kyrgyzstan, Turkmenistan and Kazakhstan, it is less than 1 percent of the total irrigated area. On average, in Central Asia, groundwater represents 7.3 percent of total full control area equipped for irrigation.

Tajikistan is the only country that gives a figure for mixed surface water and groundwater, accounting for 13 075 ha or 1.8 percent of the country's total irrigated area (Table 13). No information is available from the other countries for other sources of water.

Information on power-irrigated area is available for all countries except Afghanistan. The power-irrigated area represents 2 percent of the total area equipped for irrigation in Kazakhstan, 5 percent in Kyrgyzstan, 40 percent in Tajikistan, 16 percent in Turkmenistan and 27 percent in Uzbekistan.

FULL CONTROL IRRIGATION SCHEME SIZES

The definition of large schemes varies from one country to another. While Tajikistan considers a large scheme to be 3 000 ha, other countries, such as Uzbekistan and Kazakhstan classify a large scheme to be a minimum of 10 000 and 20 000 ha respectively.

Table 14 shows the sizes of schemes in several countries and the criteria used. If no recent information on size of scheme is available, the information from the previous survey is used, as for Kyrgyzstan and Uzbekistan. No information on scheme sizes is available for Afghanistan and Turkmenistan.

LEVEL OF USE OF AREAS EQUIPPED FOR FULL CONTROL IRRIGATION

Information on actually irrigated areas is provided for all Central Asia countries (Table 15). In Kyrgyzstan and Turkmenistan the total area equipped for full control irrigation is actually irrigated,

TABLE 14
Scheme sizes in areas equipped for full control irrigation

Country	Year	Criteria		Small schemes		Medium schemes		Large schemes		Total area
		Small	Large	Area	% of total	Area	% of total	Area	% of total	
		ha	ha	ha	%	ha	%	ha	%	ha
Afghanistan	2002	-	-	-		-		-		3 208 480
Kazakhstan	2002	< 10 000	> 20 000	424 000	44	200 000	21	343 000	35	967 000
Kyrgyzstan	1990	< 1 000	> 5 000	204 500	19	229 400	21	643 200	60	1 077 100
Tajikistan	2009	< 500	> 3 000	40 000	5	50 000	7	652 051	88	742 051
Turkmenistan	2006	-	-	-	-	-	-	-	-	1 990 800
Uzbekistan	1994	< 10 000	> 10 000	640 930	15	0	0	3 639 580	85	4 280 510

TABLE 15
Cropping intensity on actually irrigated areas

Country	Area equipped for full control irrigation		Area actually irrigated		as % of area equipped	Harvested irrigated crop area	Cropping intensity
	Year	ha	Year	ha	%	ha	%
	ha	(1)		(2)	(3)=100x(2)/(1)	(4)	(5)=100×(4)/(2)
Afghanistan	2002	3 208 480	2011	1 896 000	59	2 176 000	115
Kazakhstan	2010	1 199 600	2010	1 182 100	99	1 182 100	100
Kyrgyzstan	2005	1 021 400	2005	1 021 400	100	1 021 400	100
Tajikistan	2009	742 051	2008	674 416	91	729 283	108
Turkmenistan	2006	1 990 800	2006	1 990 800	100	2 013 800	101
Uzbekistan	2005	4 198 000	2005	3 700 000	88	3 700 000	100
Central Asia		**12 360 331**		**10 464 716**	**85**	**10 822 583**	**103**

which in Kazakhstan is 99 percent. Tajikistan and Uzbekistan have a rate of 91 and 88 percent respectively. Afghanistan has a lower use rate accounting for 59 percent. Low rates in general are explained by deteriorating infrastructure because of a lack of maintenance (lack of experience or the use of unsuitable techniques) or for political and economic reasons. Other causes are inadequate management of technical means of production under irrigation, impoverished soils, salinization, local instability and insecurity and reduced public funds for irrigation.

CROPPING INTENSITY IN FULL CONTROL IRRIGATION SCHEMES

Cropping intensity, another indicator of the use of equipped areas, is calculated based on the area of harvested irrigated crops over the part of the area equipped for full control irrigation and actually irrigated. The calculation only refers to irrigated crops. This means that in a country with one or two wet seasons only irrigated crops are considered. Crops grown on the full control equipped area during the wet season without irrigation (but using residual soil humidity) are not included in the irrigated crop area when calculating cropping intensity.

The calculation of cropping intensity therefore is straightforward for dry countries because irrigation is indispensable for the growing of crops in all seasons. However, the calculation is more problematic for countries with both a dry and wet season, during which the crops use the soil moisture provided by precipitation. On these areas the irrigated cropping intensity is 100 percent, while the harvested area is double.

National cropping intensity on actually irrigated areas in full control irrigation schemes ranges from 100 percent in Kazakhstan, Kyrgyzstan and Turkmenistan to 115 percent in Afghanistan (Table 15). Tajikistan and Turkmenistan account for 108 percent and 101 percent respectively. On average, the region has a cropping intensity of harvested irrigated areas over actually irrigated areas in full control irrigation areas of 103 percent.

IRRIGATED CROPS IN FULL CONTROL IRRIGATION SCHEMES

Cropping patterns have changed extensively since the Central Asian countries became independent. Cotton is still one of the most important crops, although between 1990 and 1998 its share of irrigated agriculture decreased from 45 to 25 percent. In the same period, the area under cereals (wheat, rice, maize and others) increased from 12 to more than 50 percent. Wheat became the dominant crop in the region. Fodder crops occupied less than 20 percent of the total irrigated area in 1998, compared to 28 percent in 1990 (CAWaterInfo, 2011).

Table 16 shows the national distribution of harvested irrigated crop areas. Even though, in many countries, no distinction is made for statistics for irrigated and rainfed crops, an effort has been made in this survey to provide the most accurate data for irrigated crops.

Cereals represent 49 percent of all harvested irrigated crop areas in the region. Wheat alone represents about 39 percent, ranging from 18 percent in Kazakhstan to 60 percent in Afghanistan. Cotton is the second most widespread harvested irrigated crop, accounting for 23 percent on average. Mainly cultivated in Uzbekistan, Tajikistan and Turkmenistan, cotton represents 38, 33 and 32 percent of total harvested irrigated cropped area respectively. Fodder accounts for 11 percent of the irrigated crops in the region, of which temporary fodder occupies 4 percent, permanent grass and fodder 2 percent and permanent meadows and pastures 5 percent. Vegetables represent 3 percent, with special importance in Kazakhstan (15 percent). Potatoes account for 2 percent of the total irrigated cropped area, with special importance in Kyrgyzstan (7 percent), Kazakhstan (5 percent) and Tajikistan (4 percent).

TABLE 16 A
Harvested irrigated crops on areas equipped for full control irrigation actually irrigated (in hectares)

Crop	Afghanistan	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Central Asia
Year	2011	2010	2005	2009	2006	2005	
Wheat	1 303 000	208 000	360 700	179 742	917 000	1 295 000	4 263 442
Barley	116 000	92 000	86 600	18 017	-	-	312 617
Maize	183 000	95 600	61 500	14 743	-	-	354 843
Rice	208 000	94 000	5 000	14 126	11 000	52 000	384 126
Other cereals	-	-	1 600	7 225	-	-	8 825
Vegetables incl. roots and tubers	69 000	182 600	40 600	37 162	29 400	-	358 762
Potatoes and sweet potatoes	15 000	60 000	76 000	29 901	8 800	-	189 701
Pulses	27 000	-	20 800	4 667	-	-	52 467
Oil crops*	20 000	40 000	59 200	3 493	-	-	122 693
Cotton	33 000	134 200	45 500	237 130	652 000	1 406 000	2 507 830
Sugarcane and sugar beet**	4 000	8 720	14 500	-	12 000	-	39 220
Temporary fodder	-	-	35 800	8 323	93 000	300 000	437 123
Permanent grass and fodder	-	26 000	73 400	34 043	-	100 000	233 443
Other temporary crops***	-	6 430	33 300	886	100 100	247 000	387 716
Other permanent crops****	198 000	54 000	-	98 957	65 000	200 000	615 957
Permanent meadows, pastures	-	180 550	106 900	40 868	125 500	100 000	553 818
Total	**2 176 000**	**1 182 100**	**1 021 400**	**729 283**	**2 013 800**	**3 700 000**	**10 822 583**
Area actually irrigated	1 896 000	1 182 100	1 021 400	674 416	1 990 800	3 700 000	10 464 716
Cropping intensity in %	115	100	100	108	101	100	103

* of which in Afghanistan 10 000 ha sesame and 10 ha sunflower, in Kyrgyzstan and Tajikistan all sunflower
** of which in Afghanistan 2 000 ha sugarcane and 2 000 ha sugar beet, in all other countries only sugar beet
*** of which 1 600 ha tobacco in Kazakhstan and 5 600 ha tobacco in Kyrgyzstan
**** of which 61 000 ha grapes in Afghanistan

TABLE 16 B

Harvested irrigated crops on areas equipped for full control irrigation actually irrigated (in percentages)

Crop	Afghanistan	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Central Asia
Year	2011	2010	2005	2009	2006	2005	
Wheat	59.9	17.6	35.3	24.6	45.5	35.0	39.4
Barley	5.3	7.8	8.5	2.5	-	-	2.9
Maize	8.4	8.1	6.0	2.0	-	-	3.3
Rice	9.6	8.0	0.5	1.9	0.5	1.4	3.5
Other cereals	-	-	0.2	1.0	-	-	0.1
Vegetables incl. roots and tubers	3.2	15.4	4.0	5.1	1.5	-	3.3
Potatoes and sweet potatoes	0.7	5.1	7.4	4.1	0.4	-	1.8
Pulses	1.2	-	2.0	0.6	-	-	0.5
Oil crops	0.9	3.4	5.8	0.5	-	-	1.1
Cotton	1.5	11.4	4.5	32.5	32.4	38.0	23.2
Sugarcane and sugar beet	0.2	0.7	1.4	-	0.6	-	0.4
Temporary fodder	-	-	3.5	1.1	4.6	8.1	4.0
Permanent grass and fodder	-	2.2	7.2	4.7	-	2.7	2.2
Other temporary crops	-	0.5	3.3	0.1	5.0	6.7	3.6
Other permanent crops	9.1	4.6	-	13.6	3.2	5.4	5.7
Permanent meadows, pastures	-	15.3	10.5	5.6	6.2	2.7	5.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Trends

In 2001 the population of the Central Asia region was 79 million, or 1.3 percent of the world's population. Ten years later, in 2011, it was 94 million, still 1.3 percent of the world's population. Population density rose from 17 to 20 inhabitants/km^2. The population growth rate over the last ten years has been 1.7 percent/year, a decrease from the 2.1 percent/year for 1991–2001.

TREND IN WATER WITHDRAWAL BY SECTOR

By sector the proportions of water withdrawal have changed only slightly: agricultural water withdrawal has decreased from 93 to 89 percent, while municipal withdrawal has increased from 3 to 5 percent and industrial withdrawal from 5 percent to 7 percent. The total volume of water withdrawal has decreased by 11 percent over the last ten years (Table 17). Agriculture withdraws the most water, around 90 percent of the total, and the decrease is entirely the result of reduced agricultural water withdrawal (–15 percent), while both municipal water withdrawal and industrial water withdrawal increased by 52 percent and 23 percent respectively.

Between the two survey dates, annual withdrawal per inhabitant fell by 307 m^3. This is because of an increase in total population and a decrease in total water withdrawal in the region from 164 km^3 to 145 km^3. Turkmenistan is the only country in the region where annual water withdrawal per inhabitant has increased, from 5 723 m^3 to 5 952 m^3.

Looking at the municipal sector, water withdrawal per capita has increased from 58 m^3/year, or 159 litres/day, to 75 m^3/year, or 205 litres/day. This situation varies between countries: in

TABLE 17
Trend in water withdrawal by sector

Country	Year	Annual water withdrawal by sector								
		Agriculture		Municipal		Industry		Total		
		million m^3	% of total	million m^3	% of total	million m^3	% of total	million m^3	% of region	m^3 per inhab
Afghanistan	1987	25 849	99.0	261	1.0	0	0.0	26 110	16.0	1 702
	1998	20 000	98.2	203	1.0	170	0.8	20 373	14.1	937
Kazakhstan	1993	27 413	81.0	583	2.0	5 678	17.0	33 674	20.6	2 002
	2010	14 002	66.2	878	4.2	6 263	29.6	21 143	14.6	1 319
Kyrgyzstan	1994	9 496	94.0	301	3.0	289	3.0	10 086	6.2	2 257
	2006	7 447	93.0	224	2.8	336	4.2	8 007	5.5	1 575
Tajikistan	1994	10 961	92.0	412	3.0	501	4.0	11 874	7.3	2 001
	2006	10 441	90.8	647	5.6	408	3.5	11 496	7.9	1 762
Turkmenistan	1994	23 291	98.0	349	1.0	139	1.0	23 779	14.5	5 723
	2004	26 364	94.3	755	2.7	839	3.0	27 958	19.3	5 952
Uzbekistan	1994	54 366	94.0	2 582	4.0	1 103	2.0	58 051	35.5	2 501
	2005	50 400	90.0	4 100	7.3	1 500	2.7	56 000	38.6	2 158
Central Asia	**1999**	**151 376**	**93.0**	**4 488**	**3.0**	**7 710**	**5.0**	**163 574**	**100.0**	**2 118**
	2009	**128 654**	**88.7**	**6 807**	**4.7**	**9 516**	**6.6**	**144 977**	**100.0**	**1 811**
Change		**-22 722**	**-15%**	**2 319**	**52%**	**1 806**	**23%**	**-18 597**	**-11%**	

Kazakhstan municipal water withdrawal has increased from 36 to 55 m^3/year, in Tajikistan from 72 to 99 m^3/ha, in Turkmenistan from 85 m^3/year to 161 m^3/year and in Uzbekistan from 115 to 158 m^3/year while in Afghanistan it has decreased from 21 to 9 m^3/year and in Kyrgyzstan from 66 to 44 m^3/year.

In agriculture, the annual water withdrawal per hectare of area equipped for irrigation seems to have decreased from 12 000 to 10 000 m^3. These data should be used with caution, since the reason for this is not clear. It may be the result of computation methods, data quality, changed cropping pattern or improved irrigation techniques.

TREND IN WATER WITHDRAWAL BY SOURCE

For Central Asia as a whole, annual freshwater withdrawal has decreased from 141 to 136 km^3, which represents a decrease of 4 percent, but with great variation between countries (Table 18). Direct use of treated wastewater has increased from 0.274 to 0.530 km^3, representing an increase of 93 percent. Direct use of agricultural drainage water has decreased from 28 to 8 km^3, which represents an annual rate of decrease of 71 percent. However, the figures on direct use of agricultural drainage water should be looked at with caution, especially for Kazakhstan, Tajikistan and Turkmenistan. It is not clear whether there is a real decrease or whether the part considered as direct use in the previous survey was, in fact, secondary fresh water since it was returned to the system. Only Kazakhstan reports the use of desalinated water for domestic purposes: 1.328 km^3 in 1993 and 0.853 km^3 in 2010, a decrease of 36 percent.

TREND IN AREAS UNDER IRRIGATION

Table 19 presents the trends in the area under irrigation. For Central Asia, the decrease in the equipped area is 9 percent, which is equal to an annual rate of decrease of 0.81 percent using a weighted year index. This is calculated by allocating a weighting coefficient to the year for each country that is proportional to its area equipped for irrigation, therefore giving more importance to countries with the largest areas under irrigation. The area under full control irrigation has an annual rate of decrease of 0.63 percent, which is lower than the annual rate of decrease for total irrigation. This is explained by the fact that area under spate irrigation and equipped lowlands has decreased more than for areas under full control irrigation. Since the previous survey, Afghanistan, Tajikistan and Turkmenistan have increased their equipped area, accounting for an annual rate of increase of 0.03, 0.21 and 1.11 percent respectively, while Kazakhstan, Kyrgyzstan and Uzbekistan show a decrease of 3.14, 0.48 and 0.18 respectively, amongst others due to salinization.

TABLE 18
Trend in primary and secondary water withdrawal

Country	Year	Total	Increase
		million m^3	%
Afghanistan	1987	26 110	- 22
	1998	20 373	
Kazakhstan	1993	25 287	- 21
	2010	19 988	
Kyrgyzstan	1994	9 786	- 21
	2006	7 707	
Tajikistan	1994	8 094	38
	2006	11 196	
Turkmenistan	1994	18 379	50
	2004	27 542	
Uzbekistan	1994	53 759	- 9
	2005	49 160	
Central Asia	**1999**	**141 415**	**- 4**
	2009	**135 966**	

TREND IN FULL CONTROL IRRIGATION TECHNIQUES

Table 20 presents the trends in irrigation techniques. There is no information on irrigation techniques in this survey for Afghanistan and Uzbekistan. Thus to facilitate the regional comparison between

TABLE 19
Trend in areas under irrigation

Country	Year	Full control irrigation	Spate irrigation	Equipped lowlands	Total irrigation	Total increase	Annual increase*
		ha	ha	ha	ha	%	%
Afghanistan	1993	3 199 000			3 199 000	0.30	0.03
	2002	3 208 480			3 208 480		
Kazakhstan	1993	2 313 100	1 104 600	138 700	3 556 400	-41.91	-3.14
	2010	1 199 600	866 300		2 065 900		
Kyrgyzstan	1994	1 077 100			1 077 100	-5.17	-0.48
	2005	1 021 400			1 021 400		
Tajikistan	1994	719 200			719 200	3.18	0.21
	2009	742 051			742 051		
Turkmenistan	1994	1 744 100			1 744 100	14.14	1.11
	2006	1 990 800			1 990 800		
Uzbekistan	1994	4 280 510			4 280 510	-1.93	-0.18
	2005	4 198 000			4 198 000		
Central Asia	**1999**	**13 333 010**	**1 104 600**	**138 700**	**14 576 310**	**-9.26**	**-0.81**
	2009	**12 360 331**	**866 300**		**13 226 631**		
Change		**- 972 679**	**- 238 300**	**- 138 700**	**-1 349 679**		

* Annual increase for the region was calculated using a weighted year index. The weighted year index is calculated by allocating to the year for each country a weighing coefficient proportional to its area equipped for irrigation, therefore giving more importance to countries with the largest areas under irrigation.

TABLE 20
Trend in full control irrigation techniques

Country	Year	Surface irrigation		Sprinkler irrigation		Localized irrigation		Total
		Area	% of total	Area	% of total	Area	% of total	
		ha	%	ha	%	ha	%	ha
Afghanistan	1993	3 046 088	95,22	152 912	4.78			3 199 000
	2002	3 055 166	95,22	153 314	4.78			3 208 480
Kazakhstan	1993	1 763 500	76,24	549 600	23.76			2 313 100
	2010	1 158 800	96,60	30 000	2.50	10 800	0.90	1 199 600
Kyrgyzstan	1994	1 040 100	96,56	37 000	3.44			1 077 100
	2005	1 021 000	99,96	400	0.04			1 021 400
Tajikistan	1994	719 200	100,00					719 200
	2009	742 051	100,00					742 051
Turkmenistan	1994	1 743 700	99,98			400	0.02	1 744 100
	2006	1 990 800	100,00					1 990 800
Uzbekistan	1994	4 276 000	99,89			4 510	0.11	4 280 510
	2005	4 193 577	99,89			4 423	0.11	4 198 000
Central Asia	**1999**	**12 588 588**	**94,42**	**739 512**	**5.55**	**4 910**	**0.04**	**13 333 010**
	2009	**12 161 394**	**98,39**	**183 714**	**1.49**	**15 223**	**0.12**	**12 360 331**
Change		**- 427 194**	**-3%**	**- 555 798**	**-75%**	**10 313**	**210%**	**- 972 679**

1999 and 2009, the same percentage has been applied to the most recent figure for full control irrigation as that of the previous survey.

The area under surface irrigation, the most important technique, has decreased by 427 194 ha or 3 percent. Proportionally, in all countries for which new data are available, the percentage of surface irrigation has increased, particularly in Kazakhstan where it has changed from 76 percent to 97 percent, even though the physical area under surface irrigation in this country has decreased from 1.8 million ha to 1.2 million ha. Sprinkler irrigation has decreased by 555 798 ha or 75 percent.

The area under surface irrigation has decreased especially in Kazakhstan, followed by Kyrgyzstan. Localized irrigation, which requires less water, has increased by 10 313 ha. Most development has been achieved in Kazakhstan, which reports 10 800 ha, while no figure was provided in the previous survey. Central Asia has not yet adapted a large area for sprinkler and localized irrigation; this has even decreased over the last ten years.

TREND IN ORIGIN OF WATER FOR FULL CONTROL IRRIGATION

Table 21 presents the trends in the origin of water used for full control irrigation. There is no data in this present survey for Kyrgyzstan and Uzbekistan concerning the origin of irrigation water. To facilitate the regional comparison between 1999 and 2009, the same proportion of surface water and groundwater has been estimated as for the previous survey, even though this might not be completely correct.

There are no important changes since the last survey on proportions for the origin of water. These are similar to proportions reported in the previous survey. The physical area irrigated using surface water for the whole region has decreased from 12.2 million ha to 11.4 million ha, though its proportion over the entire area under full control irrigation has increased from 91.5 to 92.6 percent. The explanation is that other sources of water have decreased proportionately. The area irrigated by groundwater has decreased from 1.1 million ha to 0.9 million ha, representing a change from 8.0 percent to 7.3 percent of the total full control equipped area.

TABLE 21
Trend in the origin of water used in full control irrigation

Country	Year	Surface water		Groundwater		Other sources		Total
		Area	% of total	Area	% of total	Mix of surface water and groundwater	% of total	Area
		ha	%	ha	%	ha	%	ha
Afghanistan	1993	2 706 354	84.6	492 646	15.4	0	0.0	3 199 000
	2002	2 631 324	82.0	577 156	18.0	0	0.0	3 208 480
Kazakhstan	1993	2 088 729	90.3	178 109	7.7	46 262	2.0	2 313 100
	2010	1 197 600	99.8	2 000	0.2	0	0.0	1 199 600
Kyrgyzstan*	1994	1 070 100	99.4	7 000	0.6	0	0.0	1 077 100
	2005	1 011 186	99.0	10 214	1.0	0	0.0	1 021 400
Tajikistan	1994	626 200	87.1	68 000	9.5	25 000	3.5	719 200
	2009	696 476	93.9	32 500	4.4	13 075	1.8	742 051
Turkmenistan	1994	1 700 500	97.5	43 600	2.5	0	0.0	1 744 100
	2006	1 981 190	99.5	9 610	0.5	0	0.0	1 990 800
Uzbekistan*	1994	4 006 510	93.6	274 000	6.4	0	0.0	4 280 510
	2005	3 929 282	93.6	268 718	6.4	0	0.0	4 198 000
Central Asia	**1999**	**12 198 393**	**91.5**	**1 063 355**	**8.0**	**71 262**	**0.5**	**13 333 010**
	2009	**11 447 058**	**92.6**	**900 198**	**7.3**	**13 075**	**0.1**	**12 360 331**

* For Kyrgyzstan and Uzbekistan the year for the total area under full control irrigation (2005) is different from the year for the different origins of water for full control irrigation (1994). Thus, for the purpose of this table, the same proportion has been applied to the most recent figure of full control irrigation.

TREND IN IRRIGATED CROPS IN FULL CONTROL IRRIGATION SCHEMES

As shown in the above *Irrigated crops in full control schemes*, significant changes have occurred in cropping patterns in the countries of Central Asia since their independence from the Former Soviet Union. Cotton is still one of the most important crops, although between 1990 and 1998 its share of irrigated agriculture decreased from 45 to 25 percent. In the same period, the area under cereals (wheat, rice, maize and others) increased from 12 to over 50 percent. Wheat became the dominant crop in the region (CAWaterInfo, 2011).

Over the last ten years the main change has been an increase in the wheat area from 2.8 to 4.3 million ha, covering 23 percent and 39 percent of the total irrigated harvested area respectively (Table 22). Together rice, barley and maize represent 10 percent in both the present and previous survey, though the total area for the three crops together has decreased from 1.3 to 1.1 million ha. In the previous survey, 2.2 percent of the total harvested irrigated crop area was under other cereals, while in the present survey this is only 0.1 percent.

Cotton has decreased from 2.7 to 2.5 million ha, but its proportion has increased from 22 to 23 percent. The proportion of vegetables remains at 3 percent of the total. In the previous survey, the area under fodder accounted for 2.9 million ha or 23 percent of the total irrigated harvested area. Temporary fodder, permanent grass and fodder and permanent meadows and pastures in this survey together account for just 1.2 million ha or 11 percent of the total area. The area under permanent crops (excluding fodder) has decreased from 1.1 to 0.6 million ha, indicating that a lower percentage of irrigated area is dedicated to these crops.

USE RATE OF AREAS EQUIPPED FOR IRRIGATION

In four out of the six Central Asia countries, the use rate of equipped areas has fallen over the last ten years. The area actually irrigated in Afghanistan has decreased from 83 percent of the equipped area in 1993 to 59 percent in 2002. In Tajikistan, the area actually irrigated has declined from 100 percent in 1994 to 91 percent of the equipped area in 2009. In Uzbekistan, the area actually irrigated has decreased from 98 percent of the equipped area in 1994 to 88 percent in 2005. In Kazakhstan, Kyrgyzstan and Turkmenistan the area actually irrigated represented 100 in both the previous and present surveys.

TABLE 22

Trend in harvested irrigated crop areas by different types of crops

Crop	1999		2009		change
	million ha	% of total	million ha	% of total	1999-2009
Wheat	2.8	23	4.3	39	50%
Cotton	2.7	22	2.5	23	-8%
Other cereals	1.6	13	1.1	10	-32%
Vegetables, potatoes, pulses, sugar	0.5	4	0.6	6	23%
Oil crops	0.2	1	0.1	1	-34%
Fodder, pasture	2.9	23	1.2	11	-58%
Other temporary crops	0.6	5	0.4	4	-32%
Other permanent crops	1.1	9	0.6	6	-44%
Central Asia	**12.4**	**100**	**10.8**	**100**	**-13%**

Legislative and institutional framework for water management

In all the countries of Central Asia water management is based on a water code or on a specific water law or act. **Afghanistan** introduced a Water Law in 1981 to improve water rights. The Law, however, needs to be updated and revised before it is ready to be enforced. For the other five Central Asian countries, during the Soviet period, the 1970 Law 'Basics of water legislation of the USSR and Union Republics' served as the legal framework for water relations, but this changed after their independence. **Kazakhstan** adopted a Water Code in 1993, which was amended and supplemented in 2003 and 2009. **Kyrgyzstan** accepted a Water Code in 2005 based on IWRM. **Tajikistan** adopted a Water Code in 2000 that amended a previous Water Code signed in 1993. **Turkmenistan** issued a Water Code in 1972 that describes in detail the responsibilities of the Cabinet of Ministers; the specialized state authority for water use and protection; local executive power; civil societies and individuals. **Uzbekistan** approved a Water Law in 1993, which introduced water rights, the legal framework is constantly being improved. In 2009, a new law was approved on 'Introducing amendments to some legislative acts of the Republic of Uzbekistan in connection with the deepening of economic reforms in agriculture and water management'.

At regional level different organizations take part in water resources management. At the top is the International Fund for Saving the Aral Sea (IFAS), led by the five presidents (Afghanistan not included). Under that are the Interstate Commission for Water Coordination (ICWC) and the Interstate Commission on Sustainable Development (ICSD) of Central Asia, and below that are the river basin water organizations, such as the Amu Darya and Syr Darya River Basin Water Organizations.

In **Afghanistan** the Ministry of Water and Energy is responsible for mapping, monitoring and managing surface water and groundwater resources. The Ministry of Agriculture, Irrigation and Livestock is in charge of natural resources management; the Ministry of Public Works for urban water supply; the Ministry of Mines for groundwater investigation and the Ministry of Rural Development designs deep wells and networks for parts of Kabul City outside the Master Plan.

In **Kazakhstan** the Water Resources Committee of the Ministry of Agriculture is responsible for the management and protection of water resources at the national level; the Ministry of Environment for the environment; the Republican State Enterprise 'Kazgidromet' of the Ministry of Environment monitors the quantity and quality of surface water resources, while the Committee of State Sanitary and Epidemiological Surveillance oversees the quality of drinking water.

In **Kyrgyzstan** the State Committee on Water and Land Reclamation is entrusted with water resources management, state irrigation and land reclamation. The Emergency Ministry is responsible for water protection, legislation of environmental protection and control of sewerage disposal in water bodies. The Agency on Geology and Mineral Resources deals with groundwater resources management.

In **Tajikistan** the Ministry of Land Reclamation and Water Resources is responsible for the planning and management of water resources for agriculture, water distribution and delivery to the farm inlet and water quality. The Ministry of Agriculture is in charge of the operation and maintenance of the irrigation network. The State Unitary Enterprise 'Khojagii Manziliu

Kommunali' is responsible for domestic water supply and wastewater treatment and the Committee on Nature Protection protects water resources.

In **Turkmenistan** the responsibility for water resources and maintenance of a reliable water supply for agricultural, municipal and the industrial sectors lies with the Cabinet of Ministers. The Ministry of Water Resources constructs and operates irrigation and drainage systems; the Ministry of Nature Protection is responsible for the control of water pollution and depletion. The State Corporation (SC) 'Turkmengeologiya' assesses the use of groundwater aquifers and prevents their pollution and depletion.

In **Uzbekistan** water management falls under the Ministry of Agriculture and Water Resources' (MAWR) General Authority of Water Resources. During the Soviet era water resources were administered at the regional and district level. After Uzbekistan gained independence the system of water resources management changed in 2003 with the creation of the Basin Authorities of Irrigation Systems (BAIS), to one that is based on hydrological basins and principles. The MAWR, Central Asia Scientific Research Institute of Irrigation, which was once responsible for all of Central Asia, now researches the water resources development sector. The Goskompriroda (State Committee of the Republic of Uzbekistan for Nature Protection) monitors water quality and controls industrial and municipal pollutants.

During the Soviet period, water management was the responsibility of state institutions. After the demise of the USSR, the newly emerging states began to change their agricultural policies.

In **Kazakhstan**, *sovkhoz* (state farms) and *kolkhoz* (collective farms) still predominated in 1993; land reform was extended after 1994. Most land was transferred to farmers or companies through private ownership or long-term leases.

In **Tajikistan**, during the land reform period (1996–2000) *sovkhoz* and *kolkhoz* were privatized and divided into a number of small private (*dehkan*) farms. Water user associations (WUAs) were established on the irrigated areas of the former *sovkhoz* and *kolkhoz*. WUAs are currently responsible for almost 35 percent of the irrigated area of Tajikistan, but they remain weak.

In **Turkmenistan**, all inter-farm canals are managed by authorized state agencies. Farm unions manage all on-farm canals, even when the irrigated land is rented or privately owned by individual farmers. Water resources management at on-farm level is the responsibility of the local authorities (*hakimliks, archyns*) and includes distribution of water between final water users (farmers, tenants and brigades); repair; restoration and construction works; clearing of channels; drains and collectors. The *mirap* (irrigator) position was introduced for decision-making on these matters at the level of the municipal authorities.

In **Uzbekistan**, initially the government considered individual farms to be experimental therefore allocated land was of low fertility with a poor water supply. In 1996, collective farm land was leased to farmers and WUAs were introduced. At the beginning of 2003, the government began to transform the collective farms into individual farms. Under this policy, priority was given to the development of individual farms as the major producers of agricultural commodities. Between 2004 and 2006, 55 percent of collective farms were transformed into individual farms. By 2004, individual farms occupied 17 percent of agricultural land. Land privatization accompanied the transfer of irrigation management and the introduction of farm organizations and WUAs. In 2003, Uzbekistan reformed the water management system by transferring water management from that of an administrative-territorial system to a basin approach. The main goal of this reform was to consolidate water management through the establishment of WUAs and Canal Management Organizations (CMOs), operating within single hydraulic units to ensure equal access to water for different users and to improve the efficiency of water use. On

29 December 2009, the "Water and water use" law was revised and the previously used WUA concept related to irrigation was renamed into the Water Consumers Association (WCA). The distinction between them was clarified as follows: "water user" refers to not affecting the actual amount of available water (such as fisheries and hydropower) and "water consumer" refers to reducing the actual amount of available water (such as irrigation).

In **Afghanistan**, a senior representative called *wakil* (*herat*), *mirab* (water master) or *chak bashi* (*kunduz and balkh*) leads system management. This person is usually a well-respected community member and landowner with experience and knowledge of the system as well as influence with the local government. In addition to system management, the representative has the broader responsibility of liaising with adjacent irrigation communities, particularly for customary rights on the location and operation of the *sarband*. This representative, or village committee, is usually responsible for the management, operation and maintenance of the community's canals and structures downstream of the secondary canals to farm turnouts.

Most countries in the Central Asia region have reported the importance of WUAs in the management of water and irrigation.

In **Afghanistan** the use of water is free of charge.

Kazakhstan was the first country in Central Asia to implement water fees in 1994. The price of water is different in each province, and is defined by volume, based on the added value irrigation could bring to agricultural production. Water user fees fund maintenance of hydraulic structures and water facilities. Facilities that are of importance at the national and *oblast* level are partly funded by the national budget.

In **Tajikistan**, fees have been charged since 1996 for irrigation water services. The water fee is rated 2–6 times less than required to ensure adequate operation and maintenance of the irrigation and drainage systems, especially for pump irrigation. Some of these lift irrigation systems are not economically viable under current energy costs and economic conditions. These systems, built in the Soviet period with very different economic considerations, pump in what is called a cascade system consisting of several stages of pumping, which are often used for low value crops.

In **Kyrgyzstan**, the Water Resources Department, and the basin water resources departments (BWRDs), are financed out of the state budget. The *rayon* water resources departments (RWRDs) are financed out of the state budget and water users' funds for water delivery. Agreements were concluded between the RWRDs and each water user in the rayon for water delivery services. Bills for payment are delivered monthly. Payment rates for water delivery are established by Parliament. Approximately 50 percent of the actual expenditure for operation and maintenance is covered by the state budget and 50 percent by payment for water delivery. Fees for water use is collected from all water users irrespective of the department they belong to, their citizenship, kinds and patterns of ownership, except for cases established by special legislation of Kyrgyzstan (public health services, recreation, sports, rest, etc.). However, these amounts are still largely inadequate to cover actual operation and maintenance needs.

In **Turkmenistan**, the state is responsible for all expenses related to capital investment for irrigated agriculture, such as the development of land, construction of main structures and water infrastructure. Except for the on-farm irrigation system, the costs of operating water infrastructure are met by the state budget. Water for irrigation is supplied without charge. The 'private charges' for operation and maintenance of irrigation systems is accepted practice. This comprises a deduction of 3 percent from the total of crops produced by the tenants. Water for drinking and household purposes is provided to the population free of charge. Water for industry is supplied against payment based on set tariffs. Enterprises are fined if they exceed the limits set for intake or for discharge of unprocessed industrial waste.

In **Uzbekistan**, in 1995 a land tax was introduced. The amount payable depends on irrigation and land quality, which is calculated by province based on a soil fertility parameter. A WCA is in charge of operating and maintaining the on-farm water infrastructure through irrigation service fee (ISF) collection. However, most WCAs are still not able to take full responsibility and generate sufficient investment for the infrastructure maintenance. Within the general objective of water savings, Article 30 of the Water Law emphasizes the need for water pricing, although it still leaves room for subsidies to the water sector.

In all the countries in the region financial assistance (grants and loans) has been obtained from international donors, lenders and foreign governments, such as the World Bank, United Nations Development Programme (UNDP), International Bank for Reconstruction and Development (IBRD), Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD) and FAO, for major construction projects in the agricultural and energy sectors. Austria, Denmark, Finland, France, Germany, Japan, Kuwait, Switzerland, Turkey, United Kingdom and United States of America also provide assistance and support to water issues in the region.

Environment and health

WATER QUALITY

In the Central Asia region, surface water and groundwater quality is commonly affected by agricultural, industrial and municipal wastewater.

In **Afghanistan** surface water quality is excellent in the upper basins of all rivers throughout the year and good in the lower basins in spite of the large irrigated areas. Groundwater quality is generally good, but varies from place-to-place. In the lower reaches of river valleys, groundwater is frequently saline or brackish and cannot be used for drinking or irrigation (Favre and Kamal, 2004). The country faces many environmental problems, mainly the lowering of water tables, degradation of wetlands and deforestation (some 40 percent of forests have been cut down). Excessive use of groundwater for a variety of purposes has significantly depleted aquifers throughout Afghanistan and, if the trend is not reversed, the country will face a severe shortage of drinking water. The recurrent droughts, low precipitation and poor water management have exacerbated the country's water crisis. Over the past several years, groundwater sources have reduced by about 50 percent. Limited access to surface water has prompted many farmers, mostly in the drought-stricken south and north, to increasingly use groundwater to irrigate agricultural land or dig deep wells. Most of the population uses groundwater as the prime, and often only, source of drinking water (IRIN, 2008).

In **Kazakhstan**, the quality of most water sources is unsatisfactory. Most water pollution is caused by discharge from the chemical, oil, manufacturing and metallurgical industries. Out of 44 water sources researched by the Kazakhstan Hydrometeorology Service Bureau, in 2002 only nine rivers, two lakes and two reservoirs were considered clean water sources; six rivers and one reservoir were listed as dirty or very dirty. In addition to industrial, mineral extracting and refinery enterprises there are other polluters such as urban buildings, farms, irrigated fields, waste containers and storage facilities for liquid and solid wastes and oil products (UNDP, 2003). Salinity in lakes varies from 0.12 g/litre in east Kazakhstan to 2.7 g/litre in the central region. More than 4 000 lakes inventoried are considered saline. Irrigation development during the 1980s and 1990s 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. Recently it has been estimated that about 8 000 small lakes have dried up because of the overexploitation of water resources.

In **Kyrgyzstan**, water quality in rivers is good. Rivers are fed by glacial melt, which has a low salt concentration and low pollution level. Observations carried out in all basins show a low concentration of nitrates, organic matter and nutrients. There are cases of water pollution related to incorrect storage and use of fertilizers and chemicals, industrial waste, non-observance of the sanitary code, improper conditions for sewerage systems, cattle breeding and industrial effluent. About 90 percent of all drinking water supplied by centralized systems is groundwater, which mostly meets the standards for drinking water quality. Nuclear tailing dump is a very serious problem in Kyrgyzstan, not fully solved yet and threatening the whole region.

In **Tajikistan**, water is drinkable, except for some lakes and groundwater sources. General salinity level of water in sources is 0.05–0.40 g/litre.

In **Turkmenistan**, water in the rivers and the drainage networks is of very poor quality, containing high concentrations of salts and pesticides both from the country itself and from upstream countries. This affects the Aral Sea area, where some of the main collector-drainage canals discharge. During the past decades water quality in the Amu Darya has deteriorated considerably as a result of discharge of drainage and industrial water from neighbouring countries. Average annual salinity level was 0.3 g/litre before 1962, which increased to 0.8 g/litre in 1967. In the 1990s, this stabilized within the range of 1.5–1.6 g/litre reaching 2.0 g/litre during certain periods (Berdiyev, 2006). Human pressure on surface water is high; although pollution caused by biogenic elements or organic substances has not yet reached dangerous levels, special attention must be paid to monitoring concentration (especially phenols and nitrates). About 4 km^3 of drainage water with salinity level of 6.5–8.5 g/litre is discharged annually into the Amu Darya from neighbouring Uzbekistan.

In **Uzbekistan**, salinity of irrigation water in the middle reaches of rivers is 1–1.1 g/litre with a low content of organic substances, and in the lower reaches at certain periods it is, on average, 2 g/litre and more (compared to the original 0.2–0.3 g/litre), and organic substances 29.6 mg/litre. In some rivers, discharged sewage and municipal wastewater leads to increased pollution all along the course of the river from its origin downstream to the sea. Pollution from petroleum products is 0.4 to 8.2, which is the maximum allowable concentration (MAC), by phenols up to 6 MAC, by nitrates up to 3.7 MAC, by heavy metals up to 11 MAC. The contamination rate of groundwater has also increased.

IRRIGATION-INDUCED SALINIZATION AND WATERLOGGING

Salinization normally occurs in arid areas because there is little rainwater to dissolve the salts that have accumulated in the soil. Evaporation and evapotranspiration extract water from the soil and salt concentrations tend to increase. Direct evaporation from the soil surface causes a rapid accumulation of salt in the top layers. When significant water is provided by irrigation, with no adequate provision for leaching of salts, the soils rapidly become salty and unproductive. Consecutive accumulation of salts year-after-year degrades the soils and renders them unproductive.

Assessment of salinization at the national level is difficult, and very little information on the subject could be found during the survey. Furthermore, there are no commonly agreed methods to assess the degree of irrigation-induced salinization. Figures on area salinized, as a result of irrigation, are available for five of the six countries (Table 23).

In the Aral Sea basin climatic and hydro-geological conditions make soil particularly vulnerable to salinization. Some land, especially in inter-mountain valleys, is initially salt affected because of the arid climate. The process of salt accumulation is intensified under the influence of pressure from deep saline artesian water and the following two factors: (a) additional infiltration of irrigation water into the drainage network, (b) deterioration of downstream water quality. This is the result of natural evaporation processes and the use of overly saline irrigation water as well as of naturally poor land drainage conditions.

TABLE 23
Salinization in irrigation areas

Country	Year	Area equipped for irrigation	Area salinized by irrigation	as % of area equipped for irrigation
		ha	ha	%
Afghanistan	2002	3 208 480	-	-
Kazakhstan	2010	2 065 900	404 300	20
Kyrgyzstan	2005	1 021 400	49 503	5
Tajikistan	2009	742 051	23 235	3
Turkmenistan	2002	1 990 800	1 353 744	68
Uzbekistan	1994	4 198 000	2 141 000	51

The intensity of irrigation in Central Asia requires artificial drainage to control waterlogging and salinization. Currently there are about 5.35 million ha with drainage, of which about 59.6 percent is surface, 26.2 percent subsurface and 14.2 percent vertical drainage (tube-wells). Uzbekistan has most of the artificially drained land, approximately 1 million ha. There have been several innovations in the region for drainage design to address seepage from irrigation canals and upstream irrigated land, percolation from excess irrigation water, groundwater fluxes to the root zone and the accompanying salts moving into the crop-root zone.

Deeper subsurface drainage depths are considered essential to control waterlogging and salinity. Until the 1990s, significant investment was available for drainage, however, with the demise of the USSR, and the deterioration of economic conditions in Central Asia, drainage investment declined. Drainage systems are no longer properly maintained and the areas suffering from salinization and waterlogging have increased (Dukhovny *et al.,* 2007).

In **Afghanistan**, as far as is known the presence of saline soil on irrigated areas is not caused by poor water quality but rather by over-irrigation (causing waterlogging) or lack of irrigation water (Qureshi, 2002).

In **Kazakhstan**, about 242 000 ha (11 percent) of the irrigated area was classed as saline by Central Asian standards (toxic ions exceed 0.5 percent of total soil weight), in 1993. This area is mainly concentrated in the south. In 2010, irrigated areas subject to salinity amounted to 404 300 ha.

In **Kyrgyzstan**, the area salinized by irrigation was an estimated 49 503 ha in 2005. In 2006, according to the Land Reclamation Cadastre 85 percent of the total irrigated area was in good condition, 6 percent satisfactory and 9 percent unsatisfactory, which is caused by high groundwater level (37 percent), soil salinity (52 percent) and a combination of the two (11 percent). Irrigation has caused waterlogging on 35 399 ha in 2005.

In **Tajikistan**, the two major land quality problems are the interrelated issues of salinity and waterlogging, caused by high groundwater levels. Salinization of irrigated land in lowland areas has increased because of inadequate drainage systems and inefficient irrigation systems resulting in high water losses. Irrigation has caused salinization on 23 235 ha. The waterlogged area in irrigated areas is 25 742 ha.

In **Turkmenistan**, around 90–95 percent of the irrigation land has become saline (Berdiyev, 2006). In 2001, the total area salinized by irrigation was an estimated 1 353 744 ha, including land with medium and high salinity. In 2001, direct economic loss on land with different degrees of salinization was an estimated US$142 million. Waterlogging also appears in desert pastures because of drainage water discharge. In 2002, irrigation caused waterlogging on about 756 500 ha.

In **Uzbekistan**, intensive development of new irrigated areas in 1960–1980s caused land salinization, waterlogging, land degradation and increased the discharge of highly saline drainage water into the Amu Darya through a system of collector drains. Waterlogging and salinization already affect 50 percent of irrigated areas. The total area salinized by irrigation in 1994 was 2 141 000 ha.

DRAINAGE IN IRRIGATION AREAS

Drainage facilities need to be installed as a measure to prevent irrigation-induced waterlogging and salinization in arid and semi-arid areas. Drainage, in combination with adequate irrigation scheduling, enables the leaching of excess salts from the plant-root zone. Figures on drained areas are available for five of the six countries, of which two are from the previous survey, since no new information could be obtained (Table 24). Figures are unavailable for Afghanistan. The area equipped for irrigation with drainage facilities varied from 17 and 14 percent in Kazakhstan and Kyrgyzstan respectively to 66 percent in Uzbekistan. In Central Asia, almost the entire drained area is located in the area equipped for irrigation. However, the drained area is low compared to actual needs in the region.

TABLE 24
Drainage in irrigation areas

Country	Year	Area equipped for irrigation	Area equipped for irrigation with drainage facilities	as % of area equipped for irrigation
			ha	%
Afghanistan	-	3 208 480	-	-
Kazakhstan	2010	2 065 900	343 000	17
Kyrgyzstan	2000	1 021 400	144 910	14
Tajikistan	2009	742 051	345 200	47
Turkmenistan	1998	1 990 800	1 011 897	58
Uzbekistan	1994	4 198 000	2 840 000	66

In Central Asia, drainage takes mostly place through open drains. In 2000, subsurface drainage was practised on only 26 percent of the drained area. In general, newly reclaimed areas are equipped with subsurface drainage rather than surface drains.

In **Kazakhstan**, the area equipped for irrigation with a drainage system was 433 100 ha in 1993 and was 343 000 ha in 2010. Horizontal surface drains were installed on 264 600 ha or 61 percent of the total drainage area. The area equipped with subsurface drains amounted to 15 600 ha (4 percent), with vertical drainage being carried out on about 152 900 ha (35 percent). There has been little maintenance of the drainage network since 1990. Moreover, part of the agricultural drainage system does not work properly because of poor design and construction. It is estimated that about 90 percent of the vertical drainage systems are not used because of the high cost of pumping.

In **Kyrgyzstan**, in 2000 only 144 910 ha were equipped for drainage and 3 000 ha were cultivated drained area without irrigation. In 1994 surface and subsurface drainage accounted for 56 and 44 percent respectively. Subsurface drainage was mainly developed on newly reclaimed areas in the north and southwest. With the government's limited budget, it will be difficult to effectively maintain and operate or improve or extend the existing drainage system. For this reason, problems related to salinity and drainage will likely worsen.

In **Tajikistan**, the total area equipped for irrigation with a drainage system, amounts to 345 200 ha, including 69 200 ha of subsurface drainage (20 percent). Because there is inadequate operation and maintenance, a substantial portion of the subsurface drainage is not being used.

In **Turkmenistan**, the construction of mostly open drainage systems started at the beginning of the 1950s. About 90 percent of the total length of drainage was constructed during the period 1965–1985. The intensive development of virgin land for agriculture, with little attention paid to the installation of water regulators on the irrigation canals, resulted in the irrational use of water. Further, construction of drainage structures continued to lag behind the development of virgin land and the construction of unlined irrigation canals. All these factors resulted in catastrophic soil salinity. The economic crisis at the beginning of the 1990s resulted in the shutting down of the construction of any new drainage structures. In 1998, drainage infrastructure was constructed on about 1 011 897 ha of the irrigated area. In 1995, subsurface drainage accounted for approximately 32 percent of the total drainage area, mainly on newly reclaimed areas, horizontal surface drainage for 60 percent, and vertical drainage for 8 percent.

In 2000, the trans-Turkmen collector for drainage water was initiated with the construction of a huge artificial lake in the middle of the Kara Kum desert, the Turkmen Golden Age Lake, on the site of a natural dry lake in the Karashor lowlands. The lake is to be filled with drainage water through two collectors, the Great Turkmen Collector from the south and the Dashoguz Collector from the north, with a combined length of over 1 000 km. The lake's capacity will be 150 km^3, with a surface area of 3 500 km^2 and a depth of 130 m. Starting in 2009, the collectors divert up to 10 km^3 of saline drainage water into the lake annually, which once discharged into the Amu Darya. However, as an additional consequence, it also further reduces return flows into the Amu Darya. Construction of the trans-Turkmen collector aims to improve water quality in the Amu Darya (Stanchin and Lerman, 2006).

In **Uzbekistan**, only 2.8 million ha were equipped with drainage infrastructure in 1994. Most of the drainage systems are open drains. Horizontal surface drainage is carried out on 1.7 million ha (61 percent), subsurface drainage on 0.7 million ha (25 percent) and vertical pumping drainage on 0.4 million ha (14 percent), mainly on clay soils. During the transition period, the development of drainage almost stopped and the infrastructure continued to deteriorate. However, since 2007, after the creation of a special fund to improve irrigated land, more than US$110 million annually is spent on infrastructure improvement, with the result that main and inter-farm collectors are in satisfactory condition. The intra-farm open collector-drainage network is satisfactorily maintained in Bukhara, Kashkadarya, Ferghana and Namangan regions. In other areas it is in disrepair. In addition, the "Drainage, Irrigation and Wetland Improvement Project" in South Karakalpakstan recently improved the drainage in that region.

FLOODS AND DROUGHTS

As reported by the following countries a significant area of the Central Asia region is subject to flooding.

In **Afghanistan**, floods are generally violent and can cause serious damage to agricultural land or inhabited areas. About 50 gabion river protection works and 50 flood protection masonry walls were constructed before the war, mostly in the Nangarhar and Parwan provinces, in the east. There have been several seasons of drought in Afghanistan in recent decades. Localized droughts have a periodicity of 3-5 years and droughts covering large areas recur every 9-11 years. Afghanistan began experiencing unusual droughts beginning in 1995. It remained this way until heavy snow began falling in the 2002-2003 winter season. However, since then the country began to see again more droughts.

In **Kazakhstan**, over 300 floods have been recorded over the last 10 years. Most damage is caused by floodwaters from the Ural, Tobol, Ishim, Nura, Emba, Torgai, Sarysu, Bukhtarma rivers and their numerous tributaries (UNDP, 2004). Since Kazakhstan and the Russian Federation are a major grain exporting countries, droughts cause an overall quantity of cereals available for export to decline due to a decrease in production and in some cases the introduction of exports bans. In 2008 and 2010, both factors increased world grain prices and negatively affected poor grain importing countries. During the 2012 drought Kazakhstan wheat production was less than half of the production in 2011.

In **Tajikistan**, mud torrents occur mostly in the Zeravshan river basin, on average 150 times/year and in the Vakhsh and Panj river basins, on an average of 70 times/year, mostly in April (35 percent) and in May (28 percent). There are 102 mud torrents, hazardous rivers, annual mud torrents and floods that result in great damage. Flood damage in 2005 alone amounted to US$50 million (MLRWR and UNDP, 2006). The government manages floods and mudflows, but lacks the equipment, materials and capacity to efficiently implement hazard mitigation measures. Droughts are common and recurrent natural phenomenon for Tajikistan. Since only half of its wheat is irrigated, the impact of dryness is high on the production of the rainfed crop.

The problems in **Kyrgyzstan** are similar to the ones in Tajikistan and each year the damages for flooding, landslides and mudflows into irrigation canals amount to millions of US$.

Both **Turkmenistan** and **Uzbekistan** consists largely of arid desert, so agriculture is depends more or less entirely on irrigation. Cereals and cotton are by far the largest irrigated crop areas and water shortage for irrigation is causing friction especially between cereal farmers and cotton growers, as was for example the case in 2011.

HEALTH AND WATER-RELATED DISEASES

Only three out of the six countries in the Central Asia region reported on water-related diseases for this survey, although these diseases are certainly present in other countries in the region. The major factors favouring the development and dispersion of these diseases are as follows:

- use of untreated wastewater to meet water shortage;
- lack of infrastructure, especially related to wastewater treatment and disposal;
- lack of health awareness and proper handling of polluted water;
- lack of regulations related to the protection of the environment and public health.

In **Kyrgyzstan**, 122 800 inhabitants were reported to be affected by water-related diseases in 2005.

In **Turkmenistan** in 2004, people affected by water-related diseases amounted to 12 295, of which 7 955 by intestinal infections, 22 by typhoid and 4 318 by virus hepatitis in 2004. In 1998, there was an outbreak of malaria with 137 cases. Since then, cases of malaria have fallen and Turkmenistan has made significant progress with malaria control; the disease is reported as having been eliminated.

In **Uzbekistan**, as the Aral Sea level falls by 1 m/year, more land is exposed, and chemical pesticides used for cotton production are concentrated in a crust on the newly exposed land. Winds disperse the crust as a cloud of lethal dust, causing the population to suffer health problems and agricultural productivity to be reduced as a result of land and water salinization. In these regions people suffer from high levels of anaemia, together with rising levels of tuberculosis, while children suffer from liver, kidney and respiratory diseases, micronutrient deficiencies, cancer, immunological problems and birth defects. In Karakalpakstan 40 percent of the rural population depend on small subsistence plots for their livelihoods. These plots are adversely affected by water shortages or pollution and, consequently, the rural population faces increasing hardship, malnutrition and illness. In 2001 and 2002, the situation in Karakalpakstan and Khorezm further deteriorated as a result of two consecutive years of drought that resulted in water shortages that negatively impacted domestic and personal hygiene. The population was exposed to the higher risk of water-related diseases such as typhoid, diarrhoea and worm infections. Although the government has made progress, only 54 percent of the urban and 3 percent of the rural population have access to adequate sewage systems, those without rely on basic and unhygienic pit latrines (UNICEF, 2003).

CLIMATE CHANGE

Global climate change poses serious threats to the region's environment, ecological and socio-economic systems. In this region, agricultural production has already decreased in some commodity groups and quantities and qualities of water resources are at risk of being severely affected by climate change. On the other hand, Central Asia significantly contributes to global warming by generating large volumes of greenhouse gas (GHG) emissions. Kazakhstan is the thirtieth largest emitter of carbon dioxide worldwide, and Uzbekistan is the most carbon intensive economy globally, followed by Kazakhstan on the second place and Turkmenistan on the fourths place (EBRD, 2011). There is increasing concern about climate change, especially because climate change affects the Central Asia region's water and energy security. This may lead to political tension between the countries unless they collaborate in carful management of their resources.

Most of the flow of the Amu Darya and Syr Darya comes from rainfall and snow melt in the mountains. It is estimated, that reduced contribution of glacier melt could reduce flows in the Amu Darya basin by 5-15 percent by 2085 and in the driest years this could be as much as 35 percent of current discharge. Although there is a high degree of statistical uncertainty this is clearly a very real threat that cannot be ignored in any future plans for the basin's water resources. Thus, in the worst case in 80 years time, it is possible that in extreme years it may only be possible to meet half the current demand for water. Experts in the subregion suggest that such risks need to be integrated into a comprehensive adaptation/risk management strategy for the basin as a whole (FAO, 2010).

As a response to climate change, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan have already established an environmental legal and regulatory framework (specifically air protection laws) to meet commitments under the United Nations Framework Convention on Climate Change (UNFCCC). As non-Annex countries, the five countries have committed to periodically carry out an inventory of GHG emissions and to conduct vulnerability and mitigation studies.

Any reduced GHGs in Central Asia would contribute to easing global warming, especially relating to the collaborative international mitigation of climate change. Moreover, the Kyoto Protocol has opened up new opportunities to engage Central Asia countries in GHG mitigation projects.

To alleviate the situation in the years to come, Central Asia countries, with the assistance of the international community, will undertake two types of activities. First, national legislation will be amended to take into account climate change in their socio-economic and environmental policies. Secondly, this legislation creates possibilities for designing and implementing national climate change policies and practical actions in compliance with the Kyoto Protocol. The region will carry out GHG emission inventories and participate in the Clean Development Mechanism (CDM) efforts (Perelet, 2007).

It is foreseen that climate change will alter the hydrological cycle, and is unlikely to relieve water scarcity. In this arid region, water is an important limiting factor for ecosystems, food and fibre production, human settlements and human health. Climate change and human activities may further influence the levels of the Caspian and Aral Seas, which will affect associated ecosystems, agriculture, and human health in the surrounding areas. Win-win opportunities exist that offer the potential for reducing pressure on resources and improving human welfare in the region, and may reduce vulnerability to the adverse impacts of climate change (Perelet, 2007).

It is not the purpose of this survey to deal in detail with climate change issues. Much other research is being done specifically on this issue, which has resulted in many reports, such as FAO's Water Report on "Climate change, water and food security" (FAO, 2011).

THE ARAL SEA CRISIS

The environmental crisis of the Aral Sea basin is a major disaster that has affected all six Central Asia countries located in the Aral Sea basin. The intensive extraction of water for irrigation from the Amu Darya and Syr Darya over the last 40 years has caused the level of the Aral Sea to fall by 17–19 m and reduced the volume of its water resources by 75 percent. As a result, the mineral (saline) concentration of the seawater has increased from 10 to 60 percent (UNDP, 2004). By the end of the 1980s, the Aral Sea no longer reached its former borders. As the waters receded, the Aral Sea split into the Northern Aral Sea within Kazakhstan, and the larger South Aral Sea shared by Kazakhstan and Uzbekistan.

The desiccation of the Aral Sea has resulted in serious economic, social, and environmental degradation. Fresh fish production has almost disappeared, salinity and pollution levels have risen dramatically, dust and salt storms have occurred often, and there have been measurable changes to the local climate. Drinking water supplies have become polluted and human health problems have increased sharply. Tens of thousands of jobs have been lost in the fishing, agricultural and service sectors (World Bank 2008). In 2002, the heads of the Central Asian states developed a 'Programme for concrete action to improve the environmental and economic environment of the Aral Sea basin for 2003–2010' (UNDP, 2004). For more information, see the 'Aral Sea basin' in Section III.

Prospects for agricultural water management

Countries in the Central Asia region consider water and irrigation management to be a key factor in the use and conservation of their water resources. Future agricultural water management in this region, where information is available, will consider: Rehabilitation and modernization of the irrigation and drainage infrastructure; increase of water use efficiency and productivity; introduction of crops requiring less water and change of cropping patterns; recovery of the expenses for water supply services; rehabilitation of dams and construction of new dams only in selected strategic locations and properly negotiated among the riparian countries; reuse of water; desalination; integrated water resources management; strengthening of river basin organizations and of water user organizations; strengthening of extension services; flood and drought contingency plans; sustainable environmental management; water saving measures in all sectors and appropriate measures for developing new additional land and water resources.

Most countries recognize the importance of developing or strengthening WUAs, to be coupled with the improvement of the service provided by the irrigation scheme managers. This is linked to the need expressed in several countries to improve the overall performance and water use efficiency of irrigation schemes.

Water scarcity and the interdependency between water use sectors are pushing countries to develop integrated water resources management programmes. Water quality is also a concern in several countries, especially where industrial development is important. In Afghanistan, a sustainable environmental management plan is foreseen.

Changes in rainfall pattern resulting from climate change will significantly disrupt the farmers' cropping system particularly in rainfed areas. It will become more difficult and risky for farmers to rely on rainfall for their planting calendar. Extreme climate events will likely impinge the hydrological system in most river basins meaning that water will become either 'too much' or 'too little'.

Changes in recharge and discharge patterns may alter the distribution of surface water and groundwater resources. First an increase in flows is expected due to more intensive snow melting. Then stream flow will be significantly reduced and groundwater levels decline. Attention should be placed on the demand and supply of water management in order to address water scarcity. This could be achieved by rehabilitating water sources, water conservation, augmenting water supply, including utilization of non-conventional sources.

Flooding and excessive runoff could be mitigated by improved drainage facilities. The design of irrigation systems could include a review of design methods to address the effects of climate change and properly designed drainage facilities to protect standing crops. The construction of rainwater harvesting structures (e.g. small water impounding project) to collect and store rainwater in the uplands could contribute to flood mitigations downstream and water availability during the dry season.

The efficiency and productivity of water use could be improved by securing land tenure which will provide an incentive for private investment for adopting efficient irrigation techniques and use modern methods for irrigation scheduling. Increasing the net benefit per unit of land and water will be possible if crops cultivated require less water.

In **Afghanistan**, there is great potential for developing both shallow and deep groundwater systems for irrigation and other uses. Precaution must be taken to avoid adversely affecting users of existing systems. Afghanistan does not use the water from the Amu Darya as it should. Proper use of water from the Amu Darya would bring thousands of hectares under irrigation in northern Afghanistan. It is estimated that with rehabilitation of systems and improved management, water use could increase to 35 km^3 per year (ICARDA, 2002; Rout, 2008). The country is considering improving system efficiency and productivity by improving infrastructure, increasing the equity of water allocations, developing water storage systems and protecting against water losses.

In **Kazakhstan**, structural reforms on irrigated land are needed to maintain food security, to ensure a high level of the population's self-sufficiency in agricultural production. This includes increasing economic performance, meeting environmental requirements and introducing water-saving technologies. Restructuring of irrigated cultivated areas comprises reducing cotton and cereals and increasing the share of oilseeds and legumes, including perennial grasses. In parallel an increase in productivity in rainfed areas, where most of the cereals are grown, is important. Further socio-economic development and the solving of various ecological problems will be determined by a water policy that focuses on the development and control of water management (UNDP, 2004).

In **Kyrgyzstan**, extending irrigation to about 1 200 000 ha could be accomplished on dry lands, pasture and hayfields. Assuming a 1 percent annual growth rate, the population will be 5.6 million in 2015 and 6.2 million in 2025. Feeding a larger population can be achieved by increasing the arable land area, by intensifying crop production and increasing crop yields, by importing additional food needed, or by a combination of all. Basic measures required to increase food production are to increase land and crop productivity; train farmers; introduce advanced agricultural techniques (soil tillage, crop selection, crop rotation and fertilizers) and land reclamation techniques (irrigation, drainage, leaching), and promote appropriate measures for the development of additional land and water resources.

In **Tajikistan**, the government, in participation with international organizations and experts, aims to reform the system of water resources management and transfer agricultural production to a real market economy. This will change cropping patterns in irrigated areas, especially on pump-irrigated land. As a result, farmers will be motivated to adopt water-saving irrigation technologies for economic reasons and, therefore, contribute to environmental preservation. District-level, state water management units will be included in BWMO, which will transfer all water management responsibilities in stages to WUAs for secondary and tertiary canals. In establishment of the new tandem management structure BWMO+WUA will be fundamental to the introduction of IWRM.

Turkmenistan mostly uses surface water resources. The government states the irrigated area can be doubled and water supply ensured by increasing irrigation efficiency from 0.51 to 0.75. This can be done by canal lining and modernization and rehabilitation of irrigation systems; improving land levelling; optimizing furrow length and introducing crops that require less water; introducing IWRM principles and automated irrigation management systems; introducing modern irrigation technologies including localized and sprinkler irrigation on 260 000 ha; using about 1 km^3 of drainage water with salinity level up to 3 g/litres for irrigation; constructing the trans-Turkmen collector for drainage water to improve removal of salts from irrigated land; improving the quality of groundwater to meet irrigation requirements; and increasing treated wastewater use for cultivation of agricultural crops (cotton).

In **Uzbekistan** the population is growing by 0.5 million people/year, meaning there is need for more products and expansion of irrigated land, requiring even more water. In 10–15 years the population may reach 32–35 million, water requirements will far exceed those available in the country (Akhmadov, 2008). Increasing the efficiency of irrigation water use is essential for supporting rural livelihoods, producing sufficient food for the growing population, and producing commodity crops, that are important to the national economy and continuing social and economic development (USAID, 2003). Even if policy changes reduce cotton exports, it is far more likely that any water 'saved' from reduced cotton production will instead be used to produce other crops, as has been the pattern to date (Abdullaev *et al.,* 2009).

According to available information, the current use of non-conventional sources of water (desalinated water and/or direct use of treated wastewater and agricultural drainage water) concerns four out of the six countries in the region, representing only 6 percent of the region's total withdrawals. In general non-conventional sources of water are not included as a high priority in water management plans and policies. These sources are, however, mentioned by some countries such as Kyrgyzstan and Turkmenistan.

Countries sharing transboundary river basins need to prepare joint water management plans for each basin. This will ensure clear communication and avoid approaches that may cause conflicts of interest, unilateral development, and inefficient water management practices that could result in international crisis in these countries. Since the change from a centrally managed system in 1991 and the emergence of independent states, countries across the region have viewed water from a national perspective rather than from a river basin point of view (FAO, 2010). Having created regional institutions to improve coordination, such as IFAS and ICWC, Central Asian countries should grasp the opportunity and use them in their quest for mutually beneficial agreements for all countries in the basin.

TABLE 25
Central Asia compared to the world

Variable	Unit	Central Asia	World	Central Asia as % of the world
Total area 2011	1 000 ha	465 513	13 459 150	3.5
Cultivated area	1 000 ha	40 177	1 503 388	2.7
- in % of total area	%	9	11	-
- per inhabitant	ha	0.43	0.22	-
- per economic active person engaged in agriculture	ha	3.32	1.15	-
Total population 2011	inhabitants	93 800 000	6 974 041 000	1.3
Population growth 2010-2011	%/year	1.8	1.1	-
Population density	inhabitants/km²	20	52	-
Rural population as % of total population	%	65	49	-
Economically active population engaged in agriculture	%	30	39	-
Precipitation	km³/year	1 270	109 224	1.2
	mm/year	273	812	-
Internal renewable water resources	km³/ year	242	42 519	0.6
- per inhabitant	m³/year	2 576	6 097	-
Actual total renewable water resources	km³/ year	292	53 928	0.5
Total water withdrawal by sector	km³/year	145	3 923	3.7
- agricultural	km³/year	129	2 723	4.7
- in % of total water withdrawal	%	89	69	-
- municipal	km³/year	7	469	1.5
- in % of total water withdrawal	%	5	12	-
- industrial	km³/year	10	732	1.3
- in % of total water withdrawal	%	7	19	-
Total freshwater withdrawal	km³/year	136	3 750	3.6
- in % of internal renewable water resources	%	56	9	-
- in % of total actual renewable water resources	%	47	7	-
Irrigation	1 000 ha	13 227	303 462	4.4
- in % of cultivated area	%	33	20	-

Main sources of information

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SECTION III
Country and river basin profiles

EXPLANATORY NOTES

In this section country profiles for Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan and the river basin profile for the Aral Sea river basin have been designated as an extra to the publication with their exclusive assigned numbers to figures and tables, and including a detailed map for each country and for the river basin.

The main reason for this is that these profiles have also been included on the AQUASTAT country web page (http://www.fao.org/nr/water/aquastat/countries_regions/index.stm), where each country and river basin can be downloaded as a stand-alone profile in PDF format.

A hyphen (-) in the country and river basin tables indicates that no information is available.

Afghanistan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Afghanistan is a landlocked country in Central Asia with a total area of about 652 000 km^2 (Table 1). It is bordered by Turkmenistan, Uzbekistan and Tajikistan to the north, China to the northeast, Pakistan to the east and south and the Islamic Republic of Iran to the west. It is characterized by its rugged terrain and an average elevation of 1 100 m above sea level, ranging from 150 to 8 000 m. One-quarter of the country's land lies at more than 2 500 m above sea level.

About three-quarters of the territory is comprised of mountains and hills, while lowlands include river valleys in the north and desert regions in the south and southeast. The Hindu Kush range, the westernmost extension of the Himalaya-Pamir mountain range, divides the country from west to east, while the Suleiman and Karakoram mountains flank the southern border with Pakistan. Major river valleys radiate from these mountains to the north, west and south, creating fertile valleys along which most agricultural and irrigation development occurs (Rout, 2008).

Administratively, the country is divided into 34 provinces (*welayat*): Badakhshan, Badghis, Baghlan, Balkh, Bamyan, Daykundi, Farah, Faryab, Ghazni, Ghor, Helmand, Herat, Jawzjan, Kabul, Kandahar, Kapisa, Khost, Kunar, Kunduz, Laghman, Logar, Nangarhar, Nimroz, Nuristan, Paktika, Paktya, Panjshir, Parwan, Samangan, Sari Pul, Takhar, Uruzgan, Wardak and Zabul.

In 2009, cultivated area was an estimated 7.91 million ha, of which 7.79 million were under temporary crops and 0.12 million ha under permanent. The major cultivated area is located in the north and west of the country.

Climate

Afghanistan is characterized by a dry continental climate, though the mountains cause many local variations. Temperatures vary from minus 10 °C in winter to 34 °C in summer. Annual distribution of rainfall is that of an essentially arid country, more than 50 percent of the territory receives less than 300 mm of rain. The eastern border regions are an exception, as they lie at the limit of monsoon influence. About 50 percent of precipitation occurs in winter (January to March), much of which falls as snow in the central mountainous regions. A further 30 percent falls in spring (April to June). Runoff from snowmelt in the spring and summer months, when day temperatures are high, is the lifeblood of Afghan agriculture.

Population

In 2011, total population was an estimated 32.3 million inhabitants, of which 77 percent rural (80 percent in 1999). The population density is about 50 inhabitants/km^2. During the period 2001–2011 annual population growth rate was an estimated 3.2 percent.


The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
KYRGYZSTAN
CHINA
UZBEKISTAN
TAJIKISTAN
TURKMENISTAN
ISLAMIC REPUBLIC OF IRAN
PAKISTAN
INDIA
Jammu and Kashmir
Arabian Sea
Kara Kum Canal
Amu Darya
Vakhsh
Bartang
Pamir
Wakhan
Murghab
Hari Rod
Herat
Qal'ah-ye Now
Chaghcharan
Salma
Farah Rud
Farah
Harut Rud
Khash Rud
Lashkar Gah
Helmand-Arghandab Scheme
Helmand
Zaranj
Hamoun (Intermittent Lake)
Sistan Marsh
Kandahar
Dahla
Arghandab
Qalat
Kajaki
Abe-Istada Lake
Indus
Kabul
Band-e Amir
Maimanah
Shiberghan
Mazar-e Sarif
Sar-e Pul
Kunduz
Taloqan
Faizabad
Aibak
Kunar
Logar
HINDU KUSH
HERAT
FARAH
NIMROZ
HELMAND
KANDAHAR
ZABUL
PAKTIKA
GHAZNI
URUZGAN
DAYKUNDI
GHOR
BADGHIS
FARYAB
BALKH
SAMANGAN
BAGHLAN
BAMYAN
PARWAN
WARDAK
LOGAR
KUNDUZ
TAKHAR
BADAKHSHAN
NURISTAN
SAMANGAN
BAGHLAN
TAKHAR
BADAKHSHAN
NURISTAN
Mahmud-e Raqi
PANJSHIR
KAPISA
LAGHMAN
KUNAR
BAMYAN
Bamyan
PARWAN
Maidan Shahr
Kabul
Kabul Scheme
Mehtar Lam
Asadabad
Jalalabad
NANGARHAR
WARDAK
Pul-e-Alam
LOGAR
DAYKUNDI
PAKTYA
Gardez
Ghanzi
KHOST
Khost
GHAZNI
Sharan
PAKTIKA
ZABUL
1 Darunta
2 Naghlu
3 Qargha
4 Sardeh
5 Surobi
6 Shah wa Arus
7 Chak E Wardak
8 Band-e Surkhab
9 Band-e Amir
Indian Ocean
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
Zone of Irrigation Development
Irrigation Scheme
Marsh
Salt Pan
River
Intermittent River
Canal
Dam
Lake
Intermittent Lake
0 50 100 200 300 Km
Albers Equal Area Projection, WGS 1984
AFGHANISTAN
FAO - AQUASTAT, 2012
Disclaimer
The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	65 223 000	ha
Cultivated area (arable land and area under permanent crops)	2009	7 910 000	ha
• as % of the total area of the country	2009	12	%
• arable land (annual crops + temp fallow + temp meadows)	2009	7 793 000	ha
• area under permanent crops	2009	117 000	ha
Population			
Total population	2011	32 358 000	inhabitants
• of which rural	2011	77	%
Population density	2011	50	inhabitants/km^2
Economically active population	2011	10 474 000	inhabitants
• as % of total population	2011	32	%
• female	2011	24	%
• male	2011	76	%
Population economically active in agriculture	2011	6 217 000	inhabitants
• as % of total economically active population	2011	59	%
• female	2011	32	%
• male	2011	68	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	17 243	million US$/yr
• value added in agriculture (% of GDP)	2010	30	%
• GDP per capita	2010	549	US$/yr
Human Development Index (highest = 1)	2011	0.398	
Access to improved drinking water sources			
Total population	2010	50	%
Urban population	2010	78	%
Rural population	2010	42	%

In 2010, half the population had access to improved water sources (78 and 42 percent in urban and rural areas respectively). Sanitation coverage accounted for 37 percent (60 and 30 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, Afghanistan's gross domestic product (GDP) was US$17 243 million of which the agricultural sector accounted for 30 percent (Table 1).

In 2011, total economically active population was 10.5 million, or 32 percent of total population. Economically active agricultural population is an estimated 6.2 million, or 59 percent of total economically active population, of which 32 percent are female.

Water is the lifeblood of the people of Afghanistan, not just for living but also for the economy, which has traditionally been dominated by agriculture. Decades of war have destroyed much of Afghanistan's irrigation and other water supply systems, which are vital for the agricultural economy. In recent years the situation has been complicated by the drought. As an arid and semi-arid country, irrigation is essential for food production and there can be no food security without water security. The major staple crop is wheat, of which 80 percent is sown as a winter crop.

WATER RESOURCES AND USE

Water resources

Although Afghanistan is located in a semi-arid environment, it is still rich in water resources mainly because of the high mountain ranges such as Hindu Kush and Baba, which are covered with snow. Over 80 percent of the country's water resources originate in the Hindu Kush mountain ranges at altitudes of over 2 000 m. The mountains function as natural water storage, with snow during the winter and snowmelt in the summer that supports perennial flow in all the major rivers (ICARDA, 2002).

The country has five major river basins (Table 2):

1. *Kabul river basin:* The Kabul river originates in the central region of the Hindu Kush, about 100 km west of Kabul, and has a drainage area of 54 000 km^2 in Afghanistan. It flows eastward through Kabul and, after entering Pakistan, joins the Indus river east of Peshawar. Its main tributaries include the Logar, Panjsher (with its own major tributary the Ghorband), Laghman-Alingar and Kunar rivers. Most of these rivers are perennial with peak flows during the spring months as their drainage area encompasses the snow-covered central and northeastern parts of the Hindu Kush. The Kabul river is the only river in Afghanistan that is tributary to a river system, the Indus river, which reaches the Indian Ocean. Other minor Indus tributaries, with a combined drainage area of 18 600 km^2, drain southeastern Afghanistan and all flow eastwards into Pakistan and eventually join the Indus river. The Kabul river, and other tributaries of the Indus together drain 11 percent of Afghanistan.
2. *Helmand river basin and western flowing rivers:* The 1 300 km long Helmand river rises out of the central Hindu Kush mountains, close to the headwaters of the Kabul river. The river flows in a southwesterly direction, then westwards to its terminus in the Sistan marsh or depression along the border with the Islamic Republic of Iran. The Helmand river flow is mostly supplied by the upper catchment areas that receive snowfall in the winter months. The river and its tributaries, such as the Arghandab and Ghazni rivers, drain about 29 percent of Afghanistan's area or about 190 000 km^2. The Adraskan or Harut Rud, the Farah Rud, and the Khask Rud rivers also drain into the Sistan marsh. These rivers drain the southwestern part of Afghanistan, which is 80 000 km^2 or 12 percent of Afghanistan's area.
3. *Hari Rod and Murghab river basins:* The Hari Rod river, which has a drainage area of about 40 000 km^2, or 6 percent of the area of Afghanistan, flows west from its source 250 km west of Kabul through the city of Herat and into the Islamic Republic of Iran. At the Iranian border, the river turns northwards and eventually empties into the Tejen Oasis in Turkmenistan. Because of the narrow and elongated configuration of this river basin, the Hari Rod does not have significant tributaries. Another river, the Murghab river, with a drainage area of 40 000 km^2, or 6 percent of the area of Afghanistan, also dies out in Turkmenistan.
4. *Northern flowing rivers:* These rivers originate on the northern slopes of the Hindu Kush and flow northwards towards the Amu Darya river. Most of these rivers die out on the Turkistan plains before reaching the Amu Darya. From west to east, the main rivers include the Shirin Tagab, the Sarepul, the Balkh and the Khulm rivers. These river basins cover 12 percent of Afghanistan, or about 75 000 km^2.
5. *Amu Darya river basin:* The Amu Darya river, also called the Oxus in Afghanistan, originates in the Afghanistan part of the Pamir river. Formerly called the Abi-Panja, it forms over 1 100 km of Afghanistan's northern border with Tajikistan and Turkmenistan. Two main tributaries drain Afghanistan, the Kunduz river (and its tributary the Khanabad) and the Kokcha river, both originate in northeastern Hindu Kush. The rivers are perennial with substantial flows from snowmelt in the spring

months. These two river basins, and the upper drainage area of the Amu Darya, cover 14 percent of Afghanistan or about 91 000 km^2.

Together the Kabul and Amu Darya river basins cover one-quarter of the country and contribute almost two-thirds of surface water resources generated within its borders; or the internal renewable surface water resources (IRSWR) (Table 2).

Total IRSWR is an estimated 37.5 km^3/year and total internal renewable groundwater resources (IRGWR) an estimated 10.65 km^3/year. Afghanistan being an arid country, the overlap is thought to be only 1 km^3/year, or less than 10 percent of groundwater resources. This brings total internal renewable water resources (IRWR) to 47.15 km^3/year.

The Amu Darya (Panj) river is the border river between Afghanistan and Tajikistan, then between Afghanistan and Uzbekistan and finally between Afghanistan and Turkmenistan before entering Turkmenistan. It never enters Afghanistan. The total flow of the river, where it flows from Tajikistan to the border, and where the border river is called the Panj river, is an estimated 33.4 km^3/year. According to an agreement in 1946 with the Former Soviet Union, Afghanistan was entitled to use up to 9 km^3 of water from the Panj river. The contribution of Afghanistan to the Amu Darya is 6 km^3/year from the Kunduz tributary and 5.7 km^3/year from the Kokcha tributary. The incoming flow of the Kunar river, from Pakistan to Afghanistan, is an estimated 10 km^3/year.

The Kunar river joins the Kabul river at Jalalabad, about 180 km downstream of the border. The outflow of the Kabul river to Pakistan, which is 80 km further downstream, and of several other tributaries of the Indus that originate in Afghanistan is an estimated 21.5 km^3/year. They all join the Indus river in Pakistan. The outflow of the Helmand river to the Islamic Republic of Iran is an estimated 6.7 km^3/year. Other rivers originate in Afghanistan and cross its border, but most of these are ephemeral and, moreover, evaporate in depressions at or just over the border and are therefore not counted as outflow.

The outflow of the Hari-Rod river, which becomes the border between Afghanistan and the Islamic Republic of Iran is 1.07 km^3/year. Based on the agreement between the Islamic Republic

TABLE 2

Renewable water resources by river basin (Adapted from: Favre and Kamal, 2004; Rout, 2008; Uhl and Tahiri, 2003)

River basin	Area (km^2)	Part of total area %	IRSWR [a] (km^3/year)	TARSWR [b] (km^3/year)	Groundwater recharge (km^3/year)
Kabul (Indus)	72 600	11	11.5 [c]	21.5 [c]	1.92
Helmand and Western	270 000	41	9.3 [d]	8.48 [d]	2.98 [e]
Hari Rod-Murghab	80 000	12	3.1	3.1	0.64 [f]
Northern	75 000	12	1.9	1.9	2.14 [f]
Amu Darya (Panj)	91 000	14	11.7 [g]	20.7 [g]	2.97
Other	63 400	10			
Total	**652 000**	**100**	**37.5**	**55.68**	**10.65**

a IRSWR = Internal Renewable Surface Water Resources
b TARSWR = Total Actual Renewable Surface Water Resources
c Flow of Kunar, entering from Pakistan into Afghanistan, is 10 km^3
d 0.82 km^3/year is to be reserved for the Islamic Republic of Iran from the Helmand river according to an agreement from 1972
e Groundwater recharge: Helmand 2.48 km^3 and Western 0.5 km^3
f Groundwater recharge: the figure for Northern (2.14 km^3) includes Murghab, while the figure of Hari Rod-Murghab (0.64 km^3) excludes Murghab (Source: Uhl and Tahiri, 2003).
g The flow of border river Panj where the Bartang enters is 33.4 km^3. According to a treaty in 1946 with the Soviet Union 9 km^3/year can be used by Afghanistan

of Iran and Turkmenistan regarding this flow, it is considered to enter the Islamic Republic of Iran. The outflow of the Murghab river to Turkmenistan is 1.25 km^3/year. This brings the total natural inflow to 10 km^3/year and the total natural outflow to 42.22 km^3/year.

Afghanistan's water resources are still largely underused. It is not fully understood, however, how much of this 'potential' resource can be accessed without damage to livelihoods and ecosystem. For example, it is not fully known how much of the groundwater can be extracted without leading to an excessive decline in groundwater levels, which may result in a stage of 'water mining' (Qureshi, 2002). Problems may arise in the Kabul and Eastern Helmand river basins.

There are few environmentally important natural wetlands and lakes in Afghanistan (Favre and Kamal, 2004).

In 1992 the installed capacity of the major hydroelectric plants was 281 MW, about 70 percent of total installed capacity. Considerable potential exists for hydropower generation, both by large dams and micro-hydropower stations. Total large dam capacity is an estimated 3.658 km^3. Information exists about the following dams:

- The Kajaki dam was constructed in the 1950s by an American construction company as part of the Helmand Arghandab Valley Authority Project. The project was an ambitious undertaking by the governments of Afghanistan and the United States and was designed to store water for downstream irrigation. In the 1970s, the United States Agency for International Development (USAID) funded hydropower plant construction at the dam, which included two 16.5 MW generators. Reservoir capacity was 1.2 km^3. Years of neglect, however, have taken their toll on the dam and its ability to perform as designed. Work is ongoing to improve power generation and the dam's irrigation component.
- The Darunta dam is an hydroelectric dam on the Kabul river, approximately 7 km west of Jalalabad, the capital of Nangarhar province. Companies from the Former Soviet Union constructed the dam in the early 1960s. It contains three vertical Kaplan units with a rated output of 3.85 MW each. Originally, the dam supplied 40 to 45 MW of electrical power but silting and damage to the system during the Afghan civil war reduced its output to 11.5 MW. The plant is currently in poor condition and requires major rehabilitation, including possible replacement of all three turbines. USAID funded rehabilitation of the Darunta hydroelectric plant, completion was foreseen in January 2012.
- The Dahla dam is the largest dam in Kandahar province, and the second largest in Afghanistan. First built between 1950 and 1952, years of disrepair and war left it functioning at reduced capacity. One of Canada's projects in Afghanistan was to repair the dam and its irrigation system (2008–2011), with a budget of US$50 million. As a result of this project, 80 percent of Kandaharis living along the Arghandab irrigation system have access to a secure water supply to stimulate agricultural production. It was anticipated that at project end irrigated land in the Arghandab river basin would double. For centuries, the Arghandab valley, where the dam is located, has been known as the breadbasket of Afghanistan. The region could become the most productive agricultural area in the country, the greatest scope being for the creation of food surpluses for processing and export (Government of Canada, 2011).
- The Naghlu dam on the Kabul river has a design capacity of 100 MW. It is the largest power plant in Afghanistan and generates most of Kabul's electricity. It is currently being rehabilitated and only three of the four generators are operational. Its reservoir has a storage capacity of 0.550 km^3. Commissioned in 1968, the power station fell into disrepair, by the 2001 invasion of Afghanistan, only two generators were operational. In August 2006, Afghanistan's Ministry of Energy and a Russian company rehabilitated the two inoperable generators and replaced the transformers. The first of the two became operational in September 2010 and the transformers were replaced in early

2012. The World Bank is funding rehabilitation. The second unit was to be operational by the end of 2012.

- Several other dams, such as the Surubi dam, a hydropower dam, on the Kabul river in Kabul province; the Sardeh dam on the Gardeyz river in Ghazni province with a total capacity of 0.259 km^3; the Band-e Amir dam on the Balkh river in Bamyan province; the Chak E Wardak dam on the Logar river in Wardak province; the Qargha dam in Kabul province.
- The Salma dam (an hydroelectric dam) is under construction. Originally constructed in 1976, on the Hari Rod river the dam was damaged early in the civil war. India committed to funding the completion of the Salma dam in 2006. Once completed, the hydroelectric plant could produce 42 MW, in addition to providing irrigation on 75 000 ha (stabilizing the existing irrigation on 35 000 ha and development of irrigation facilities on an additional 40 000 ha). Further, the Shah wa Arus dam is under construction on the Sharkardara river in Kabul province, estimated opening in 2016.

Another 11 hydropower projects are planned, total cost US$6 405 million, with an output of 2 196 MW and reservoir capacity of 4.4 km^3 (Khurshedi, 2011) (Table 3).

International water issues

All major rivers in Afghanistan originate in the central highlands region or the northeastern mountains. The only notable exception is the Kunar river, its source is in the Karakoram mountains across the border in Pakistan, and the Amu Darya river, which originates in Tajikistan and is only a border river for Afghanistan. Many rivers are shared with Afghanistan's neighbouring countries therefore use of water from rivers with their source in Afghanistan takes on a regional dimension. Most Afghan rivers drain into inland lakes or dry up in sandy deserts or irrigation canals. The only exception is the Kabul river itself, and other rivers in the Kabul river basin, which flow to Pakistan where they join the Indus river before flowing into the Indian Ocean.

In 1921, Afghanistan and the United Kingdom signed a treaty to establish relationships with neighbouring countries. The United Kingdom agreed to permit Afghanistan to draw water from a pipe for use by residents of Tor Kham. Afghanistan agreed to permit British officers and tribespeople on the British (now Pakistan) side of the border to use the Kabul river for navigation and to maintain existing irrigation rights (Favre and Kamal, 2004).

In 1950, Afghanistan and Iran created the Helmand River Delta Commission, which had the task of measuring and dividing river flows between the two countries. In 1972, a document was

TABLE 3
Planned hydropower projects in Kabul river basin (Source: Khurshedi, 2011)

Sub-basin	Name of project	Cost (million US$)	Output (MW)	Reservoir capacity (km^3)
Punjshir	Totumdara	332	200	0.4
	Barak	1 174	100	0.5
	Punjshir	1 078	100	1.3
	Baghdara	607	210	0.4
Logur Upper Kabul	Haijana	72	72	0.2
	Kajab	207	15	0.4
	Tangi Wadag	356	56	0.4
	Gat	51	86	0.5
Lower Kabul	Laghman	1 434	1 251	0.3
	Konar (A)	1 094	95	
	Kama		11	
Total		**6 405**	**2 196**	**4.4**

signed between Afghanistan and Iran for the allocation of the discharge of 26 m^3/s of Helmand river water to Iran year round, which is equal to about 0.82 km^3/year.

International agreements on the use and quality of Amu Darya transboundary water between Afghanistan and the former Soviet Union were signed during the two different eras. The first being the Stalin era (mid-1920s ~1953) during which Afghanistan and the former Soviet Union signed the border agreement in 1946. Afghanistan gave Kuczka region back to the Former Soviet Union. This circumstance entailed closer relationship between both nations. An international water agreement was reached in 1946, under which entitled Afghanistan to use up to 9 km^3 of water from the Panj river. The second Soviet era was the Khruchchyov-Daoud era (1953~1963).

The Former Soviet Union steadily promoted economic assistance and military aid. In 1954, the Soviet Union offered grants of US$240 million to Afghanistan and built 100 km of pipeline from Termez, Uzbekistan. In 1955, the Soviet Union announced further assistance, such as agricultural development, hydroelectric generation and construction of irrigation infrastructure. In 1956, Afghanistan signed a contract accepting Russian supervisors for the construction of water facilities. At the beginning of 1958, Afghanistan and the former Soviet Union reconfirmed and signed the border agreement. The second international agreement on the use and quality of Amu Darya transboundary water was signed in 1958.

These agreements founded an international commission to cope with the uses and quality of transboundary water resources. After the second era, however, the relationship between the two nations deteriorated. The Soviet invasion disrupted Afghanistan from 1979 to 1989. After withdrawal in 1989, the Soviet Union collapsed in 1991. Formal frameworks for international coordination in the Amu Darya river basin between Afghanistan and the new (former Soviet Union) countries in Central Asia no longer existed after the second era (Fuchinoue, Tsukatani and Toderich, 2002; Favre and Kamal, 2004).

The environmental problems of the Aral Sea basin are among the worst in the world. Water diversions, farming methods and industrial waste resulted in the Sea disappearing, salinization and organic and inorganic pollution. The problems of the Aral Sea basin, which previously had been an internal issue for the Soviet Union, became internationalized after its demise in 1991. In 1992, five major riparian (former Soviet Union) countries – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan – signed an agreement to coordinate policies concerning their transboundary waters and established the Interstate Commission for Water Management Coordination to manage, monitor and facilitate the agreement (Favre and Kamal, 2004). Two international freshwater agreements were signed by the Central Asian Republics covering the Amu Darya river.

The first agreement was the 'Agreement on joint activities in addressing the Aral Sea crises and the zone around the Sea, improving the environment, and enduring the social and economic development of the Aral Sea region', signed in 1993. The second agreement was the 'Resolution of the Heads of States of Central Asia on work of the Economic Commission of the Interstate Council for the Aral Sea (ICAS) on implementation of an Action Plan on improvement of the ecological situation in the Aral Sea Basin for the 3–5 years to come with consideration of social and economic development of the region', signed in 1995 (Fuchinoue, Tsukatani and Toderich, 2002). As a result of conflicts Afghanistan, which is a critical partner to any future transboundary water management agreement, has so far been unable to participate in any discussions or agreements (Favre and Kamal, 2004).

Afghanistan uses only about 2 km^3/year of the 9 km^3/year of water from the Panj river that it is entitled to use under the 1946 treaty with the Former Soviet Union. The Panj river has an annual flow of 19 km^3, if Afghanistan develops agriculture in the north, this will radically change the flow of the Amu Darya (Favre and Kamal, 2004).

Once Afghanistan implements plans for the construction of dams and facilities on its rivers for flood control, electricity generation and irrigation expansion (Table 3), this will impact the amount of water and timing of peak runoff to the Islamic Republic of Iran, Pakistan, Uzbekistan and Turkmenistan (Khurshedi, 2011).

Water use

In 1998, total water withdrawal was estimated at 20.373 km^3, of which 20.0 km^3 or 98 percent was for agriculture, 1 percent for municipal and 1 percent for industrial purposes (Table 4 and Figure 1). Of total water withdrawal 17.317 km^3 or 85 percent was from surface water sources and the remainder 3.056 km^3 or 15 percent from groundwater (Figure 2) (Rout, 2008). In 1987, total water withdrawal was an estimated 26.11 km^3 of which 25.8 km^3 or 99 percent for agricultural purposes.

Referring to the Government of Afghanistan's 1980s yearbook statistics, the total annual groundwater extraction amounted to some 3 km^3 (Favre and Kamal, 2004). Uhl and Tahiri (2003) estimated groundwater withdrawal for irrigation to be 2.8 km^3/year.

Historically, groundwater withdrawal has been largely limited to water from shallow unconfined aquifers abstracted using *karez* and traditional wells from which water is drawn using animal power (*arhad*). More recently, deeper confined aquifers are being developed for domestic and municipal water supply using modern well-drilling techniques (Rout, 2008).

TABLE 4
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	327	mm/yr
	-	213 300	million m^3/yr
Internal renewable water resources (long-term average)	-	47 150	million m^3/yr
Total actual renewable water resources	-	65 330	million m^3/yr
Dependency ratio	-	29	%
Total actual renewable water resources per inhabitant	2011	2 019	m^3/yr
Total dam capacity	2009	3 658	million m^3
Water withdrawal			
Total water withdrawal by sector	1998	20 373	million m^3/yr
- agriculture	1998	20 000	million m^3/yr
- municipalities	2005	203	million m^3/yr
- industry	2005	170	million m3/yr
• per inhabitant	1998	937	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	1998	20 373	million m^3/yr
• as % of total actual renewable water resources	2000	31	%
Non-conventional sources of water			
Produced municipal wastewater		-	million m^3/yr
Treated municipal wastewater		-	million m^3/yr
Direct use of treated municipal wastewater		-	million m^3/yr
Desalinated water produced		0	million m^3/yr
Direct use of agricultural drainage water		-	million m^3/yr

FIGURE 1
Water withdrawal by sector
Total 20.373 km³ in 1998

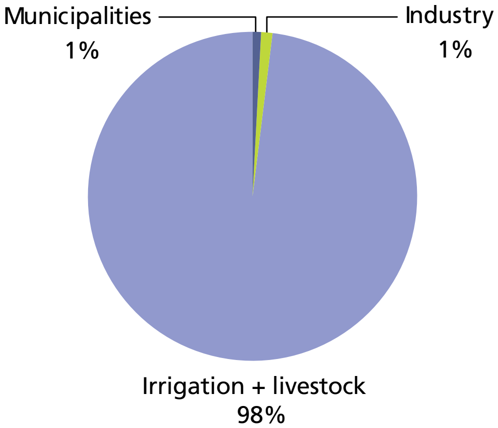
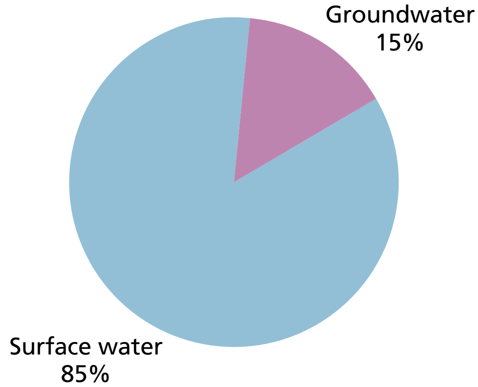


FIGURE 2
Water withdrawal by source
Total 20.373 km³ in 1998



IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

The history of irrigated agriculture in Afghanistan goes back more than 4 500 years to an ancient settlement near Kandahar (ICARDA, 2002).

By 1978, the surface water potential was more or less fully exploited by existing irrigation systems, if no further regulation works were constructed, although the efficiency of exploitation left room for considerable improvement. Irrigated areas could have been expanded by building major dams and other water regulation structures, all of which required major capital investment. There is no estimate, even rough, of irrigation potential.

For the past 30 years, the rural sector has been severely impacted by war and civil unrest. Irrigation system structures have been damaged, sometimes deliberately. While many rehabilitation efforts have necessarily been emergency assistance, long-term strategies to improve the performance and reliability of irrigation systems are also required (Rout, 2008). An estimated 27 to 36 percent of all irrigation systems were directly affected by war before 2000. These figures do not take into account the indirect effects of neglect and abandonment.

Irrigated land is usually located in the river basins of the north, west and southwest (ICARDA, 2002). Almost 75 percent is located in the northern and Helmand river basins. A FAO satellite survey, conducted in 1993, Table 5 lists irrigated land cover by river basin. It shows total irrigated area as 3.21 million ha, of which 48 percent is intensively cultivated and 52 percent intermittently with one or more crops each year. It is assumed that the survey covers both informal and formal irrigation systems (Table 6).

Not listed, however, is the area used for private gardens, vineyards and fruit trees, which could be over 90 000 ha and could receive some form of irrigation (Rout, 2008). It is estimated that in 2002 the area was the same, area actually irrigated was 1.73 million ha, or 54 percent of the area equipped for irrigation. In 2011, the area actually irrigated was an estimated 1 896 000 ha.

In 1967, a survey estimated the total irrigation area to be 2.72 million ha. The survey shows the existence of nearly 29 000 systems, of which 27 percent drew from surface water sources (rivers and streams), and the remainder from groundwater sources (springs, *karez* and wells) (Rout, 2008). While surface water systems made up less than one-third of the total number, they covered 86.5 percent of the irrigated area, confirming the importance of surface water as the

TABLE 5
Area equipped for irrigation (Source: Rout, 2008)

Water basin	Irrigation areas (ha)				Total (%)
	Intensively cultivated (2 crops/year)	Intensively cultivated (1 crops/year)	Intermittently cultivated	Total	
Kabul	62 000	244 000	178 100	484 100	15
Helmand	95 000	380 800	900 200	1 376 000	43
Hari Rod-Murghab	34 500	138 000	128 400	300 900	9
Northern	40 000	197 800	387 000	624 800	19
Amu Darya	106 200	247 800	48 100	402 100	13
Non-drainage area	3 880	10 000	6 700	20 580	1
Total	**341 580**	**1 218 400**	**1 648 500**	**3 208 480**	**100**

main irrigation water source. Springs account for 6.9 percent of the area, karezes for 6.2 percent and shallow and deep wells for 0.4 percent (Favre and Kamal, 2004). In 2002 it was estimated that 18 percent of the total area equipped for irrigation on 3.21 million ha and 16 percent of actually irrigated area on1.73 million ha were irrigated using groundwater (Figure 3).

In 1963, some 114 000 ha were reported to be equipped for sprinkler irrigation.

Irrigation systems can be divided into two main categories: informal irrigation systems (surface water systems, karez, springs and wells) and formal irrigation systems.

Informal systems are centuries-old and traditionally developed and managed by local communities within the constraints of local resources. They have undergone social and physical changes, and expand or contract based on water availability or challenges arising from years of conflict. Informal systems account for 88 percent of the country's irrigated area (Rout, 2008). They are divided into four categories:

- *Informal surface water systems:* They make up 75 percent of the irrigated area. Their prevalence largely results from widespread availability of both water resources from rivers and streams as well as adjacent land suitable for development, usually along river terraces and alluvial plains. The key infrastructure typically found in surface water systems includes: diversion structures (*sarband*); main, secondary and tertiary canals (predominantly made of unlined earth); control structures (weirs, *sehdarak* bifurcators, offtakes and spillways); conveyance structures (siphons, aqueducts, super-passages and culverts); protection structures (embankments as well as gabion and retaining walls); and access and ancillary structures (water mills, bridges and access points). Some schemes include small retention dams and water-harvesting structures (Rout, 2008). Small-scale informal surface water systems are the traditional irrigation systems, many of which have been established for centuries. Large-scale informal surface water systems are located mainly on

FIGURE 3
Source of irrigation water on area equipped for full control irrigation
Total 3 208 480 ha in 2002

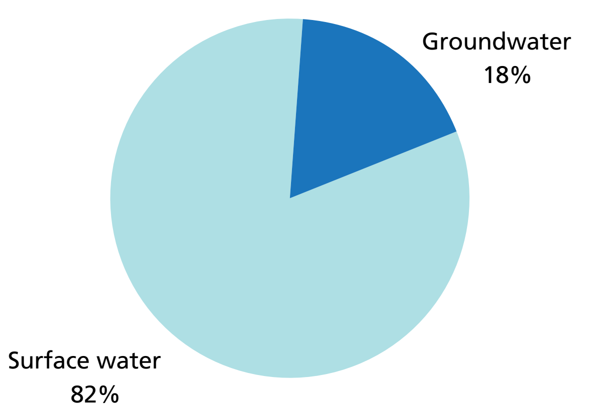


TABLE 6
Irrigation and drainage

Irrigation potential				ha
Irrigation				
1. Full control irrigation: equipped area		2002	3 208 480	ha
- surface irrigation			-	ha
- sprinkler irrigation		1967	114 000	ha
- localized irrigation			-	ha
• % of area irrigated from surface water		2002	82	%
• % of area irrigated from groundwater		2002	18	%
• % of area irrigated from mixed surface water and groundwater				%
• % of area irrigated from mixed non-conventional sources of water				%
• area equipped for full control irrigation actually irrigated		2011	1 896 000	ha
- as % of full control area equipped		2002	59	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2002**	**3 208 480**	**ha**
• as % of cultivated area		2002	42	%
• % of total area equipped for irrigation actually irrigated		2002	59	%
• average increase per year over 10 years		1993-2002	0	%
• power irrigated area as % of total area equipped				%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2002**	**3 208 480**	**ha**
• as % of cultivated area		2002	42	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< ha		-	ha
Medium-scale schemes	> ha and < ha		-	ha
Large-scale schemes	> ha		-	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production (wheat and barley)			-	metric tons
• as % of total grain production			-	%
Harvested crops				
Total harvested irrigated cropped area		2011	2 176 000	ha
• Temporary crops: total		2011	1 978 000	ha
- Wheat		2011	1 303 000	ha
- Rice		2011	208 000	ha
- Barley		2011	116 000	ha
- Maize		2011	183 000	ha
- Potatoes		2006	15 000	ha
- Sugar beet		2006	2 000	ha
- Pulses		2006	27 000	ha
- Vegetables		2011	69 000	ha
- Cotton		2011	33 000	ha
- Sesame		2006	10 000	ha
- Sunflower		2006	10 000	ha
- Sugarcane		2006	2 000	ha
• Permanent crops: total		2011	198 000	ha
Grapes		2011	61 000	ha
Fruit trees		2011	137 000	ha
Irrigated cropping intensity (on full control actually irrigated area)		2011	115	%
Drainage - Environment				
Total drained area		-	-	ha
- part of the area equipped for irrigation drained			-	ha
- other drained area (non-irrigated)			-	ha
• drained area as % of cultivated area			-	%
Flood-protected areas			-	ha
Area salinized by irrigation			-	ha
Population affected by water-related diseases			-	inhabitants

the plains and along the main valleys. Although called informal, their operation and maintenance was highly structured. Large parts of these schemes were abandoned because land became infertile because of waterlogging and salinization, particularly in the Hari Rod, Farah Rud and Helmand valleys.

- *Karez (qanat):* These date back several millennia. They comprise an unlined underground gallery in the hillside that brings water by free flow from underground aquifers to be used for surface irrigation. Dug by local craftspeople from shafts at close intervals, they are small but may be many kilometres long. Although most are shorter than 5 km, the length of the karez can run up to 16 km; it is said the longest Afghanistani karez is 70 km long. It is estimated that 6 740 kareze still supply water to 168 000 ha, as in 1967, the date of the last inventory. Average irrigated area per karez is 25 ha, but ranges from less than 10 ha to more than 200 ha. It should be noted that kareze are often used for domestic water supply. Karez irrigation is common in the south and southwest of the country and less in the north. Most karez systems are located within the Helmand river basin (Rout, 2008). One of the disadvantages of the karezes is that there is no mechanism to stop water flowing during winter, or when there is no need for irrigation. In each karez about 25 percent of total annual volume of water is wasted (ICARDA, 2002). The karez provides sustained perennial flow and good quality water and has the advantage of being relatively immune to natural disasters (such as earthquakes and floods) and human destruction in war (Tamuri, 2007). However, these systems may commonly face problems such as vulnerability to collapse of subsurface infrastructure, water losses in canals, flood damage and groundwater depletion. Karez are organized and operated by local communities, traditionally under a karezkan specialist responsible for construction and maintenance of subsurface sections; a *mirab* (water master) oversees surface distribution operations. Water allocations, similar to surface water systems, are based on water entitlements and rotations (Rout, 2008). Most karez are no longer in use (World Bank, 2009).
- *Springs:* Many rural communities depend on the nearly 5 558 spring-fed systems estimated to irrigate approximately 187 000 ha. The relatively low flow rate of springs means that the systems are often supplemented by diverted surface water flows when available. The systems are commonly found in upper and tributary catchments and are concentrated in the more mountainous central and southeastern provinces (Rout, 2008). When the groundwater level falls such as during drought years, the result is reduced outflow from springs. This is why some of the worst drought-stricken areas of the country are located in regions where farmers depend heavily on spring water for irrigation (ICARDA, 2002).
- *Wells:* Estimates from the late 1960s indicated that less than 1 percent of the total irrigated area is supplied by water from wells. Groundwater is lifted from large diameter shallow wells with the help of a wheel (*arhad*), animal power supplies irrigation water to an individual farmer's fields. The irrigated land does not exceed 3 ha. The total number of shallow wells in Afghanistan is 8 595, which irrigate around 12 000 ha of land. In recent years, however, the use of modern well-drilling and pumping technology has been more widespread, considerably increasing the number of wells and their capacity (ICARDA, 2002; Rout, 2008) (Table 7).

Formal systems are large-scale irrigation schemes that have been developed with central government assistance, financing, management, operation and maintenance. With additional support from bilateral and multilateral donors, most of these schemes were developed between the late 1940s and the 1970s. Afghanistan has ten formal schemes totalling nearly 333 000 ha. The largest is the Helmand-Arghandab scheme (Helmand province). The other systems are: Sardeh (Ghazni), Parwan (Parwan and Kabul), Nangarhar (Nangarhar), Sang-i-Mehr (Badakhshan), Kunduz-Khanabad (Kunduz), Shahrawan (Takhar), Gawargan (Baghlan), Kelagay (Baghlan) and Nahr-i-Shahi (Balkh) (Table 8) (Rout, 2008; Favre and Kamal, 2004).

TABLE 7
Irrigation area by origin of water in the late 1960s (Source: Favre and Kamal, 2004)

System and area	Rivers and streams	Springs	Karez	Wells (arhad)	Total
Systems (number)	7 822	5 558	6 741	8 595	28 716
Systems (%)	27.2	19.4	23.5	29.9	
Area (ha)	2 348 000	187 000	168 000	12 000	2 715 000
Area (%)	86.5	6.9	6.2	0.4	

TABLE 8
Formal irrigation schemes built by the government of Afghanistan (Source: Favre and Kamal, 2004)

No	Name of scheme	Province	Area under irrigation (ha)	Main structures	Remarks
1	Helmand-Arghandab project	Helmand and Kandahar	103 000	Kajaki and Dhala Dams, Diversion of Boghra, Main canal of Boghra, Shahrawan, Shamalan, Darweshan and Baba Walee	Water flow managed by government, maintenance by NGOs
2	Sardeh	Ghazni	15 000	Reservoir (capacity 164 million m^3). Left and right canal	Water flow managed by government, maintenance by NGOs
3	Parwan	Parwan and Kabul	24 800	Diversion, Main canal. Eastern and Southern canal. Pumping station. Power house	Water flow managed by government, maintenance by NGOs
4	Nangarhar irrigation system	Nangarhar	39 000	Darunta dam and power station, Main canal, pumping station, state farms	Water flow managed by government, maintenance by NGOs
5	Sang-i-Mehr	Badakhshan	3 000	Intake and main canal	Run by community, maintenance by NGOs
6	Kunduz-Khanabad	Kunduz	30 000	Diversion, left and right canal, regulator	Not completed, not operational
7	Shahrawan	Takhar	40 000	Intake, main canal	Water flow managed by government, maintenance by NGOs
8	Gawargan	Baghlan	8 000	Intake, main canal	8 000 out of 20 000 ha currently cultivated, water flow managed by government, Maintenance by NGOs
9	Kelagay	Baghlan	20 000	Intake, main canal	Water flow managed by government, maintenance by NGOs
10	Nahr-i-Shahi	Balkh	50 000	Diversion, main canal and division structures	Run by government and community
Total			**332 800**		

Most of these schemes are supplied by surface water, and very little is known about the formal irrigation schemes supplied by groundwater from deep and shallow wells. In Khost/Paktia province, surface water irrigation schemes were supplied by some 100 deep wells until the late 1980s (ICARDA, 2002). Several of the schemes have storage dams and capacity to generate hydropower. Over the past 30 years, the schemes have become heavily degraded because of lack of funding and loss of technical and institutional capacity to support operation and maintenance (Rout, 2008). By 1993, only a small part of these schemes was operational. Land tenure was different than most traditional systems in that ownership of land was registered.

Some schemes were operated under private land ownership agreements, while others were operated as state farms where land ownership was deeded to the State. Since 2003, a number of ongoing rehabilitation initiatives have been launched (Rout, 2008).

There have been no concerted efforts to exploit water using modern technology, mainly because of the high initial and maintenance costs (ICARDA, 2002).

Small-scale schemes (< 3 ha) account for 83 percent of irrigated farms and 8 percent of rainfed, medium-scale schemes (3-6 ha) account for 14 percent of irrigated farms and 8 percent of rainfed, while large-scale schemes (> 6 ha) account for 3 percent of irrigated farms and 84 percent of rainfed (Qureshi, 2002). The average irrigated farm is 1.4 ha, while the average rainfed farm is 6–7 ha.

Role of irrigation in agricultural production, economy and society

In 2011, total harvested irrigated cropped area was an estimated 2 176 000 ha. Wheat accounts for 1 303 000 ha, or 59.9 percent of the harvested irrigated copped area, followed by rice 208 000 ha (9.6 percent), maize 183 000 ha (8.4 percent), fruit trees (including grapes) 198 000 ha (9.1 percent), barley 116 000 ha (5.3 percent), vegetables 69 000 ha (3.2 percent), cotton 33 000 ha (1.5 percent) and other crops on 99 000 ha (4.5 percent) (Table 6 and Figure 4).

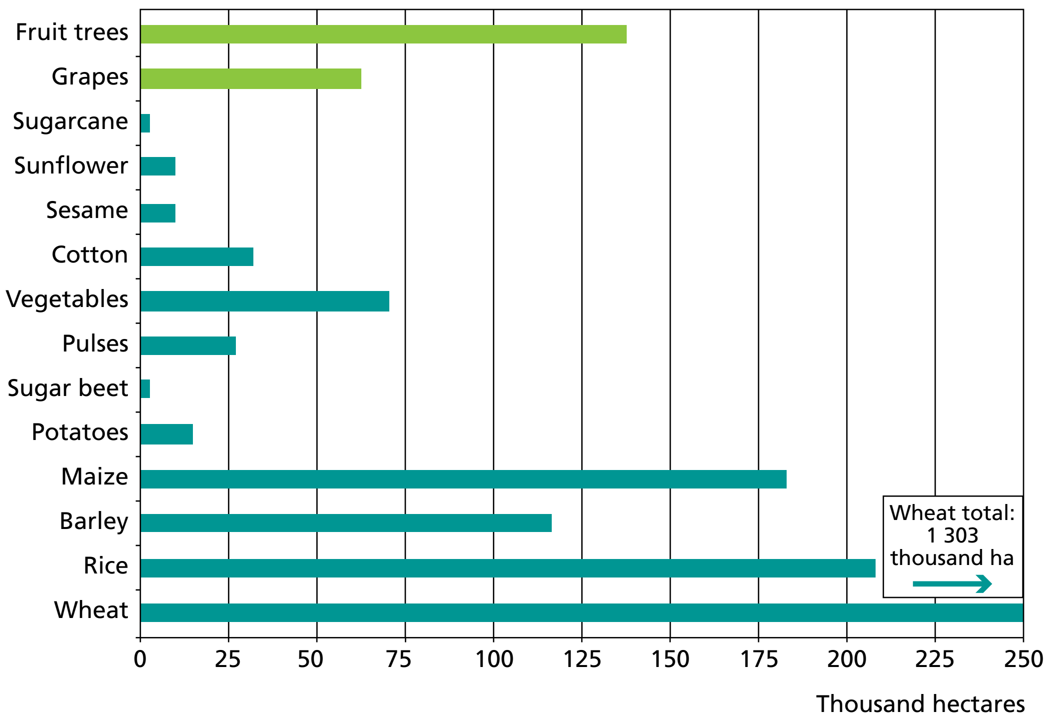
Sustaining and increasing productivity on irrigated land is essential for the overall food security of Afghanistan.

Cropping intensity varies widely from system-to-system according to the relative scarcity of water in relation to land. It may achieve 200 percent in large, formal systems with full water control (upstream of the river systems, when climatic conditions allow an early wheat crop), while in other systems up to two-thirds of the equipped area are kept fallow each year on a rotation basis.

FIGURE 4

Irrigated crops on area equipped for full control irrigation

Total harvested area 2 176 000 ha in 2011 (cropping intensity on full/control equipped area: 115%)



Per capita wheat consumption in Afghanistan is one of the highest in the world. Pre-war, irrigated land produced 77 percent of all wheat and 85 percent of all food and agricultural crops. Irrigated yields are estimated to be three times that of rainfed yields.

In 1993, the average cost of irrigation scheme rehabilitation was an estimated US$200/ha for small schemes. Rehabilitation costs for large, modern schemes, including main structures, are considerably higher.

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

Institutions

The Ministry of Water and Energy (MWE) is responsible for mapping, monitoring and management of surface water and groundwater resources. Following the United States invasion of Afghanistan the Ministry had the task of coordinating an effort to reintroduce power to areas of Afghanistan that had been cut off.

The Ministry of Agriculture, Irrigation and Livestock (MAIL) has the mission to restore Afghanistan's licit agricultural economy through increasing production and productivity, natural resources management, improved physical infrastructure and market development (MAIL, 2011).

Urban water supply is the responsibility of the Ministry of Public Works. Water supply and sewerage disposal in the Microrayon area of Kabul is the duty of the Microrayon Maintenance Department.

The mandate of the Central Authority for Water and Sanitation is urban water supply within the areal limits of the Master Plan of the city.

The Ministry of Mines is responsible for groundwater investigation and survey, especially for 'deep' hydrogeological mapping of strategic plans for optimal exploitation of resources.

The municipalities are responsible for surface water drainage and solid waste disposal.

The Ministry of Rural Development is active in designing deep wells and networks for parts of Kabul City outside the Master Plan, where shallow groundwater is salty.

Water management and finances

As described in Rout (2008), overall system management is led by a senior representative called *wakil* (Herat) or *mirab bashi* (Kunduz and Balkh). This person is usually a well-respected community member and landowner with experience and knowledge of the system as well as influence with the local government. In addition to system management, the representative also has the broader responsibility of liaising with adjacent irrigation communities, particularly over customary rights on the location and operation of the *sarband*. In some locations, a main canal committee supports the *wakil* or *mirab bashi*, while in others by a *mirab* or *chak bashi*. In both cases, the supporting role represents the different upper, middle and lower sections of a system. In larger systems, a *badwan* is responsible for operation and maintenance of the *sarband* because of its importance and high maintenance requirements.

Through a *mirab* (water master) (Herat) or *chak bashi* (Kunduz and Balkh) or a village committee, the recipient community is usually responsible for the management of operation and maintenance of all canals and structures downstream of the secondary canals to farm turnouts. The *mirab* or *chak mirab* is typically a well-respected landless sharecropper with a working knowledge of system operation and maintenance. This official, may have one or two assistants, and is usually elected by water rights holders (landowners), or their sharecropping representatives, and serves as a link between the government water authority personnel and farmers. *Mirabs* generally receive some compensation in the form of farm products, such as wheat, for performance of their duties (ICARDA, 2002). Payment for the services of system representatives is traditionally set as a unit weight of crop (e.g. wheat). The amount of payment received depends on the level of the official.

Surface water systems are largely managed as autonomous units. While there are variations in structure, they essentially follow similar principles regarding election of representatives, payment for services, and contributions to maintenance and capital works. These organizations follow many of the concepts behind water user associations: stakeholder participation, community-based representation, financial independence and hydraulic integrity. Government involvement is generally minimal and largely confined to provision of emergency rehabilitation, dispute resolution and, in some instances, holding the register of water rights.

System maintenance generally takes place in early spring to coincide with low or no-flow, when labour is readily available.

Three decades of conflict have adversely affected the performance of irrigation systems and the ability of communities to sustain them. Since 2001, several initiatives have been launched to develop the irrigation sector and to better manage water resources. MWE, the lead government institution for revitalizing the irrigation system sector, receives support from international and bilateral donors. The major programmes are:

- Emergency irrigation and rehabilitation project (EIRP), financed by the World Bank, in all the basins (budget: US$75 million);
- Emergency infrastructure, rehabilitation and reconstruction project, financed by the Asian Development Bank (ADB), Japan Fund for Poverty Reduction (JFPR), in the northern river basin (budget: US$15 million);
- Balkh basin integrated water resources management project, financed by the JFPR (budget: US$10 million);
- Kunduz river basin project, financed by the European Commission (EC) (budget: US$15 million);
- Western Basins Project, financed by the ADB, Canadian International Development Agency (CIDA) and Abu Dhabi Fund (budget: US$ 90 million), in the Hari Rod-Murghab basin;
- Amu Darya river basin management programme, financed by the EC (budget: US$5 million).

Numerous other agencies have contributed to rehabilitating irrigation systems, among them: the Ministry of Rehabilitation and Rural Development; the Danish Committee for Aid to Afghan Refugees; German Agro-Action, Urgence Réhabilitation Developpement, World Vision and USAID (Rout, 2008).

Since 1990, FAO has actively been involved in irrigation rehabilitation and development activities (FAO, 2008). The nationwide Emergency Irrigation Rehabilitation Project (EIRP) financed by the World Bank, started in June 2004, implemented by the MWE with support from FAO. With this project farmers and their families will benefit from improved, reliable and equitably distributed irrigation water, which leads to increased agricultural productivity, better income, improved food security and reduces the farmers' vulnerability to drought. As of May 2008, 495 299 ha of agricultural land had been rehabilitated, of which about 80 000 ha was brought back under irrigation.

Project monitoring and evaluation recorded that satisfactory changes have been achieved by the project, for instance the average yield in irrigated areas has increased by 24 percent. Significantly increased wheat yield has improved rural household income, farm employment and poverty alleviation. The provision of irrigation water has contributed to increased production of high-value crops including barley, maize, rice, vegetables, cotton, orchards and horticulture, which could potentially earn foreign exchange (FAO-Water, 2011).

Maloma canal, in the Karokh district of Herat province, is one scheme that has been recently rehabilitated under the EIRP, with a capacity of 2 m^3/s. Dawandar Wash feeds this canal. During the period of conflict this irrigation scheme suffered from the direct and indirect impacts of the war such as bombing, lack of proper maintenance because of farmers' displacement or migration, erosion, river regime change, etc. This canal is the only source of water for irrigation as well as drinking for four main villages with 1 330 households. Since 1990, FAO has rehabilitated more than 1 200 similar schemes. More than 700 schemes at an approximate cost of US$460 million were ready for implementation on availability of funding (FAO, 2008).

In the north of Afghanistan, at Kokcha river in Kunduz and Takhar provinces, EIRP is completing a feasibility study for a Lower Kokcha Irrigation and Hydropower Project. Once completed, this project will supply water to a further 132 000 ha of agricultural land (FAO-Water, 2011).

In light of the success of EIRP, the World Bank has agreed to allocate a further US$28 million with additional scope of work for the next two years in addition to the US$75 million originally allocated. During the period, preparations for a follow-up phase will be launched to target up-scaled irrigation rehabilitation, restoring incomplete bulk water supply systems (such as dams and reservoirs), installation and operation of hydro-meteorological networks; preparation of river basins water master plans in addition to capacity development and institutional strengthening. The World Bank also plans to allocate US$200 million for a four-year follow-up phase based on multi-donor funding basis and inter-ministerial coordination (FAO-Water, 2011).

Between 2004 and 2011, FAO-assisted irrigation projects helped Afghanistan increase its crop productivity and coverage of irrigated land. Some 778 000 ha of land have been rehabilitated, of which 158 000 is newly irrigated. As a result, wheat productivity in project areas has increased by more than 50 percent (FAO, 2012).

USAID has rehabilitated three major rural irrigation systems – Char Dara, Bala Doori and Darqad – and returned more than 300 000 ha of cultivated land to full irrigated production. This included de-silting and widening irrigation canals, repairing and replacing water intakes, canal banks, protection walls, turnouts and sluice gates. In general, the completed projects are providing a reliable source of water for irrigation and could potentially double the regions' crop yields. The irrigation projects were all completed in 2004. Hundreds of local farmers were employed on the project sites (USAID, 2009).

USAID has allocated US$1.5 million to introduce hydroflumes, a simple water-saving system. The system is designed to increase domestic crop production through the efficient distribution of water. Officials at MAIL said the technology could improve productivity, but how rural farming communities access and use it will be a challenge, since most farmers are illiterate and uneasy about using new technology (IRIN, 2009).

With the support of the United States agribusiness development teams, canals across provinces in eastern Afghanistan are being restored to protect the nation's valuable water resources. Major irrigation rehabilitation projects in Nangarhar have focused on strengthening the capacity of the provincial level agriculture ministry's ability to develop, execute, monitor and assess water management projects. The Nangarhar Provincial Directorate of Agriculture, Irrigation and

Livestock has recently rehabilitated 24 major rural irrigation systems and returned more than 240 ha of cultivated land to full production (US Central Command, 2011).

It is important to note that a great deal of information, resources and institutional capacity for accurate monitoring and reporting on natural resources were lost during the years of conflict. While significant efforts are underway to fill the information void, many inaccuracies and gaps remain (Rout, 2008).

Policies and legislation

The Afghanistan Government instituted the 1981 Water Law to improve the situation of water rights. The Water Law, however, needs updating and revision before it is ready to be enforced. The Water Law has seven chapters, including issues such as ownership of water, which belongs to the public and is preserved by the government. Drinking water and water for other living requirements has been given priority over other uses. Use of water is free of charge. The Law deals with special regulation of the use of water for agriculture (water rights, water distribution, water user associations, *mirab*, and tax breaks for converting dry cropping land to irrigated land); drinking water and water for transportation; water pollution, water distribution, etc. Chapter two mainly deals with assigning authority and responsibility to MWE (ICARDA, 2002).

ENVIRONMENT AND HEALTH

Afghanistan faces many environmental problems, mainly the degradation of water tables and wetlands and deforestation (some 40 percent of forests have been cut down) (IRIN, 2003).

Excessive use of groundwater for a variety of purposes has significantly depleted water tables and aquifers throughout Afghanistan and, if the trend is not reversed soon, the country will face a severe shortage of drinking water. The recurrent droughts, low precipitation and poor water management have exacerbated the water crisis. Over the past several years, groundwater sources have been reduced by about 50 percent. Limited access to surface water has prompted many farmers, mostly in the drought-stricken south and north, to increasingly use groundwater to irrigate agricultural land or dig deep wells. The majority of the population uses groundwater as its prime, and often only, source of drinking water. As groundwater reduces, therefore, the number of people with access to drinking water declines (IRIN, 2008).

Surface water quality is excellent in the upper basins of all rivers throughout the year and good in the lower basins in spite of large irrigated areas. As far as known, the presence of saline soil in irrigated areas is not caused by poor water quality but rather by either over-irrigation (waterlogging) or lack of irrigation water (fallow fields and high groundwater table) (Qureshi, 2002).

Groundwater quality is generally good, but varies from place to place. In lower reaches of river valleys, groundwater is frequently saline or brackish and not usable for either drinking or irrigation (Favre and Kamal, 2004).

The problems in a river basin are usually intricate and interlinked. Therefore, no single and isolated solution can work effectively. A holistic and integrated approach is needed to tackle the problems. It essentially requires the setting of goals, preparing plans, collaborating with different institutions and stakeholders and above all effective implementation of the proposed management options (ICARDA, 2002).

Floods are generally violent and can cause serious damage to agricultural land or inhabited areas. About 50 gabion river protection works and 50 flood protection masonry walls were constructed before the war, mostly in the Nangarhar and Parwan provinces, in the eastern region.

Across the country 174 hydrological stations are being installed, the network of stations will measure rainfall, relative humidity, water level, water quality, temperature and sunshine (FAO-Water, 2011).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

The long-term development of the irrigation sector should consider the following key issues (Rout, 2008):

- improving system efficiency and productivity through enhancing infrastructure, increasing the equity of water allocations and developing water storage systems;
- enhancing system operation and maintenance by improving the organization of informal systems, financial self-sufficiency, design of structures to reduce de-silting, protection against water loss and approaches to maintenance;
- increasing sustainability of water resources through development of integrated catchment management plans and sustainable environmental management.

There is great potential for developing both shallow and deep groundwater systems for irrigation and other uses, but precaution must be taken to avoid adversely affecting users of existing systems (Rout, 2008).

Afghanistan does not use the water from the Amu Darya river as it should. Proper use of water from the Amu Darya river would bring thousands of hectares of land under irrigation in northern Afghanistan (ICARDA, 2002).

With rehabilitation of systems and improved management, it is estimated that water use will increase to 35 km^3 per year (Rout, 2008).

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Kazakhstan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

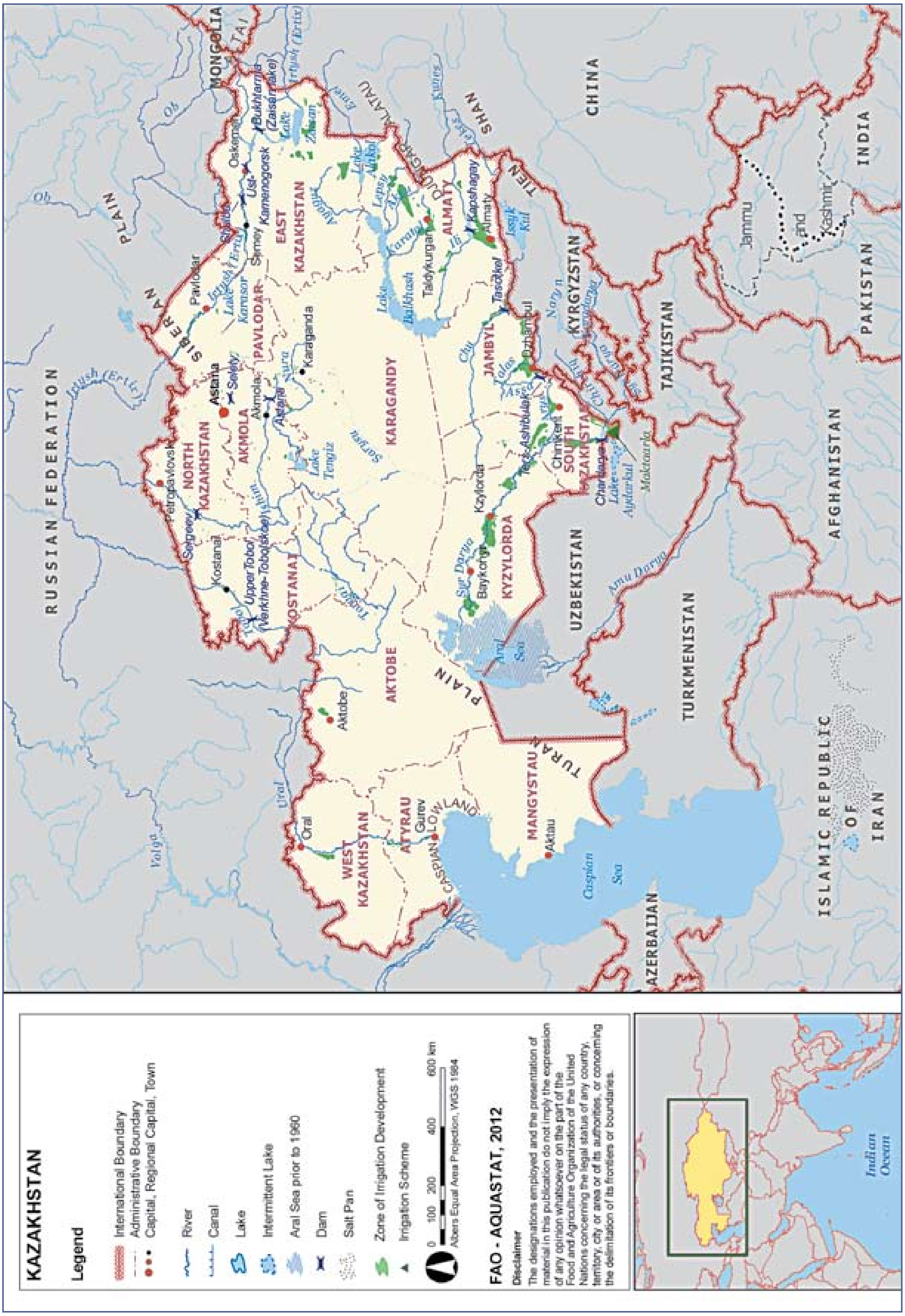
Kazakhstan, with a total area of just over 2.72 million km^2, is the second largest country of the Former Soviet Union, after the Russian Federation, and the ninth largest country in the world (Table 1). It is bordered in the northwest and north by the Russian Federation, in the east by China, in the south by Kyrgyzstan and Uzbekistan, and in the southwest by Turkmenistan and the Caspian Sea. It declared its independence from the Union of Soviet Socialist Republics (USSR) in December 1991. For administrative purposes, the country is divided into 14 provinces (*oblasts*) – Akmola, Aktobe, Almaty, Atyrau, West Kazakhstan, Jambyl, Karagandy, Kostanai, Kyzylorda, Mangystau, South Kazakhstan, Pavlodar, North Kazakhstan, East Kazakhstan – and three cities (*qalalar*) – Almaty, Astana and Baykonyr (former Leninsk). In 1995, the governments of Kazakhstan and the Russian Federation entered into an agreement whereby the Russian Federation would lease an area of 6 000 km^2 enclosing the city of Baykonyr and its space launch facilities for 20 years. In 2004 a new agreement extended the lease to 2050 (CIA, 2011).

Deserts and steppes account for more than 80 percent of the total area. In the central region is 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 lowlands. In the east and southeast, mountain chains (Altai, Djungar Alatau, Tien Shan) alternate with depressions (Zaisan, Balkhash-Alakol, Ili and Chu-Talas) comprising sandy deserts (Sary-Ishikotrau and Muynkum). The country's highest peak (Khan-Tengri) is about 7 000 m above sea level in the Tien Shan mountain range in the southeast.

The cultivable area, including pastures and grazing, notably the steppes, is an estimated 222 million ha, or 81 percent of the total area. In 2009 the cultivated area was an estimated 23 480 000 ha, or 11 percent of the cultivable area, of which 23 400 000 ha or 99.7 percent were temporary crops and 80 000 ha or 0.3 percent permanent. Since 1950 there has been a dramatic increase in cultivated area, mainly because of the political decision taken that year to develop agriculture on semi-arid land, called 'virgin land', notably in the northern and central regions of the Republic. The cultivated area increased from 7.8 million ha in 1950 to 28.5 million ha in 1960. In 1992 the cultivated area was 35.2 million ha; although this area has decreased over the last two decades.

Climate

The climate of Kazakhstan is typically continental, with cold dry winters and hot dry summers. In the south, average temperatures vary from minus 3 °C in January to 30 °C in July. In the north, average temperatures vary between minus 18 °C in January and 19 °C in July, while records show temperatures of minus 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.


KAZAKHSTAN
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
River
Canal
Lake
Intermittent Lake
Aral Sea prior to 1960
Dam
Salt Pan
Zone of Irrigation Development
Irrigation Scheme
0 100 200 400 600 km
Albers Equal Area Projection, WGS 1984
FAO - AQUASTAT, 2012
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RUSSIAN FEDERATION
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MONGOLIA
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TURKMENISTAN
AFGHANISTAN
PAKISTAN
INDIA
ISLAMIC REPUBLIC OF IRAN
AZERBAIJAN
TURAN PLAIN
CASPIAN LOWLAND
TIEN SHAN
Caspian Sea
Aral Sea
Lake Balkhash
Lake Tengiz
WEST KAZAKHSTAN
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MANGYSTAU
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KOSTANAI
NORTH KAZAKHSTAN
AKMOLA
PAVLODAR
KARAGANDY
EAST KAZAKHSTAN
ALMATY
JAMBYL
KYZYLORDA
SOUTH KAZAKHSTAN
Oral
Gurev
Aktau
Aktobe
Kostanai
Petropavlovsk
Astana
Akmola
Karaganda
Pavlodar
Semey
Oskemen
Taldykurgan
Almaty
Kapshagay
Dzhambul
Chimkent
Kzylorda
Baykonyr
Volga
Ural
Ob
Syr Darya
Amu Darya
Indian Ocean

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	272 490 000	ha
Cultivated area (arable land and area under permanent crops)	2009	23 480 000	ha
• as % of the total area of the country	2009	9	%
• arable land (annual crops + temp fallow + temp meadows)	2009	23 400 000	ha
• area under permanent crops	2009	80 000	ha
Population			
Total population	2011	16 207 000	inhabitants
• of which rural	2011	41	%
Population density	2011	6	inhabitants/km^2
Economically active population	2011	8 682 000	inhabitants
• as % of total population	2011	54	%
• female	2011	49	%
• male	2011	51	%
Population economically active in agriculture	2011	1 181 000	inhabitants
• as % of total economically active population	2011	14	%
• female	2011	24	%
• male	2011	76	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	149 059	million US$/yr
• value added in agriculture (% of GDP)	2010	5	%
• GDP per capita	2010	9 301	US$/yr
Human Development Index (highest = 1)	2011	0.745	
Access to improved drinking water sources			
Total population	2010	95	%
Urban population	2010	99	%
Rural population	2010	90	%

Precipitation is insignificant, except in the mountainous regions. Average annual precipitation is an estimated 250 mm, ranging from less than 100 mm in the Balkhash-Alakol depression in the central-eastern region or near the Aral Sea in the south, up to 1 600 mm in the mountain area in the east and southeast. About 70–85 percent of annual rainfall occurs during the winter, between October and April. Snow often falls in November. Summer rains are often combined with severe thunderstorms, which sometimes lead to flash flooding. Almost the entire territory of Kazakhstan is characterized by strong winds that may gust at speeds over 40 m/s.

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

Population

The total population was an estimated 16.2 million inhabitants in 2011 of which 41 percent rural, in 2001 the rural population was 44 percent. During the period 2001–2011 the annual population growth rate was an estimated 0.9 percent. Average population density is 6 inhabitants/km^2, but varies from 2 inhabitants/km^2 in the central province of Jeskazgan to 20 inhabitants/km^2 in Almaty province in the southeast.

In 2010, 95 percent of the population had access to improved water sources (99 and 90 percent in urban and rural areas respectively) (Table 1). Sanitation coverage accounted for 97 percent (97 and 98 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, Kazakhstan's gross domestic product (GDP) was US$149 059 million, of which the agriculture sector accounted for 5 percent (Table 1).

In 2011, the total economically active population was 8.7 million, or 54 percent of the total population. The economically active population in agriculture is an estimated 1.2 million (14 percent of total active population), of which 24 percent female.

Agriculture plays an important role in the development of Kazakhstan, the most important crops are wheat, maize, rice, oats, buckwheat, cotton, potatoes, vegetables, sugar beets, sunflowers. An important factor of subsistence support is self-sufficiency in grain for the production of bread and for livestock forage. The national economy's priority is grain production, as basic subsistence of the population appears more problematic each year. Increased yields of high quality crops could provide a good basis for economic stabilization (UNDP, 2008).

Kazakhstan is one of the world's six largest grain exporters, mainly spring wheat, which is exported to 40 countries worldwide. The principle buyers are the Russian Federation, Azerbaijan, Turkey and Saudi Arabia. Kazakhstan is gradually increasing wheat exports to the Islamic Republic of Iran, Jordan, Tunisia, Italy, France and Afghanistan. Export volumes total from 2 to 6 million tonnes per year (UNDP, 2008).

WATER RESOURCES AND USE

Water resources

Four major hydrologic regions can be identified: the Ob river basin draining to the Arctic Ocean, the Caspian Sea basin, the Aral Sea basin and internal lakes, depressions or deserts.

There are about 39 000 rivers and streams, 7 000 of which are over 10 km. Surface water resources are extremely unevenly distributed within the country and are marked by significant perennial and seasonal dynamics. Central Kazakhstan has only 3 percent of total water resources in the country. The western and southwestern regions (Atyrau, Kyzylorda and in particular Mangystau region) are significantly water deficit; there is hardly any fresh water. The Balkhash-Alakol and Irtysh (Ertix) river basins in the east and northeast account for almost 75 percent of surface water resources generated within the country (Table 2). About 90 percent of the runoff occurs in spring, exceeding reservoir storage capacity (UNDP, 2003).

Eight Basins Waterworks Departments (BWD) have been formed in Kazakhstan, covering the following main river basins (UNDP, 2004):

1. The Syr Darya basin occupies about 345 000 km^2 and includes South Kazakhstan and Kyzylorda regions. The main Syr Darya begins outside Kazakhstan in the Fergana Valley in Uzbekistan at the junction of the rivers Naryn and Karadarya originating in Kyrgyzstan. The total length from the junction to the Aral Sea is 2 212 km. The length within Kazakhstan from Chardarya reservoir near the border with Uzbekistan to the Aral Sea is 1 627 km. The largest tributaries within Kazakhstan are Keles, Arys, Badam, Boroldai, Bugun and some smaller rivers, flowing from the southwestern slopes of the Karatau Ridge.
2. The Balkhash-Alakol basin occupies a vast area in southeast Kazakhstan, a part of China and a small part of Kyrgyzstan. Its area is 413 000 km^2, including 353 000 km^2 in Kazakhstan (Almaty province and a part of Jambyl, Karagandy and East Kazakhstan provinces). The permanent rivers flowing into Lake Balkhash – Ili, Karatal, Aksu, Lepsy, Ayaguz – originate in the mountain regions of Tien Shan, Tarbagatai and

TABLE 2
Long-term average annual renewable surface water resources (RSWR) by river basin in Kazakhstan in km³/year (adapted from UNDP, 2003, 2004 and 2008)

River basin	Internal RSWR	Inflow				Total actual RSWR	Minimum in dry years (95% probability)
		Total		Secured by agreements - from	Accounted		
Syr Darya	3.3	33.27 [a]	10	Uzbekistan	10	13.3	14.2
Balkhash – Alakol	16.4	12.37		China (12.01); Kyrgyzstan (0.36)	12.37	28.77	17.8
Chu – Talas - Assa	1.2	6.74 [b]	2.03 [c]	Kyrgyzstan	2.03	3.23	2.7
Irtysh	24.5	9.53		China	9.53	34.03	19.7
Nura – Sarysu	1.7	0		Endorheic	0	1.7	0.1
Ishim	2.6	0		Endorheic	0	2.6	0.3
Tobol – Torgai	1.5	0.6		Russian Federation	0.6	2.1	0.3
Ural – Caspian	5.3	8.6		Russian Federation	8.6	13.9	3.0
Total	**56.5**	**71.11**			**43.13**	**99.63**	**58.1**

a Equal to inflow from Kyrgyzstan (27.42), Tajikistan (1.01) and Uzbekistan (4.84)
b Chu (5.0) and Talas-Assa (1.74)
c Chu (1.24) and Talas-Assa (0.79)

Genghis Tau. Ili river flows into the Western Balkhash, while the other rivers flow into the Eastern Balkhash.

3. The Chu-Talas-Assa basin is formed by the rivers Chu (Shu in Kazakh), Talas and Assa. The basin's total area is 64 300 km², including the part in Kyrgyzstan. In addition there are 140 small rivers in the Chu river basin, 20 small rivers in the Talas river basin and 64 small rivers in the Assa river basin. The flow of the rivers Chu, Talas and Kukureu-su (the main tributary of the Assa river) is formed completely in Kyrgyzstan.
4. The Irtysh river basin is located in East Kazakhstan and Pavlodar regions, with a total area of 316 500 km². The river originates in China on the western slopes of the Mongolian Altai and is called the Black Irtysh until it flows into lake Zaisan in Kazakhstan. After flowing through northeast Kazakhstan it enters the Russian Federation and joins the Ob river. The total length of the Irtysh river is 4 280 km, of which 618 km in China, 1 698 km in Kazakhstan and 1 964 km in the Russian Federation. This basin is the most secure from the viewpoint of water resources.
5. The Nura-Sarysu basin includes the basins of the rivers Nura and Sarysu, and the lakes Tengiz and Karasor. The Irtysh-Karagandy canal (currently the Satpaev canal) was built to increase the water resources in this basin. The largest river in the basin, the Nura is 978 km long, begins on the western flanks of the Kyzyltas mountains and flows into lake Tengiz. The main tributaries of the Nura river are the Sherubainura, Ulkenkundyzdy and Akbastau. The Sarysu river begins in two branches of the Zhaksysarysu and flows 761 km downstream from their junction into lake Telekol (Kyzylorda province). The main tributaries are Karakengir and Kensaz.
6. The Ishim (Yesil) river basin within Kazakhstan covers Akmola and North Kazakhstan oblasts and occupies 245 000 km². This basin is the least secure with respect to water resources. Groundwater reserves here are the lowest in Kazakhstan and comprise only 4 percent in the water balance of the basin. The Ishim river has a number of large tributaries that flow from the north from the Kokshetau upland and from the flanks of the Ulytau mountains. The river begins in springs in the Niaz mountains, Karagandy province and is 2 450 km long, including 1 717 km in Kazakhstan. The most significant tributaries in terms of water and length are the Koluton, Zhabai, Tersakkan, Akan-Burluk and Iman-Burluk rivers. Surface runoff of the Ishim river is used to supply water to Astana, Kokshetau, Petropavlovsk and villages in Akmola and North Kazakhstan regions as well as for regular and flood irrigation and gardens in the suburbs.
7. The Tobol-Torgai basin includes the rivers Tobol, Torgai and Irgiz. This is Kazakhstan's

poorest basin with regards to water resources. The annual flow of the rivers can fluctuate significantly and is characterized by alternating high-water and low-water years. The duration of high-water periods varies from 8 to 10 years, and the duration of low-water years varies from 6 to 20 years. The Tobol river begins in the Ural mountains. The left-bank tributaries, Sytasty, Ayat and Ui, also begin on the slopes of the Ural mountains. The only right-bank river is the Ubagan river.

8. The Ural-Caspian basin occupies 415 000 km^2 within Kazakhstan. The Ural river basin includes part of the Russian Federation and in Kazakhstan includes West Kazakhstan and Atyrau provinces and part of Aktobe province. The principal water artery of the basin is the Ural river, which originates in the Russian Federation.

Total internal renewable surface water resources are 56.5 km^3/year and total actual renewable surface water resources, including agreements on the Syr Darya and on the Chu, Talas and Assa rivers, are 99.63 km^3/year (Table 2).

Current volume of river runoff in Kazakhstan seems to differ significantly from previous estimations and long-term averages. Reduced surface runoff could provide evidence of significant climatic and anthropogenic effects on water resources and reflects the strong tendency towards possible reduction of surface water resources in the country.

Groundwater is extremely unevenly distributed throughout the country and the variable quality prevents exploitation of part of groundwater resources for economic activity. Groundwater is available in almost all the mountainous regions. About half groundwater resources (about 50 percent) are concentrated in southern Kazakhstan. Significantly fewer of these resources (up to 20 percent) are formed within western Kazakhstan. About 30 percent of all groundwater resources are located in central, northern and eastern Kazakhstan (UNDP, 2004). A total of 626 groundwater fields have been explored with total reserves of 15.93 km^3/year (43.38 million m^3/day); probable reserves with a salinity rate of up to 1 g/litre are an estimated 33.85 km^3/year and reserves of groundwater with salinity rate up to 10 g/litre are an estimated 57.63 km^3/year (UNDP, 2004). Annual renewable groundwater resources in Kazakhstan are an estimated 33.85 km^3/year, of which 26 km^3/year corresponds to the overlap with surface water resources. Total actual renewable water resources (TARWR), including agreements, can thus be estimated at 107.48 km^3/year (=99.63+33.85-26).

In 2010, the total direct use of treated wastewater was 0.194 km^3 (WRC, 2011). Direct use of agricultural drainage water was 0.108 km^3. In 2002, about 0.150 km^3 of wastewater and 0.030 km^3 of agricultural drainage water were directly used (UNDP, 2004). In 2010, desalinated water produced was 0.853 km^3 (WRC; Agency of Statistics 2011). In 1993, total wastewater produced was 1.8 km^3/year, of which 0.270 km^3/year was treated and used directly.

In 1993, about 1.3 km^3 of Caspian Sea water was desalinated by the Mangistau nuclear power plant, for industry and to supply water to the cities of Mangistau and Novi Uzen. In 2002, water withdrawn from the Caspian Sea was an estimated 0.64 km^3 (UNDP, 2004).

Lakes and dams

The Caspian Sea is the largest lake in the world. Its level currently varies significantly. During the 1990s, the Caspian Sea level rose by about 2 m, which resulted in waterlogging of towns and villages, and the loss of agricultural land. On the other hand, the level and volume of the Aral Sea has dramatically decreased, mainly because of irrigation development upstream. This has resulted in environmental problems, which have been tentatively addressed by the Central Asia Interstate Commission for Water Coordination (ICWC).

Excluding the Caspian and Aral seas, there are 48 262 lakes, ponds and reservoirs that cover 45 000 km^2, estimated volume of water 190 km^3. The number of small lakes, with a surface area of less than 1 km^2, accounts for 94 percent of these lakes but only 10 percent of the total area. There are 3 014 large lakes that have a surface area of more than 1 km^2, with a total surface area of 40 800 km^2, including 21 lakes that are over 100 km^2 with a total surface area of 26 900 km^2, or 59 percent of the total; 45 percent of all lakes are in the north, 36 percent in the centre and south and 19 percent in other regions (UNDP, 2003). The largest lakes are: lake Balkhash, 18 000 km^2, volume 112 km^3; lake Zaisan about 5 500 km^2; and lake Tengiz, with an area of 1 590 km^2. The main natural depression is the Arnasay depression where lake Aydarkul, with a capacity of 30 km^3, was created artificially with water released from the Chardarya reservoir and with the return flow from the Hunger steppe irrigated land, which is shared with Uzbekistan.

Kazakhstan is dominated by vast desert plains and high mountain ranges to the east of the plains, which create particularities in the normal water cycle where glaciers play an important role, being the only freshwater reservoirs. The majority of glaciers are located in the south and east at more than 4 000 m above sea level. There are 2 724 glaciers covering 1 963 km^2. The glaciers contain 95 km^3 of water, which is almost equal to the annual flow of all rivers in the country (UNDP, 2003).

More than 200 water reservoirs have been constructed, for a total capacity of 95.5 km^3, not counting ponds, small reservoirs and seasonally regulated reservoirs (UNDP, 2003). There are 19 large reservoirs, with a capacity of over 0.1 km^3 each, accounting for 95 percent of total capacity. Most reservoirs are designed for seasonal flow regulation, only about 20 reservoirs are regulated year-round. The largest reservoirs, with a capacity of over 1 km^3 are Bukhtarma on the Irtysh river, with a total capacity of 49.6 km^3, Kapshagay on the Ili river in the Balkhash basin with 18.6 km^3, Chardarya on the Syr Darya river at the border with Uzbekistan with 5.2 km^3, Shulba on the Irtysh river with 2.4 km^3. Most are multipurpose: hydropower production, irrigation and flood control. The reservoirs in the eastern and southeastern regions are mainly used for agriculture and in the central, northern and western regions for drinking water and industry. Bukhtarma, Shulba, Kapshagay and Chardarya are all connected to hydroelectric power stations to generate electricity (UNDP, 2003 and 2004).

Reservoir capacity in the Irtysh river basin is the largest in Kazakhstan. Besides the Bukhtarma and Shulba, an additional reservoir has been constructed on the Irtysh river, the Ust-Kamenogorsk reservoir, total capacity 0.7 km^3, which regulates the river's flow (UNDP, 2004).

In 1997, the gross theoretical hydropower potential was an estimated 110 000 GWh/year, with an economically feasible potential of about 35 000 GWh/year. Total installed capacity of the hydropower plants exceeds 3 GW. Hydroelectricity represents 12 percent of total electricity generation, which meets only 85 percent of total electricity demand, the remainder being imported from neighbouring countries.

International water issues

Collaboration between countries concerning water allocation is important for Kazakhstan, the problem of sharing is one of the priorities of foreign policy, specifically because a considerable portion of the country is located in the lower reaches of transboundary rivers.

During the Soviet period, the sharing of water resources among the five Central Asian republics was based on the master plans for development of water resources in the Amu Darya (1987) and Syr Darya (1984) river basins.

After gaining independence, regional cooperation regarding water resources management needed strengthening. Based on the principle of equal rights and efficient use, passed in 1992, the parties entered into a number of agreements to regulate cooperation for joint management, protection and use of water resources. The first intergovernmental agreement (1992) established the ICWC. International agreements have addressed water allocation between Kazakhstan and its neighbours:

- For the Syr Darya, the existing principles governing water sharing among the Central Asian countries (Agreement of 18 February 1992) remains valid until the adoption of a new water strategy for the Aral Sea basin, endorsed by the ICWC. Under the agreement, the part of the Syr Darya surface water resources allocated to Kazakhstan has to be no less than 10 km^3/year downstream of the Chardarya reservoir.
- For the Chu and Talas rivers, flowing in from Kyrgyzstan, an interstate agreement was reached with Kyrgyzstan in 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 water evaporated from the lakes and reservoirs. On average, surface water resources allocated to Kazakhstan are considered to be 1.24 km^3/year for the Chu basin and 0.79 km^3/year for the Talas and Assa river basin.

This new agreement was confirmed by the 'Agreement on joint actions to address the problem of the Aral Sea and socio-economic development of the Aral Sea basin', signed by the Heads of the five states in 1996. Over the years, the main achievement of the ICWC has been a conflict-free supply of water to all water users, despite the complexities and variations of dry and wet years.

In 1993, with the development of the Aral Sea basin programme, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) to coordinate implementation of the programme and the International Fund for Saving the Aral Sea (IFAS) to raise and manage its funds. In 1997, the two organizations merged to create IFAS (UNDP, 2004).

The most acute disagreement in the Syr Darya basin relates to the operation of the Toktogul reservoir in Kyrgyzstan, leading to a clash of interests between Kyrgyzstan, Uzbekistan and Kazakhstan. The two downstream countries are interested in maintaining storage for summer irrigation from the Toktogul reservoir, whereas winter energy generation from the reservoir is beneficial to Kyrgyzstan. A similar set of issues exist between Tajikistan and Uzbekistan regarding the management of Karikkum reservoir in Tajikistan. Changes in the operations of the Toktogul reservoir have led to the following negative developments in Kazakhstan (UNDP, 2004):

- worsening conditions for agriculture in the region: insufficient water for irrigation;
- deteriorating social, economic and living conditions of the population;
- non-productive water loss to the Aral Sea, when its winter surpluses (resulting from insufficient carrying capacity of the lower flow of the river) overfill the Chardarya reservoir and have to be released into the Arnasai depression in Uzbekistan;
- flooding of populated areas and agricultural land in Uzbekistan, Tajikistan and Kazakhstan;
- worsening environmental and sanitary situation in the basin;
- decreasing regulation capacity of Toktogul reservoir.

In 1998, Kazakhstan, Kyrgyzstan and Uzbekistan signed an agreement concerning dams in the upper Syr Darya river basin, which includes provisions for Kazakhstan and Uzbekistan to share equally in the purchasing of summer hydropower from Kyrgyzstan, while payments can be made in cash or by delivery of coal or gas (SIWI, 2010).

Three rounds of experts' negotiations have been held with China to discuss management of cross-border rivers. Kazakhstan and China agreed on a list of 23 cross-border rivers and the scope of work. In 2001, the governments of Kazakhstan and China signed a cooperation agreement for the use and protection of cross-border rivers. China is unilaterally beginning to implement plans to expand the use of water resources from the Irtysh and Ili rivers within its borders and has declared its intent to accelerate full-scale development of western China, which is one of the most underdeveloped regions of the country. This plan includes the building of a water canal Cherniy Irtysh-Karamai in the Jingxian-Uighur Autonomous Region. Part of the water from the upstream Irtysh river will be transferred along the canal to the oilfield region near Karamai (UNDP, 2004). In 2009, China and Kazakhstan discussed the reasonable and mutually acceptable use and protection of transboundary river resources (SIWI, 2010).

Several cross-border rivers link Kazakhstan and the Russian Federation to each other. The main rivers include the Ural, Irtysh, Ishim and the Tobol.

Considering the circumstances, an interstate agreement between Kazakhstan and the Russian Federation on the joint use and safeguarding of cross-border water facilities was signed in 1992. Based on this agreement, a Kazakhstan-Russia committee meets twice a year to approve the work schedule for reservoirs designated for joint use, set limits for water extraction and develop measures for the repair and operation of water facilities designated for joint use. In 1997 the validity of the agreement was extended to 2002, and further extended for another five years to 2006 (UNDP, 2004). In 2010, the agreement on joint use and protection of transboundary water bodies between the Russian Federation and Kazakhstan was signed, based on the principles of the 17 March 1992 Convention concerning protection and use of transboundary watercourses and international lakes. Both parties are members of this United Nations Economic Commission for Europe (UNECE) Convention.

Kazakhstan, Uzbekistan and the Russian Federation are exploring the possibility of diverting the Ob and Irtysh rivers. The proposed project consists of building a canal from Siberia, across Kazakhstan, to Uzbekistan. In theory, the project would solve the problem of the limited water resources available to Uzbekistan. The project would also enable the Russian Federation to play a greater role in the region and especially in Uzbekistan. There are fears related to salinization of water during transfer, significant technical issues and the possibly high cost to Central Asia of financial and geopolitical costs (SIWI, 2010).

The International Caspian Environmental Programme (CEP) was developed in 1997 to encourage cooperation in protection of the environment in the Caspian Sea region. In 1998, the Global Environment Facility (GEF) project addressing transboundary environmental issues in the Caspian Sea region was established under the CEP framework. The governments of the Caspian Sea countries, took it upon themselves to ensure its implementation, and approved the project. The GEF project, implemented at regional and national levels, has set up organizational structures to develop a coordinated mechanism to manage the Caspian Sea regional environment.

The Syr Darya Control and North Aral Sea Phase I Project, currently underway, is the first phase of the rehabilitation of the Syr Darya river and was identified under the Aral Sea Basin Programme, approved by the heads of the five Central Asian States in 1994. The objectives of the project are: to sustain and increase agriculture (including livestock) and fish production in the Syr Darya basin in Kazakhstan, to maintain the Northern Aral Sea and to enhance ecological/environmental conditions for improved human health and conservation of biodiversity. The project's components include: building water infrastructure to rehabilitate the Northern Aral Sea, improving the hydraulic control of the Syr Darya river, rehabilitating the Chardarya dam, restoring aquatic resources and promoting fisheries development and building institutional capacity. To maintain the integrity of the Northern Aral Sea, the 13 km Kok-Aral dyke was constructed to separate the Northern Aral Sea from the South Aral Sea, it was completed in August 2005. Several additional hydraulic structures were constructed on the river and existing hydraulic structures and the Chardarya dam were rehabilitated to increase the flow capacity of the Syr Darya river. The successful restoration efforts initiated by Phase I provided a catalyst for approval of Phase II in 2009. Efforts are continuing to improve water resources management in the Kazakh portion of the Syr Darya river basin. Based on the results obtained during Phase I, Phase II should ensure further improvements to the supply of irrigation water for agriculture, revitalization of the fisheries industry, enhanced public health and ecosystem recovery in the Aral Sea (World Bank, 2008).

In 2000 Kazakhstan and Kyrgyzstan signed an agreement regarding shared water resources of the Chu and Talas rivers, where the parties agreed to share operational and maintenance costs for transboundary infrastructure in proportion to the received water amounts (SIWI, 2010).

The European Union Water Initiative (EUWI) and its Eastern Europe, Caucasus and Central Asia (EECCA) programme is a partnership that seeks to improve water resources management in the EECCA region. In 2002, a partnership was established between the EU and the EECCA countries at the World Summit for Sustainable Development. A significant component is 'Integrated water resources management, including transboundary river basin management and regional seas issues' (SIWI, 2010).

In 2002, the Central Asian and Caucasus (CACENA) Regional Water Partnership was formed under the Global Water Partnership (GWP). Within this framework, state departments, local and regional organizations, professional organizations, scientific and research institutes, as well as the private sector and NGOs, cooperate to establish a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for the Economies of Central Asia (UN-SPECA). In collaboration with EUWI and UNECE it is engaged in developing integrated water resources management in the Central Asian States. In cooperation with Germany and other countries of the EU, UNECE may also play a role in the implementation of the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

Water use

Water withdrawals increased regularly until the mid-1980s. Over the past two decades withdrawals have slightly decreased in the agricultural sector mainly because of the adoption of water conservation methods, and in industry as a result of the sector's decline since independence.

Total annual water withdrawal fluctuated between 19.7 and 28.8 km^3 during 1995–2002 (UNDP, 2003).

In 2010, total water withdrawal was an estimated 21.143 km^3, of which 14.002 km^3 or 66 percent was for agriculture (including irrigation, livestock and aquaculture), 0.878 km^3 or 4 percent for municipal, 6.263 km^3 or 30 percent for industry (Figure 1 and Table 3). Of total withdrawal, 18.959 km^3 or 89.7 percent is for primary and secondary surface water, 1.029 km^3 or 4.9 percent, primary and secondary groundwater, 0.853 km^3 or 4 percent desalinated water, 0.194 km^3 or 0.9 percent direct use of treated wastewater, and 0.108 km^3 or 0.5 percent direct use of agricultural drainage (Figure 2).

Water from the Syr Darya, Ili, Chu, Talas and Irtysh rivers is mainly used for irrigation. The most intensive use is in Kyzylorda, South Kazakhstan and Almaty provinces, where 90 percent of overall irrigation water is used (UNDP, 2003).

Central heating energy enterprises, metallurgy and the oil industry account for the bulk of industrial water withdrawal. Three provinces use 90 percent of all industrial water: Karagandy (43 percent), Pavlodar (41 percent) and East Kazakhstan (6 percent) (UNDP, 2003).

FIGURE 1
Water withdrawal by sector
Total 21.143 km³ in 2010

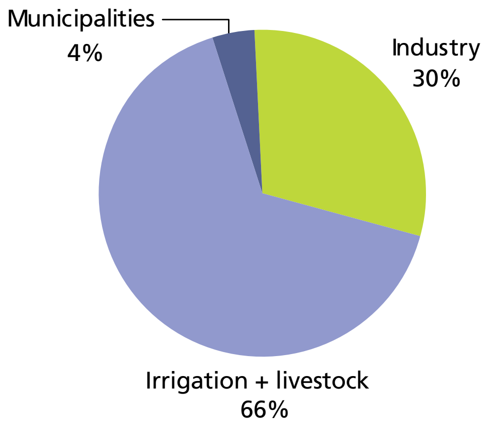


FIGURE 2
Water withdrawal by source
Total 21.143 km³ in 2010

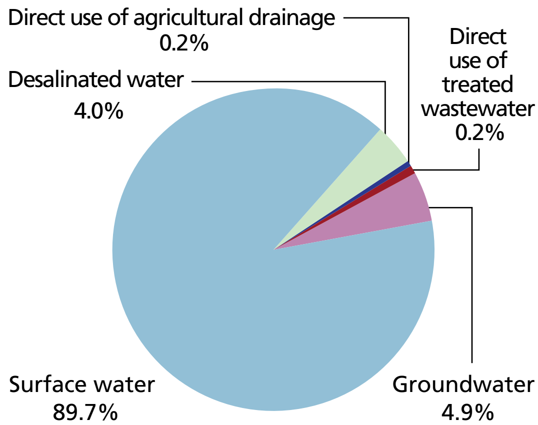


TABLE 3
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	250	mm/yr
	-	681 225	million m^3/yr
Internal renewable water resources (long-term average)	-	64 350	million m^3/yr
Total actual renewable water resources	-	107 480	million m^3/yr
Dependency ratio	-	40	%
Total actual renewable water resources per inhabitant	2011	6 632	m^3/yr
Total dam capacity	2010	95 500	million m^3
Water withdrawal			
Total water withdrawal by sector	2010	21 143	million m^3/yr
- agriculture	2010	14 002	million m^3/yr
- municipalities	2010	878	million m^3/yr
- industry	2010	6 263	million m3/yr
• per inhabitant	2010	1 319	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	2010	19 988	million m^3/yr
• as % of total actual renewable water resources	2010	19	%
Non-conventional sources of water			
Produced municipal wastewater		-	million m^3/yr
Treated municipal wastewater		-	million m^3/yr
Direct use of treated municipal wastewater	2010	194	million m^3/yr
Desalinated water produced	2010	853	million m^3/yr
Direct use of agricultural drainage water	2010	108	million m^3/yr

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Irrigation potential is an estimated 3 768 500 ha.

In 1992 and 1993, the full control area equipped for irrigation was 2.24 million ha and 2.31 million ha respectively (UNDP, 2004 and FAO, 1997). During the following decade there was a sharp decrease, to less than 1 million ha in 2002, caused by the collapse of many state farms during the transition period, because they were unable to compete in the new market economy.

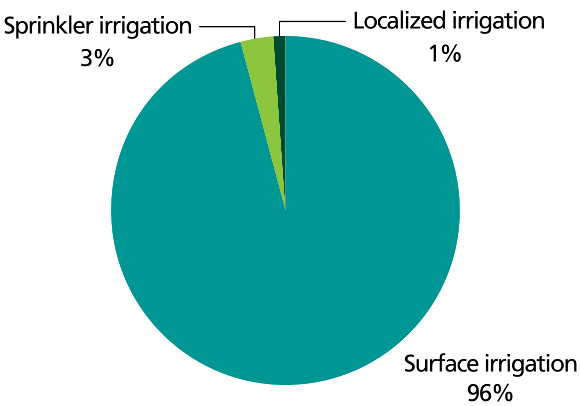
In 2010 the area equipped for full control irrigation was an estimated 1 199 600 ha, of which 96.6 percent surface irrigation, 2.5 percent sprinkler irrigation and 0.9 percent localized irrigation (Table 4 and Figure 3) (Kazgiprovodkhoz, 2010). In the northern regions sprinkler irrigation was the dominant technique in 1990 on about 667 000 ha in 1990. This fell, however, to about 549 600 ha in 1993 and in 2010 to 30 000 ha. In 2010, the area equipped for full control irrigation on actually irrigated area was an estimated 1 182 100 ha, or 98.5 percent of the area equipped for full control irrigation. The area covered by spate irrigation is 866 300 ha, but in 2008 only 82 870 ha were actually irrigated (Kazgiprovodkhoz, 2010). This brings the total area equipped for irrigation to 2 065 900 ha, of which 1 264 970 ha, or 61 percent, is actually irrigated.

Most of the area that has been equipped for full control irrigation (about 93 percent) is in four southern regions, in the Syr Darya and Chu, Talas and Assa, and Ili river basins, distributed as follows: South Kazakhstan 36 percent, Almaty 37 percent, Kyzylorda 12 percent and Jambyl 15 percent. The most commonly irrigated crops are cereals (wheat, maize, rice and barley), cotton, oil crops (sunflower and soybeans) and fodder (permanent and temporary grasses and maize for silage). In nine northern regions the area equipped for full control irrigation (7 percent) is distributed as follows: East Kazakhstan 29 percent, Pavlodar 11 percent, Akmola 8 percent, North Kazakhstan 1 percent, Karagandy 13 percent, Kostanai 10 percent, Aktobe 15 percent, West Kazakhstan 6 percent and Atyrau 7 percent.

The most commonly irrigated crops are potatoes, vegetables, grains and permanent grasses. The largest irrigation schemes in South Kazakhstan region include Maktaaral (138 800 ha), Aris-Turkestan (106 200 ha), Kyzylkum (76 100 ha), Shauldersky (36 500 ha) and Keles (64 500 ha). In Jambyl region large schemes cover 105 900 ha. In Almaty region irrigation schemes include Akdalinsky (30 700 ha) and other smaller schemes. In Kyzylorda region irrigation schemes include Kyzylordinskie Pravoberezhny and Levoberezhny, Kazalinsky Pravoberezhny and Levoberezhny.

In 1993, the area equipped for full control irrigation in the Syr Darya river basin was 32 percent of the total and in the Chu and Talas river basins 10 percent. About 45 percent of the area covered by spate irrigation was located in the Caspian Sea basin. The equipped wetland and inland valley bottoms were spread throughout the country and were mainly cultivated as pastures or for hay.

FIGURE 3
Irrigation techniques on area equipped for full control irrigation
Total 1 199 600 ha in 2010



According to a World Bank report, almost 680 000 ha of irrigated land were not being used because of soil salinization, waterlogging, incomplete distribution systems, improper farming practices, limited inputs: fertilizers and fuel and, in some instances, lack of water.

In 2010, the source of irrigation water for full control irrigation was mainly surface water, covering 99.8 percent of the area (Figure 4). In 1993, the full control irrigation area received water as follows: 32 percent from river diversion, 32 percent from reservoirs, 26 percent from pumping from rivers, 8 percent from groundwater and 2 percent from the direct use of agricultural drainage water.

TABLE 4
Irrigation and drainage

Irrigation potential			3 768 000	ha
Irrigation				
1. Full control irrigation: equipped area		2010	1 199 600	ha
- surface irrigation		2010	1 158 800	ha
- sprinkler irrigation		2010	30 000	ha
- localized irrigation		2010	10 800	ha
• % of area irrigated from surface water		2010	99.8	%
• % of area irrigated from groundwater		2010	0.2	%
• % of area irrigated from mixed surface water and groundwater			-	%
• % of area irrigated from mixed non-conventional sources of water			-	%
• area equipped for full control irrigation actually irrigated		2010	1 182 100	ha
- as % of full control area equipped		2010	98.5	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation		2008	866 300	ha
Total area equipped for irrigation (1+2+3)		**2010**	**2 065 900**	**ha**
• as % of cultivated area		2010	9	%
• % of total area equipped for irrigation actually irrigated		2010	61	%
• average increase per year over the last 17 years		1993-2010	-3.1	%
• power irrigated area as % of total area equipped		2010	1.9	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2010**	**2 065 900**	**ha**
• as % of cultivated area		2010	9	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< 10 000 ha	2002	424 000	ha
Medium-scale schemes	> 10 000 ha and < 20 000 ha	2002	200 000	ha
Large-scale schemes	> 20 000 ha	2002	343 000	ha
Total number of households in irrigation		2010	130 000	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production (wheat and barley)			-	metric tons
• as % of total grain production			-	%
Harvested crops				
Total harvested irrigated cropped area		2010	1 182 100	ha
• Temporary crops: total		2010	921 550	ha
- Wheat		2010	208 000	ha
- Maize		2010	95 600	ha
- Rice		2010	94 000	ha
- Barley		2010	92 000	ha
- Vegetables		2010	182 600	ha
- Cotton		2010	134 200	ha
- Potatoes		2010	60 000	ha
- Oil seeds		2010	40 000	ha
- Sugar beet		2010	8 720	ha
- Tobacco		2010	1 600	ha
- Other temporary crops		2010	4 830	ha
• Permanent crops: total		2010	80 000	ha
- Fodder		2010	26 000	ha
- Fruits and grapes		2010	54 000	ha
• Permanent meadows and pastures		2010	180 550	ha
Irrigated cropping intensity (on full control area actually irrigated)		2010	100	%
Drainage - Environment				
Total drained area		2010	343 000	ha
- part of the area equipped for irrigation drained		2010	343 000	ha
- other drained area (non-irrigated)			-	ha
• drained area as % of cultivated area			-	%
Flood-protected areas			-	ha
Area salinized by irrigation		2010	404 300	ha
Population affected by water-related diseases		2000	3 220	inhabitants

FIGURE 4
Source of irrigation water on area equipped for full control irrigation
Total 1 199 600 ha in 2010

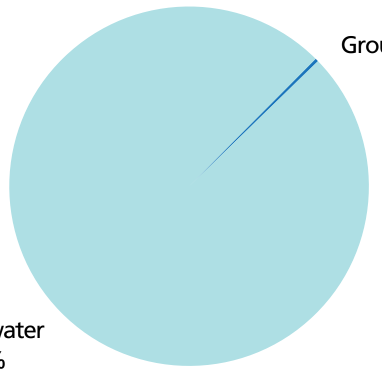
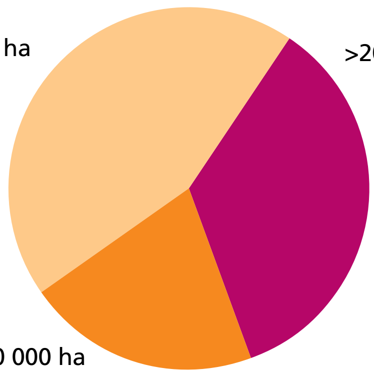


FIGURE 5
Type of full control irrigation schemes
Total 967 000 ha in 2002



The Kirov interstate canal (Kyrgyzstan-Kazakhstan) is an important hydraulic infrastructure, which was constructed from 1913 to 1957 in the Talas river basin to irrigate the Hunger steppe. The canal has a capacity of 220 m^3/s at his head and is 137 km long. The Irtysh-Karagandy canal was constructed between 1962 and 1974 to supply the water-scarce region of Karaganda with water from the Irtysh river. It is about 458 km long with a capacity of 76 m^3/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.

Other main canals are the Dostyk interstate canal that takes water from the Syr Darya river in Uzbekistan and delivers it to South Kazakhstan region, the Kyzylkum and Arys main canals in South Kazakhstan, the Kyzylordinskie Pravoberezhny and Levoberezhny main canals and the Kazalinsky Pravoberezhny and Levoberezhny main canals in Kyzylorda region, the Big Chu interstate canal in (Kyrgyzstan-Kazakhstan) in Jambyl region, and the Grand Almaty canal in Almaty region. There are an estimated 14 000 km of inter-farm canals in Kazakhstan.

In 2002, out of the total 967 000 ha of regular irrigation, irrigation schemes smaller than 10 000 ha totaled 424 000 ha (44 percent). Schemes of between 10 000 and 20 000 ha occupied 200 000 ha (21 percent), and schemes larger than over 20 000 ha occupied 343 000 ha (35 percent) (Figure 5).

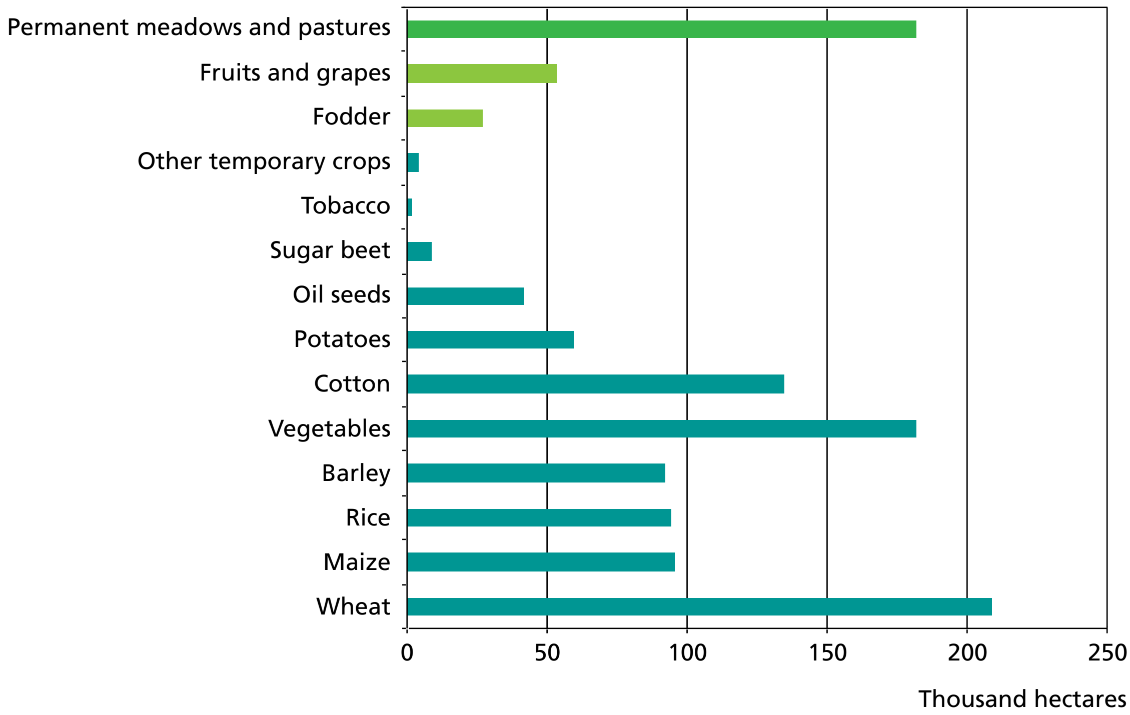
Role of irrigation in agricultural production, economy and society

In 2010, harvested irrigated area was 1 182 100 ha, of which 78 percent temporary crops and 22 percent permanent crops and permanent meadows and pasture. The main temporary irrigated crops are: wheat (18 percent), maize, rice and barley (about 8 percent each), vegetables (15 percent), cotton (11 percent) (Table 4 and Figure 6).

In 1993, wheat, rice, cotton and potatoes were the major export crops and the irrigated crop yields were 1.5 tonnes/ha for wheat, 4.3 tonnes/ha for rice, 1.8 tonnes/ha for cotton, 3 tonnes/ha for maize and 2.5 tonnes/ha for grapes. Fodder crops, required for winter-feeding of the large livestock population, were grown in many areas where salinity and poor drainage conditions prevented cultivation of other crops. The fodder crop yields declined 15–40 percent in the first years of the 1990s.

In 1993, the development cost of irrigation schemes for rice using unlined canals, predominant along the Syr Darya river in the south, was US$3 500–5 000/ha. Furrow irrigation systems in the south were US$3 700–5 800/ha. The development of sprinkler irrigation in the centre

FIGURE 6
Irrigated crops on area equipped for full control irrigation
Total harvested area 1 182 100 ha in 2010 (cropping intensity on full control area actually irrigated: 100%)



of the country amounted to US$5 500–7 200/ha. Between 1985 and 1990, the average cost of irrigation 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.

Status and evolution of drainage systems

In 1993, out of the total irrigated area of 2 313 100 ha, over 700 000 ha required drainage, though it had been developed on only 433 100 ha. Horizontal surface water accounted for 264 600 ha or 61 percent of the total drainage area. The area equipped with subsurface drains amounted to 15 600 ha (4 percent), while vertical drainage was carried out on about 152 900 ha (35 percent). These two drainage techniques were developed on reclaimed areas in the 1990s, these are the Hunger steppe, the Kyzylkum scheme and the Kyzyl-Orda scheme, all are in the south. Almost all drained areas (99 percent) are located in the five southern provinces. 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 carried out 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 percent of the vertical drainage systems are not used because of the high cost of pumping. There is also the significant problem of disposal of highly saline water. In 2010, the area equipped for irrigation with a drainage system was 343 000 ha (Table 4).

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

Institutions

The State manages water resources in Kazakhstan, an authorized state body the Water Resources Committee, manages water use and conservation, local representatives and executive bodies (*maslikhats, akims* or *oblasts*, cities, districts, *auls*/villages), and other state bodies, manage aspects of water use within their competencies. For example, groundwater management is carried out by the WRC in cooperation with the state body for geology and conservation of mineral resources. Other specialized authorized state bodies involved in water use and conservation include those dealing with environmental protection, mineral resources, fishery, flora, fauna, and state sanitary and veterinary supervision. The relationships between state management bodies concerning the rational use and conservation of water is regulated by Kazakhstan's legislation (UNDP, 2004).

The WRC of the Ministry of Agriculture carries out state management and protection of water resources at the national level; participates in the development and implementation of state policies for use and protection of water resources; develops programmes for the development of the water sector; and plans complex use and protection of water resources; issues licenses for special water use; allocates water resources between territories and sectors; adopts standard rules for water use and cooperates with neighbouring countries on water relations and other functions.

The basin water management units are territorial subdivisions of the WRC and provide integrated management of water resources and coordination between water users in the basin (UNDP, 2004). They carry out integrated management of the use and protection of water resources at the basin level, coordinate activities concerning water relations within the basin, perform state control of use and protection of water resources and compliance with water legislation, conduct state accounting, monitoring and public water inventory in conjunction with the environmental bodies and agencies for geology, protection of natural resources and hydrometeorology, issue licenses for special water use and other functions.

The Ministry of Environment carries out state control over the environment and issues permits to discharge treated wastewater into natural water bodies. The Republican State Enterprise 'Kazgidromet' of the Ministry of Environment monitors the country's quantity and quality of surface water resources.

The Committee of State Sanitary and Epidemiological Surveillance oversees drinking water quality.

Local representatives (*maslikhats*) and executive (*akimats*) bodies manage water relations at the regional level, within their authorities. For example, *maslikhats* set the rules for common water use, based on regulations approved by the authorized body. They also approve regional programmes for the rational use and conservation of water bodies, control their implementation and regulate the leasing of water facilities under communal administration. *Akimats* set up water organizations to manage and maintain water facilities under communal administration. They also define water conservation areas and sanitary zones to protect sources of potable water supply, in coordination with basin water bodies and territorial bodies for geology and sanitary controls; transfer water bodies into separate or joint use, in coordination with the authorized body; work out and implement regional programmes for the rational use and conservation of water bodies; and coordinate the location and use of enterprises and structures affecting water, as well as conditions of work on ponds and in water conservation areas; and impose restrictions on the use of water bodies (UNDP, 2004).

The first water user organizations (WUAs) were established in 1996.

Water management

In 1993, *sovkhoz* (state farms) and *kolkhoz* (collective farms) were still predominant in Kazakhstan covering 92 percent of the cultivated area, which accounted for 35 million ha, with private plots covering 0.6 percent, and the joint stock companies and farmers associations 7.4 percent. The land reform process was extended further after 1994, and most land was transferred to farmers or companies, through private ownership or long-term leases (99 years).

State water management in Kazakhstan is based on the principles of recognizing the national and social importance of water resources, sustainable water use, separating the functions of state control and management and basin management. Based on these principles, in 1998 the government began structural reorganization of the water system, aimed at clear assignment of responsibilities at national and local levels. According to Government Resolution No. 1359 of 30 December 1998, *oblast* committees for water resources were reorganized into "republican state enterprises for water", charged with technical maintenance of hydrosystems, water headworks, mains systems, pumping stations, group water pipelines, i.e. the facilities that provide consumers with water. The next stage of reform was the 2001–2002 transition of water facilities (excluding facilities of national importance) from national to communal ownership, as well as assigning the local level with the authority to manage them. Delineation of water resources management functions and improving the mechanisms of regulating water use allows consideration of the interests of water users, both within the entire basin and in a certain area. It also allows effective measures to be taken to protect basin waters from exhaustion (UNDP, 2004).

A number of water projects of national and regional importance are being implemented at national and basin levels. For example, the construction of hydraulic structures for various purposes in the surface water bodies, construction of groundwater intakes, regulation of river flows and modes of operation for large reservoirs, implementation of measures for maximum reduction of loss of water and its supply and distribution. At state level management, operation and maintenance of state-run water networks and facilities is carried out as well as control over the operation of water facilities owned by cooperatives, WUAs and individuals to ensure the safety and effectiveness of these facilities.

Because of the lack of national funds to address water issues, leading to deterioration of facilities and structures, there is a need to involve the private sector in the water sector – mostly in water supply and rehabilitation and maintenance of water systems. In forming this water 'market', the basin water management units will play an important role in setting clear goals for privatization in the water industry and elaborating its rules and legal base (UNDP, 2004).

The country is seeking assistance from international financial institutions to resolve water sector issues such as the World Bank, Asian and Islamic Development Banks, UNDP and others. Germany, Japan, France, the United Kingdom, Austria and Kuwait will provide assistance and support to resolve water issues in Kazakhstan. The WRC project management team is coordinating implementation of the following water management projects funded by foreign loans and grants (UNDP, 2004): regulation of the Syr Darya riverbed and preservation of the northern portion of the Aral Sea (Phase 1); water supply for the towns of Aralsk, Kazalinsk and Novokazalinsk; water supply and sanitation for northeast Kazakhstan; restoration and management of the environment in the Nura-Ishim basin.

The UNDP Project 'National integrated water resources management and water efficiency plan' has the following goals: Development of a national integrated water resources management (IWRM) and water efficiency plan; creation of river basins councils; and development of a strategy for achieving Millennium Development Goals (MDG) on water supply and sanitation. The project supports a campaign for raising public awareness in regard to the water situation in the country, the importance of MDGs, principles of IWRM and the importance of achieving those (UNDP, 2006).

The government is attending to water supply and water allocation. The programme 'Ak Bulak' was developed to provide quality drinking water and wastewater services from 2011 to 2020. The programme is designed in accordance with the Strategic Plan of Development of the Republic of Kazakhstan until 2020, approved by the the President of the Republic of Kazakhstan's Decree No. 922, dated 1 February 2010. This programme provides for the protection of water sources from pollution by sewage; involves private capital in water supply and water removal; maintains the efficient and profitable operation of enterprises and organizations; upgrades water supply and drainage systems; maximizes use of groundwater for drinking water supply and improves the quality of design and survey work for water management.

Finances

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.

Water user fees fund maintenance of hydraulic structures and water facilities. Facilities on state property that are import to the nation and *oblasts*, are partly funded by the national budget (UNDP, 2004). Rates for water supply services to water users, water delivery and water drains are approved in accordance with Kazakhstan legislation on natural monopolies and regulated markets. The procedure and terms of payment for water supply services are determined by the agreements between the parties.

Despite numerous water-related problems over the 1990s, the government has taken measures to help ameliorate this critical situation. As of 2002, the government resumed financing of the water sector and allocated US$6 million in that year, for a total of US$15 million. The national 'Drinking water programme', which was passed by the government, commited to investing US$40 million to implement the programme until 2010 (UNDP, 2004).

Policies and legislation

During the Soviet period the Law of 1970 'Basics of water legislation of the USSR and Union Republics' and the Water Code of the Kazakh SSR of 1972 served as a legal framework for water relations. After declaring sovereignty in 1993 Kazakhstan adopted the Water Code of the Republic of Kazakhstan. Over the past period many provisions of the prior Water Code of the Republic of Kazakhstan (1993) have become obsolete and are constraining market reforms in the water sector (UNDP, 2004).

In 2003, a new Water Code was adopted, which was required to address development of market relations in the water sector and agriculture. Specifically, the new Water Code provides for transfer of waterworks facilities to water users for rent, trust management or use without charge. The document was based on the international principles of the fair and equal access of water users to water; priority was given to drinking water supply. The new Water Code designated the WRC to issue all approvals related to surface water and groundwater. Prior to this, the Committee of Geology and Conservation of Earth Resources, under the Ministry of Power Engineering and Mineral Resources was in charge of issues pertaining to the use and protection of groundwater (UNDP, 2004).

An important innovation of the Water Code has been the strengthening of the principles of water management related to basins. For example, the role and goals of the Basin Water Departments, previously defined by WRC, are now included in the Water Code. In order to define and coordinate the activities of various governmental and non-governmental entities, such as WUAs, non-governmental water organizations, and basin councils. the Water Code provides for their entering into basin agreements to rehabilitate and protect water sources.

A basin council is an advisory body at the basin level that jointly resolves issues related to water fund use and the protection and implementation of signed basin agreements. In addition, the Code focused attention on transboundary waters and included a special section on international cooperation (UNDP, 2004). In 2009 the Code was amended and supplemented.

The Land Code contains a special chapter on water fund land, which includes land occupied by reservoirs, hydraulic structures and other water facilities, as well as water protection areas and strips and zones that provide sanitary protection of water intakes for drinking water. The main economic purpose of water fund land is to serve the use and protection of water. This type of land, therefore, is subject to special legislative provisions specifically reflecting the legal status of land in this category.

The Code on 'Administrative Offences' of 2001 sets out the responsibilities of legal entities and individuals for violation of the water legislation of Kazakhstan (UNDP, 2004).

In 2003, the 'Law on rural consumer cooperatives of water users' was adopted. This law deals with issues pertaining to the rights and responsibilities of water users, water management at sources for irrigation and water supply development, procedures for establishing rural WUAs, the legal capacity of these associations, membership, property rules, as well as procedures for the reorganization and liquidation of such associations (UNDP, 2004).

The Environmental Code (2007) defines the legal, economic and social basis of environmental protection. It regulates the use of natural resources, including protection from domestic and industrial pollution. The Code also establishes a framework for economic instruments, such as payment for the use of natural resources and disposal of household and industrial waste as well as economic incentives for environmental protection.

ENVIRONMENT AND HEALTH

Most of Kazakhstan is located in the arid zone, agriculture in these circumstances is extremely risky, and most grassland belongs to the desert or semi-arid type. Peculiarities of the country's location at the centre of the Eurasian continent, with the associated climatic characteristics, means that Kazakhstan is among those countries having the most vulnerable ecosystems.

The quality of most water sources is unsatisfactory. Most water pollution is caused by discharge from the chemical, oil, manufacturing and metallurgical industries. Out of 44 water sources researched by the Kazakhstan Hydrometeorology Service Bureau, in 2002 only nine rivers, two lakes and two reservoirs where considered to be clean water sources; six rivers and one reservoir were listed as dirty or very dirty. In addition to industrial, extracting and refinery enterprises there are other polluters such as urban buildings, farms, irrigated fields, waste containers and storage facilities for liquid and solid wastes and oil products (UNDP, 2003).

The environmental crisis in the Aral Sea basin is a major disaster that has affected the territories of all five riparian Central Asian states, with a total population of over 40 million people. The intensive extraction of water for irrigation from the Amu Darya and Syr Darya rivers over the last 40 years has caused the level of the Aral Sea to fall by 17 19 m and reduced the volume of its water resources by 75 percent. As a result, the mineral (saline) concentration of the seawater has increased from 10 to 60 percent (UNDP, 2004). By the end of the 1980s, the Aral Sea no longer reached its former borders. As the waters receded, the Aral Sea split into the Northern Aral Sea within Kazakhstan and the larger South Aral Sea shared by Kazakhstan and Uzbekistan.

The desiccation of the Aral Sea has resulted in serious economic, social, and environmental degradation. Fresh fish production has virtually disappeared, salinity and pollution levels have risen dramatically, dust and salt storms have occurred often, and there have been measurable changes to the local climate. Drinking water supplies became polluted and human health problems increased sharply. Tens of thousands of jobs were lost in the fishing, agricultural and service sectors (World Bank 2008). In 2002, the heads of the Central Asian states decided to develop a 'Programme of concrete action to improve the environmental and economic environment of the Aral Sea basin for 2003-2010' (UNDP, 2004).

Salinity in lakes varies from 0.12 g/litre in east Kazakhstan to 2.7 g/litre in the central region. More than 4 000 lakes have been inventoried as saline. Irrigation development during the 1980s and 1990s 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. It has been estimated that about 8 000 small lakes have dried up recently because of the overexploitation of water resources.

In 1993, about 242 000 ha (11 percent) of the irrigated areas were classed as saline by Central Asian standards (toxic ions exceed 0.5 percent of total soil weight). These areas are mainly concentrated in the south. In 2010, irrigated areas, subject to salinity, amounted to 404 300 ha.

Over the past 10 years, over 300 floods have been recorded caused by different phenomena. Most damage is caused by flooding of the Ural, Tobol, Ishim, Nura, Emba, Torgai, Sarysu, Bukhtarma rivers and their numerous tributaries (UNDP, 2004).

Studies conducted in the framework of technical assistance from the Asian Development Bank 'The availability of water supply services as part of poverty assessment' showed that lack of water leads to the population becoming incapable of observing norms of sanitation and hygiene, resulting in increased morbidity; income level in water deficient areas per capita is almost two-times lower than the officially established subsistence level. As with many other countries, Kazakhstan is interested in finding solutions to the problems of environmental protection and promoting the rational use of natural resources.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Structural reforms on irrigated land are needed to maintain food security in Kazakhstan, to ensure a high level of the population's self-sufficiency in agricultural production. This includes increasing economic performance, meeting environmental requirements and introducing water-saving technologies. Restructuring of irrigated cultivated areas consists of reducing cotton and cereals and increasing the share of oilseeds and legumes, including perennial grasses. In parallel an increase in productivity in rainfed areas, where most of the cereals are grown, is important.

Further socio-economic development and the solution of various ecological problems will be greatly determined by a water policy that addresses development and control of water management. Radical economic reforms taking place – including in the area of water management – also make specific demands on water policy (UNDP, 2004).

The aim of the national water-use strategy is to first protect water and implement efficient water-saving technologies in all spheres of water management. This will decrease the volume of water consumed as well as the amount of sewage discharged. National water conservation plans should be systematic for all aspects of water use, thus creating a basis for transition to integrated management of water resources. The main objective of a regional water strategy and policy is the implementation of agreed national activities for preservation of the resource potential of the river system and its ecological security.

Rapprochement between neighbouring countries for national policies and strategies, for protection and use of transboundary waterways, should be based on the general provisions found in international conventions, and the principles concerning use and protection of transboundary waterways. National strategies for the protection and use of water resources should stipulate a transition to ecosystem control over water resources, unification of criteria and purpose-oriented indicators of water quality, application of concerted methods of data collection and exchange of information. A regional basin organization should be created to coordinate all the above and to promote interstate cooperation and the pursute of a common water policy in the river basin (UNDP, 2004).

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Kyrgyzstan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Kyrgyzstan is a landlocked country in Central Asia with a total area of 199 949 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 Former Soviet Union in August 1991. The country is divided into seven provinces (*oblasts*), which are Batken, Chu, Djalal-Abad, Issyk-Kul, Naryn, Osh and Talas.

Largely mountainous, the country is dominated by the western reaches of the Tien Shan range in the northeast and the Pamir-Alay in the southwest. The highest mountain is 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. About 94 percent of the country rises over 1 000 m, and 40 percent at more than 3 000 m above sea level. Much of the mountain region is permanently covered with ice and snow and there are many glaciers, covering about 4 percent 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, is Issyk-Kul, in the northeast with a surface area of 6 236 km^2.

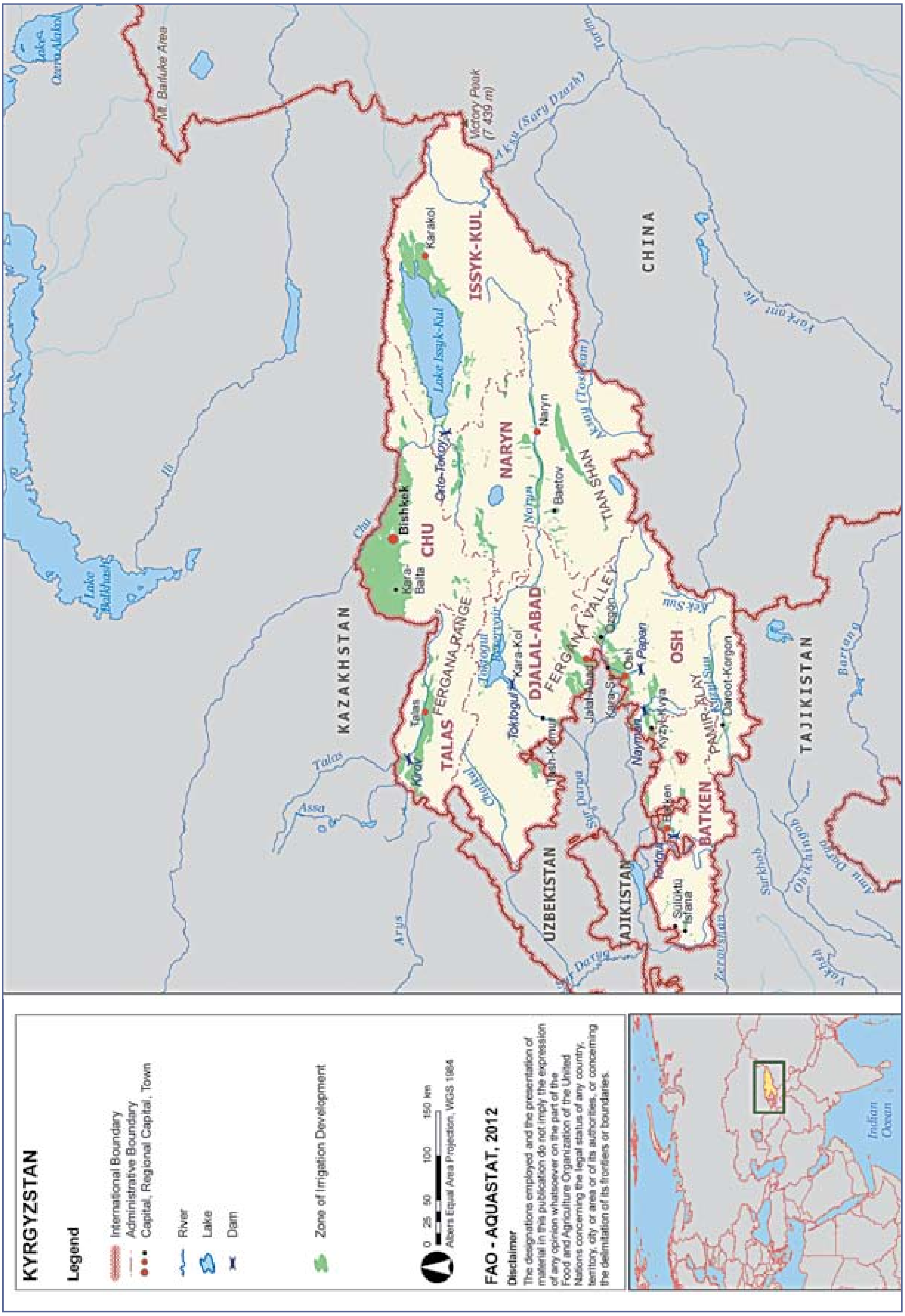
The cultivable area is an estimated 10 670 000 ha, or 53 percent of the total area, including 9 179 000 ha of permanent pasture. In 2009, the cultivated area was 1 351 000 ha, of which 1 276 000 ha temporary crops and 75 000 ha permanent (Table 1). In 1995 and 2000 the cultivated area was an estimated 1 326 000 ha and 1 423 000 ha respectively.

Climate

The climate is continental with hot summers and cold winters, during which frost occurs throughout the country. There is a frost-free period of 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 a few vegetables. Average temperatures in the valleys vary from minus18 °C in January to 28 °C in July. Absolute temperatures vary from minus 54 °C in winter to 43 °C in summer. Average annual precipitation is an estimated 533 mm, varying from 150 mm on the plains (Fergana valley) to over 1 000 mm in the mountains. Precipitation occurs during the winter, mainly between October and April, when temperatures are low. Rainfed agriculture is therefore limited. Snowfall forms an important part of total precipitation. About 10 percent of the territory, at the lowest altitude, is classed as arid.

Population

The total population is about 5.4 million (2011), of which around 65 percent is rural (Table 1). The annual demographic growth rate was an estimated 0.8 percent during the period 2001–2011.


KYRGYZSTAN
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
River
Lake
Dam
Zone of Irrigation Development
0 25 50 100 150 km
Albers Equal Area Projection, WGS 1984
FAO - AQUASTAT, 2012
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The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.
KAZAKHSTAN
CHINA
TAJIKISTAN
UZBEKISTAN
CHU
TALAS
NARYN
ISSYK-KUL
DJALAL-ABAD
OSH
BATKEN
Bishkek
Kara-Balta
Karakol
Naryn
Baetov
Talas
Osh
Jalal-Abad
Kara-Su
Ozgon
Kara-Kol
Tash-Kumyr
Kyzyl-Kiya
Daroot-Korgon
Batken
Sulukta
Isfana
Lake Issyk-Kul
Lake Balkhash
Toktogul Reservoir
Orto-Tokoy
Toktogul
Kirov
Papan
Nayman
Tortgul
FERGANA RANGE
FERGANA VALLEY
TIAN SHAN
PAMIR-ALAY
Victory Peak (7 439 m)
Chu
Ili
Talas
Assa
Arys
Naryn
Syr Darya
Kek-Suu
Kyzyl-Suu
Aksu (Sary Dzazh)
Aksai (Toshkan)
Yarkant He
Indian Ocean

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	19 994 900	ha
Cultivated area (arable land and area under permanent crops)	2009	1 351 000	ha
• as % of the total area of the country	2009	6.8	%
• arable land (annual crops + temp fallow + temp meadows)	2009	1 276 000	ha
• area under permanent crops	2009	75 000	ha
Population			
Total population	2011	5 393 000	inhabitants
• of which rural	2011	65	%
Population density	2011	27	inhabitants/km^2
Economically active population	2011	2 491 000	inhabitants
• as % of total population	2011	46	%
• female	2011	43	%
• male	2011	57	%
Population economically active in agriculture	2011	507 000	inhabitants
• as % of total economically active population	2011	20	%
• female	2011	29	%
• male	2011	71	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	4 616	million US$/yr
• value added in agriculture (% of GDP)	2010	21	%
• GDP per capita	2010	865	US$/yr
Human Development Index (highest = 1)	2011	0.615	
Access to improved drinking water sources			
Total population	2010	90	%
Urban population	2010	99	%
Rural population	2010	85	%

Population density is 27 inhabitants/km^2. Average population density varies from six inhabitants/km^2 in the eastern mountainous zone to about 70 inhabitants/km^2 in the north.

In 2010, 90 percent of the total population had access to improved water sources (99 and 85 percent in urban and rural areas respectively) and 93 percent had access to improved sanitation (94 and 93 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, the gross domestic product (GDP) was US$4 616 million and agriculture accounted for 21 percent of GDP (Table 1), while in 2000 it accounted for 37 percent. In 2011, the total economically active population was 2.49 million or just over 46 percent of the total population. The population economically active in agriculture is an estimated 507 000, or 20 percent of the total economically active population, while in 1996 it accounted for 30 percent. Of the total population economically active in agriculture 29 percent are female.

Agriculture is a significant part of the Kyrgyzstan's economy. There are 301 935 farms, grouped into six different categories (Table 2).

For most food products, actual consumption is far more than that produced. If no immediate measures are taken the gap between actual production and consumption may increase substantially.

TABLE 2
Number of farms by type (2005)

Type of farm	Number
State	111
Joint-stock company	51
Joint peasant economies	147
Agricultural cooperatives	926
Additional economies of state organizations and enterprises	538
Peasant farms	300 169
Total	**301 935**

WATER RESOURCES AND USE

Water resources

Water resources are formed by perennial and ephemeral rivers, brooks and springs, freshwater and brackish lakes, including the world's second largest high-mountain lake Issyk-Kul.

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

There are six main river basin groups (Table 3). No rivers flow into Kyrgyzstan. The river basins, listing the largest first and progressing to the smallest area are:

1. Syr Darya river basin covers 55.3 percent of the country. In Kyrgyzstan the river is called the Naryn river before it reaches the Fergana valley. It then flows into Uzbekistan as the Syr Darya river, then into Tajikistan and then again into Uzbekistan where it receives the Chatkal river, a tributary that also rises in Kyrgyzstan. It then flows towards Kazakhstan.
2. Chu, Talas and Assa river basins, cover 21.1 percent of the country: All three rivers flow to Kazakhstan, where the portion that is not withdrawn is lost in the desert.
3. Southeastern river basins cover 12.9 percent of the country: These are different river basins that drain into the Tarim basin, China. The main rivers are the Aksu (Sary Dzhaz), Aksay (Toshkan) and Kek Suu, and are located at high elevations.
4. Lake Issyk-Kul internal and interior basin, cover 6.5 percent of the country: The lake has low salinity. The estimated flow from all rivers into the Issyk-Kul lake basin that does not evaporate is used for irrigation or municipalities. The lake and the surrounding rivers that drain into the lake are all within Kyrgyzstan.
5. Amu Darya river basin covers 3.9 percent of the country: The Amu Darya river rises mainly in Tajikistan, but receives a contribution from the Kyzyl Suu tributary, which originates in the southwest of Kyrgyzstan.
6. Lake Balkhash basin covers 0.3 percent of the country: The Karkyra river, which rises in Kyrgyzstan is a small tributary of the Ili river and flows to lake Balkhash in Kazakhstan.

The average natural surface water flow is an estimated 46.46 km^3/year, all internally produced. The inflow from China from the rivers on the west slope of the Barluke mountain is an estimated 0.558 km^3/year. The Union of Soviet Socialist Republics (USSR) allocated a portion of these water resources to the Kirghiz Soviet Socialist Republic, with the rest going to the neighbouring Kazakh, Uzbek and Tajik Soviet Socialist Republics. This rule only referred to water flows within the USSR (36.09 km^3/year) and did not concern resources generated in the southeastern basins (5.36 km^3/year), since they flow towards China, lake Issyk-Kul basin

TABLE 3
Renewable surface water resources (RSWR) by major river basin

River basin	Region	Part of territory (%)	Internal RSWR (km^3/year)	Outflow to	Outflow secured through agreements (km^3/year)	Actual RSWR (km^3/year)
Syr Darya (Naryn, Chatkal)	West	55.3	27.42	Uzbekistan and Tajikistan	22.33	5.09
Chu, Talas and Assa	North	21.1	6.74	Kazakhstan	2.03	4.71
Southeastern (Tarim* basin)	Southeast	12.9	5.36	China	-	5.36
Rivers of the Lake Issyk-Kul **	Northeast	6.5	4.65	Endorheic and internal basin	-	4.65
Amu Darya (Kyzyl Suu)	Southwest	3.9	1.93	Tajikistan	1.51	0.42
Karkyra (Lake Balkhash*** basin)	Northeast	0.3	0.36	Kazakhstan	-	0.36
Inflow from west slopes of Barluke mountain						0.558
Total		**100**	**46.46**		**25.87**	**21.148**

* Tarim river is located in China
** This is an endorheic basin and all rivers flowing into it originate in the country, therefore outflow does not include this basin
*** Lake Balkhash is located in Kazakhstan

(4.65 km^3/year), which is an endorheic basin located entirely in Kyrgyzstan, and the very limited resources generated in the Balkhash lake basin (0.36 km^3/year). This allocation was re-endorsed by the five new states of Central Asia, until the Interstate Commission for Water Coordination can propose a new strategy for water sharing in the Aral Sea basin. Surface water resources allocated to Kyrgyzstan are calculated every year, depending on existing flows. On average, however, surface water represents a volume of 10.22 km^3/year out of the total 36.09 km^3/year. Adding the 5.36 km^3/year of the southeastern basin, the 4.65 km^3/year for lake Issyk-Kul basin and the 0.36 km^3/year of lake Balkhash basin area, and the inflow of the west slopes of Barluke mountain (0.558 km^3/year), gives a total of 21.148 km^3/year of actual renewable surface water resources (RSWR) (Table 3).

Annual renewable groundwater resources are an estimated 13.69 km^3/year, of which about 11.22 km^3/year is common to surface water resources (Table 4). In 1991, the groundwater resources, for which abstraction equipment existed, was an estimated 3.39 km^3/year, mainly in the Chu river basin (2.02 km^3/year), the Syr Darya river basin (0.73 km^3/year) and the lake Issyk-Kul basin (0.52 km^3/year).

Total internal renewable water resources are thus equal to 48.93 km^3/year (Table 4) and total actual renewable water resources equal to 23.62 km^3/year (Table 5), which is equal to actual renewable surface water resources (21.15) plus groundwater resources (13.69) minus the overlap between surface water and groundwater (11.22) (Table 3 and Table 4).

In 2005, produced and treated wastewater accounted for 144 and 142 million m^3 respectively.

In 1994, 1 720 million m^3/year of agricultural drainage water was collected in the collector-drainage canals, and about 380 million m^3/year of municipal and industrial untreated wastewater, for a total of 2 100 million m^3/year, of which 30 percent in the Chu river basin and 70 percent in the Syr Darya river basin. Of this total, about 1 800 million m^3/year returned to the rivers (300 million m^3/year in the Chu river and 1 500 million m^3/year in the Syr Darya river), which could be reused by downstream countries. Of the remaining 300 million m^3/year, direct use of treated wastewater accounted for 0.14 million m^3, while 299.86 million m^3/year was directly used for irrigation, after natural desalting treatment (phytomelioration).

TABLE 4
Internal renewable surface water resources (IRSWR) and internal renewable groundwater resources (IRGWR) by river basin (km^3/year)

River basin	IRSWR	IRGWR	Overlap	Total IRWR
Syr Darya	27.42	5.25	4.70	27.97
Southeastern (Tarim * basin)	5.36	1.76	1.76	5.36
Chu	5.00	3.60	2.56	6.04
Rivers of the Lake Issyk-Kul	4.65	2.02	1.61	5.06
Amu Darya	1.93	0.23	0.23	1.93
Talas and Assa	1.74	0.83	0.36	2.21
Karkyra (Lake Balkhash ** basin)	0.36	-	-	0.36
Total	**46.46**	**13.69**	**11.22**	**48.93**

* Tarim river is located in China
** Lake Balkhash is located in Kazakhstan

TABLE 5
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	533	mm/yr
	-	106 573	million m^3/yr
Internal renewable water resources (long-term average)	-	48 930	million m^3/yr
Total actual renewable water resources	-	23 618	million m^3/yr
Dependency ratio	-	1	%
Total actual renewable water resources per inhabitant	2011	4 379	m^3/yr
Total dam capacity	1995	23 500	million m^3
Water withdrawal			
Total water withdrawal by sector	2006	8 007	million m^3/yr
- agriculture	2006	7 447	million m^3/yr
- municipalities	2006	224	million m^3/yr
- industry	2006	336	million m3/yr
• per inhabitant	2006	1 575	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	2006	7 707	million m^3/yr
• as % of total actual renewable water resources	2006	33	%
Non-conventional sources of water			
Produced municipal wastewater	2005	144	million m^3/yr
Treated municipal wastewater	2005	142	million m^3/yr
Direct use of treated municipal wastewater	1994	0.14	million m^3/yr
Desalinated water produced		-	million m^3/yr
Direct use of agricultural drainage water	1994	299.86	million m^3/yr

Water in most rivers comes from glaciers and snow, and low and unreliable flows are often the rule in August and September, in the latter part of the growing season. Regulation of these flows is required to ensure adequate water supplies are available over the entire cropping period.

In 1995, total dam capacity was an estimated 23 500 million m^3. There were nine reservoirs in the Syr Darya river basin with a total capacity of 22 300 million m^3, six in the Chu river basin with a total capacity of 600 million m^3, and three in the Talas river basin with a total capacity of 600 million m^3. The Toktogul dam, with a reservoir capacity of 19 500 million m^3, is on the Naryn (Syr Darya) river. This multipurpose dam is used for irrigation, hydropower production, flood protection and regulation. However, because of its location near the border with downstream Uzbekistan, it does not play an important role in the irrigation of areas within Kyrgyzstan. The same applies to the Kirov dam, which has a capacity of 550 million m^3 and is located on the Talas river near the border with downstream Kazakhstan. Twelve of the reservoirs are only used for irrigation, each of which has a capacity of more than 10 million m^3 (Table 6).

In 1985, gross theoretical hydropower potential was an estimated 162 500 GWh/year, and the economically feasible potential an estimated 55 000 GWh/year. Hydropower installed capacity is about 3 GW, a number of hydropower plants are part of the Naryn-Syr Darya cascade, controlled by the Toktogul dam. Hydropower plays a key role in Kyrgyzstan and is the country's main source of energy (about 90 percent of electricity generation in 1995), given its limited gas, oil and coal resources. However, hydropower production mainly releases water in winter, while downstream countries need water for the summer cropping season. At the 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 transfer energy, coal or gas to Kyrgyzstan in the period of power deficit, to compensate Kyrgyzstan for not releasing water for hydropower in winter.

International water issues

During the Soviet period, the sharing of water resources among the five Central Asian republics was based on the master plans for development of water resources in the Amu Darya (1987) and Syr Darya (1984) river basins.

The USSR allocated only part of the transboundary surface water flow of 36.09 km^3/year internally produced in the Kirghiz Soviet Socialist Republic to the Republic itself, the rest being allocated to the neighbouring states of Kazakh, Uzbek and Tajik Soviet Socialist Republics. This rule did not concern the resources generated in the southeastern basins (5.36 km^3/year), since they flow towards China, lake Issyk-Kul basin (4.65 km^3/year), which is an endorheic basin located entirely in Kyrgyzstan, and the very limited resources generated in the lake Balkhash basin (0.36 km^3/year).

In 1992, with the establishment of The Interstate Commission for Water Coordination (ICWC), the newly independent republics decided, with the Agreement of 18 February 1992, to prepare a regional water strategy and continue to respect existing principles until the proposal and adoption of a new ICWC water-sharing agreement. The new agreement was confirmed

TABLE 6
List of irrigation dams and their characteristics

Nr	Reservoir	Oblast	Date of completion	Volume (million m^3)	Height (m)	Irrigation area (ha)
1	Tortgul	Batken	1971	90	34	11 500
2	Stepninskoe	Chu	1935	0.8	3.5	1 880
3	Ala-Archa, off-channel	Chu	1966	51	24.5	17 500
4	Sokuluk	Chu	1968	11.5	28	4 000
5	Spartak	Chu	1978	23	15	3 000
6	Ala-Archa, in-channel basin	Chu	1986	90	35	20 000
7	Bazar-Kurgan	Djalal-Abad	1962	30	25	18 000
8	Orto-Tokoy	Naryn	1956	470	52	220 000
9	Nayman	Osh	1966	40	41	6 000
10	Papan	Osh	1981	260	120	45 000
11	Kirov	Talas	1975	550	86	142 000
12	Kara-Bura	Talas	Incomplete	27	58	7 915

as the 'Agreement on joint actions to address the problem of the Aral Sea and socio-economic development of the Aral Sea basin', which was signed by the Heads of the five states in 1996. The main achievement of the ICWC over the years has been the conflict-free supply of water to all water users, despite the complexities and variations of dry and wet years.

In 1993, with the development of the Aral Sea basin programme, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) to coordinate implementation of the programme and the International Fund for Saving the Aral Sea (IFAS) to raise and manage its funds. In 1997, the two organizations merged to create the IFAS (UNDP, 2004).

The most acute disagreement in the Syr Darya basin relates to the operation of the Toktogul reservoir in Kyrgyzstan, which leads to a conflict of interests between Kyrgyzstan, Uzbekistan and Kazakhstan. The two downstream countries are interested in maintaining storage in the Toktogul reservoir for summertime irrigation, whereas winter energy generation from the reservoir is beneficial to Kyrgyzstan (UNDP, 2004).

In 1998, an agreement was reached between Kazakhstan, Kyrgyzstan and Uzbekistan for the use of water and energy resources in the Syr Darya basin.

IFAS is under the authority of the deputy prime ministers of the Central Asian states, but excludes Afghanistan. The organization's task is to administer the Aral Sea Basin Programme, or more specifically, to prepare a general strategy for water distribution, rational water use, and protection of water resources in the Aral Sea Basin (SIWI, 2010).

In 2000 Kyrgyzstan and Kazakhstan signed an agreement regarding shared water resources of the Chu and Talas rivers. The parties agreed to share operational and maintenance (O&M) costs regarding transboundary infrastructure in proportion to received water amounts. The agreement is regarded a success and has been described as the 'way forward' for Central Asian water politics (SIWI, 2010).

In 2002, the Central Asian and Caucasus countries formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework state departments; local, regional and professional organizations; scientific and research institutes; and the private sector and NGOs cooperate in the establishment of a common understanding concerning the critical issues threatening water security in the region (SIWI, 2010).

The partnership between the European Union Water Initiative (EUWI) and its Eastern Europe, Caucasus and Central Asia (EECCA) programme seeks to improve management of water resources in the EECCA region. This partnership was established at the World Summit for Sustainable Development in 2002. A significant component is 'Integrated water resources management, including transboundary river basin management and regional seas issues' (SIWI, 2010).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for the Economies of Central Asia (UN-SPECA). In collaboration with EUWI and the United Nations Economic Commission for Europe (UNECE) is developing integrated water resources management in the Central Asian States. In cooperation with Germany and other countries of the European Union (EU), UNECE may play a role implementing the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

Tensions exist between Kyrgyzstan and Uzbekistan in the Fergana valley. The Andijan reservoir, lying in a border area and currently leased to Uzbekistan, increases tensions. Kyrgyzstan claims that it does not receive any compensation for the lease, while Uzbekistan has been reluctant to enter into negotiations (SIWI, 2010).

Water use

In 2006, water withdrawal was an estimated 8 007 million m^3, of which about 93 percent was withdrawn by agriculture, 3 percent by municipalities and 4 percent by industry (Table 5 and Figure 1). Primary and secondary surface water and groundwater account for 92.4 percent and 3.8 percent respectively of total water withdrawal. Direct use of irrigation drainage water represents 3.7 percent and direct use of treated wastewater 0.002 percent (Figure 2). In 1994, water withdrawal was an estimated 10 100 million m^3. In some basins (Syr Darya, Chu, Talas) there was a fairly severe water shortage, while in others (Amu Darya, Issyk-Kul, southeastern) there was a surplus. About 90 percent of all drinking water supplied by centralized systems is provided by groundwater.

Reduced water withdrawal from 1994 to 2006 may be explained by:

- reduced canal capacity because of lack of means for cleaning;
- acute recession in industrial production;
- insufficient means of peasant farmers who are unable to cultivate their irrigated land;
- incentive to use irrigation water economically with the introduction of payment for water use;
- changes in crops from cotton, sugar beet, tobacco, maize, grasses to those having a shorter vegetative period (grain crops).

FIGURE 1
Water withdrawal by sector
Total 8 007 million m^3 in 2006

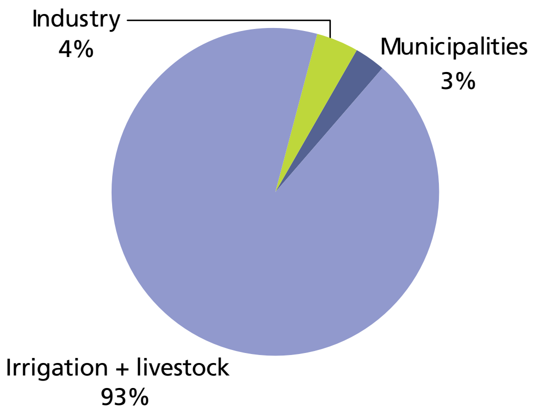
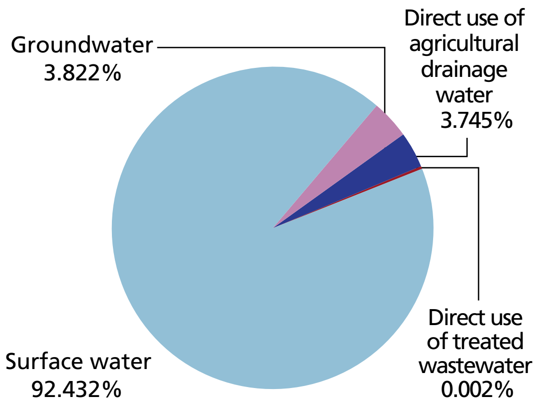


FIGURE 2
Water withdrawal by source
Total 8 007 km^3 in 2006



IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Irrigation is of key importance to the agricultural sector. Irrigation potential is about 2.25 million ha. Compared with 0.43 million ha in 1943, irrigation covered an estimated 1 077 000 ha in 1994, developed mainly in the Syr Darya river basin (42 percent), the Talas and Chu river basins (41 percent), and around lake Issyk-Kul. In 2005, the area equipped for full control irrigation was an estimated 1 021 400 ha, three-quarters of the cultivated area. Irrigated area was reduced between 1994 and 2005 because most irrigation schemes constructed during the Soviet period, have become rainfed because of the high price of electricity and spare parts for irrigation equipment.

The main irrigation technique is surface irrigation (Figure 3). In 1990, sprinkler irrigation was practised on 141 000 ha and 12 ha of localized irrigation. Because of the lack of spare parts (all equipment was produced in the Russian Federation of the former Soviet Union, and because of the substantial increase in energy costs, sprinkler irrigation decreased during the 1990s. About 37 000 ha were in use in 1994, only 400 ha in 2005.

In 1994, water was mainly supplied from diverted rivers (80 percent). Only 13 percent relied on reservoir water, 6 percent on pumping from rivers and 1 percent on groundwater (Figure 4). The

FIGURE 3
Irrigation techniques on area equipped for full control irrigation
Total 1 021 400 ha in 2005

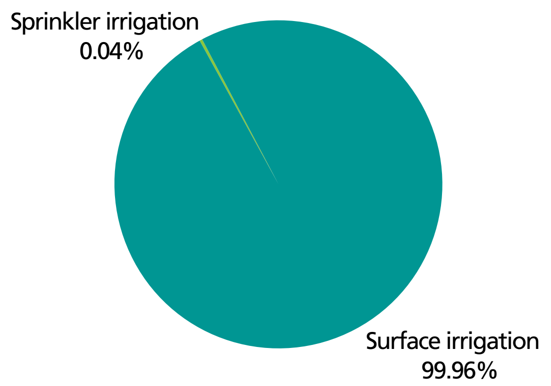
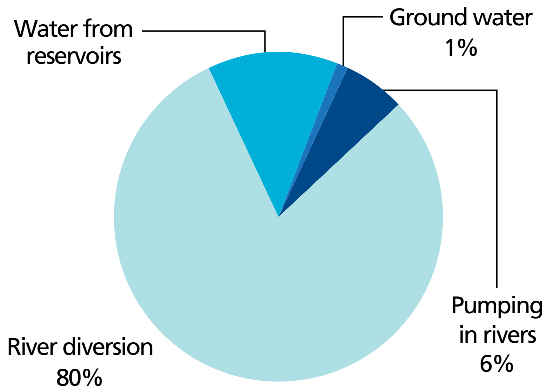


FIGURE 4
Source of irrigation water on area equipped for full control irrigation
Total 1 077 500 ha in 1994



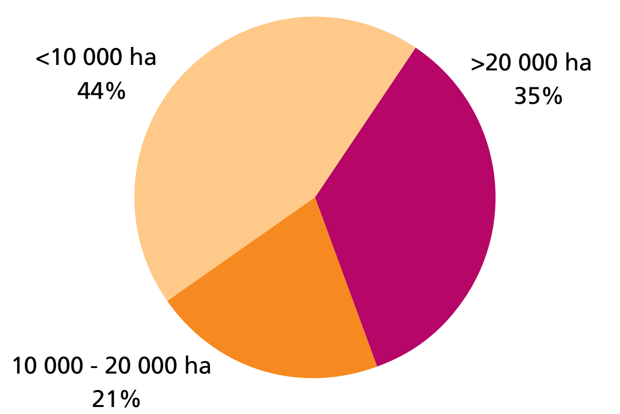
irrigation network comprises 12 835 km of canals, of which 82 percent are earthen, 17 percent concrete and 1 percent are pipes.

Irrigation schemes are subdivided according to their technical characteristics:

- Engineering irrigation schemes represent 40.2 percent of the area. They have water-inlet structures on rivers, which provide silt protection, are available for flash flood water flow and provide guaranteed off-take from irrigation sources. The canals are lined.
- Semi-engineering schemes have water-inlet structures, but canals are only partly lined and partly equipped with water distribution structures. The area served by such schemes represents 34.4 percent.
- Non-engineering schemes have no water-inlet structures; canals are not equipped with water distribution structures and are not lined. The area served by such schemes accounts for 25.4 percent.

In 1990, there were 1 346 irrigation schemes. Large schemes (>5 000 ha), mainly *kolkhoz* or *sovkhoz*, represented 60 percent of the irrigated area, medium schemes (1 000–5 000 ha) 21 percent, and small schemes (< 1 000 ha) 19 percent (Figure 5 and Table 7).

FIGURE 5
Type of full control irrigation schemes
Total 967 000 ha in 2002



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 an estimated conveyance/distribution efficiency of 55 percent.

Role of irrigation in agricultural production, economy and society

In 2005, the harvested irrigated area was 1 021 400 ha. Temporary crops represent 82.3 percent of total harvested irrigated area.

Main irrigated crops are wheat (35.3 percent), temporary and permanent fodder (10.7 percent), barley (8.5 percent) and potatoes (7.4 percent) (Table 7 and Figure 6). Permanent meadows and pastures account for 106 900 ha. Although the yields for irrigated land are generally low by world standards, they are about two to five times higher than yields on non-irrigated areas. In 1997, the average yields for wheat, barley and rye were 2.2, 2.2 and 1.9 tonne/ha respectively on irrigated land and 1.1, 0.9 and 1 tonne/ha respectively on rainfed land.

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

Status and evolution of drainage systems

It is estimated that 750 000 ha of irrigated land would need drainage. In 2000 only 144 910 ha were equipped for drainage, and 3 000 ha represented un-irrigated cultivated, drained area (Table 7). In 1994 surface and subsurface drainage accounted for 56 and 44 percent respectively. Mainly subsurface drainage was developed on newly reclaimed areas in the north and southwest. With the very restricted budget of the Ministry of Agriculture, Water Resources and Process Industry, it is unlikely that the government will be able to maintain, and effectively operate the existing drainage system or to undertake any improvement or extension. For this reason, salinity and drainage problems will most likely worsen.

The inter-farming collector and drainage network is about 646 km, out of which 619 km is surface and 27 km subsurface drainage, and 158 km is in unsatisfactory condition. The on-farm

FIGURE 6
Irrigated crops on area equipped for full control irrigation
Total harvested area 1 021 400 ha in 2005 (cropping intensity on actually irrigated area: 100%)

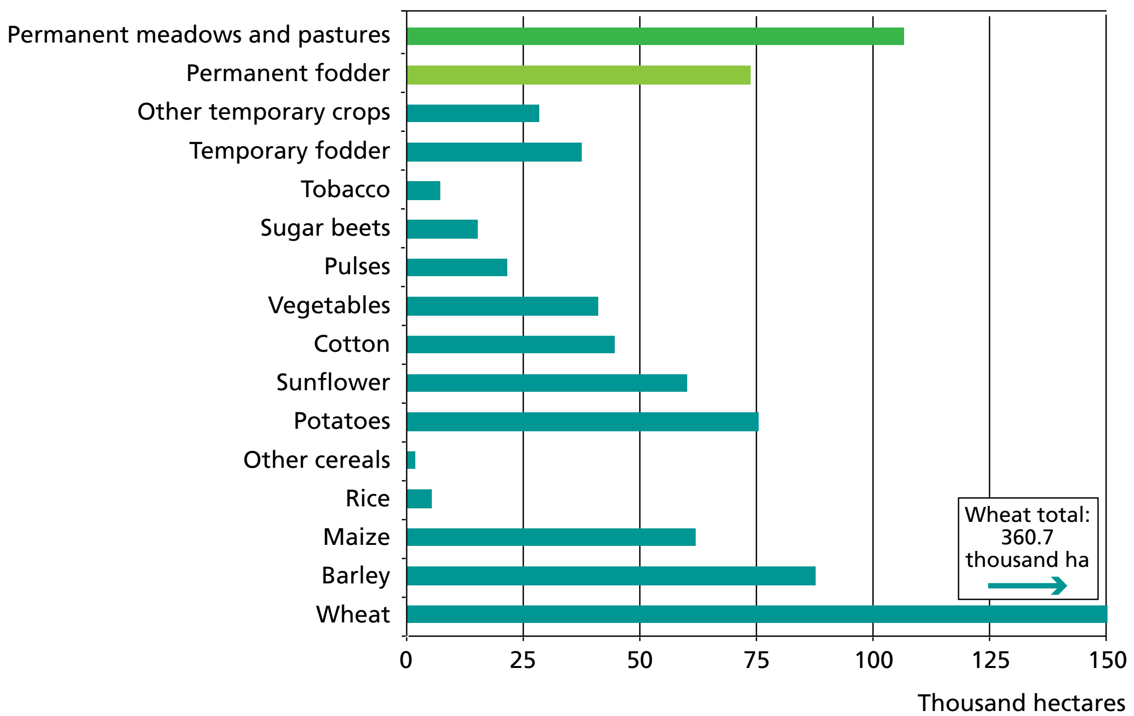


TABLE 7
Irrigation and drainage

Irrigation potential			2 247 000	ha
Irrigation				
1. Full control irrigation: equipped area		2005	1 021 400	ha
- surface irrigation		2005	1 021 000	ha
- sprinkler irrigation		2005	400	ha
- localized irrigation		2005	0	ha
• % of area irrigated from surface water		1994	99	%
• % of area irrigated from groundwater		1994	1	%
• % of area irrigated from mixed surface water and groundwater			-	%
• % of area irrigated from mixed non-conventional sources of water			-	%
• area equipped for full control irrigation actually irrigated		2005	1 021 400	ha
- as % of full control area equipped		2005	100	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2005**	**1 021 400**	**ha**
• as % of cultivated area		2005	75.3	%
• % of total area equipped for irrigation actually irrigated		2005	100	%
• average increase per year over the last 11 years		1994 -2005	-0.5	%
• power irrigated area as % of total area equipped			5.2	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2005**	**1 021 400**	**ha**
• as % of cultivated area		2005	75.3	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< 1 000 ha	1990	204 500	ha
Medium-scale schemes	> 1 000 ha and < 5 000 ha	1990	229 400	ha
Large-scale schemes	> 5 000 ha	1990	643 200	ha
Total number of households in irrigation		1990	705 825	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production			-	metric tons
• as % of total grain production			-	%
Harvested crops				
Total harvested irrigated cropped area		2005	1 021 400	ha
• Temporary crops: total		2005	841 100	ha
- Wheat		2005	360 700	ha
- Barley		2005	86 600	ha
- Maize		2005	61 500	ha
- Rice		2005	5 000	ha
- Millet		2005	80	ha
- Sorghum		2005	4	ha
- Other cereals		2005	1 516	ha
- Potatoes		2005	76 000	ha
- Sugar beet		2005	14 500	ha
- Pulses		2005	20 800	ha
- Vegetables		2005	40 600	ha
- Tobacco		2005	5 600	ha
- Cotton		2005	45 500	ha
- Sunflower		2005	59 200	ha
- Fodder (temporary)		2005	35 800	ha
- Other temporary crops		2005	27 700	ha
• Permanent crops: total		2005	73 400	ha
- Fodder (permanent)		2005	73 400	ha
• Permanent meadows and pastures		2005	106 900	ha
Irrigated cropping intensity (on full control area equipped)		2005	100	%
Drainage - Environment				
Total drained area		2000	147 910	ha
- part of the area equipped for irrigation drained		2000	144 910	ha
- other drained area (cultivated non-irrigated)		2005	3 000	ha
• drained area as % of cultivated area		2000	10.4	%
Flood-protected areas			-	ha
Area salinized by irrigation		2005	49 503	ha
Population affected by water-related diseases		2005	122 800	inhabitants

drainage network is about 4 893 km, which is managed by rural local governance, water user associations, peasant farms and others. About 1 936 km is in unsatisfactory condition, of which 1 112 km is surface and 824 km is subsurface drainage (Table 8).

In 2005, land reclamation was carried out to improve conditions on irrigated land, with the financial support of the Water Resources Department, the state register and regional budgets. This resulted in the cleaning of 127 km surface drainage and the washing out of 39 km of subsurface drainage networks. Furthermore, 55 hydraulic engineering constructions, 133 hydro stations, 920 observation wells and five vertical drainage systems were repaired, and 3.3 km of surface drainage network was cut along collectors to address flash flooding.

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

Institutions

The following institutions are responsible for water resources management:

The National Parliament, Jogorku Kenesh, is responsible for: water regulation legislation, exercising state ownership rights for water resources, developing the water code and water-protection legislation, developing a state policy on the use and protection of the water fund, legislative regulation of paid water use, international contracts and agreements for water problems.

The government is responsible for: state water-economic programmes and their investment, coordination of activities between institutions and scientific-research, adoption of basic rates of payments for water use, regulation of water use and water protection, external affairs concerning water relations and water pollution.

Until 2010, the basic water management functions were concentrated in three administrative bodies: the Ministry of Agriculture, Water Resources and Process Industry (MAWR&PI), the Emergency Ministry (EM) and the Agency for Geology and Mineral Resources.

MAWR&PI was the central state body for water management with the following functions: regulation of the use of the water fund; management of state-owned hydro-economic capital assets; meeting the water requirements of the population and agricultural producers; development of irrigation infrastructure; conducting state accounting of water use; administrating the state water cadastre on water use section and control of state water use. The national-level Water Resources

TABLE 8
Technical condition of collector and drainage systems (2005)

Oblast	Availability of drainage network (km)		Availability of on-farm drainage network (km)	
	Total	Unsatisfactory condition	Total	Unsatisfactory condition
Batken	22.8	12.1	268.2	88.3
Djalal-Abad			254.57	73.7
Issyk-Kul	23.88	16.46	206.262	169.87
Naryn			120.24	69.84
Osh	19.2	12.1	354.7	242.13
Talas	4	-	270.44	134.5
Chu	575.6	125.1	3 418.3	1 201.1
Total	**646.45**	**158.36**	**4 892.7**	**1 938.28**

Department (WRD) of MAWR&PI was the basic state executing body for management of water resources for irrigation. Each *oblast* has a basin water resources department (BWRD); each *rayon* (second order administrative division) has a *rayon* water resources department (RWRD). In 2010, the State Committee on Water and Land Reclamation was established and entrusted with water resources management, state irrigation and land reclamation.

The Emergency Ministry is responsible for prevention of accidents and natural disasters; management of water protection; legislation of environmental protection, including water fund protection; control of sewerage disposal in water bodies, sewage treatment norms and sewage use; state water cadastre on 'surface waters' and 'water quality' sections; and monitoring of surface water bodies.

The Agency for Geology and Mineral Resources carries out the following functions: state accounting of groundwater storage; monitoring of groundwater deposits; licenses for groundwater use and the protection of groundwater.

Oblasts and *rayon* water resources departments are the lowest-level territorial government agencies for water management implemented by WRD. They carry out the state policy for O&M of water bodies, and regulate distribution and use of water resources, water supply to agricultural water users, water use control.

The State Water Inspection, established in 1999, is responsible for monitoring the use of water bodies, water facilities and irrigation infrastructure. It supervises the observance of legislative and statutory acts on the use of the state water fund; prevents infringement of use of water resources; conducts the state inventory on use of water resources; and promotes the rational use of irrigation water and irrigated land to prevent desertification, soil erosion, salinization and waterlogging.

Local state administration bodies (municipal bodies) participate in the management of the water fund. They are responsible for protection of the rights of water users and the allotment of land for the water fund.

Water management

Kyrgyzstan has sufficient quantities of water of excellent quality for municipal and industrial use for the foreseeable future. Because of commitments to downstream countries, water availability may become a constraint to expanding irrigation, extending land reclamation, and improving the productivity of irrigated areas, unless water use efficiency is significantly improved, and a major effort made to conserve water.

Currently, a multistage branch management system for water resources is used in Kyrgyzstan, meaning that functions and responsibilities are distributed between the various ministries and departments. These are the National Parliament, the Government, MAWR&PI (with the specialized WRD), EM, the Agency of Geology and Mineral Resources, other water use ministries and departments, local governance bodies, unions and water user associations (WUA).

The WUAs carry out the following functions with voluntary cooperation:

- operation of irrigation, water supply and drainage networks, waste network and ponds, reservoirs, pumping stations, sprinkler machines, water-outlets and other hydraulic engineering constructions and devices;
- water distribution among WUA members according to license conditions;
- construction, modernization, repair, cleaning and other actions to support the proper condition for WUAs' irrigation network and its development;
- prevention of water pollution;
- organization to improve the professional skills of members for irrigated agriculture.

The following projects are being completed, or have already been completed, to improve the quality of water supply and water distribution:

- Irrigation schemes rehabilitation project (World Bank credit), 1998–2006: 31 water-economy entities have been rehabilitated, including 27 linear irrigation schemes and four reservoirs have been constructed. Rehabilitation covers an irrigation area of 120 400 ha. The total project cost: US$43.8 million.
- Water management improvement project, started in 2006, assisted rehabilitation of 20 irrigation schemes with 84 000 ha abolished irrigated land. Total project cost: US$28 million.

The following investment projects have been prepared:

- Irrigation scheme rehabilitation project, Phase II, 2007–2012: Primary activity is restoration of design parameters, modernization of inter-economic irrigation schemes and dam safety on an irrigated area of about 106 222 ha. Estimated cost US$46 million. An additional US$3 million is reserved for organizational aspects.
- New land development project, Phase I, 2007–2010: Primary activity is the restoration of design parameters, modernization of inter-economic irrigation schemes and dam safety on an irrigated area of about 28 000 ha. Estimated cost US$55 million.

In 2007 the MAWR&PI published the Agricultural Development Strategy in collaboration with numerous government agencies, donors, private sector organizations and civil society representatives. The three-year process was facilitated and funded by the Asian Development Bank (ADB) at a cost of US$600 000. Since there is limited scope for expansion of the agricultural area, the principal source of growth must be through increasing agricultural productivity. The strategy focuses on ensuring continuous flows of knowledge and innovations to private production entities and government administration agencies.

In 2010, a new Agricultural Development Strategy (2011–2020) was formulated by the new government, which requested assistance from FAO to support the strategy. Eight priority sectors were selected: public sector services; agro-processing and marketing; land market development; water resources management; training, research and development; trade and tax policy; rural credit and rural development. The anticipated impact of the strategy will be to reduce rural poverty and food insecurity through providing a more stable agricultural policy.

Finances

The WRD and BWRDs are financed by the state budget through MAWR&PI. The RWRDs are financed from the state budget and water users funds received for water delivery services. Agreements have been concluded between the RWRDs and each water user in the *rayon* concerning water delivery services. Bills for payment are delivered monthly. The government authorizes the text of the contract. Payment rates for water delivery are established by Parliament. Approximately 50 percent of actual expenditure for O&M is covered by the state budget and 50 percent by payment for water delivery service.

Water use is chargeable according to the 'Water Act' currently in force in Kyrgyzstan. The payment is collected from all water users irrespective of the department they belong, their citizenship, kinds and patterns of ownership, except for cases established by special legislation of Kyrgyzstan (public health services, recreation, sports, rest, etc.). The order, conditions and amount paid for use of water bodies and water resources vary for different users and are determined by specific legislation. However, these amounts are still largely inadequate to cover actual O&M needs.

In 1997, the annual O&M cost of full cost recovery was an estimated US$350/ha, but the actual operational costs did not exceed US$60/ha in the four years prior to 1997. 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. In 1992–1993, a water fee was imposed on the *kolkhoz* and *sovkhoz*.

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

Policies and legislation

In 2005, the Water Code was based on the concept of integrated water resources management (IWRM). The Code covers the fundamental principles of recognition of the economic value of water resources, consolidation of controlling functions over water resources within the framework of a newly established specific state authority, organization of water resources management based on hydrographic (basin) and the participation of water users in planning and management. The Water Code promotes transparent legal relations between state authorities for the management of irrigation infrastructure and the newly established and growing group of cooperative users of irrigation water (UNDP, 2010).

ENVIRONMENT AND HEALTH

Water quality in rivers is good. Rivers are fed by glacial melt, which has a low salt concentration (0.04–0.15 g/litre) and low pollution level. Observations in all basins show a low concentration of nitrates, organic matter and nutrients (less then 1 mg/litre). There are cases of wastewater pollution; the reasons are:

- incorrect storage and use of fertilizers, chemicals, industrial waste;
- non-observance of the sanitary code;
- improper technical conditions for sewerage systems, ineffective cleaning of agriculture, cattle-breeding and industrial effluent.

About 90 percent of all drinking water supplied by centralized systems is groundwater, which mostly meets standards for drinking water quality.

Nuclear tailing dump is a very serious problem in Kyrgyzstan not fully solved yet and threatening the whole region.

In 2005, irrigation caused salinization of an estimated 49 503 ha. In 1994, about 60 000 ha were considered saline by Central Asia standards (toxic ions exceeded 0.5 percent of total soil weight). In addition there were 60 000 ha, divided 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 percent of the irrigated area is considered saline, while this figure falls to 5 percent in the Syr Darya river basin. In 2005, irrigation caused waterlogging on 35 399 ha.

In 2006, according to the Land Reclamation Cadastre 85 percent of the total irrigated area is in good condition, 6 percent in satisfactory condition and 9 percent in unsatisfactory condition. Unsatisfactory condition is caused by high groundwater level (37 percent), soil salinity (52 percent) and a combination of the two (11 percent). Poorly functioning vertical drainage systems have caused land deterioration on reclaimed land.

Harvest losses are as follows: 13–17 percent on low saline land, 32–37 percent on medium saline land and 60–64 percent on highly saline land. On average, around 27 percent of harvest is lost on saline land and up to 38 percent on land where the groundwater level is high.

Land is removed from agricultural rotation also because of the high level of soil pollution, caused by toxic waste from the mineral resource industry. Mercury, antimony, mining and smelting industries pollute the surrounding territories with heavy metals. The pollution level from heavy metals near mining and smelting enterprises exceeds by 3 to 10 times the maximum permissible concentration. High-level pollution may be controlled in the largest plants, along traffic lines and near waste disposal.

In 2005, 122 800 inhabitants were affected by water-related diseases.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Extension of irrigation land could be implemented on dry land, pastures and hayfields. This refers to about 1 200 000 ha, including 632 000 ha of land in good condition; 517 000 ha where a drainage system could be constructed; 28 000 ha requiring leaching; 1 168 000 ha needing investment; 208 000 ha where gypsum needs to be applied; 519 000 ha requiring stone collection; 1 173 000 ha requiring erosion prevention measures, 50 000 ha needing terracing. Development cost per hectare: US$2 630–US$26 320.

Assuming a 1 percent annual population growth rate, population will be 5 6 million in 2015 and 6 million in 2025. Feeding a larger population can be achieved by increasing the arable land area or by intensifying crop production and yield, or a combination of the above. Basic measures to increase food production are:

- increasing productivity of available agricultural land by taking the necessary steps to increase land and crop productivity;
- training agriculturists and introducing agricultural techniques: soil tillage, crop selection, crop rotation and fertilizers, and techniques for land reclamation including irrigation, drainage, leaching;
- evaluating current use of agricultural land to ensure productive use;
- preventing status change from agricultural land to industrial or other construction;
- adopting appropriate measures to develop additional land and water resources.

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Tajikistan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Tajikistan is a mountainous, landlocked country in southeastern Central Asia. It has a total area of about 142 550 km^2 (Table 1). It is bordered in the west and northwest by Uzbekistan (910 km borderline), in the northeast by the Kyrgyzstan (630 km), in the east by China (430 km) and in the south by Afghanistan (1 030 km). The country became independent in September 1991. The mountainous landscape covers 93 percent of the country. Administratively, the country is divided into four provinces: Badakhshan (64 200 km^2), Khatlon (24 800 km^2), Sughd (25 400 km^2) and Regions (*Raions*) of Republican Subordination (28 154 km^2).

The north Sughd and east Badakhshan regions are separated by high mountain ranges and are often isolated from the centre and south during winter. The Fergana valley, which is a major agricultural area, covers part of the north. A few valleys in the centre are between several mountain chains; most of the country is over 3 000 m above sea level. In the east are the Pamir mountains, which form 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 Former Soviet Union (FSU), is the Ismoili Somoni peak, which rises to 7 495 m. Tunnels are being constructed through two mountain ranges to connect the capital Dushanbe with north Sughd province and China to the east of the Pamir mountains. A bridge, built over the Panj (upstream Amu Darya) river in the south connects the country with Afghanistan.

In 2009, total cultivated area was an estimated 875 000 ha. About 742 000 ha under temporary crops and 133 000 ha permanent.

Climate

The climate is continental, but the country's mountainous terrain gives rise to wide variations. In areas cultivation takes place, mainly on the river floodplains, the climate is hot and dry in summer and mild and warm in winter. Average annual precipitation is 691 mm, ranging from less than 100 mm in the southeast and up to 2 400 mm on the Fedchenko glacier in the centre. Precipitation occurs during the winter, between September and April. Average temperature is 16–17 °C and absolute maximum temperature recorded is 48 °C in July; absolute minimum is minus 49 °C in January. The daily temperature is about 7 °C in winter and 18 °C in summer. Evapotranspiration varies from 300 mm/year to 1 200 mm/year, for stony soils and can be as much as 1 500 mm/year.

Population

Total population in 2011 was an estimated 7 million inhabitants, of which 74 percent rural. During the period 2001–2011, the annual population growth rate was an estimated 1.1 percent, while during the 1980s it was 3.3 percent. The main reasons for the decline were emigration and lower birth rates as a result of deteriorating socio-economic conditions. The population density is about 49 inhabitants/km^2, ranging from three inhabitants/km^2 in the southeast to


KAZAKHSTAN
UZBEKISTAN
KYRGYZSTAN
TAJIKISTAN
CHINA
AFGHANISTAN
PAKISTAN
Jammu and Kashmir
FERGANA VALLEY
SUGHD
ZERAVSHAN RANGE
GISSAR RANGE
REGIONS OF REPUBLICAN SUBORDINATION
BADAKHSHAN
KHATLON
PAMIR MOUNTAINS
Arys
Syr Darya
Chardarya Reservoir
Chirchik
Naryn
Karadarya
Kayrakkum Reservoir
Isfara
Isfana
Zeravshan
Kyzyl Suu
Surkhob
Obikhingob
Kizilsu
Panj
Vakhsh
Kofarnihon
Surkhandarya
Amu Darya
Kokcha
Kunduz
Balkh
Bartang
Lake Karakul
Lake Sarez
Pamir
Wakhan
Indus
Khujand
Istarafshan
Isfara
Panjakent
Rasht
Garm
Dushanbe
Tursunzoda
Gissar (Hisor)
Yavan
Dangara
Kulob
Qurghonteppa
Khorugh
Rogun
Nurek
Baipaza
Sangtuda1
Sarband
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.
Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
Indian Ocean
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
River
Lake
Dam
Zone of Irrigation Development
0 25 50 100 150 200 Km
Albers Equal Area Projection, WGS 1984
TAJIKISTAN
FAO - AQUASTAT, 2012
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TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	14 255 000	ha
Cultivated area (arable land and area under permanent crops)	2009	875 000	ha
• as % of the total area of the country	2009	6	%
• arable land (temporary crops + temp fallow + temp meadows)	2009	742 000	ha
• area under permanent crops	2009	133 000	ha
Population			
Total population	2011	6 977 000	inhabitants
• of which rural	2011	74	%
Population density	2011	49	inhabitants/km^2
Economically active population	2011	2 901 000	inhabitants
• as % of total population	2011	42	%
• female	2011	47	%
• male	2011	53	%
Population economically active in agriculture	2011	778 000	inhabitants
• as % of total economically active population	2011	27	%
• female	2011	53	%
• male	2011	47	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	5 640	million US$/yr
• value added in agriculture (% of GDP)	2010	21	%
• GDP per capita	2010	820	US$/yr
Human Development Index (highest = 1)	2011	0.607	
Access to improved drinking water sources			
Total population	2010	64	%
Urban population	2010	92	%
Rural population	2010	54	%

186–243 inhabitants/km^2 in the districts around Dushanbe; 221–359 inhabitants/km^2 in the districts around Qurghonteppa and 223–377 inhabitants/km^2 in the districts around Khujand.

In 2010, 64 percent of the population had access to improved water sources (92 and 54 percent in urban and rural areas respectively). Sanitation coverage accounted for 94 percent (95 and 94 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, Tajikistan's gross domestic product (GDP) was US$5 640 million of which the agriculture sector accounted for 21 percent (Table 1).

In 2011, the total economically active population was 2.9 million, or 42 percent of the total population. The economically active population in agriculture was an estimated 0.8 million (27 percent of total active population), of which 53 percent is female.

According to the World Bank poverty assessment, the poverty rate decreased from 82 percent in 1999 to 64 percent in 2003. Over the past two decades, unemployment has become a problem, aggravated by the world financial crisis. More than 600 000 Tajiks work in other countries, mainly in the Russian Federation.

Tajikistan cities import about 50 percent of wheat, meat, milk, eggs, fruit including melons and watermelons. The main reason is lack of irrigated land, and another is under-developed agricultural production. The main export goods are aluminum and cotton. In 2008, the export of cotton fibre fell by 30 percent as compared to 2007.

About 95 percent of crop production is from irrigated land. Rainfed agriculture in arid Tajikistan is not guaranteed because of low precipitation. Rainfed land is used to grow cereals and for pastures. Cereal yields on irrigated areas are 2–3 times higher than on rainfed land.

Climate conditions allow for cultivation of a wide variety of crops, such as cereals, legumes, vegetables, orchards (apricots, grapes, apples, pears, pomegranates, figs, walnuts, pistachio, peaches, cherries, plums, cucurbitaceous, citrus), watermelons, melons, pumpkins, non-food crops (cotton, including fine fibre, tobacco, geranium), medicinal herbs.

WATER RESOURCES AND USE

Water resources

Tajikistan can be divided into four major river basin groups (Table 2):

1. Amu Darya river basin: About 76 percent of the flow of the Amu Darya river is generated in Tajikistan. The Panj river, the largest tributary of the Amu Darya river originates in the Pamir mountainous ranges and forms the border between Tajikistan and Afghanistan for almost its entire length flowing from east to west. The Bartang river is the first large tributary of the Panj river. Before the confluence with the Vakhsh river, the annual average flow of the Panj river is 33.4 km^3/year. During the Soviet era, based on an agreement in 1946, entitled Afghanistan use of up to 9 km^3/year of water from the Panj river. The Vakhsh river is the largest river in Tajikistan, crossing the country from the northeast to the southwest. Originating in Kyrgyzstan, where it is called the Kyzyl Suu river, it enters Tajikistan, where it is called the Surkhob river. After the confluence of the Surkhob and Obikhingob rivers, it becomes the Vakhsh river. Its catchment area lies in the highest part of Tajikistan, at over 3 500 m. After the confluence of the Vakhsh and Panj rivers, at the border with Afghanistan, it becomes the Amu Darya river. The Kofarnihon river is another large tributary of the Amu Darya river. Originating in Tajikistan, it becomes the border between Tajikistan and Uzbekistan for several tens of kilometres, then it re-enters Tajikistan, after which it flows into the Amu Darya river, which is about 36 km downstream of the confluence

TABLE 2
Renewable surface water resources (RSWR) by river basin in Tajikistan

River basin	Part of total area of the country	Internal RSWR	Inflow			Outflow			Actual RSWR
			Total	Secured by agreements		Total	Secured by agreements		
	%	km^3/year	km^3/year		From:	km^3/year		To:	km^3/year
Amu Darya (including Surkhandarya and Zeravshan, which join further downstream)	88	59.45	1.93	1.51	Kyrgyzstan	61.38[b]	22.00 21.32[c]	Uzbekistan Turkmenistan (through Uzb.)	17.64
Syr Darya	11	1.01	32.26[a]	11.80	Uzbekistan	33.27[d]	11.54	Uzbekistan	1.27
Northeast	1	-		-			-	China	-
Total	**100**	**60.46**	**34.19**	**13.31**		**94.65**	**54.86**		**18.91**

a Equal to the flow from Kyrgyzstan through Uzbekistan (27.42) and flow from Uzbekistan (4.84=IRSWR Uzbekistan)
b Equal to IRSWR (59.45) and inflow from Kyrgyzstan (1.93)
c Share for Turkmenistan is 22, including the IRSWR of Turkmenistan (0.68). Therefore secured is 21.32 (=22.00-0.68)
d Equal to IRSWR (1.01) and inflow from Kyrgyzstan through Uzbekistan (27.42) and inflow from Uzbekistan (4.84)

of the Panj and Vakhsh rivers, at the border between Tajikistan and Afghanistan. About 65 km further downstream, the Amu Darya leaves the Tajikistan border to become the border between Afghanistan and Uzbekistan. The Surkhandarya river also originates in Tajikistan, then enters Uzbekistan and joins the Amu Darya river at the border between Uzbekistan and Afghanistan. The Zeravshan river originates between the mountain ranges of Zeravshan and Gissar in Tajikistan, and the total flow generated within Tajikistan is an estimated 3.09 km^3/year. The river then enters Uzbekistan and joins the Amu Darya river at the border between Uzbekistan and Turkmenistan. However, while the Zeravshan river was once the largest tributary of the Amu Darya river, before it began to be tapped to irrigate land in Uzbekistan, the flow no longer reaches the city of Bukhara in Uzbekistan. Total water generated within Tajikistan in the Amu Darya river basin is an estimated 59.45 km^3/year.

2. Syr Darya river basin: The northwest of the country forms part of the Syr Darya basin. Only 1 percent of the total flow of the Syr Darya river is generated within Tajikistan by the shallow rivers Khodzhabakirgan, Isfara and Isfana, with a total flow of 1.01 km^3/year.
3. In the extreme northeast of the country a small river, the Marcansy, drains towards China. No figures on flows are available.
4. Small closed basins: There are a few small closed basins, such as those formed by the small Kattasoy and Basmandasoy rivers, but the annual flow is negligible compared to the total renewable flow generated in Tajikistan.

Total internal renewable surface water resources (IRSWR) are an estimated 60.46 km^3/year (Table 2). During the Soviet period, water resources were shared among the five Central Asia republics based on master plans for water resources development in the Amu Darya and Syr Darya river basins. With the establishment of the Interstate Commission for Water Coordination (ICWC) in 1992, the newly independent states prepared a regional water strategy (Agreement of 18 February 1992), but continued to respect existing principles until the adoption of a new water-sharing agreement. Surface water resources allocated to Tajikistan are thus calculated every year, depending on existing flows. On average, however, incoming surface water resources that are available to Tajikistan are thought to be 13.31 km^3/year (1.51 Amu Darya and 11.8 Syr Darya). Considering an outflow of 54.86 km^3/year, secured by agreements, this means that the total renewable surface water resources (TRSWR) for Tajikistan are18.91 km^3/year (60.46+13.31-54.86) (Table 2).

Internally generated renewable groundwater resources are an estimated 6 km^3/year, of which 3 km^3/year overlap with surface water resources. In 1999, the portion of groundwater resources for which abstraction equipment exists was an estimated 2.2 km^3/year.

Tajikistan's total actual renewable water resources (TARWR) may thus be estimated at 21.91 km^3/year (Table 2 and Table 3).

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 municipal and industrial wastewater. The main portion of the return flow, about 3.94 km^3/year, flowed back to rivers, of which 2.85 km^3 into the Amu Darya river and 1.09 km^3 into the Syr Darya river. Around 0.35 km^3/year (8 percent of total return water) were directly used for irrigation. The remaining 0.06 km^3/year of return flow were directed to natural depressions. Since 2000, the average return flow has decreased to 3.5 km^3/year, because water intake from rivers for irrigation and other water sector needs has been reduced. The main portion of the return flow, about 3 km^3/year, flows back to the Amu Darya and Syr Darya rivers. Around 0.3 km^3/year is directly reused for irrigation. In 2008, wastewater produced accounted for 92 million m^3 of which 89 million m^3 were treated.

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 percent of the lakes are in the mountain area over 3 500 m

TABLE 3
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	691	mm/yr
	-	98 500	million m^3/yr
Internal renewable water resources (long-term average)	-	63 460	million m^3/yr
Total actual renewable water resources	-	21 910	million m^3/yr
Dependency ratio	-	17.3	%
Total actual renewable water resources per inhabitant	2011	3 140	m^3/yr
Total dam capacity	2010	29 500	million m^3
Water withdrawal			
Total water withdrawal by sector	2006	11 496	million m^3/yr
- agriculture	2006	10 441	million m^3/yr
- municipalities	2006	647	million m^3/yr
- industry	2006	408	million m3/yr
• per inhabitant	2006	1 762	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	2006	11 196	million m^3/yr
• as % of total actual renewable water resources	2006	51	%
Non-conventional sources of water			
Produced municipal wastewater	2008	92	million m^3/yr
Treated municipal wastewater	2008	89	million m^3/yr
Direct use of treated municipal wastewater		-	million m^3/yr
Desalinated water produced		-	million m^3/yr
Direct use of agricultural drainage water	2000	300	million m^3/yr

above sea level. The largest lake in the country, lake Karakul, is in the northeast at 3 914 m, with a surface area of 380 km^2 and a volume of 26.5 km^3. Sarez lake with 86.5 km^2 surface area and a volume of 17.5 km^3 is the second largest lake.

Water regulation is implemented by hundreds of hydraulic headworks, canals, pump stations and reservoirs. Reservoirs play the main role in water regulation for Tajikistan and downstream countries.

In 2010, there were 17 dams: 4 in the Syr Darya river basin and 13 in the Amu Darya river basin, of which 8 on the Vakhsh river, 2 on the Panj river and 3 on the Kofarnihon river. Their total reservoir capacity is about 29.5 km^3

Ten reservoirs have a capacity of more than 10 million m^3 each and their total capacity is 29 km^3. The largest reservoirs are: Nurek on the Vakhsh river (10.5 km^3), Kayrakkum on the Syr Darya river (4.16 km^3), Farhod on the Syr Darya river (350 million m^3), Boygozi on the Vakhsh river (125 million m^3), Kattasoy on the Kattasoy river (55 million m^3), Muminabad on the Obi Surkh river (31 million m^3), Dahanasoy on the Dahanasoy river (28 million m^3) and Sangtuda 1 on the Vakhsh river (25 million m^3). Sangtuda 2 reservoir (5 million m^3) on the Vakhsh river was inaugurated in 2011. The Nurek headwork incorporates a unique rock-filled dam with a central core, 310 m high a power plant with a capacity of 3 000 MW. Nurek and Kayrakkum reservoirs hold water for irrigation in Uzbekistan, Turkmenistan and Kazakstan. Rogun reservoir on the Vakhsh river (13.3 km^3) is under construction the first phase of construction was finished in 2012.

The gross theoretical hydropower potential is an estimated 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 percent of the country's electricity. In 1999, Tajikistan ranked third in the world for hydropower development, after the United States and the Russian Federation.

International water issues

The main rivers in Tajikistan are classified as transboundary, because they cross the boundaries of two countries (Vakhsh, Panj, Kofarnihon and Zeravshan rivers) or four countries (Amu Darya, Syr Darya). The supply of water for irrigation suffers difficulties only in drought years.

During the Soviet era, sharing of water resources among the five Central Asia republics was based on the master plans for the development of water resources in the Amu Darya (1987) and Syr Darya (1984) river basins. A regional water strategy was prepared with the establishment of the ICWC in 1992, by the newly independent states (Agreement of 18 February 1992). Existing principles continue to be respected until the implementation of a new water-sharing agreement. The agreement included the construction of Kambarata 1 reservoir in Kyrgyzstan and Rogun reservoir in Tajikistan. The new agreement 'Agreement on joint actions to address the problem of the Aral Sea and socio-economic development of the Aral Sea basin', was signed by the Heads of the five states in 1996.

Over the years, the main achievement of the ICWC has been the conflict-free supply of water to all water users, despite the complexities and variations of dry and wet years. The ICWC meets twice annually to set surface water withdrawal quotes, taking into account the main rivers water flow prognosis for the October–March and April–September seasons. For Tajikistan the Ministry of Land Reclamation and Water Resources (MLRWR) participates in the ICWC meetings and takes decisions at the interstate level concerning management of the Amu Darya and Syr Darya rivers water resources.

Uzbekistan is not in agreement regarding construction of reservoirs in the mountain areas of Tajikistan and Kyrgyzstan. Disputes between Tajikistan and Uzbekistan regard the management of the Kayrakkum reservoir in Tajikistan (UNDP, 2004). Tajikistan and Kyrgyzstan state that the reduction of the Aral Sea is caused mainly by inefficient water use for irrigation (<30 percent). Afghanistan has notified that it plans to develop irrigation and hydropower in the Amu Darya river basin.

In 1993, with the development of the Aral Sea basin programme, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) to coordinate implementation of the programme and the International Fund for Saving the Aral Sea (IFAS) to raise and manage its funds. In 1997, the two organizations merged to create IFAS (UNDP, 2004).

The partnership between the European Union Water Initiative (EUWI) and its Eastern Europe, Caucasus and Central Asia (EECCA) programme seeks to improve the management of water resources in the EECCA region. The partnership was established between the European Union and the EECCA countries at the World Summit for Sustainable Development in 2002. A significant component is the 'Integrated water resources management, including transboundary river basin management and regional seas issues' (SIWI, 2010).

In 2002, Central Asian countries and the Caucasus formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework, state departments, local and regional organizations, professional organizations, scientific and research institutes and the private sector and NGOs cooperate to establish a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for

FIGURE 1
Water withdrawal by sector
Total 11.496 km³ in 2006

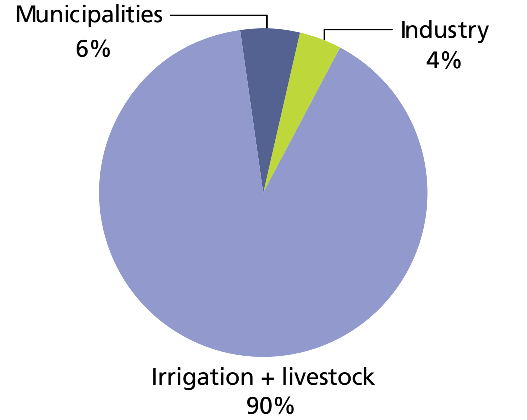
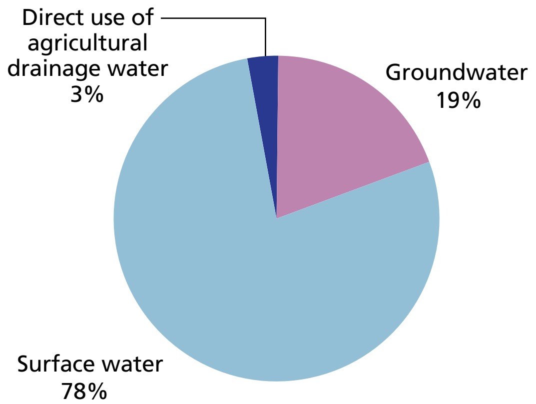


FIGURE 2
Water withdrawal by source
Total 11 870 km³ in 1994



the Economies of Central Asia (UN-SPECA). In collaboration with the EUWI and the UNECE is developing integrated water resources management in the Central Asian States. In cooperation with Germany and other EU countries, UNECE may play a role in the implementation of the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

Water use

On average, annual water withdrawal for the monitoring period 1985–2008 was 10.0–14.5 km^3/year. In 2006, total water withdrawal was an estimated 11.5 km^3, of which 91 percent for agricultural, 6 percent for municipal use and 3 percent for industry (Figure 1 and Table 3). The volume of water used to fill fishponds (aquaculture) 2005– 2009 was approximately 55 million m^3/year (State Unitary Department 'Mohiyi Tojikiston', 2009). For hydropower about 32–34 km^3/year of water flows through turbines.

In 1994, total water withdrawal was an estimated 11.9 km^3 (92 percent for agricultural purposes), of which 9.26 km^3 (78 percent) was surface water, 2.26 km^3 (19 percent) groundwater and an estimated 0.35 km^3 (3 percent) direct use of collector-drainage water and wastewater for irrigation (Figure 2). Groundwater is mostly withdrawn by industry.

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Irrigation in Tajikistan is important for the development of agriculture and the national economy. 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 m^3/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 m^3/s and the canal extended to irrigate the Akgazy plateau.

During the Soviet era, significant irrigation development took place in the Kofarnihon river basin, in southern Tajikistan. Together with Uzbekistan, Tajikistan built the Large Gissar canal in 1940, which carries water from the Kofarnihon river to the Surkhandarya river basin in Uzbekistan. In 1994, the irrigated area in the Kofarnihon river basin in Tajikistan was 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 through a 13.7 km irrigation tunnel to irrigate 76 000 ha in the Dangara valley. In the Vakhsh basin, a large irrigation system (40 000 ha), located in the Yavan and Obikiik valleys, which is extremely short of water, is supplied with water from the Baipaza reservoir through a 7.3 km long tunnel.

Recently, the irrigation potential area has been estimated as 1.58 million ha, which is about 11 percent of the total area of the country. In 1960, the total area equipped for irrigation was an estimated 408 000 ha. In 1994 it was 719 200 ha, which was 74 percent of the total cultivated area. About 33 percent of the total irrigated area (240 200 ha) is in the Syr Darya river basin and 67 percent (479 000 ha) in the Amu Darya river basin, of which 20 000 ha in the Zeravshan basin, 49 000 ha in the Kofarnihon basin, 18 000 ha in the Panj basin and 392 000 ha in the Vakhsh basin. In 2009, total area equipped for irrigation was 742 051 ha (Table 4). The area equipped for irrigation is mainly in north Sughd (Syr Darya basin), 282 374 ha, and south Khatlon (Amu Darya basin), 336 158 ha. Because of the lack of investment the country annually develops only 700–1 200 ha, which is around ten times less than necessary according to the 'Water sector development strategy for 2010–2025' (MLRWR and OSCE, 2009). In 2008, the area actually irrigated was an estimated 674 416 ha, or approximately 91 percent of the equipped area.

In northern Tajikistan, where irrigation is mainly based on the water resources of the Syr Darya river, water is (80 percent) delivered by pumping stations. The Tajik part of the Hunger steppe is bordered in the northwest by Uzbekistan. This region belongs to a semi-arid zone and the irrigated area is about 39 000 ha and mainly used for cotton. Water is taken from the Farkhad power plant diversion canal in two stages by remote-controlled pumping stations, which lift the water to 170 m. In 1994, the total power irrigated area was an estimated 318 000 ha.

Surface irrigation is the only irrigation technique used in Tajikistan. Drip, sprinkler and micro-sprinkler irrigation technologies have been used in a small area only at the experimental level. It is expected, however, that increased power tariffs will accelerate the spread of modern and water-saving technologies in pump-fed irrigation areas. In 1994, furrow irrigation was practised on over 96.3 percent of the equipped area and borderstrip irrigation on about 1.7 percent. On hill slopes the irrigation delivery network for gardens and grapes was comprised of pipes (2 percent). The irrigation technique used on fields is also surface irrigation. Cascade irrigation is practised on around 14 000 ha for rice cultivation.

All irrigation is full control irrigation. In 1994, out of a total area equipped for irrigation 719 200 ha, about 68 000 ha (or 9.4 percent) were irrigated with groundwater and about 25 000 ha (3.5 percent) agricultural drainage water and wastewater was used. Water pumped from rivers provided some 250 000 ha (34.8 percent); elsewhere water was gravity fed from river diversions (24.5 percent) or reservoirs (27.8).

In 2009, surface water irrigated about 696 476 ha (or 93.9 percent of total full control irrigation area), groundwater about 32 500 ha (4.4 percent) and about 13 075 ha (1.8 percent) mixed surface water and groundwater (Figure 3) was used. Monitoring of direct use of agricultural drainage water and treated wastewater is difficult. Water pumped from rivers irrigates 298 500 ha.

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 percent were concrete canals. On-farm canal networks totalled 5 259 km, with 13.3 percent concrete canals, 21.9 percent pipes and the remaining 64.8 percent unlined earthen canals. Water losses between the source and the fields depend on canal conditions and vary from 50 to 65 percent; field water use efficiency varies from 55 to 70 percent. Total water use efficiency ranges from 27 to 46 percent.

In Tajikistan, as with other Central Asia countries, large-scale irrigation schemes prevail. Large-scale schemes (>3 000 ha) cover 652 000 ha (88 percent), medium-scale irrigation schemes (500–3 000 ha) cover 50 000 ha (7 percent) and small-scale schemes (<500 ha) in mountainous areas, cover the remaining 40 000 ha (5 percent) (Figure 4). In 2009, approximately 62 percent of farms were privatized, 16 percent were family farms and 22 percent public.

FIGURE 3
Source of irrigation water on area equipped for full control irrigation
Total 742 051 ha in 2009

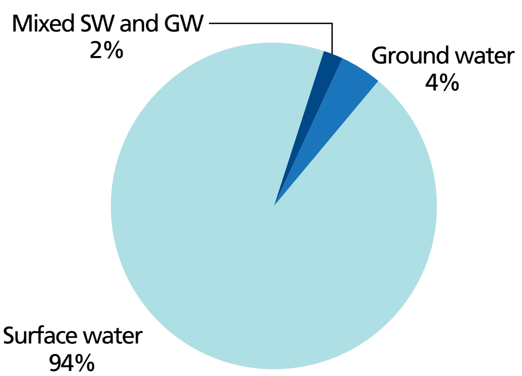
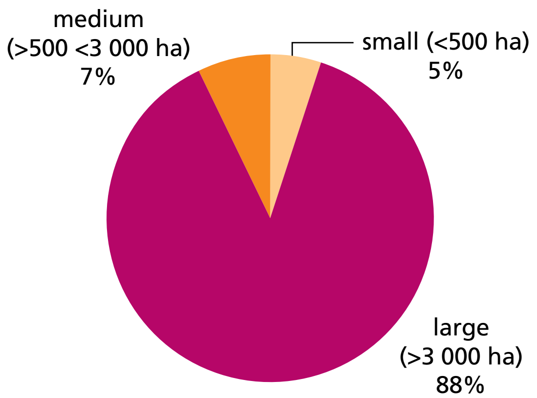


FIGURE 4
Type of full control irrigation schemes
Total 742 051 ha in 2009



Role of irrigation in agricultural production, economy and society

In 2009, total harvested irrigated cropped area was an estimated 729 283 ha. The main irrigated crop in Tajikistan is cotton, accounting for 237 130 ha or 33 percent of total irrigated harvested area. Around one million rural people are involved in cotton production and processing. The area has decreased since 1990, when it accounted for 300 000 ha. During the Soviet era, Tajikistan had the highest cotton yield in Central Asia, with a national average yield of 3 tonnes/ha. During the last 5 years, however, the yield barely achieves 1.6–1.7 tonnes/ha. The second largest area is irrigated wheat with 179 742 ha (25 percent). After harvesting of wheat in June–July, farmers sow maize for forage, vegetables and legumes as a second crop. In the mountainous Badakhshan region, and other districts over 1 500 m, wheat harvesting months are July and August. Temporary and permanent fodder and permanent meadows and pastures account for 83 234 ha or 11 percent of the harvested irrigated cropped area, vegetables represent 37 162 ha (5 percent) and other perennial crops 98 957 ha (14 percent) (Figure 5 and Table 4). Cotton, fruits and grapes were the most important export crops during the 1990s.

FIGURE 5
Irrigated crops on area equipped for full control irrigation
Total harvested area 729 283 ha in 2009 (cropping intensity on actually irrigated area: 108 %)

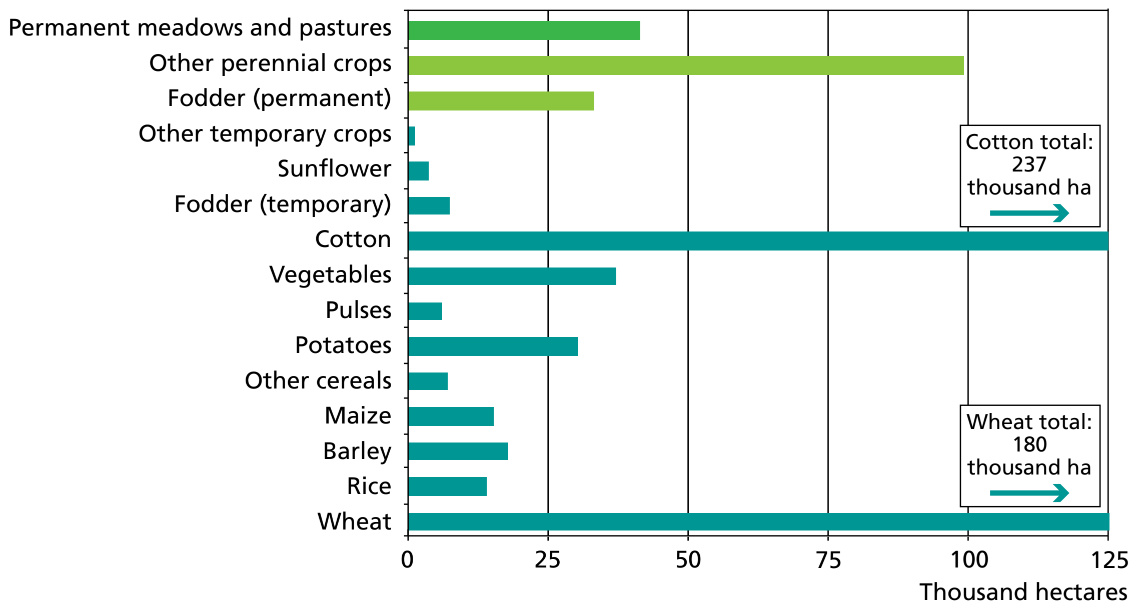


TABLE 4
Irrigation and drainage

Irrigation potential			1 580 000	ha
Irrigation				
1. Full control irrigation: equipped area		2009	742 051	ha
- surface irrigation		2009	742 051	ha
- sprinkler irrigation			-	ha
- localized irrigation			-	ha
• % of area irrigated from surface water		2009	93.9	%
• % of area irrigated from groundwater		2009	4.4	%
• % of area irrigated from mixed surface water and groundwater		2009	1.8	%
• % of area irrigated from mixed non-conventional sources of water			-	%
• area equipped for full control irrigation actually irrigated		2008	674 416	ha
- as % of full control area equipped		2008	91	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2009**	**742 051**	**ha**
• as % of cultivated area		2009	85	%
• % of total area equipped for irrigation actually irrigated		2008	91	%
• average increase per year over the last 14 years		1994-2009	0.2	%
• power irrigated area as % of total area equipped		2009	40	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2009**	**742 051**	**ha**
• as % of cultivated area		2009	85	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< 500 ha	2009	40 000	ha
Medium-scale schemes	> 500 and < 3 000 ha	2009	50 000	ha
Large-scale schemes	> 3 000 ha	2009	652 051	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production (wheat and barley)			-	metric tons
• as % of total grain production			-	%
Harvested crops				
Total harvested irrigated cropped area		2009	729 283	ha
• Temporary crops: total		2009	555 415	ha
- Wheat		2009	179 742	ha
- Rice		2009	14 126	ha
- Barley		2009	18 017	ha
- Maize		2009	14 743	ha
- Millet		2009	237	ha
- Other cereals		2009	6 988	ha
- Potatoes		2009	29 901	ha
- Sugar beet		2009	53	ha
- Pulses		2009	4 667	ha
- Vegetables		2009	37 162	ha
- Tobacco		2009	210	ha
- Cotton		2009	237 130	ha
- Fodder (temporary)		2009	8 323	ha
- Soyabeans		2009	7	ha
- Sunflower		2009	3 493	ha
- Sesame		2009	616	ha
• Permanent crops: total		2009	133 000	ha
- Fodder (alfalfa)		2009	34 043	ha
- Other perennial crops		2009	98 957	
• Permanent meadows and pastures: total		2009	40 868	ha
Irrigated cropping intensity (on full control area actually irrigated)		2009	108	%
Drainage - Environment				
Total drained area		2009	345 200	ha
- part of the area equipped for irrigation drained		2009	345 200	ha
- other drained area (non-irrigated)			-	ha
• drained area as % of cultivated area		2009	39	%
Flood-protected areas			-	ha
Area salinized by irrigation		2009	23 235	ha
Population affected by water-related diseases			-	inhabitants

Around 95 percent of agriculture production comes from irrigated areas. Rainfed land is mainly located upland where wheat is grown and there are pastures. The wheat yield in rainfed areas is very low, 1.2–1.8 tonnes/ha.

If water is available in winter, farmers irrigate to improve soil conditions. In pump irrigation areas winter irrigation is not practiced.

Annual expenditure for operation and maintenance (O&M) of irrigation and drainage systems is an estimated US$68.8 million. 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. In 1999, the average cost of irrigation development was an estimated US$10 000–18 000/ha for large-scale surface irrigation schemes using standard modern technologies, including agricultural development. Estimated cost of implementation would be US$2 500–5 000/ha if localized irrigation were to be developed on existing irrigated land.

Status and evolution of drainage systems

Total area equipped for irrigation, also equipped with a drainage system, amounts to 345 200 ha, including 69 200 ha of subsurface drainage (20 percent) (Table 4). Because O&M is inadequate, a substantial portion of subsurface drainage is currently not used. In 2008, 19 364 ha of medium salinization and 3 871 ha of high salinization (toxic ions exceeding 0.5 percent of total soil weight) were monitored. Unsatisfactory land conditions for agricultural use were estimated on 43 474 ha, of which 54 percent is the result of waterlogging.

According to MLRWR data new drainage systems need to be constructed on 7 000 ha, existing drainage systems rehabilitated on 23 400 ha and soils leached on 14 200 ha. The water table has risen because of water losses from the irrigation network. Modernization and rehabilitation of the on-farm irrigation network on 449 600 ha can lower the water table considerably and increase agriculture production efficiency.

Because of increased fuel prices over the last 5 years, the cost of excavation work has increased and, accordingly, there has been a three-fold increase in the cost of drainage construction and rehabilitation. The average cost of surface drainage development is an estimated US$1 500–1 800/ha and that of subsurface drainage development US$1 500–2 000/ha.

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

Institutions

Interdepartmental coordination of water resources management is carried out by the government. Water management involves many government organizations: Ministry of Land Reclamation and Water Resources (MLRWR), Ministry of Energy and Industry, Ministry of Foreign Affairs, Ministry of Agriculture, Ministry of Economical Development and Trade, Ministry of Health, Ministry of Justice, State Unitary Organization on Water Supply, State Inspectorate on Mining and Technical Supervision, State Committee on Environmental Protection, State Committee on Land Management and Geodesy, National Geological Agency, Committee on Emergency Situation and Civil Protection.

Institutionally, water management follows a hierarchy: state, province, district, farm or water user association (WUA). The first three levels fall under the MLRWR, which is responsible for the planning and management of water resources for agriculture, water distribution and delivery to the farm inlet, assistance to the water users for implementation of advanced technology and control of water use and water quality. The special reclamation services at provincial level are the responsibility of the MLRWR, which monitors irrigated land (groundwater level, drainage discharge, soil salinity) and plans maintenance and improvement of soil conditions, including leaching, repair and cleaning of collectors and drainage network and rehabilitation. O&M, rehabilitation and modernization and construction of new irrigation schemes, inter-farm level irrigation and drainage networks have been implemented by the Ministry and its subdivisions in *viloyats* (provinces).

MLRWR is a member of the ICWC of Central Asia countries.

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

The State Unitary Enterprise *Khojagii Manziliu Kommunali* is responsible for domestic water supply and the treatment of wastewater. The Committee on Nature Protection is responsible for the protection of water resources.

Water management

WUAs in Tajikistan are a new initiative to manage water structures on irrigated areas belonging to the former *kolkhoz* (collective farms) and *sovkhoz* (state [Soviet] farms). In 1994, there were 297 000 households on 262 *kolkhoz*, occupying 48.4 percent of the cultivated area, and 199 700 households on 393 *sovkhoz*, occupying 44.3 percent of the cultivated area. Private plots and land leased to state-farm employees (about 33 000 households) totaled about 7.3 percent of the cultivated area. During land reform (1996–2000) *kolkhoz* and *sovkhoz* were privatized and divided into a number of small, private (*dehkan*) farms. There are WUAs on irrigation schemes of 1–500 ha each. Currently, WUAs cover almost 35 percent of the irrigated area, but they remain weak. District-level state water management organizations supply water to WUAs gates on a contract basis and these implement on-farm water management. In some areas, several WUAs have established a federation of WUAs. Because agriculture is inefficient and low incomes, often farmers are unable to pay water fees to the state water management organizations.

The MLRWR established the Support Unit to assist WUAs. A number of international and local NGOs conduct training and provide technical assistance to increase the capacity of the WUAs.

Finances

A water fee system has been in place since 1996 for the supply of irrigation water services from state water management organizations. The current financial mechanism has shortcomings and will be settled during upcoming irrigation reform.

MLRWR accords actual expenditures of O&M, including electricity price, and estimates the water fee, which is provided to the Ministry of Economy Development and Trade for its approval. The water fee is rated 2–6 times less than required to ensure adequate O&M of the irrigation and drainage systems, especially for pump irrigation. Some of these lift irrigation systems are not economically viable under current energy costs and economic conditions. These systems, built in the Soviet period without any economic considerations, pump in what is called a cascade system consisting of 4, 5 and up to 6 stages of pumping. The current water fee for gravity irrigation is US$4.13/1 000 m^3 and US$6.58/1 000 m^3 for pump irrigation (including 20 percent VAT). The recent increase in the price of electricity will influence changes to the water fee for irrigation services.

The government annually subsidises construction of irrigation infrastructure on 700–1 000 ha.

Since 2000, rehabilitation of irrigation and drainage facilities, pump stations and pressure pipes has cost more than US$200 million, funded mainly by the Asian Development Bank (ADB) and World Bank investments and grants.

Policies and legislation

The current legal basis for water management is the ‘Water Code of Tajikistan’, adopted in 2000. The main target of water legislation is to ensure water supply to users. A previous ‘Water Code of Tajikistan’ was signed in 1993.

The WUAs Law was adopted in 2007, which provided a legal basis for the establishment and development of WUAs to improve on-farm water management within the bounds of privatized former *kolkhoz* and *sovkhoz*.

There are almost 50 laws linked to water management.

ENVIRONMENT AND HEALTH

The environmental problems in Tajikistan are the result of its climate, natural conditions (steep slopes), land-use change and the structure of the national economy. Erosion affects 97 percent of agricultural land and is a major threat to sustainable agriculture, particularly in hilly areas. In the löss zone, steep slope grazing land has been converted to cultivated agriculture over the last 15 years resulting in significant loss of sediments, which has caused damage downstream.

The irrigated area is subject to substantial erosion, landslides, sagging and deformation. The area affected is an estimated 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 sediment-loaded drainage water runoff. Collector-drainage water is the principal water polluter (common salinization, pesticides and other waste). Environmental pollution is increasing as a consequence of industrial production.

The two major land quality problems are the interrelated issues of salinity and waterlogging, caused by high groundwater levels. Salinization of irrigated land in lowland areas has increased because of inadequate drainage systems, low irrigation efficiency resulting in high water losses. The total area salinized by irrigation is 23 235 ha. The area waterlogged in irrigation areas is 25 742 ha.

Except for some lakes and groundwater sources, the water quality is considered drinkable. General salinity level of water at source is 0.05–0.40 g/litres.

According to research during the Soviet era, around 10–12 percent of irrigation water supplied to fields leaches to aquifers, and around 40 percent returns to rivers. In the Amu Darya river basin Tajikistan withdraws only 10–12 percent of the annual river flow, thus changes to water quality are insignificant.

Mud torrents occur mostly in the Zeravshan river basin on average 150 times/year and in the Vakhsh and Panj river basins on an average of 70 times/year, mostly in April (35 percent) and in May (28 percent). There are 102 mud torrents, hazardous rivers and annual mud torrents and floods result in great damage to the country. Flood damage alone in 2005 amounted to US$50 million (MLRWR and UNDP, 2006).

The Committee on Emergency and Civil Protection and MLRWR manage floods and mudflows. Lack of equipment, materials and capacity, however, has led to inefficient hazard mitigation measures.

Around 2 012 km of bank protection dykes and mud torrent discharge channels have been constructed to protect social and economic infrastructure. Reservoirs play an important role in protection of property and infrastructure from floods and mud torrents.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

The objective of water sector reforms is to create an efficiently planned, developed and managed water sector based on sound policies, joint analysis and management of groundwater and surface water. The different water using sectors are balanced, using the basin as the management area, to secure economic benefit to Tajikistan, without compromising ecological integrity. This water sector reform has adopted the guiding principle of integrated water resources management (IWRM).

District-level state water management units will be included in Basin Water Management Organizations (BWMO). The BWMOs will transfer all water management responsibility in stages to WUAs for secondary and tertiary canals . In some cases WUAs will manage water at the primary canal level. Establishing the new tandem management structure BWMO+WUA is fundamental to the introduction of IWRM in Tajikistan. The government expects to create 11 BWMOs: Syr Darya, Istarafshan, Zeravshan, Gissar (Hisor), Rasht, Yavan, Dangara, Kulob, Lower Kofarnihon, Vakhsh and Badakhshan.

Establishment of WUAs has started at the secondary and tertiary canal level, the government aims to cover all irrigated areas with WUAs. The relationship between state BWMOs and non-government WUAs will be based on water supply contracts. The main goal of government irrigation reform is to reduce state budget expenditures for O&M for irrigation and drainage systems. Although the government subsidizes only 10–15 percent of requested expenditures for O&M, efforts are directed to the establishment of self-funding water resources management systems. It seems difficult, however, to cover the highest cost systems (highest lifts) of water supply services. The drought mitigation strategy includes introducing water-saving measures in the summer and limitation of water intake from sources for all economy sectors during drought years. The aim of the ICWC is to reduce the regions water intake quotes by 10–25 percent.

The deteriorating condition of irrigation and drainage, water supply and sanitation infrastructure has forced the government to pursue investment from all accessible sources. State investment and water fees are insufficient to rehabilitate infrastructure.

Several key issues must be addressed for the effective implementation of water sector reforms. These include the formulation of an investment and realistic finance plan for the implementation of water sector reform; application of water related reform laws; inventory of irrigation systems and prioritization of the most viable for modernization/rehabilitation; support to WUAs for the successful O&M of irrigation and drainage systems with the application of a fair and realistic tariff system; and support to alternative high cost systems (high lift systems) to sustain livelihoods in upland areas.

With the participation of international organizations and experts, the government aims to reform the water sector and transfer the centrally planned economy to a real market economy. This will change cropping patterns in irrigated areas. As a result, farmers will become interested in adopting water-saving irrigation technologies for economic reasons and, therefore, contribute to the preservation of the environment.

MAIN SOURCES OF INFORMATION

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Turkmenistan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Turkmenistan 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 the Islamic Republic of Iran. Total area is 488 100 km^2 (Table 1). The country formally declared independence from the Union of Soviet Socialist Republics (USSR) in October 1991. For administrative purposes, the country is divided into five provinces (*velayat*) and one independent city, Ashgabat, which is the capital.

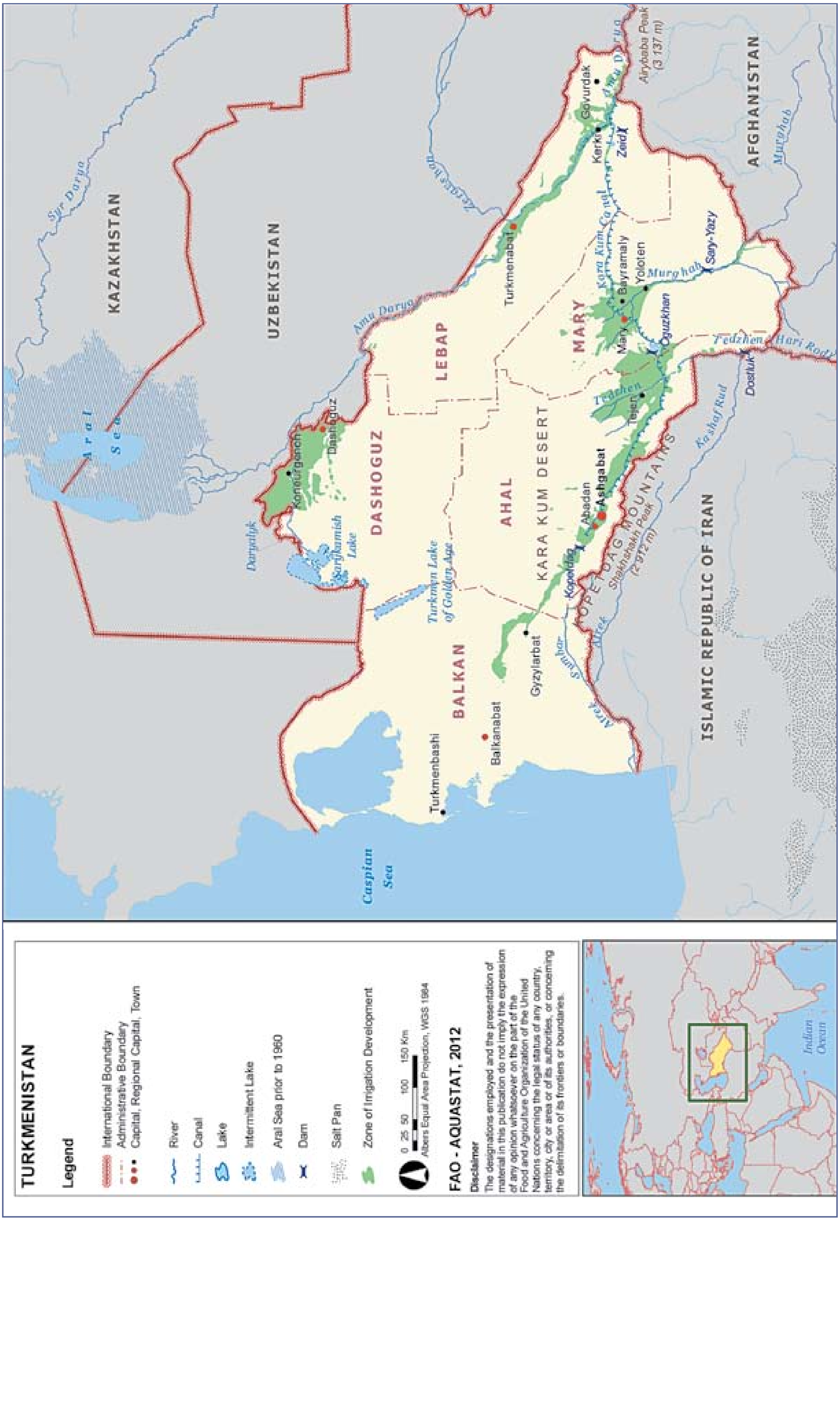
The Kara Kum desert covers 80 percent of the country. In the southwest, along the border with the Islamic Republic of Iran, lies the Kopetdag mountain chain where the Shakhshakh peak rises to 2 912 m above sea level. The highest point is the Airybaba peak, which is 3 137 m, in the Kougitantau mountain range in the east, on the border with Uzbekistan. About 12 percent of the country is covered by water and non-soil formations (talus, rocks, precipices) (AST and MOA, 1961).

The cultivable area is an estimated 7 million ha, or 14 percent of the total area. In 2009, total cultivated area was an estimated 1 910 000 ha, of which 1 850 000 ha was comprised of temporary crops, and 60 000 ha permanent, mostly vineyards, pistachio nuts, figs and olives. In 1994, the cultivated area 1 755 200 ha, was divided into *kolkhoz* (collective farms) and *sovkhoz* (state farms), which together covered 1 596 400 ha (91 percent of total cultivated area); the 'citizens' land', corresponds to gardens and individual plots, on 109 900 ha (6 percent); and private farms, owned by 4 500 households, on 48 900 ha (3 percent). In May 1994, the government approved land reform, which should eventually result in the privatization of agricultural land. The *sovkhoz* and *kolkhoz* land are to be distributed to employees under a lease contract of 99 years. At the end of 1994, about 720 000 ha of this land (or 41 percent of total cultivated land) had been distributed to 260 000 farmers.

Climate

The climate in Turkmenistan is distinctly continental and arid, because of the nature of the underlying surface, and the presence of mountain ranges in the southeast and south. Average annual precipitation is about 191 mm, ranging from less that 80 mm in the northeast to 300 mm in the Kopetdag mountains in the southwest. Precipitation occurs during winter, between October and April. Sometimes there may be no precipitation during summer. Agriculture, therefore, depends entirely on irrigation.

Average annual temperature varies from 11 13 °C in the north to 15–18 °C in the southeast. Winters are mild, with little snow and moderate frost. The average temperature in January, the coldest month, is about minus 4 °C throughout most of the country, except in the southwest where the climate is milder with an average temperature of 4 °C in the coldest month. The summer is very hot and dry. In July, average temperatures exceed 30 °C throughout the country. Average annual evaporation from water surface varies from 2 000 to 2 300 mm (Berdiyev, 2006).


TURKMENISTAN
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
River
Canal
Lake
Intermittent Lake
Aral Sea prior to 1960
Dam
Salt Pan
Zone of Irrigation Development
0 25 50 100 150 Km
Albers Equal Area Projection, WGS 1984
FAO - AQUASTAT, 2012
Disclaimer
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Indian Ocean
KAZAKHSTAN
UZBEKISTAN
AFGHANISTAN
ISLAMIC REPUBLIC OF IRAN
Caspian Sea
Aral Sea
Syr Darya
Amu Darya
Daryalyk
Sarykamish Lake
Turkmen Lake of Golden Age
DASHOGUZ
LEBAP
AHAL
BALKAN
MARY
KARA KUM DESERT
KOPETDAG MOUNTAINS
Shahshakh Peak (2 912 m)
Airybaba Peak (3 137 m)
Koneurgench
Dashoguz
Turkmenabat
Kerki
Govurdak
Zeid
Kara Kum Canal
Bayramaly
Yoloten
Murghab
Sary-Yazy
Mary
Oguzkhan
Tedzhen
Tejen
Hari Rod
Dostluk
Kashaf Rud
Ashgabat
Abadan
Kopetdag
Gyzylarbat
Sumbar
Atrek
Balkanabat
Turkmenbashi

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	48 810 000	ha
Cultivated area (arable land and area under permanent crops)	2009	1 910 000	ha
• as % of the total area of the country	2009	3.9	%
• arable land (temporary crops + temp fallow + temp meadows)	2009	1 850 000	ha
• area under permanent crops	2009	60 000	ha
Population			
Total population	2011	5 105 000	inhabitants
• of which rural	2011	50	%
Population density	2011	10	inhabitants/km^2
Economically active population	2011	2 431 000	inhabitants
• as % of total population	2011	48	%
• female	2011	47	%
• male	2011	53	%
Population economically active in agriculture	2011	714 000	inhabitants
• as % of total economically active population	2011	29	%
• female	2011	53	%
• male	2011	47	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	20 001	million US$/yr
• value added in agriculture (% of GDP)	2010	12	%
• GDP per capita	2010	3 967	US$/yr
Human Development Index (highest = 1)	2011	0.686	
Access to improved drinking water sources			
Total population	2006	84	%
Urban population	2010	97	%
Rural population	2006	72	%

Population

The total population was an estimated 5.1 million inhabitants in 2011, of which 50 percent rural, while in 2001 54 percent was rural. During the period 2001–2011, annual population growth rate was an estimated 1.1 percent. The population density is about 10 inhabitants/km^2.

In 2006, 84 percent of the population had access to improved water sources (97 and 72 percent in urban and rural areas respectively). Sanitation coverage accounted for 98 percent (99 and 97 percent in urban and rural areas respectively) (Table 1).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, the gross domestic product (GDP) was US$20 001 million, of which the agriculture sector accounted for 12 percent, in 2000 it accounted for 24 percent (Table 1).

In 2011, the total economically active population was 2.4 million, or 48 percent of the total population. The economically active population in agriculture is an estimated 0.7 million (29 percent of total active population), of which 53 percent is female.

Practically all the rural population possess irrigated land ranging from 0.01 to 0.25 ha for small- scale agricultural production, mainly fruit, vegetables, beans, berries and for raising cattle and poultry. A considerable proportion of the urban population possesses rural irrigated land of up to 0.01 ha, used to grow agricultural products for their own consumption. During the past years the urban population has tended towards accessing their rural plots to keep cattle and poultry (National Bureau, 2000).

In 2004, about 576 large-scale farm associations and 600 other legal entities, took part in large-scale agricultural production (Turkmenmillihasabat, 2005). About 6 100 individuals participated in medium-scale production and more than 620 000 families engaged in small- scale agricultural production.

The Government priority is to ensure food self-sufficiency by focussing on key food products. Wheat and rice are the main traditional crops cultivated to ensure food security. These crops are closely correlated to large-scale irrigation schemes. Individual rural entrepreneurs produce 99 percent of potatoes, 69 percent of watermelons, 24 percent of grape production, 82.5 percent of meat, 96 percent of milk and 93 percent of eggs. The population’s food demands are met by large-scale irrigation schemes, small-scale production and imported goods. In 2004, the importation of cattle breeding stock amounted to US$55.6 million, crops to US$28 million and animal and vegetable oils and fats to US$13.9 million (Turkmenmillihasabat, 2005).

WATER RESOURCES AND USE

Water resources

River runoff originating within the country is an estimated 1.0 km^3/year (Table 2). There are several rivers in Turkmenistan, but most flow into the country from neighbouring countries.

Turkmenistan’s main source of water is the Amu Darya river, which rises in the snow-covered mountains of Tajikistan, enters the country in the southeast along the Afghan–Uzbek border, flows in a northwestern direction, then becomes the border with Uzbekistan before

TABLE 2

Renewable surface water resources (RSWR) by major river basin in Turkmenistan

River basin	Location	Part of country	Internal RSWR		Inflow			Outflow	Total actual
		%	IRSWR (km^3/year)	%	Total	Secured through agreements		To	TARSWR (km^3/year)
					(km^3/year)		From		
Amu Darya	Northeast	73.7	0.68	68	66.08[a] 11.7[b]	43.32[d]	Uzbekistan Afghanistan	Uzbekistan[e]	22.00[f]
Atrek (Sumbar/ Chandyr)	Southwest	4.4	0.02	2	0.10	0.04	Islamic Republic of Iran	Caspian Sea	0.06
Murghab	Southeast	9.6			1.25[c]	-	Afghanistan	Desert	1.25
Tedzhen	South	11.3	0.30	30	1.07	0.75	Islamic Republic of Iran, Afghanistan	Desert	0.75
Other	South	1.0			-	-	Islamic Republic of Iran	Desert	0.30
Total		**100.0**	**1.00**	**100**	**80.20**	**44.11**			**24.36**

a Equal to the flow from Uzbekistan (4.7) and flow originating in Kyrgyzstan (1.93) and flow originating in Tajikistan (59.45), both through Uzbekistan to Turkmenistan.

b Even though Afghanistan is not part of an agreement on allocation between the five ex-USSR states (and therefore in Afghanistan the 11.7 is not considered as being outflow secured through agreements), because of the fact that the allocation between the five states is based on measurements at Kerki station in Turkmenistan, the 11.7 flow is included in the total flow.

c Total inflow from Afghanistan is 3.1, but most is lost in depressions at the border.

d The agreement among the five Central Asian Republics stipulates that on average 22 km^3/year are to be reserved for Turkmenistan (of which 0.68 km^3/year are IRSWR of Turkmenistan) and 22 km^3/year for Uzbekistan. It has been considered that the latter comes into Turkmenistan before being used downstream in Uzbekistan.

e The natural outflow is equal to 78.46, which is equal to the IRSWR of all countries in the Amu Darya basin: 1.93 (Kyrgyzstan) + 59.45 (Tajikistan) + 4.70 (Uzbekistan) + 11.7 (Afghanistan) + 0.68 (Turkmenistan).

f Equal to 44/2 and includes 0.68 IRSWR of Turkmenistan.

entering Uzbekistan on its way to the rapidly dying Aral Sea. Most of the Amu Darya water is withdrawn by Turkmenistan and Uzbekistan along this section of their common border (Stanchin and Lerman, 2006).

The part of the Amu Darya flow that is allocated to Turkmenistan and Uzbekistan is 50 percent each of the actual river flow at the Kerki gauging station, based on an agreement between the two countries signed in January 1996, which supplemented the 1992 Five Central Asia Countries Agreement. The Turkmen allocation corresponds to 42.27 percent of the portion of Amu Darya surface water resources on which agreements have been concluded. These agreements are calculated based on about 67 percent of the total flow produced in the Amu Darya basin, which is on average 78.46 km^3/year, calculated by adding the basin' internal renewable surface water resources (IRSWR) in the different countries: Kyrgyzstan 1.93 km^3/year, Tajikistan 59.45 km^3/year, Uzbekistan 4.70 km^3/year, Afghanistan 11.70 km^3/year and Turkmenistan 0.68 km^3/year. The surface water resources allocated to Turkmenistan are thus calculated every year, depending on the flows. On average, water resources allocated to Turkmenistan in the Amu Darya basin are about 22 km^3/year, including 0.68 km^3/year of IRSWR. Even though Afghanistan is not part of the five former Soviet states, and therefore not part of the agreement concerning allocations between the five states, the flow of 11.7 km^3/year is included in the flow measured at Kerki station in Turkmenistan, based on which allocations to the five states are calculated.

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 each year Turkmenistan receives a quantity equal to 70 percent of the total Tedzhen average runoff, and 50 percent 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 (including 0.02 km^3/year IRSWR).

Renewable groundwater resources are an estimated 0.405 km^3/year, while the overlap between surface water and groundwater is considered negligible. Total internal renewable water resources (IRWR) are thus estimated at 1.405 km^3/year. Total actual renewable water resources (ARWR) are an estimated 24.765 km^3/year, equal to the total actual renewable surface water resources (ARSWR) of 24.36 plus the groundwater resources of 0.405 km^3/year (Table 2 and Table 3).

The largest and most important waterway in Turkmenistan is the Kara Kum canal. This canal was constructed in the 1950s and is at 1 400 km the longest canal in the world. The canal capacity is an estimated 630 m^3/s. Its inlet on the Amu Darya river is located just after the river enters Turkmenistan from Uzbekistan. The Kara Kum canal pools the Amu Darya, Murghab and Tedzhen rivers into the integrated water management system and supplies water to the densely populated southern region and irrigates more than 1 200 000 ha. The canal brings water to the capital Ashgabat and to the oases in the south. Each year the canal takes 10–12 km^3 from the Amu Darya river (Orlovsky and Orlovsky, after 2002).

Produced and treated desalinated water and wastewater do not play a significant role in Turkmenistan. Agricultural drainage water, however, is a substantial additional source for pasture irrigation (the Sarajin sheep breed can drink water with a salinity of up to 10 g/litre), growing salt-resistant trees and forage crops and for fisheries. Currently, a drainage water collector is being constructed, which will accumulate practically all drainage water from all regions of Turkmenistan into the artificial 'Golden Age Lake', located southwest of Sarykamish lake in the north.

In 2004, wastewater production was an estimated 1.275 km^3,and treated wastewater 0.336 km^3 all of which was directly reused. In 1994, the volume of treated industrial and municipal wastewater was an estimated 0.025 km^3/year, all of which was directly reused. For the period 1990–1994, agricultural drainage water was on average an estimated 5.4 km^3/year. After being

TABLE 3
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	161	mm/yr
	-	78 580	million m^3/yr
Internal renewable water resources (long-term average)	-	1 405	million m^3/yr
Total actual renewable water resources	-	24 765	million m^3/yr
Dependency ratio	-	97	%
Total actual renewable water resources per inhabitant	2011	4 851	m^3/yr
Total dam capacity	2004	6 219.5	million m^3
Water withdrawal			
Total water withdrawal by sector	2004	27 958	million m^3/yr
- agriculture	2004	26 364	million m^3/yr
- municipalities	2004	755	million m^3/yr
- industry	2004	839	million m3/yr
• per inhabitant	2004	5 952	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	2004	27 542	million m^3/yr
• as % of total actual renewable water resources	2004	111	%
Non-conventional sources of water			
Produced municipal wastewater	2004	1 275	million m^3/yr
Treated municipal wastewater	2004	336	million m^3/yr
Direct use of treated municipal wastewater	2004	336	million m^3/yr
Desalinated water produced		-	million m^3/yr
Direct use of agricultural drainage water	1994	80	million m^3/yr

collected in the collector-drainage canals, about 2.35 km^3/year (44 percent) is returned to rivers, mainly the Amu Darya river, about 2.97 km^3/year (55 percent) went to natural depressions, mainly the Sarykamish lake in the north on the border with Uzbekistan, and the remaining 0.08 km^3/year (1 percent) was reused for irrigation.

In 2004, total dam capacity accounted for about 6.22 km^3. All reservoirs were designed and constructed for irrigation and heavily affected by silt. There are five dams with a capacity of more than 0.5 km^3: Zeid on the Kara Kum canal (2.20 km^3), Dostluk on the Tedzhen river (1.25 km^3), Oguzkhan on the Kara Kum canal (0.88 km^3), Sary-Yazy on the Murghab river (0.66 km^3) and Kopetdag on the Kara Kum canal (0.55 km^3). The Dostluk dam is on the border between the Islamic Republic of Iran and Turkmenistan and has been designed for flood control, hydropower generation and flow regulation.

In 1993, gross hydropower potential was an estimated 5.8 GWh, while total installed capacity was about 0.7 GWh.

The outflow of agricultural drainage water has led to the creation of artificial lakes in natural depressions. The largest is Sarykamish lake, which stores about 8 km^3. A major environmental issue in Turkmenistan is the permanent accumulation of pollutant salt in these lakes, which leads to the degradation of flora and fauna.

International water issues

Water resources in Turkmenistan are almost fully formed from transboundary watercourses such as the Amu Darya, Murghab, Tedzhen, Atrek rivers and small rivers.

During the period Soviet era, water sharing among the five Central Asian republics was based on master plans for water resources development in the Amu Darya (1987) and Syr Darya (1984) basins.

After the country's independence, Turkmenistan confirmed its obligations to agreements concerning transboundary rivers and water. These obligations are set out in the following (Berdiyev, 2005):

- Agreement of 20 February 1926 between the USSR and Persia about the joint use of rivers and water along the borderline from the river Geri-Rud (Tedjen) to the Caspian Sea;
- Protocol (*paragraph 11*) to Agreement of 2 December 1954 between the USSR and Iran about settlement of borderline and financial issues;
- Treaty of 15 May 1957 between the USSR and Shahinshah Government of Iran about the Soviet-Iranian boundary and procedures to address borderline conflicts and case adjustment;
- Soviet-Iranian Agreement of 11 August 1957 on the Araks (with the Caucasus countries) and Atrek rivers;
- Agreement of 5 March 1958 between the USSR and Shahinshah Government of Iran on the preparation of draft projects on the equitable use of the Araks (with the Caucasus countries) and Atrek rivers for irrigation and power generation.

In 1992, with establishment of the Interstate Commission for Water Coordination (ICWC), the newly independent republics prepared a regional water strategy covered by the Agreement of 18 February 1992. It was decided,that existing principles be respected until a new water sharing strategy could be adopted. This new 'Agreement on joint actions to address the problem of the Aral Sea and socio-economic development of the Aral Sea basin', was signed by the Heads of the five states in 1996. Over the years, the ICWC has achieved the conflict-free supply of water to all water users, despite the complexities and variations of dry and wet years.

In 1993, with the development of the Aral Sea basin programme, two new organizations came into being: the Interstate Council for the Aral Sea (ICAS) to coordinate implementation of the programme and the International Fund for Saving the Aral Sea (IFAS) to raise and manage its funds. In 1997, the two organizations merged to create IFAS (UNDP, 2004).

Turkmenistan and Uzbekistan signed agreements on the principles of basic water allocation, which have proved viable. Both countries have gained experience in the joint management of the Amu Darya river. ICWC played and still plays a positive role in this respect. All the above led to the conclusion of a permanent agreement in 1996 between Turkmenistan and Uzbekistan on cooperation on water management issues. This agreement is based on the principles that the parties:

- recognize the need for joint use of interstate rivers and other water sources;
- reject application of economic and other means of pressure when solving water issues;
- acknowledge the interdependence of water problems and the responsibility for rational water use;
- focus on increased water inflow to the Aral Sea;
- understand the need to respect mutual interests and settle water-related issues by consensus.

The above-mentioned agreement was signed in Turkmenabad on 15 January 1996 and established:

- land used by Uzbekistan and located within the borders of Turkmenistan is the sole property of Turkmenistan;

- waterworks and water management organizations on the Karshi and Amu-Bukhara canals and Tuyamuin reservoir, located in Turkmenistan, are the property of Uzbekistan;
- land for the Karshi and Amu-Bukhara canals and for the Tuyamuin hydro-unit are placed at the disposal of Uzbekistan on a chargeable basis;
- countries will make all necessary attempts to provide normal operation of interstate waterworks located within their territories;
- companies and organizations, including those dealing with interstate waterworks operation located on the territory of the other Party, act in accordance with international rules and the laws of that country;
- the flow of the Amu Darya river at Kerki gauging station is divided into equal shares (50/50);
- countries should allocate a portion of their shares to the Aral Sea;
- countries should stop disposal of drainage water to the Amu Darya river, independent of the quality of the drainage water;
- countries jointly implement measures on the reclamation of land, reconstruction and operation of interstate collectors and irrigation systems and construction of water disposal canals;
- countries will prevent channel deformations and flooding of adjacent areas, caused by operation of the Amu-Bukhara, Karshi, Sovetyab, Dashoguz, Tashsaka, Kylychbay and Shabat-Gazavat water systems;
- countries will make necessary attempts to prevent flooding of land located along the Daryalyk and Ozerny collectors crossing Turkmenistan, and will bear the costs of reconstruction of the collectors and their operation in proportion to drainage flow;
- reduce limits to water withdrawal during the driest years as defined by the ICWC, which includes ministries of water economies of all five Central Asian countries.

In a meeting in 2004, the presidents of Uzbekistan and Turkmenistan reiterated the importance of observing mutual understanding concerning all questions related to water allocation from the Amu Darya river.

The partnership between the European Union Water Initiative (EUWI) and its Eastern Europe, Caucasus and Central Asia (EECCA) programme seeks to improve management of water resources in the EECCA region. The partnership was established between EUWI and EECCA countries at the World Summit for Sustainable Development in 2002. A significant component is the ‘Integrated water resources management, including transboundary river basin management and regional seas issues’ (SIWI, 2010).

In 2002, Central Asian countries and the Caucasus, formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework, state departments, local and regional organizations, professional organizations, scientific and research institutes as well as the private sector and NGOs cooperate to establish a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

The Islamic Republic of Iran and Turkmenistan are planning to set up a joint water consortium (SIWI, 2010).

Water use

In 2004, total water withdrawal was an estimated 27.958 km^3, of which 94.3 percent for agriculture (93.6 percent for irrigated farming, 0.3 percent for livestock breeding complexes and farms, 0.3 percent for pastures, 0.1 percent for fisheries), 2.7 percent for municipalities and 3.0 percent for industries (Figure 1 and Table 3). In 1994, total annual water withdrawal was an estimated 23.8 km^3, of which 98 percent for agriculture, 1 percent for municipalities and 1 percent for industry.

Since 1970, water withdrawal from the Amu Darya and other rivers has nearly doubled. At the same time the loss rate has increased alarmingly, from 20 percent of the intake in the 1970s and the 1980s, to more than 30 percent since 2000. In 2004, the loss rate was around 31 percent. The main reasons for conveyance loss in the system are evaporation and filtration (Stanchin and Lerman, 2006).

Of total withdrawal of 27.958 km^3, 97.4 percent or 27.237 km^3 was primary and secondary surface water, 1.1 percent or 0.305 km^3 was primary and secondary groundwater, 1.2 percent or 0.336 km^3 was direct use of treated wastewater and 0.3 percent or 0.080 km^3 was direct use of agricultural drainage water (Figure 2). In 1994, 0.401 km^3 of groundwater was withdrawn, of which 0.214 km^3 for municipal use, 0.151 km^3 for agriculture and 0.036 km^3 for industry.

FIGURE 1
Water withdrawal by sector
Total 27.958 km^3 in 2004

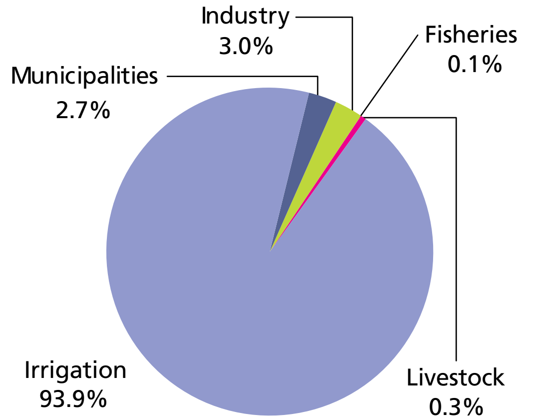
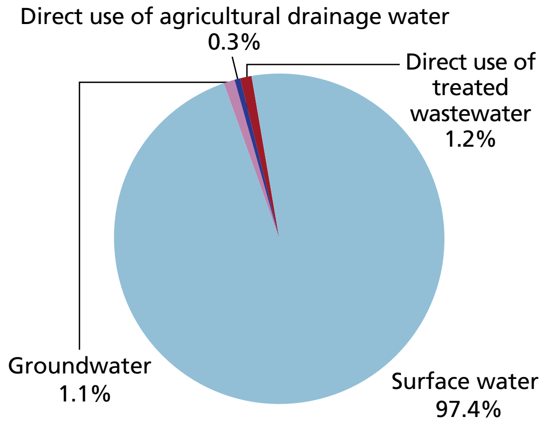


FIGURE 2
Water withdrawal by source
Total 27.958 km^3 in 2004



Increasing production of desalinated water meets less than 1 percent of the demand for drinking water and industrial needs. Desalinated water and treated wastewater (direct use) are not used for irrigation.

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Recent estimates consider irrigation potential to be 7 013 000 ha, which is equal to the cultivable area. Taking into consideration, however, water resources, are an estimated 2 353 000 ha. If techniques to desalinate the water of the Golden Age Lake become available, it is estimated that the irrigation area could be doubled. However there are varying opinions about the feasibility of this option.

Irrigation and drainage development in Turkmenistan can be divided into three stages: traditional irrigation up to the 1930s; irrigation development during the Soviet era between the 1930s and 1990s; and irrigation development since independence.

During the first stage, small and medium canals were hand dug and sporadically equipped with primitive wooden water management structures/regulators. Some main canals are 400–600 years old and are still operational. Water was taken from the rivers by means of canals and transported by gravity over 5–6 km to fields. The water intake facility was the wooden 'water wheel'. Over 400 *kyariz* (underground water gathering galleries) were used in the foothill regions. The person responsible for water management was the *mirab* who was elected by community leaders.

During the Soviet era, state institutions were responsible for water management. Up to the 1950s little technical progress was made in water management, but upon initiation of construction of the Kara Kum canal, launched in 1954, there was a boom in irrigation development. This earth canal takes water from the Amu Darya river and transports it to the west over 1 400 km through the basins of Murghab and Tedzhen to the foothills of the Kopetdag mountain system. Construction of the 840 km main section, from the Amu Darya river in the east to Gok-Tepe just west of Ashgabat, was completed in 1967. Work continued through the 1970s and well into the 1980s, extending the canal west towards the Caspian Sea. Today it is the longest canal in the world.

The virgin territories along the course of the canal were intensively developed and agriculture introduced. The canal increased the irrigated area surrounding it from 141 500 ha in 1954 to 530 000 ha 30 years later. Since the 1970s irrigation from the canal has accounted for about 50 percent of the total irrigated area in Turkmenistan (the other 50 percent receives water through a system of smaller provincial-level canals). In addition, the canal permits irrigation of 5 million ha of desert pasture. The canal is colloquially known in Turkmenistan as the "river of life" because of its role in reclaiming desert for agriculture and providing livelihoods to hundreds of thousands of rural people. Yet benefits for some people have brought adversity to others: the diversion of water from the Amu Darya river into the Kara Kum canal and of river water for irrigation has contributed to the Aral Sea disaster, adversely affecting large parts of the population in Uzbekistan and Kazakhstan.

The third stage is characterized by development of the area close to the middle section of the Amu Darya river and western territories of Dashoguz region. A great water reservoir, equipped with modern equipment for water management, constructed in collaboration with the Islamic Republic of Iran on the Tedzhen river.

The emphasis on the expansion of cotton production in the Soviet era, and the strategy of ensuring food self-sufficiency, which has been aggressively implemented since 1992, has led to accelerated growth of irrigated areas, which have increased by nearly four-fold in the last 40 years (Stanchin and Lerman, 2006).

Given the climatic and soil conditions, the entire agricultural production is dependent on irrigation (AST and MOA, 1961). In 2006, the area equipped for irrigation was an estimated 1 990 800 ha (Table 4). The entire area is actually irrigated, which is larger than the cultivated area, since the irrigated area includes irrigated permanent pasture, while permanent pasture is not included as cultivated area. In 1994 and 1975 the area equipped for irrigation was 1 744 100 ha and 857 000 ha respectively.

Irrigation in Turkmenistan is mainly concentrated in oases, where water is diverted from the Murghab, Atrek and Tedzhen rivers and from the Kara Kum canal in the south, or from a system of canals that have been built along the Amu Darya river in the north.

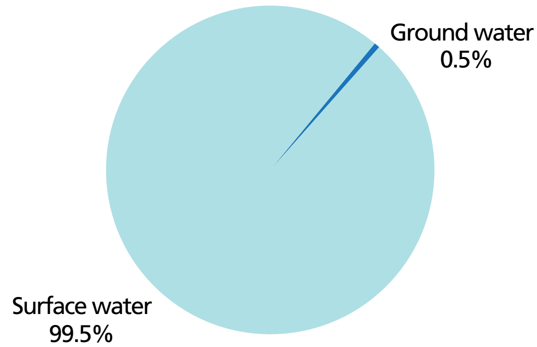
In 2006 the only technique used was surface irrigation. Options for localized irrigation are being explored in a number of ongoing pilot projects. Israeli drip-irrigation technology has been installed on 600 ha near Ashgabat (Stanchin and Lerman, 2006).

Surface water is mainly used for irrigation. The share of groundwater is small and tends to decrease because of increased demand for drinking water. In 2006, surface water covered about 1 981 190 ha or 99.5 percent of total equipped area, groundwater 9 610 ha or 0.5 percent (Figure 3). In 1994, about 98 percent of the equipped area was irrigated with surface water: 54 percent from reservoirs, 28 percent from river diversions and 16 percent from pumping from rivers. Sometimes there is direct use of agricultural drainage water with salinity level of up to 3 g/litres, where there is a substantial lack of freshwater, but total volume of this water comprises less than 1 percent of total freshwater used for irrigation (MWE, 1998).

All large water pumps and many small water pumps are electric, while less than one-third of small pumps, are diesel with a production capacity of less than 0.5 m^3/s and pressure of less than 10 m. There are no statistics regarding energy use for water pumps. The most common type of water pump is cascade. Systems with lengthy pipes (more than 1 km) comprise less than 10 percent of the total number of water pumping systems, and are used mainly in the foothills.

The total length of inter-farm irrigation canals is more than 8 000 km, out of which around 94 percent are earthen canals and about 6 percent concrete-lined canals (MWE, 1993 and 1998). The total length of on-farm canals is more than 34 000 km, of which around 83 percent are earthen canals, about 6 percent concrete-lined, 4 percent chute systems, 7 percent pipelines. The irrigation chute system is mainly in Mary and Ahal *velayats*, and irrigation is by pipeline in Ahal and Lebap *velayats.*

FIGURE 3
Source of irrigation water on area equipped for full control irrigation
Total 1 990 800 ha in 2006



The Kara Kum and Turkmenderya canals are classified as large multi-purpose canals. Canals, that serve two or more farm associations, are classified as inter-farm canals. Canals, located within a territory of one farm association (around 500–3 000 ha), are classified as on-farm canals. Almost everywhere on-farm irrigation systems have been constructed in earthen canals and almost half of the diverted water is lost as a result of seepage (MWE, 1993 and 1998).

Role of irrigation in agricultural production, economy and society

In 2006, total harvested irrigated cropping area was an estimated 2 013 800 ha. Wheat accounts for 917 000 ha or 45.5 percent, cotton 652 000 ha (32.4 percent), vegetables 29 400 ha (1.5 percent), sugar beet 12 000 ha (0.6 percent), rice 11 000 ha (0.5 percent), potatoes 8 800 ha (0.4 percent), temporary fodder 93 000 ha (4.6 percent), other temporary crops 100 100 ha (5 percent), perennial crops 65 000 ha (3.2 percent) and permanent pasture 125 500 ha (6.2 percent) (Table 4 and Figure 4). In 1994, total harvested irrigated crop area was an estimated 1 794 200 ha and cotton and vegetables were the most important export crops.

In 2004, irrigated crop yields were 1.2 tonnes/ha for raw cotton, 3.1 tonnes/ha for grains including maize, and 30.1, 26.8 and 21.0 tonnes/ha for vegetables, melons and potatoes respectively (Turkmenmillihasabat, 2005).

In 2004, the average cost of irrigation development on public schemes was an estimated US$8 654/ ha. The average annual operation and maintenance cost is about US$47/ha, the average cost of drainage development US$2 256/ha and of irrigation rehabilitation US$6 943/ ha.

Most work in the field (weeding, tipping, manual cotton harvesting, etc.) is carried out by women. Men are involved in ploughing, furrowing, sowing, fertilizing, crop harvesting with machinery, primary processing of crops, etc. (National Bureau, 2000). Manual watering is mainly done by men. Men and women participate equally in the decision-making process. However, appointments to management positions in agriculture and the water economy are made by prioritizing qualification and experience as selection criteria and not gender.

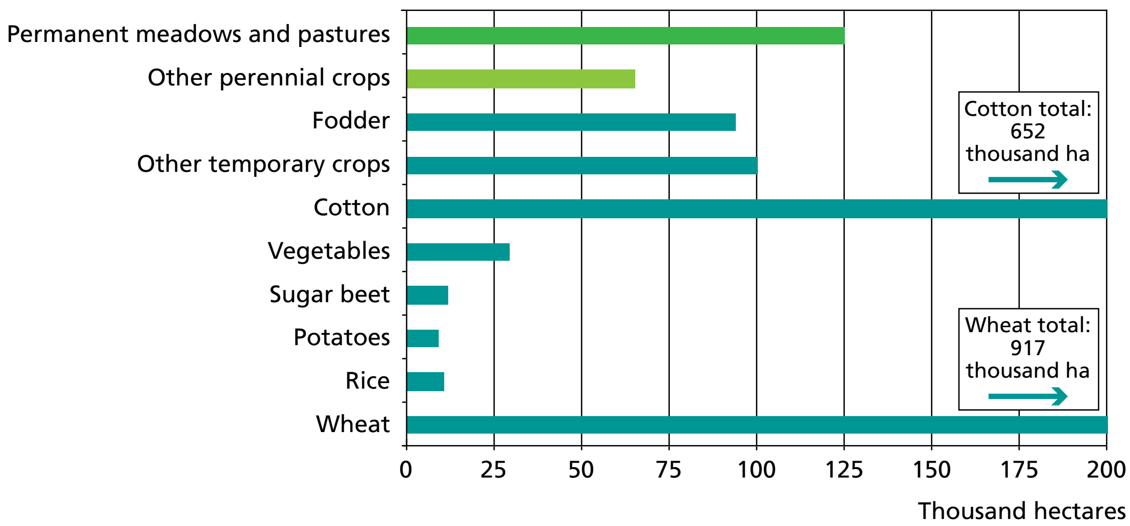
Status and evolution of drainage systems

The construction of mostly open drainage systems started at the beginning of the 1950s. About 90 percent of the total length of drainage was constructed during the period 1965–1985. The intensive development of virgin land for agriculture, with little attention being paid to the installation of water regulators on the irrigation canals, resulted in the irrational use of water. Further construction of drainage structures continued to lag behind the development

TABLE 4
Irrigation and drainage

Irrigation potential			2 353 000	ha
Irrigation				
1. Full control irrigation: equipped area		2006	1 990 800	ha
- surface irrigation		2006	1 990 800	ha
- sprinkler irrigation		2006	0	ha
- localized irrigation		2006	0	ha
• % of area irrigated from surface water		2006	99.5	%
• % of area irrigated from groundwater		2006	0.5	%
• % of area irrigated from mixed surface water and groundwater			-	%
• % of area irrigated from mixed non-conventional sources of water			-	%
• area equipped for full control irrigation actually irrigated		2006	1 990 800	ha
- as % of full control area equipped		2006	100	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2006**	**1 990 800**	**ha**
• as % of cultivated area		2006	102	%
• % of total area equipped for irrigation actually irrigated		2006	100	%
• average increase per year over the last 12 years		1994-2006	1.1	%
• power irrigated area as % of total area equipped		1994	16.3	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2006**	**1 990 800**	**ha**
• as % of cultivated area		2006	102	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< ha		-	ha
Medium-scale schemes	> ha and < ha		-	ha
Large-scale schemes	> ha		-	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production (wheat and barley)			-	metric tons
• as % of total grain production			-	%
Harvested crops				
Total harvested irrigated cropped area		2006	2 013 800	ha
• Temporary crops: total		2006	1 823 300	ha
- Wheat		2006	917 000	ha
- Rice		2006	11 000	ha
- Potatoes		2006	8 800	ha
- Sugar beet		2006	12 000	ha
- Vegetables		2006	29 400	ha
- Cotton		2006	652 000	ha
- Fodder		2006	93 000	ha
- Other temporary crops		2006	100 100	ha
• Permanent crops: total		2006	65 000	ha
• Permanent meadows and pastures		2006	125 500	ha
Irrigated cropping intensity (on full control area actually irrigated)		2006	101	%
Drainage - Environment				
Total drained area		1998	1 011 897	ha
- part of the area equipped for irrigation drained		1998	1 011 897	ha
- other drained area (non-irrigated)			-	ha
• drained area as % of cultivated area		1998	59	%
Flood-protected areas			-	ha
Area salinized by irrigation		2002	1 353 744	ha
Population affected by water-related diseases		2004	12 295	inhabitants

FIGURE 4
Irrigated crops on area equipped for full control irrigation
Total harvested area 2 013 800 ha in 2006 (cropping intensity on actually irrigated area: 101%)



of virgin land and the construction of unlined irrigation canals. All these factors – unlined canals, insufficient length of the drainage system, irrational irrigation norms and poor quality of construction works – resulted in catastrophic soil salinity, that is a currently a major problem that needs to be resolved. The economic crisis at the beginning of the 1990s resulted in the shutting down of the construction of any new drainage structures.

Following a decision adopted in 2000 by the President of Turkmenistan, the country initiated the trans-Turkmen collector for drainage water, with the construction of a huge artificial lake in the middle of the Kara Kum desert, the Turkmen Golden Age Lake, on the site of a natural dry lake in the Karashor lowlands. The lake is on the border between Ahal and Dashoguz *velayats,* 350 km north of the capital Ashgabat. The lake is to be filled with drainage water through two new collectors, the Great Turkmen Collector from the south and the Dashoguz Collector from the north, with a combined length of over 1 000 km. The lake's capacity is foreseen to be 150 km^3, with a surface area of 3 500 km^2 and a depth of 130 m. Starting in 2009, the collectors have been diverting up to 10 km^3 of saline drainage water to the lake annually. This water currently discharges into the Amu Darya river, which is a unique source of drinking water for much of the region. Construction of the trans-Turkmen collector aims to improve water quality in the Amu Darya river by stopping the discharge of drainage water into the river.

The extension of the collector-drainage network has lagged far behind irrigation expansion. The collector-drainage network was increased by 7 percent between 2000–2004, while the irrigated area increased by 26 percent. This led to accelerated raising of the groundwater table, deterioration of soil quality and increased salinity (Stanchin and Lerman, 2006).

Local water experts argue that the Golden Age Lake will reclaim 450 000 ha of waterlogged land, dramatically reduce salinization in the Amu Darya river and provide a huge reservoir of water that will be recycled for irrigation after partial desalination treatment. The exact nature of desalination is not clear, but Turkmen scientists are working on bio-plateau techniques and harnessing of solar energy for desalination. If successful, these techniques will produce huge amounts of new water for irrigation and make it possible to double the irrigated area. Cotton and wheat production would increase by at least 30 percent, and the brackish lake would create new opportunities for the development of fisheries. There is a generally optimistic vision of a ‘huge oasis’ that will arise in the desert around the lake and along the new waterways (Stanchin and Lerman, 2006).

Foreign experts working on the Aral Sea crisis are less optimistic. They claim that the lake water will simply disappear through evaporation under the fierce desert sun, leaving salt sediments that will poison the entire area. The use of recycled lake water will only increase salinization of agricultural soils, as proved by the experience of other countries that use brackish water for irrigation. They fear that, by virtue of its sheer size, the lake may be a source of considerable environmental damage to the entire region (Stanchin and Lerman, 2006).

Drainage water should be collected at a great distance from oases, otherwise the water level in the collectors will rise and many areas become waterlogged. Moreover, because of drainage water, the pasture quality has degraded and the probability of ecological risks (desertification, wind and water erosion, decreased wild populations) has increased.

Soil productivity without drainage is 30–70 percent less than the productivity of soils with drainage (MWE, 1989). Without drainage, land accumulates many toxic salts in the root zone during irrigation, which leads to doubling the level of salinity. In 1998, drainage infrastructures were constructed on about 1 011 897 ha of irrigated area. In 1995, subsurface drainage accounted for approximately 32 percent of the total drainage area, mainly on newly reclaimed areas, horizontal surface drainage for 60 percent, and vertical surface drainage for 8 percent.

Most of the known drainage types are applied, including channels for safe removal of mudflows. Vertical drainage is mainly used in urban areas for protection from waterlogging. When the water quality is good it is used to water trees in the cities.

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

Institutions

Water resources management in Turkmenistan is carried out by both national organizations and departments, and international organizations, such as the Amu Darya River Basin Authority (BVO), IFAS and the ICWC of Central Asia. The Cabinet Ministers of Turkmenistan have complete responsibility for water resources and maintenance of reliable water supply for both the agriculture, municipal and industrial sectors. The following state departments and organizations are engaged in management of water resources:

- Ministry of Water Resources (MWR): construction and operation of irrigation and drainage systems, delivery of water to water users at primary off-takes (down to inter- farm level);
- local administrations at village level (*hakimliks, archyns*): address water management issues within the limits of their territory (on-farm irrigation and drainage networks);
- land users (farmers, tenants and others): independently decide issues of operation of intra-contour irrigation and drainage network within the limits of their land areas;
- Ministry of Nature Protection: responsible for protection of water from pollution and exhaustion;
- State Corporation (SC) ‘Turkmengeologiya’: responsible for assessment, control of use and protection from pollution and exhaustion of groundwater aquifers;
- Ministry of Construction and Building Materials: responsible for licensing, technical supervision and control of activities on water supply and drainage of settlements.

Water management

During the Soviet era, water management was the responsibility of state institutions.

All inter-farm canals are managed by authorized state agencies. MWR manages water resources related to water infrastructure through specialized organizations that administer territories within the state. Production associations of *velayats* are responsible for the operation, repair-restoration, construction and auxiliary subdivisions of *etraps* (districts).

Farm unions manage all on-farm canals, even when the irrigated land is rented or privately owned by individual farmers. Water resources management at on-farm level, i.e. distribution of water between final water users (farmers, tenants and brigades), repair-restoration and construction works on structures, clearing of channels, drains and collectors, etc. is the responsibility of the local authorities (*hakimliks, archyns*). The *mirap* (irrigator) position was introduced for decisions on these matters at the level of the municipal authorities.

Training of personnel for agriculture and water management is carried out by the Turkmen State Agricultural University, named after S.A. Niyazov, including its hydro-improvement faculty. Since 2001, the Central Asian region has been working with the Training Centre at Sepang International Circuit (SIC) of the ICWC to improve the professional skills of those working in water management,.

Finances

The state is responsible for all expenses related to capital investment in irrigated agriculture, such as the development of land, construction of main structures and water infrastructure. Except for the on-farm irrigation system, the costs of operating water infrastructure are met by the state budget. Water for irrigation is supplied without charge. The so-called 'private charges' for the O&M of irrigation systems is an accepted practice, and comprises a deduction of 3 percent from the total of crops produced by the tenants. A calculation shows that over the past years these charges have amounted to US$10–18 million.

Article 58 of the Water Code states: "Water management agencies provide technical assistance to farmers' unions and other legal entities at the expense of the latter in operation of on-farm irrigation and drainage systems and hydro-technical structures...". The following principles of water consumption and use regulation in Turkmenistan are legally bound (GoT, 2004b):

- water for drinking and household use is provided to the population without charge; water supply systems construction, renovation and maintenance costs are covered by municipal and state budgets;
- water for industrial use is supplied against payment according to set tariffs;
- enterprises are fined for exceeding water intake limits and discharging unprocessed industrial liquid wastes;
- water for irrigation is supplied free within set limits; costs of water management agencies for maintenance of on-farm systems are covered by the 3 percent charges raised from the total cost of agricultural crops;
- state budget finances construction, renovation and maintenance of water supply facilities at state, inter-basin, interregional and inter-farm levels.

In 2006, total investment in irrigation and drainage was US$140 million, including US$87 million state investment (MWE, 2007). About US$53 million were classified as indirect investments because they were given as credits by banks. The long-term (up to 2030) irrigation and drainage development programme, adopted in 2007, states that investment of US$730 million is planned for irrigation and US$537 million for drainage up to 2010. Planned investment for 2010–2015 is US$4 720 million, out of which US$3 643 million is investment by the state. It is expected that the investments will be increased 2016–2020 up to US$8 770 million, including US$6 875 million state investments. The amount is estimated based on average world prices during the period 2001–2006. It should be clarified, however, that fuel prices for most local construction materials are several times lower than the world average. For example, the price of petrol in Turkmenistan is less than US$0.02 per litre.

Annual investment in land-reclamation is around US$11–12 million (MWE, 2007). Annual expenditures of the state budget for operation of irrigation systems varies between US$37– 49 million.

Policies and legislation

The constitution of Turkmenistan states that the Cabinet of Ministers undertake state management of economic and social development and ensure the rational use and protection of natural resources. The Water Code, issued on 27 December 1972, details the competences of the Cabinet of Ministers, the authorized state body for water use and protection, local executive power, civil societies and individuals. In particular, the Cabinet of Ministers defines water consumption limits for each *velayat* and *etrap*, including distribution of main water sources to the economic sectors. According to the Water Code, water is owned solely by the state, whereas both legal entities and individuals can own water structures.

In February 2007 a national development programme for the water economy of Turkmenistan up to 2030 was approved by all ministries and agencies involved (MWE, 2007). Main development priorities are to:

- reduce the water discharge rate per hectare by decreasing filtration losses and by improving watering technology (including application of drip irrigation);
- increase the capacity of water reservoirs for long-term regulation of water flows and accumulating of silt;
- construct the trans-Turkmen collector for accumulating all drainage waters from all oases into one reservoir.

The programme takes into account population growth, increase of industrial and agricultural production as well as environmental issues and international commitments of Turkmenistan.

The national programme for economic, political and cultural development of Turkmenistan up to 2020 foresees an increase in the number of private agricultural producers and their support through the implementation of infrastructure projects for development of territories paid for our of the state budget (GoT, 2002). Currently state producers use about 90 percent of irrigated land, up to 2020 it is planned that this irrigated land will be transferred to the private sector based on new legislation. Joint-stock enterprises, farm unions and cooperatives will become the organizational forms for private land use.

Legislation reforms in the water sector have overlapped with the adoption of the Land Code, which for the first time legally sets out the right for private ownership of land. In 2007 drafts of laws on 'farm' and 'farm unions' were published in the newspaper, whereby the role of farmers in decision-making process is further increased, with the objective of decentralization of land resources management (GoT, 2007a and 2007b).

ENVIRONMENT AND HEALTH

Environmental issues are particularly acute in Turkmenistan. Water in the rivers and the drainage networks is of very poor quality, containing high concentrations of salts and pesticides both from the country itself and from upstream countries. This affects the Aral Sea area, where some of the main collector-drainage canals discharge. A trans-desert collector running about 720 km from the northeast to the Caspian Sea in the far west is under construction as explained in the section: *Status and evolution of drainage system.*

The irrational use of water resources by the countries of the Central Asian region during the last 50 years is one of the most critical reasons for lack of water. This has resulted in an environmental crisis in the Aral Sea basin, salinization of irrigated lands and decreased fertility. Currently, around 90–95 percent of irrigated land in the Turkmen Aral Sea zone is saline (Berdiyev, 2006). In 2001, the total area salinized by irrigation was and estimated 1 353 744, including land with medium and high salinity.

In 2001, the direct economic loss of land with different degrees of salinization was US$142 million. By yield classes, about 32 percent are highly fertile soils. About 36 percent of the land are affected by medium and severe salinity and are exposed to secondary salinization and waterlogging because of close bedding (up to 2 m) of groundwater. Waterlogging also appears in desert pastures because of drainage water discharges. In 2002, irrigation caused waterlogging on about 756 500 ha.

During the past decades water quality in the Amu Darya river has deteriorated considerably as a result of discharge of drainage and industrial water from neighbouring countries. Average annual salinity level was 0.3 g/litre before 1962, increased to 0.8 g/litre in 1967. In the 1990s, it stabilized within the range of 1.5–1.6 g/litre reaching 2 g/litre during certain periods (Berdiyev, 2006).

The human pressure on surface water is high; although pollution with biogenic elements or organic substances has not yet reached dangerous levels, special attention must be paid to monitoring concentration (especially phenols and nitrates). About 4 km^3 of drainage water with salinity level of 6.5–8.5 g/litre is discharged annually into the Amu Darya river from neighbouring Uzbekistan. Because of this, salinity level in the Amu Darya can be up to 2.2 g/litre in certain periods, which negatively affects the health of the population in Dashoguz province, as well as the productivity of irrigated land (Berdiyev, 2006).

Over the past years, application of pesticides, herbicides, defoliants and other chemicals has decreased 2.9 times. The area of their use has been reduced four-fold, as a result of government policy to ensure food security through introduction of Integrated Pest Management (IPM). This has resulted in reduced pollution in the water catchment areas.

In 2004, people affected by water-related diseases amounted to 12 295, of which 7 955 by intestinal infections, 22 by typhoid and 4 318 by virus hepatitis.

In 1998, there was an outbreak of malaria, 137 cases were recorded. Since then, cases of malaria have fallen and Turkmenistan has made significant progress with malaria control; the disease is reported as having been eliminated.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Surface water resources are almost all entirely used. The government states that the irrigation area can be increased and that water supply to irrigated areas be ensured by (MWE, 2007):

- increasing the efficiency factor of the irrigation systems from 0.58 to 0.75 by canal lining and modernizing and rehabilitating irrigation systems;
- improving land levelling, optimizing furrow length and introducing crops requiring less water, from 6 441 m^3/ha to 5 286 m^3/ha;
- increasing the capacity of water reservoirs to 11 361 million m^3 for accumulation of water from floods and mudflows;
- introducing IWRM principles (management of water demand, intersectoral coordination, allocating management among hydrographical basins and not among administrative

territories, management of water catchment areas, etc.) and automated management systems for irrigation;

- introducing modern watering technologies including localized and sprinkler irrigation on 260 000 ha;
- using about 1 km^3 of drainage water with mineralization of up to 3 g/litre for irrigation;
- constructing the trans-Turkmen collector for drainage water to improve removal of salts from irrigated land; this should lead to decreasing demand for water flushing and/or for alternative use of water (for fisheries, improvement of pastures productivity, growing of halophytes, etc.)
- improving the quality of groundwater to meet irrigation requirements;
- increasing treated wastewater use for cultivation of agricultural crops (cotton).

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Uzbekistan

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Uzbekistan is a landlocked country in Central Asia, with a total area of 447 400 km^2. It is bordered in the west by Kazakhstan, in the northeast by the Aral Sea, in the north by Kazakhstan, in the east by Kyrgyzstan and Tajikistan, and in the south by Afghanistan and Turkmenistan. The country gained its independence from the Union of Soviet Socialist Republics (USSR) in August 1991. For administrative purposes, the country is divided into 12 provinces (*vilayats*) Andijan, Bukhara, Fergana, Jizzakh, Kashkadarya, Khorezm, Namangan, Navoiy, Samarkand, Sirdaryo, Surkhandarya and Tashkent (which includes the capital city of Tashkent), plus one autonomous republic: Karakalpakstan in the far west near the Aral Sea.

Physiographically the country can be divided into three zones:

- the desert (Kyzylkum), steppe and semi-arid region covering 60 percent 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).

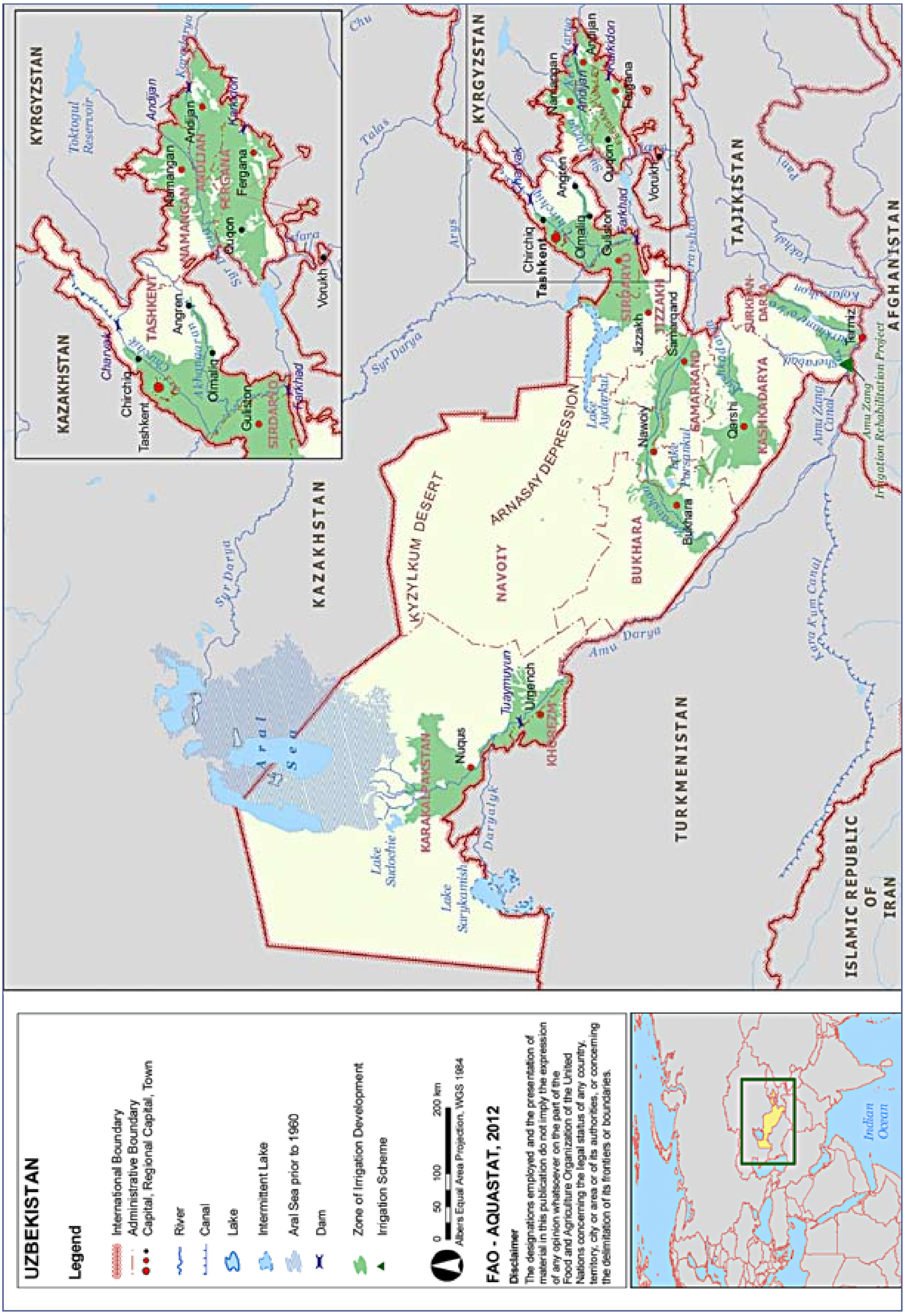
In 2009, the cultivated area was an estimated 4.65 million ha, of which 92.5 percent was under temporary crops and 7.5 percent under permanent (Table 1). Only 18 percent of the cultivable area, an estimated 25.4 million ha, is cultivated because of the water shortage.

In 1994, the agriculture area was divided into:

- *kolkhoz* (collective farms) and *sovkhoz* (state farms), occupy 89.7 percent;
- land managed by forest enterprises, occupy 8.1 percent;
- 'citizens' land', corresponding to gardens and individual plots cultivated by their owners, occupy 1.9 percent;
- land leased to farmers for agricultural production on a long-term period (*arenda*), occupy 0.3 percent.

Climate

The climate is continental; arid/deserts cover over 60 percent of the territory. Average annual rainfall is 264 mm, ranging from less that 97 mm in the northwest to 425 mm in the mountainous regions in the centre and south. In the Fergana valley, 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, mainly between October and April. There are high temperatures 42–47 °C on the plains and 25–30 °C in the mountainous regions in July, and low temperatures in winter, minus 11 °C in the north and 2–3 °C in the south in January. Because of frequent


UZBEKISTAN
Legend
International Boundary
Administrative Boundary
Capital, Regional Capital, Town
River
Canal
Lake
Intermittent Lake
Aral Sea prior to 1960
Dam
Zone of Irrigation Development
Irrigation Scheme
0 50 100 200 km
Albers Equal Area Projection, WGS 1984
FAO - AQUASTAT, 2012
Disclaimer
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Indian Ocean
KAZAKHSTAN
KYRGYZSTAN
TAJIKISTAN
AFGHANISTAN
TURKMENISTAN
ISLAMIC REPUBLIC OF IRAN
KYZYLKUM DESERT
ARNASAY DEPRESSION
KARAKALPAKSTAN
KHOREZM
NAVOIY
BUKHARA
SAMARKAND
KASHKADARYA
SURKHANDARYA
JIZZAKH
SIRDARYO
TASHKENT
NAMANGAN
ANDIJAN
FERGANA
Aral Sea
Lake Sudochie
Lake Sarykamish
Daryalyk
Nukus
Urgench
Tuyamuyun
Amu Darya
Syr Darya
Kara Kum Canal
Amu Zang Canal
Amu Zang Irrigation Rehabilitation Project
Termiz
Qarshi
Bukhara
Nawoiy
Samarqand
Jizzakh
Lake Aydarkul
Gulistan
Tashkent
Chirchiq
Olmaliq
Angren
Qo'qon
Namangan
Andijan
Fergana
Vorukh
Chu
Talas
Arys
Charvak
Farkhad
Kayrakkum
Toktogul Reservoir

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	44 740 000	ha
Cultivated area (arable land and area under permanent crops)	2009	4 651 000	ha
• as % of the total area of the country	2009	10	%
• arable land (temporary crops + temp fallow + temp meadows)	2009	4 301 000	ha
• area under permanent crops	2009	350 000	ha
Population			
Total population	2011	27 760 000	inhabitants
• of which rural	2011	64	%
Population density	2011	62	inhabitants/km^2
Economically active population	2011	12 916 000	inhabitants
• as % of total population	2011	47	%
• female	2011	46	%
• male	2011	54	%
Population economically active in agriculture	2011	2 695 000	inhabitants
• as % of total economically active population	2011	21	%
• female	2011	43	%
• male	2011	57	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2010	38 982	million US$/yr
• value added in agriculture (% of GDP)	2010	20	%
• GDP per capita	2010	1 420	US$/yr
Human Development Index (highest = 1)	2011	0.641	
Access to improved drinking water sources			
Total population	2010	87	%
Urban population	2010	98	%
Rural population	2010	81	%

frosts, between late September and April, only one crop a year can be grown. In favourable years, however, double-cropping of vegetables with a short growing period is possible.

Population

The total population was an estimated 27.8 million inhabitants in 2011 (of which 64 percent rural) (Table 1). During the period 2001–2011 annual population growth rate was an estimated 1 percent. Population density is about 62 inhabitants/km^2, which is the highest of the five former Soviet Central Asian republics. Population ranges from more than 464 inhabitants/km^2 in Andijan province in the Fergana valley in the east to only eight inhabitants/km^2 in Karakalpakstan.

In 2010, 87 percent of the population had access to improved water sources (98 and 81 percent in urban and rural areas respectively). Sanitation coverage accounted for 100 percent of the population.

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2010, Uzbekistan's gross domestic product (GDP) was US$38 982 million of which the agriculture sector accounted for 20 percent (Table 1).

In 2011, total economically active population was 12.9 million, or 47 percent of the total population. The economically active population in agriculture is an estimated 2.7 million (21 percent of the total active population) of which 43 percent is female.

Cotton, called 'white gold', was the dominant crop within Uzbekistan's agricultural sector during the Soviet period. Although cotton had been grown in the region for hundreds of years, the crop's expansion in the twentieth century was made possible by two main factors: expansion of irrigated area and Soviet central planning. Irrigation allowed for increased crop production and central planning imposed cotton as the major crop. In exchange for cotton production, central planning provided Uzbekistan with water, energy and food from elsewhere in the integrated national system.

Uzbekistan was the major cotton-growing region in the USSR, accounting for 61 percent of total production. Since the disintegration of the USSR, and Uzbekistan independence in 1991, agricultural policy has been subject to both inertia and change. On the one hand, the government has maintained significant aspects of the central planning system. The state still controls the area and quantity of cotton produced, as well as the purchase prices. In the mid-1990s, the country was the fourth largest producer of cotton in the world and the third largest cotton exporter. Cotton, with vegetables and fruits are the country's principal exports.

On the other hand, the government has allowed a shift towards increased farmer control of many aspects of production, in particular those related to land and water management. At the same time, the country has been forced to develop new trading relationships with other former Soviet states and the rest of the world, which has led to the mandated expansion of the wheat area to meet local food needs. The government mandated increase of wheat production, means the wheat growing areas are larger and the cotton-growing area smaller, because the wheat and cotton-growing season overlap.

The result has been an expansion of the winter wheat area from 620 000 ha in 1991 to 750 000 ha in 1996 with a similar decline in the cotton area. Wheat production increased substantially, from 1 million tonnes in 1991 to 5.2 million tonnes in 2004, and Uzbekistan has become a wheat exporter of some 500 000 tonnes annually (Abdullaev *et al.,* 2009). The leading export goods and their share in exports are cotton-lint (11 percent), energy resources (25 percent), services (9 percent), non-ferrous and ferrous metals (7 percent), machinery and equipment (6 percent), chemical products (5 percent), food products (10 percent), other (28 percent).

WATER RESOURCES AND USE

Water resources

Two river basins are found in Uzbekistan, which form the Aral Sea basin:

1. **Amu Darya basin** – covers 81.5 percent of the country. The entire main Amu Darya river can be divided into three reaches: the upper reach borders Afghanistan and Tajikistan, where most of the water flow is generated; the middle reach first borders Uzbekistan and Afghanistan and then enters Turkmenistan; and the lower reach, in Uzbekistan, before the river discharges into the Aral Sea. The main tributaries within Uzbekistan are the Surkhandarya, Sherabad, Kashkadarya and Zeravshan rivers. The Surkhandarya and Zeravshan rivers originate in Tajikistan. The Zeravshan was the largest tributary of the Amu Darya before it began to be tapped for irrigation. Even the remaining flow evaporates in the Kyzylkum desert near the city of Bukhara. The total flow produced in the Amu Darya basin is an estimated 78.46 km^3/year on average, calculated by adding the internal renewable surface water resources (IRSWR) of the different countries in the basin: Tajikistan 59.45 km^3/year, Kyrgyzstan 1.93 km^3/year, Afghanistan 11.70 km^3/year, Uzbekistan 4.70 km^3/year and Turkmenistan 0.68 km^3/year, while the 5 and 95 percent probabilities are an estimated 108.4 and 46.9 km^3/year respectively. The period April-September accounts for 77–80 percent and the period December–February for 10–13 percent of annual flow. This intra-annual flow

distribution is favorable for irrigated agriculture. Because of significant losses when the river flows through the desert, and because of major water withdrawal by agriculture, the flow reaching the Aral Sea is limited to less than 10 percent of this figure in the driest years. About 4.7 km^3/year, or 6 percent of the average total surface water resources of the Amu Darya river basin, are generated within Uzbekistan.

2. **Syr Darya basin** – covers 13.5 percent of the country. The entire main Syr Darya river can be divided into three reaches: the upper is in Kyrgyzstan, where most of the water flow is generated; the middle 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 Kyrgyzstan. The total flow produced in the Syr Darya basin is an estimated 36.57 km^3/year, calculated by adding the IRSWR of the different countries in the basin: Kyrgyzstan 27.42 km^3/year, Tajikistan 1.01 km^3/year, Uzbekistan 4.84 km^3/year and Kazakhstan 3.3 km^3/year, while the 5 and 95 percent probabilities are an estimated 54.1 and 21.4 km^3/year respectively. Because of significant losses in the desert areas of its course, and because of major water withdrawal by agriculture, the flow reaching the Aral Sea is limited to less than 5 percent of this figure in the driest years. About 4.84 km^3/year, or 13 percent of the average surface water resources of the Syr Darya river basin are generated within Uzbekistan.

Uzbekistan has thousands of small streams that disappear in the desert, many having been emptied by irrigation (OrexCA, 2011).

The total river flow generated inside Uzbekistan is thus estimated at 9.54 km^3/year of which 49 percent from the Amu Darya river basin and 51 percent from the Syr Darya river basin.

Surface water resources allocated to Uzbekistan are calculated every year, depending on climatic conditions and existing flows. However, the estimated average surface runoff from upstream countries is as follows (Table 2):

- Amu Darya basin: Based on an agreement between Uzbekistan and Turkmenistan signed in January 1996, which supplemented the '1992 Five Central Asia Countries Agreement', half of the water is allocated to Uzbekistan and half to Turkmenistan. Thus, of the average flow of 44 km^3/year, 22 km^3/year are reserved for Uzbekistan and 22 km^3/year for Turkmenistan (of which 0.68 km^3/year are Turkmenistan's IRSWR). This means that of the 43.32 km^3/year allocated flow from the Amu Darya river basin from Tajikistan into Uzbekistan, 21.32 km^3/year (=22–0.68) is transit flow to Turkmenistan.
- Syr Darya basin: 22.33 km^3/year from Kyrgyzstan, of which 11.8 km^3/year is transit flow to Tajikistan, of which 11.54 km^3/year again is transit flow to Uzbekistan, of which finally 10 km^3/year is reserved for Kazakhstan;

There are 94 major aquifers in Uzbekistan. The renewable groundwater resources are an estimated 8.8 km^3/year, of which 2 km^3/year are considered an overlap with surface resources. The IRWR are therefore an estimated 16.34 km^3/year and total actual renewable water resources (TARWR) are 48.87 km^3/year, equal to total actual renewable surface water resources (TARSWR) of 42.07 km^3/year, taking into consideration the allocation mechanism between the different countries, plus renewable groundwater resources of 8.8 km^3/year minus the overlap of 2 km^3/year, (Table 2 and Table 3).

Between 1990 and 1994, return flow on the Uzbekistan territory was an estimated 32.4 km^3/year, of which 21.5 km^3/year in the Amu Darya river basin and 10.9 km^3/year in the Syr Darya river basin. This total comprises 30.9 km^3/year of drainage flow from irrigated areas (of which 2.55 km^3/year is the result of vertical drainage from pumping) and about 1.5 km^3/year of untreated municipal and industrial wastewater. The main portion of the return flow, 49 percent or 15.9 km^3/year, returned to rivers: 9.5 km^3/year in the Amu Darya basin and 6.4 km^3/year in

TABLE 2
Renewable surface water resources (RSWR) by major river basin in Uzbekistan

River basin	Internal RSWR	Inflow			Outflow			Actual RSWR
		Total	Secured by agreements		Total	Secured by agreements		
	km^3/year	km^3/year		From:	km^3/year		To:	km^3/year
Amu Darya	4.7	73.76[a]	43.32[c]	Tajikistan	66.08[d]	21.32	Turkmenistan	26.70[g]
Syr Darya	4.84	28.43[b]	22.33	Kyrgyzstan	33.27[e]	11.80[f]	Tajikistan	15.37[h]
Total	**9.54**	**102.19**	**65.65**		**99.35**	**33.12**		**42.07**

a Equal to inflow from Tajikistan (59.45) and inflow from Kyrgyzstan through Tajikistan (1.93) and inflow from Afghanistan (11.7 through Turkmenistan) and inflow from Turkmenistan (0.68 IRSWR)
b Equal to inflow from Tajikistan (1.01) and inflow from Kyrgyzstan (27.42)
c Equal to total secured for Uzbekistan (22) and for Turkmenistan (22) minus IRSWR of Turkmenistan (0.68)
d Equal to IRSWR (4.7) and flow from Tajikistan 61.38, of which 59.45 originating in Tajikistan and 1.93 originating in Kyrgyzstan
e Equal to IRSWR (4.84) and flow from Kyrgyzstan and Tajikistan (28.43)
f Outflow to Tajikistan, of which 11.54 again is transit flow to Uzbekistan, of which finally 10 is reserved for Kazakhstan
g Equal to 4.7 (IRSWR) + 43.32 from Tajikistan – 21.32 to Turkmenistan
h Equal to 4.84 (IRSWR) + 22.33 from Kyrgyzstan – 11.8 to Tajikistan

TABLE 3
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	206	mm/yr
	-	92 200	million m^3/yr
Internal renewable water resources (long-term average)	-	16 340	million m^3/yr
Total actual renewable water resources	-	48 870	million m^3/yr
Dependency ratio	-	80	%
Total actual renewable water resources per inhabitant	2011	1 760	m^3/yr
Total dam capacity	2010	22 162	million m^3
Water withdrawal			
Total water withdrawal by sector	2005	56 000	million m^3/yr
- agriculture	2005	50 400	million m^3/yr
- municipalities	2005	4 100	million m^3/yr
- industry	2005	1 500	million m3/yr
• per inhabitant	2005	2 158	m^3/yr
Surface water and groundwater withdrawal (primary and secondary)	2005	49 160	million m^3/yr
• as % of total actual renewable water resources	2005	101	%
Non-conventional sources of water			
Produced municipal wastewater	2000	1 083	million m^3/yr
Treated municipal wastewater		-	million m^3/yr
Direct use of treated municipal wastewater		-	million m^3/yr
Desalinated water produced		-	million m^3/yr
Direct use of agricultural drainage water	2000	6 840	million m^3/yr

the Syr Darya basin. About 37 percent or 12 km^3/year ended up in natural depressions (Arnasay, Parsankul, Sarykamish and lake Sudochie) from which most water evaporates.

More than 4.5 km^3/year or 14 percent were used for irrigation: 2.9 km^3/year without treatment, mainly for cotton on light soils and 1.6 km^3/year after *in situ* desalting treatment (phytomelioration). Around 2000, direct use of drainage water was an estimated 6.84 km^3, of which 4.21 km^3 from the Syr Darya and 2.63 km^3 from the Amu Darya system. Around 2005, total return flow was an estimated 23 km^3 (Abdullaev *et al.,* 2009).

The collector-drainage water outflow has led to the creation of artificial lakes in natural depressions. The largest lakes are: Aydarkul, in the Arnasay depression in the middle reach of Syr Darya, which stored about 30 km^3 in 1995; the Sarykamish and Sudochie lakes, both located in the lower reach of the Amu Darya, store 8 and 2 km^3 respectively. Several lakes have formed in the centre of the country in the Amu Darya basin, the largest being Parsankul lake close to the Zeravshan river, which stores about 2 km^3.

There are at least 50 reservoirs in Uzbekistan with a total capacity of over 22 km^3. 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 and Andijan reservoirs. The Charvak reservoir, which is one of the largest hydropower plants in Central Asia, is on the Chirchik river, near the capital Tashkent and has a capacity of 1.99 km^3 and 600 MW. The Andijan reservoir on the Karadarya river in the Fergana valley, has a capacity of 1.9 km^3. In the Amu Darya basin, the largest reservoir is the Tuaymuyun, in Khorezm *vilayat*, with a storage capacity of 7.8 km^3, comprising four separate reservoirs. One reservoir in this system (Kaparas) is to provide drinking water for the Karakalpakstan area, which is experiencing severe environmental problems as a result of the shrinking of the Aral Sea. Most reservoirs were built more than 25 years ago. During this period, almost all were exposed to siltation, resulting in almost 20–25 percent loss of useful capacity.

Gross theoretical hydropower potential is an estimated 88 000 GWh/year and the economically feasible potential 15 000 GWh/year. In 1993 total installed capacity was1.7 GW, and in 1995 provided about 12 percent of the country’s electricity.

Extensive canal systems, such as the Amu-Bukhara canal and many others built during the Soviet period, have greatly altered water-flow patterns (OrexCA, 2011).

International water issues

During the Soviet period, sharing of water resources among the five Central Asian republics was based on the master plans for water resources development in the Amu Darya (1987) and Syr Darya (1984) river basins. In 1992, the Interstate Commission for Water Coordination (ICWC) was established and the newly independent republics decided, with the Agreement of 18 February 1992, to prepare a regional water strategy and continue to respect the existing principles until the adoption of a new water sharing agreement. This new agreement was confirmed by the ‘Agreement on joint actions to address the problem of the Aral Sea and socio-economic development of the Aral Sea basin’, which was signed by the Heads of the five states in 1996. Over the years, the ICWC has achieved the conflict-free supply of water to all water users, despite the complexities and variations of dry and wet years.

In 1993, with the development of the Aral Sea basin programme, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) to coordinate implementation of the programme and the International Fund for Saving the Aral Sea (IFAS) to raise and manage its funds. In 1997, the two organizations merged to create IFAS (UNDP, 2004).

Uzbekistan and Turkmenistan have signed agreements about basic water allocation principles. These principles proved viable and both countries gained experience in the joint management of the Amu Darya river. ICWC played and still plays a positive role in this respect. In 1996 a permanent agreement was reached between Turkmenistan and Uzbekistan on cooperation concerning water management issues. This agreement is based on the principles that the Parties:

- recognize the necessity of joint use of interstate rivers and other water sources;
- refuse to apply economic and other ways of pressure when solving water issues;

- acknowledge the interdependence of water problems and the responsibility for rational water use;
- focus on the increase of water inflow to the Aral Sea;
- understand the necessity of respecting mutual interests and settling water-related issues through consensus.

The above-mentioned agreement was signed in Türkmenabat, in eastern Turkmenistan, on 15 January 1996 and set out that the:

- land used by Uzbekistan and located within the borders of Turkmenistan is the sole property of Turkmenistan;
- waterworks and water management organizations on the Karshi and Amu-Bukhara canals and at the Tuyamuin reservoir, located in Turkmenistan, are the property of Uzbekistan;
- land for the Karshi and Amu-Bukhara canals and Tuyamuin hydro-unit are placed at the disposal of Uzbekistan's on a chargeable basis;
- Parties will make all necessary attempts to provide normal operation of the interstate waterworks located within their territories;
- companies and organizations, including those dealing with the operation of interstate waterworks located on the territory of the other Party, act according to international rules and the laws of that Party;
- flow of the Amu Darya river at Kerki gauging station is divided into equal shares (50/50);
- Parties should allocate a portion of their shares to the Aral Sea;
- Parties should stop disposal of drainage water into the Amu Darya river, independently of the quality of the drainage water;
- Parties jointly implement measures on land reclamation, on reconstruction and operation of interstate collectors and irrigation systems, and on construction of water disposal canals;
- Parties will prevent channel deformations and flooding of adjacent areas, caused by the operation of the Amu-Bukhara, Karshi, Sovetyab, Dashoguz, Tashsaka, Kylychbay, and Shabat-Gazavat water systems;
- Parties will make the necessary attempts to prevent flooding of land located along the Daryalyk and Ozerny collectors crossing Turkmenistan and will bear the costs of the collectors reconstruction and operation proportional to drainage flow;
- ICWC will define the reduced limits for water withdrawal during the driest years, which includes ministries of water economies in all five Central Asian countries.

In a meeting in 2004, the presidents of Uzbekistan and Turkmenistan reiterated the importance of observing mutual understanding of all questions of water allocation from the Amu Darya.

The most acute disagreement in the Syr Darya basin relates to the operation of the Toktogul reservoir in Kyrgyzstan, leading to a conflict of interest between Kyrgyzstan, Uzbekistan and Kazakhstan. The two downstream countries are interested in maintaining storage for summertime irrigation from the Toktogul reservoir, whereas winter energy generation from the reservoir is beneficial to Kyrgyzstan. A similar set of issues may be observed between Tajikistan and Uzbekistan regarding the management of the Kayrakkum reservoir in Tajikistan (UNDP, 2004).

Kazakhstan, Kyrgyzstan and Uzbekistan signed an agreement concerning dams in the upper Syr Darya river basin in 1998, which includes provisions for Kazakhstan and Uzbekistan to share equally in the purchasing of summer hydropower from Kyrgyzstan (SIWI, 2010).

Relations with upstream Kyrgyzstan and Tajikistan are not good. If a reasonable agreement on water usage and water management could be reached, Uzbekistan could avoid many of the current problems. However, the minimum requirements of such an agreement would be for Uzbekistan to commit to the delivery of much needed fossil energy, especially natural gas, to Kyrgyzstan and Tajikistan, so that they do not use hydropower during periods of water shortage. Currently Uzbekistan fails to do so, thus facing the consequences of water shortages (Akhmadov, 2008).

Most of the year, residents of Vorukh in eastern Uzbekistan and Ravot in northern Tajikistan have access to the Isfara river. Once the growing season begins however farmers from upstream Ravot irrigate their fields and unintentionally cut off access to water in Vorukh. Through the United States Agency for International Development (USAID) programme, residents of Vorukh were given the opportunity to address issues that served as sources of tension in their community. Water was, naturally, the first priority. The 3-year project, operating in the Fergana valley portions of Kyrgyzstan, Tajikistan and Uzbekistan, aims to reduce interethnic and transboundary conflicts through a combination of social and infrastructure initiatives.

The Community Initiative Group, a council of active citizens from all walks of life, undertook the design and implementation of the project, which required the repair and rehabilitation of three wells, in addition to the construction of a 3.5 km water pipeline. The total cost of the project was approximately US$17 000, with roughly half coming from the community itself. More importantly, this group stressed long-term management. In the end, the project has not only benefited the 1 235 residents of Vorukh, as they gain improved access to drinking water, it has improved relations between two Fergana valley neighbours (USAID, 2012).

Uzbekistan, in collaboration with Kazakhstan and the Russian Federation, is exploring the possibility of diverting the Ob and Irtysh rivers. The proposed project consists of building a canal from Siberia across Kazakhstan to Uzbekistan. In theory, the project would solve the problem of limited water resources available to Uzbekistan. The project would enable the Russian Federation to play a greater role in the region, especially in Uzbekistan. There are fears about the salinization of water during transfer, the significant technical issues and the high financial and geopolitical costs to Central Asia (SIWI, 2010).

The partnership between the European Union Water Initiative (EUWI) and its Eastern Europe, Caucasus and Central Asia (EECCA) programme seeks to improve the management of water resources in the EECCA region. The partnership was established between the EU and EECCA countries at the World Summit for Sustainable Development in 2002. One important component is 'Integrated water resources management, including transboundary river basin management and regional seas issues' (SIWI, 2010).

In 2002, Central Asian and Caucasus countries formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework state departments; local, regional and professional organizations; scientific and research institutes; and the private sector and NGOs cooperate to establish a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for the Economies of Central Asia (UN-SPECA). In collaboration with EUWI and UNECE, the Programme is developing integrated water resources management in the Central Asian States. In cooperation with Germany and other EU countries, UNECE may play a role in the implementation of the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

In 2007, Uzbekistan joined the 'International convention on the protection and use of transboundary watercourses and international lakes' and the 'Convention on the law of the non-navigational uses of international watercourses'.

FIGURE 1
Water withdrawal by sector
Total 56 km³ in 2005

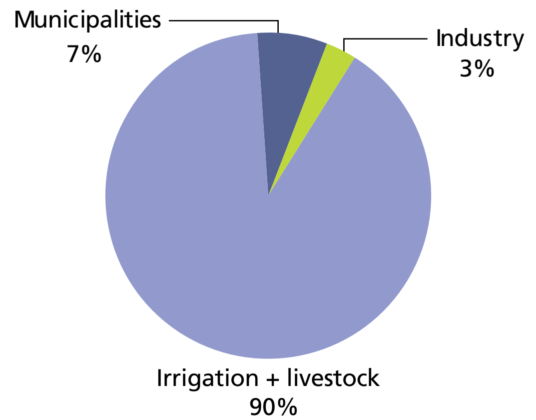
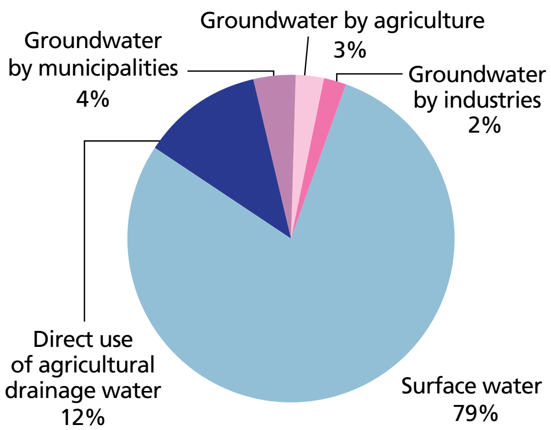


FIGURE 2
Water withdrawal by source
Total 56 km³ in 2005



Water use

In 2005, total water withdrawal was 56.0 km^3, of which 50.4 km^3 (90 percent) was for agriculture, 4.1 km^3 (7 percent) for municipal and 1.5 km^3 (3 percent) for industry (Figure 1 and Table 3). Total groundwater withdrawal was 5 km^3 or 9 percent of total water withdrawal (Figure 2), of which 49 percent for urban and rural water supply, 34 percent for irrigation and 17 percent for industry. Around 2000, the direct use of drainage water was an estimated 6.84 km^3, of which 4.21 km^3 from the Syr Darya and 2.63 km^3 from the Amu Darya system. In addition, 6.1 km^3 of water may be considered environmental flow, which is the average amount annually allowed to the Uzbek portion of the Aral Sea since the early 1990s (Abdullaev *et al.*, 2009). In 1994, total water withdrawal for agricultural, municipal and industrial use was an estimated 58.05 km^3, of which 92 percent for irrigation, 2 percent for livestock, 4 percent for municipalities and 2 percent for industries. This amount comprises 50.66 km^3 surface water, which included return flow and direct use of agricultural drainage water (the latter about 4.5 km^3) and 7.39 km^3 groundwater. Requirements for fisheries were an estimated 530 million m^3.

Total water withdrawal increased steadily from 45.5 km^3 in 1975 to 62.8 km^3 in 1985, mainly because of irrigation expansion. Since 1990, when water withdrawal was 62.5 km^3, the trend declined, because of agricultural water-saving methods and a recession in the industrial sector. In 2001 total water withdrawal was an estimated 60.6 km^3, of which 3.9 km^3 groundwater, and in 2005 this was an estimated 56 km^3, of which 5 km^3 groundwater. Water allocations are regularly reduced to promote savings, satisfy demand from new users and increase water flow to the Aral Sea. Total annual irrigation water withdrawal declined from 58.8 km^3 in 1990 to 50.4 km^3 in 2005.

The shift towards wheat production appears to have reduced the total quantity of irrigation water consumed. Cotton requires 10 000–12 000 m^3/ha, with virtually all water coming from irrigation. Winter wheat is irrigated four to six times during the growing season (October–June) and consumes approximately 8 000–9 000 m^3/ha. However, only about 60 percent is delivered by irrigation, with the rest supplied by rainfall. Thus, the shift from cotton to wheat has reduced overall irrigation water requirements (Abdullaev *et al.*, 2009).

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

In ancient times (from the fourth century before the common era or until the second century of the common era), the irrigated area in the lower reaches of the Amu Darya, Zeravshan and Kashkadarya rivers in central Asia was 3.5–3.8 million ha. During the feudal system (fourth-sixth centuries) there was a dramatic decrease in the irrigated area in Central Asia. However during the seventh century there was a gradual increase in irrigated farming, beginning in the ninth century there was rapid development. In the Middle Ages, (twelfth-fourteenth centuries) the total area was 2.4 million ha in the lower reaches of Amu Darya and Syr Darya. Medieval irrigation (before the nineteenth century) in Central Asia was characterized by radical redesign of the irrigation systems and construction of monumental waterside structures based on medieval hydraulic solutions. During this period, narrow and deep channels; a variety of water-pressure dams; water dividers; spillways and other water facilities were built. The shallow distribution and irrigation system of this time differs very much from that of the ancient. The irrigation system became a configuration with many branches, instead of channels at right angles to the main channel, as was the case during the ancient period.

The history of irrigation in Uzbekistan began more than 2 500 years ago in the seven natural oases: Tashkent valley in the northeast, Fergana valley in the east, Zeravshan valley in the east-central region, Kashkadarya valley in the southeast, Surkhandarya in the southeast, Khorezm in the west-central region and Karakalpakstan in the northwest. At the beginning of the twentieth century, about 1.2 million ha were irrigated in Uzbekistan. In 1913, during the period of Tsarist Russia, the irrigated area was 1.38 million ha. After the October Revolution in 1917, the irrigated areas were reduced, but in 1928 there was a return to the 1913 area.

Construction of numerous large canals, hydraulic engineering structures and reclamation facilities permitted an irrigated area of 1.85 million ha before the Second World War. In the postwar years, the irrigated area was 2.15 million ha. Large-scale development started in the late 1950s, when the USSR decided that Uzbekistan should specialize in the production of cotton, there was a shift from small- to large-scale irrigation, mainly in the arid and semi-arid regions where land was uninhabited and climatic conditions harsh. Often pump irrigation was used. Waterworks and reservoirs were constructed and irrigation networks reconstructed into engineering networks.

The development of irrigation in the 1970s was accompanied by a broad set of reclamation works – construction of a shallow collector-drainage network and major collector-discharge and drainage wells. Modern irrigation techniques were developed on the Hunger steppe in the centre of the country in the Syr Darya basin and on the Karshi steppe in the southeast in the Amu Darya basin. Strict principles of centralized management of water resources and irrigation by state bodies were introduced during this period, paid for completely out of the state budget. With the reclamation of the Golodnaya, Jizzakh and Karshi prairie, a completely new and powerful irrigation industry was developed and 30 years later, by the end of the 1980s, 100 000 ha of new irrigated areas had been developed, based on advanced technology.

In 1994, irrigation covered 4 280 510 ha, or about 82 percent of cultivated land, and the area actually irrigated was an estimated 4 202 000 ha, or 98 percent of the equipped area. In 2005, an estimated 4 198 000 ha was covered by irrigation (Uzgiprovodhoz Institute, 2005), or 89 percent of the cultivated area. The area actually irrigated was an estimated 3 700 000 (Abdullaev *et al.,* 2009) (Table 4). The area equipped for irrigation was reduced because the irrigated area had been completely abandoned in part of the area.

Irrigated land accounts for more than 90 percent of crop production. About 44 percent of the total irrigated area is in the Syr Darya basin and 56 percent in the Amu Darya basin. Considering the area suitable for irrigation and future water saving, irrigation potential is 4.9 million ha, although a figure of 9.7 million ha has been mentioned (Abdullaev, 2001), which may be considered unrealistic considering that withdrawal currently exceeds primary freshwater resources and some return flow is being used.

In 1994, all irrigation was full control irrigation, mainly from surface water (Figure 3). River diversion (including return flow) accounts for 53 percent of the full control equipped area.

FIGURE 3
Source of irrigation water on area equipped for full control irrigation
Total 4 280 510 ha in 1994

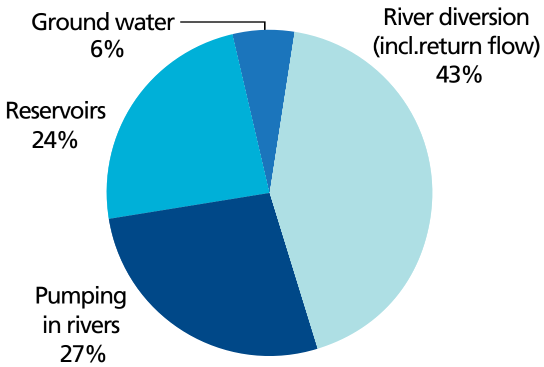
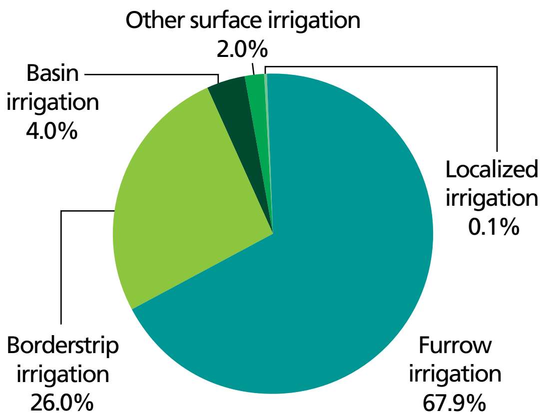


FIGURE 4
Irrigation techniques on area equipped for full control irrigation
Total 4 280 510 ha in 1994



Wastewater and most drainage water are mixed with surface water before being reused for irrigation. Thus, it is not possible to count them separately. Pumping from rivers, water from reservoirs and groundwater account for 27, 24 and 6 percent respectively.

Irrigation in Uzbekistan relies on a system of pumps and canals, which is among the most complex in the world. In 1994, water was lifted by electric pumps to irrigate 1.17 million ha and there were about 1 500 pumps. For example: the Karshi system lifts 350 m^3/s of water from the Amu Darya river over an elevation of 170 m; the Amu-Bukhara pump system discharges 270 m^3/s from the Amu Darya river to a canal situated 57 m above the river; the Amu Zang pump system discharges 20 m^3/s from the Surkhandarya river 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 about 28 000 km, of which some 33 percent is lined. The on-farm network is about 168 000 km. Most, 79 percent, is unlined earthen canals, 19 percent is concrete canals and 2 percent is pipes.

In 1994, surface irrigation was practised on 99.9 percent of the total area, mainly furrow irrigation (67.9 percent) followed by borderstrip irrigation (26 percent), basin irrigation (4 percent) and other surface irrigation (2 percent). Localized irrigation covered 4 510 ha in 1994, or only 0.1 percent of the total area. Sprinkler irrigation was no longer practiced in 1994, although it had covered some 5 000 ha in 1990. Increased energy costs, and a lack of spare parts, meant that this technique was not economically viable. Sprinkler irrigation continues on some pilot demonstration sites (Figure 4).

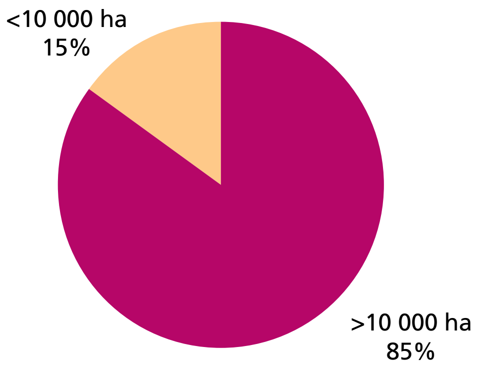
In 1994, the total area equipped for full control irrigation covered by large irrigation schemes (>10 000 ha) was an estimated 3.64 million ha (85 percent). Small irrigation schemes (<10 000 ha) covered 0.64 million ha (15 percent) (Figure 5).

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 percent (1994). 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 percent.

The total length of the inter-farm irrigation network is 27 620 km, of which 62 percent is composed of earth canals, and of the intra-farm network 167 379 km, with 80 percent composed of earth canals. There are 25 000 hydraulic works on the main and inter-farm canals and more than 44 000 on the intra-farm network. As a whole, the number of hydraulic structures is sufficient for the main and inter-farm irrigation systems, but most are in need of major repair or reconstruction.

The Amu Zang Irrigation Rehabilitation Project, presented in 2003, financed by the Asian Development Bank (ADB), helped the government improve water resources management in the south of Surkhandarya province and to rehabilitate the Amu Zang Irrigation System covering 96 800 ha near the confluence of the Amu Darya and Surkhandarya rivers, thus improving the livelihoods of about 400 000 rural people. The immediate objectives of the project were to increase the reliability, efficiency and sustainability of irrigation supplies of the Amu Zang irrigation system and to facilitate and accelerate the ongoing agricultural sector reforms in the project area. The project has four components: (i) rehabilitation of the Amu Zang irrigation system; (ii) support to improved water resources management; (iii) support to private farm development; (iv) project management, monitoring and evaluation. In addition, the project rehabilitated 102 km of drainage canals, 90 km of field canals and 258 km of field drains.

FIGURE 5
Type of full control irrigation schemes
Total 4 280 510 ha in 1995



Role of irrigation in agricultural production, economy and society

In 2005, the harvested irrigated area was 3 700 000 ha, of which 1 406 000 ha cotton (38 percent) and 1 295 000 ha wheat (35 percent) (Abdullaev *et al.,* 2009) (Figure 6 and Table 4).

Since independence in 1991, cotton production in Uzbekistan has declined by approximately one-third. The major reason was a change in government policy. After independence, the government allowed the transfer of some cotton areas to private cultivation of non-cotton crops, and encouraged a shift to wheat production to cope with economic and political disruption and to meet new targets for national food security. The result was a smaller cotton area maintained by a coercive quota system both for planting and procurement. Environmental problems also contributed to the difficulty of increasing, or even maintaining, cotton productivity (Abdullaev *et al.,* 2009).

FIGURE 6
Irrigated crops on area equipped for full control irrigation
Total harvested area 3 700 000 ha in 2005 (cropping intensity on actually irrigated area: 100%)

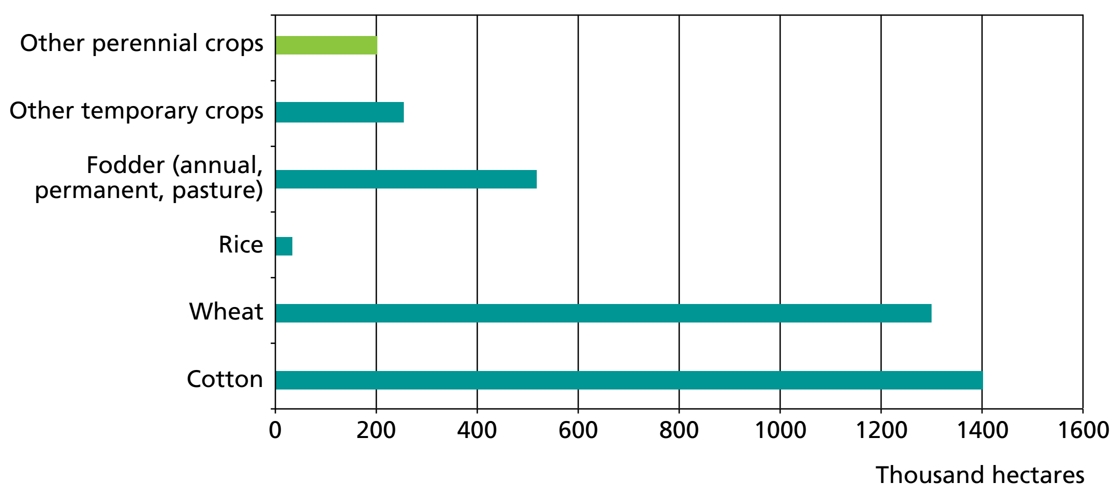


TABLE 4
Irrigation and drainage

Irrigation potential			4 900 000	ha
Irrigation				
1. Full control irrigation: equipped area		2005	4 198 000	ha
- surface irrigation		1994	4 276 000	ha
- sprinkler irrigation		1994	0	ha
- localized irrigation		1994	4 510	ha
• % of area irrigated from surface water		1994	94	%
• % of area irrigated from groundwater		1994	6	%
• % of area irrigated from mixed surface water and groundwater			-	%
• % of area irrigated from mixed non-conventional sources of water			-	%
• area equipped for full control irrigation actually irrigated		2005	3 700 000	ha
- as % of full control area equipped		2005	88	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)			-	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2005**	**4 198 000**	**ha**
• as % of cultivated area		2005	89	%
• % of total area equipped for irrigation actually irrigated		2005	88	%
• average increase per year over the last 11 years			-	%
• power irrigated area as % of total area equipped		1994	27	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2005**	**4 198 000**	**ha**
• as % of cultivated area		2005	89	%
Full control irrigation schemes	**Criteria**			
Small-scale schemes	< 10 000 ha	1994	640 930	ha
Medium-scale schemes	> and <		0	ha
Large-scale schemes	> 10 000 ha	1994	3 639 580	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes				
Total irrigated grain production (wheat and barley)			-	metric tons
• as % of total grain production		2005	96	%
Harvested crops				
Total harvested irrigated cropped area		2005	3 700 000	ha
• Temporary crops: total		2005	3 300 000	ha
- Cotton		2005	1 406 000	ha
- Wheat		2005	1 295 000	ha
- Rice		2005	52 000	ha
- Fodder (alfalfa)		2005	300 000	ha
- Other (maize, potatoes, vegetables)		2005	247 000	ha
• Permanent crops: total		2005	300 000	ha
- Fodder		2005	100 000	
- Other perennial crops		2005	200 000	
• Permanent meadows and pastures		2005	100 000	ha
Irrigated cropping intensity (on actually irrigated area)		2005	100	%
Drainage - Environment				
Total drained area		1994	2 840 000	ha
- part of the area equipped for irrigation drained		1994	2 840 000	ha
- other drained area (non-irrigated)			-	ha
• drained area as % of cultivated area			59	%
Flood-protected areas			-	ha
Area salinized by irrigation		1994	2 141 000	ha
Population affected by water-related diseases		2004	-	inhabitants

The large increase in the area under winter wheat has negatively impacted the irrigation and drainage (I&D) network. Earlier, under cotton monoculture, during the non-vegetation period of October-March, there were no crops in the field, and the I&D network was cleaned and prepared for the next season during the fallow fall-winter months. Currently, winter wheat is grown from the fall (October) to the next vegetation season (June). While the evapotranspiration of wheat during this period is low, it still requires five to six irrigations. Therefore, the I&D network is operating almost 12 months a year, leaving little time for cleaning or minor repairs. Irrigated wheat yield is an estimated 4.4 tonne/ha while rainfed wheat yield is 1.5 tonne/ha (Abdullaev *et al.,* 2009).

In 1997, the average cost of irrigation development was about US$11 200/ha for surface irrigation schemes using standard modern technologies, including agricultural infrastructure. Rehabilitation and modernization costs of the old irrigated areas were an estimated US$4 500/ha. The two main elements of such work would be laser land levelling and the introduction of modern irrigation techniques (drip, surge). The cost of drip irrigation development on existing irrigated areas varied between US$2 300 and 3 500/ha. Average annual operation and maintenance costs for full recovery was about US$450/ha for standard systems, more than US$640/ha for drip irrigation systems and US$680/ha for pump systems.

Status and evolution of drainage systems

The two major land quality problems are the interrelated issues of salinity and waterlogging caused by high groundwater levels. In 1994, only 50 percent of irrigated land was classed as non-saline by Central Asian standards (toxic ions represent less than 0.5 percent of total soil weight). In the upper reaches of the Amu Darya and Syr Darya river basins, less than 10 percent of the land is saline or highly saline, while downstream (especially in Karakalpakstan) about 95 percent of the land is saline, highly saline or very highly saline. Salinity is closely related to drainage conditions. Moreover, since 1990, a reduction in the quantity of water allocated to each farm, lower water quality, and the decline of companies responsible for maintaining the drainage network have resulted in increased salinization. Though loss of crop production, resulting from soil salinization is important, generally salinized land is still cultivated.

About 3.3 million ha of irrigated land require drainage. In 1994, only 2.8 million ha were equipped with drainage infrastructure (Table 3). Most of the drainage systems are open drains. Horizontal (surface) drainage is carried out on 1.7 million ha (61 percent), subsurface drainage on 0.7 million ha (25 percent) and vertical pumping drainage on 0.4 million ha (14 percent), mainly on clay soils. The total length of main and inter-farm collectors was about 30 000 km, while the on-farm collector-drainage network extended about 110 000 km. In total the Ministry of Agriculture and Water Resources (MAWR) mentions 7 447 wells, including 3 344 for pumped-well drainage and 4 103 vertical wells for irrigation.

During the transition period, development of drainage slowed and most infrastructure deteriorated. Since 2007, however, after the creation of a special fund to improve irrigated land, more than US$110 million is spent annually to improve infrastructure, with the result that main and inter-farm collectors are in satisfactory condition. The intra-farm open collector-drainage network is to some extent satisfactorily maintained in Bukhara, Kashkadarya, Ferghana and Namangan regions. The "Drainage, Irrigation and Wetland Improvement Project" in South Karakalpakstan, recently improved drainage in that region. In other areas it is in disrepair.

The following drainage problems remain: ongoing operational activities that do not conform to drainage design parameters; lack of funds for maintenance, repair and development of drainage. Under current conditions the unit cost for the operation and maintenance of irrigation and drainage facilities is US$86.2/ha, including a share of US$7.18 for drainage (8.3 percent).

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

Institutions

The General Authority of Water Resources (GAWR) of the MAWR carries out water management. MAWR, established in 1996 after the merger of the Ministry of Agriculture with the Ministry of Water Resources, performs the following main functions (GoU, 2011b):

- conducts monitoring of compliance with water legislation, cooperatives (*shirkat*) and private farms, considers infringement and takes appropriate decisions;
- participates in the development and implementation of branch and regional agriculture and water management development programmes in conjunction with other concerned ministries, agencies, state committees, local and government state bodies;
- together with other ministries, agencies and state committees coordinates the development and implementation of measures directed at the development of multi-sectoral agriculture and rights protection of rural producers;
- together with the Ministry of Economics and the State Demonopolization and Competition Development Committee, within the coordinated programmes, the Ministry of Finance carries out a review of agricultural market conditions in the regions for the purpose of identifying practices of artificial increase of prices, abuse of a monopoly situation in the market and unfair competition;
- prevents or addresses infringement of legislation concerning agriculture, water resources and water use;
- monitors use of budget funds of subordinate enterprises and organizations;
- conducts financial and economic analysis and provides methodical assistance to auditing commissions of cooperatives;
- together with other agencies develops a development strategy on rural industrial and social infrastructure;
- participates in the coordination of economic and social development of construction by industrial, project enterprises, organizations, agencies and their associations subordinate to the MAWR.

Institutional organizations dealing with water management at state, provincial and district level fall under the MAWR. They are responsible for water distribution and delivery to the farm inlet, to assist water users to implement advanced technologies, for water use and water quality control. The special land reclamation service, under the MAWR, monitors the main reclamation indicators of irrigated land (groundwater level, drainage discharge, soil salinity, state 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. MAWR 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.

After Uzbekistan gained independence there was a change in the water resources administration from that of a regional and district-based administrative water management system, established with the creation of the USSR, into an irrigation basin water management system based on hydrological principles. The latter involved the creation in 2003 of the Basin Authorities of Irrigation Systems (BAIS), composed of the Authorities of the Main Canals (AMC) and Irrigation Systems Authorities, following the resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 320 d/d on 21 July 2003, for 'improvement of water management'.

The Central Asia Scientific Research Institute of Irrigation (SANIIRI) undertakes research on the water resources development sector. This autonomous institute, linked to MAWR, was responsible for all Central Asia. It also manufactures irrigation equipment.

The Goskompriroda (State Committee for Nature Protection) is in charge of water quality monitoring and control of industrial and municipal pollutants.

Uzbekistan is a member of the IFAS, the ICWC, and the Amu Darya and Syr Darya River Basin Water Organizations (BWOs).

The Association of Uzbekistan for Sustainable Water Resources Development (AUSWRD) was established in 1998 and promotes cooperation in water resources development for Aral Sea basin workers. It also aims to share information on water issues, influence government decisions with regards to water and provide education on water use and sanitation. The AUSWRD vision is to have Uzbekistan become an example for sustainable water use.

In 2011, the government adopted the decision to create the National Committee on Large Dams, to represent the country's interests at the International Commission of Large Dams (ICOLD). According to this document, its main tasks are to promote the interest of Uzbekistan in ensuring the security of large dams, and Uzbekistan's position regarding the rational use of transboundary water resources. The committee will also improve the system to ensure the security of dams by studying the experience of other countries and exchanging scientific, technical and other information with similar foreign committees. The committee will also participate in the work of ICOLD.

Water management

After the demise of the USSR, the newly emerging states began to change their agricultural policies. In Uzbekistan changes included: (1) preventing social unrest by redistributing land to families; (2) increasing wheat production for food security; (3) implementing a quota system for cotton and wheat; (4) changing agricultural subsidies; (5) distributing large collective farms (Abdullaev *et al.,* 2009).

During the Soviet period, cotton was produced on large-scale collective farms, typically 2 000–3 000 ha. The farms managed all aspects of the production system, including agricultural machinery and irrigation. Because the farms were believed to be inefficient, after independence their land was split into smaller, although still collective, farm units known as *shirkats*. However, no restructuring was undertaken of other system assets such as irrigation. The result was land management units no longer matched the input units, resulting in poor performance of irrigation and drainage networks, with cotton yields being lower than they were during the 1980s.

A second trend in farm management after independence was the emergence of individual farms, which began in 1992. The government had originally considered individual farms experimental, they were allocated low fertility land with poor water supply. At the beginning of 2003, the government began to transform the collectives into individual farms. Under the new policy, priority was given to the development of individual farms as the major producers of agricultural commodities. Between 2004 and 2006, 55 percent of collective farms were transformed into individual farms. By 2004, individual farms occupied 17 percent of agricultural land and hired 765 300 workers.

The final transformation was the rise of the so-called *dehkan* farms. These are the legalized family plots from which most of the population earns their income. The state now encourages family plots to be registered as legal entities so they can acquire credit and benefit from other financial instruments. *Dehkan* farms are allowed to grow any crop except cotton and sell output on the open market. They cannot join the cotton and wheat quota system. Much of the production, primarily fruits and vegetables, grown on *dehkan* farms is exported to the neighbouring Russian Federation and to Kazakhstan. However, what is most striking about *dehkan* farms is their large contribution to agricultural GDP, an estimated 25 percent in 2004, despite their relatively small area (Abdullaev *et al.,* 2009).

During the first land reform, the state and collective farms were transformed into different economic organizations, but continued to function in the same way as former collective farms. Only a small portion of the land held by the state and collective farms was privatized, but they depended on the collective farms for water allocation and distribution. In the second land reform, collective farms were abandoned, collective farm land was leased to farmers, and water user associations (WUAs) were introduced. The second reform started in 1996, with the government contracting SANIIRI to establish a framework for WUAs in Uzbekistan. Three years later, at the end of 1999, SANIIRI completed its research on establishing WUAs. The second wave of land distribution took place at the beginning of 2000. Unprofitable collective farms were privatized, and their land distributed to former employees. Land privatization was accompanied by irrigation management, transfers and the introduction of Farm Organizations (FO) and WUAs (Wegerich, 2002).

Until 2003, the management of major irrigation canals and water reservoirs was solely under state control. All irrigation infrastructure at the main system level was managed territorially, through provincial and district-level water management organizations. Each of the territorial units (district, province) had state production quotas for cotton and wheat. As water was such a crucial factor, each governor tried to appropriate more water for his or her district. The resulting territorial fragmentation of water resources management led to inequitable water distribution and head-tail water disputes.

On 21 July 2003, the Cabinet of Ministers of the Republic of Uzbekistan issued the earlier mentioned decree No. 320 (related to the creation of the Basin Authorities on Irrigation Systems) to reform the water management system by transferring water management from an administrative-territorial system to a basin approach. The main goal of this reform was to consolidate water management through the establishment of WUAs and Canal Management Organizations (CMOs), operating within single hydraulic units, in order to ensure equal access to water for different users and improve water use efficiency (Abdullaev *et al.,* 2009). By the end of 2010 there were 1 486 successfully functioning WUAs, providing water services to more than 80 000 water users, including farmers. On 29 December 2009, the "Water and water use" law was revised and the previously used WUA concept related to irrigation was renamed into the Water Consumers Association (WCA). The distinction between them was clarified as follows: "water user" refers to not affecting the actual amount of available water (such as fisheries and hydropower) and "water consumer" refers to reducing the actual amount of available water (such as irrigation).

Karakalpakstan and Khorezm are located in the driest part of Uzbekistan. Over the last three decades, the drying up of the Aral Sea has further aggravated the water shortage problem. Since mid-2000, Karakalpakstan and Khorezm have been suffering from the worst drought in 100 years. About 90 percent of the rice crop and 75 percent of the cotton crop were lost in 2000 and 2001. The Western Uzbekistan Rural Water Supply Project was launched in 2002 with a loan from the ADB. It provided urgently needed assistance by responding to the worsening consequences of drought during the previous years in the Aral Sea area of northwest Uzbekistan. The Project covered Karakalpakstan and Khorezm by: improving potable water supply and providing support to sanitation and personal hygiene practices to about 700 000 rural population in the Project area, of whom over 60 percent were poor, by introducing water conservation measures, educating the public about the value of water and promoting health awareness campaigns.

In 2001 and 2002, USAID and MAWR implemented a large-scale pilot project on the Pakhtaabad canal which serves more than 20 000 ha of irrigated land and about 100 000 farmers in Andijan (Uzbekistan) and Jalalabad (Kyrgyzstan). Although Andijan and Jalalabad are high-yield farming areas, ineffective water management in the last decades had diminished irrigated land and reduced yields. The pilot project demonstrated how cost-effective technologies and automated systems could improve water control and management along major existing watercourses (USAID, 2003b).

To improve the situation in the water resources management sector, the government of Uzbekistan, international organizations, and International Financial Institutions (IFIs) are developing and implementing a number of projects, dealing with urban water supply, improvement of irrigation and drainage systems, improvement of sewerage systems and wastewater treatment facilities.

The Water Supply, Sanitation and Health Project (1999–2007), was prepared by the government with the International Bank for Reconstruction and Development (IBRD) and United Nations Development Programme (UNDP) assistance in support of the Aral Sea area. The objectives of the project were to improve water supply, sanitation and health in the project area (Karakalpakstan and Khorezm) through the provision of safe drinking water and sanitation facilities and the strengthening of the financial, operational and managerial capacities of water supply and sanitation utilities (UNDP, 2000).

In 2004, the government and the World Bank signed a US$74.55 million Drainage, Irrigation and Wetlands Improvement Project, to increase productivity of irrigated agriculture, employment and incomes in Karakalpakstan, to improve water quality of the Amu Darya river by safe disposal of drainage effluent, and enhance the quality of wetlands in the Amu Darya delta. It also developed institutions to improve water management, operation and maintenance of irrigation and drainage systems, and promoted sustainable irrigated agriculture through participatory irrigation management. The Ministry of Agriculture and Water Resources was responsible for the timely implementation of the project.

MAWR has initiated reforms of irrigated agriculture to increase crop productivity and system operators' administrative efficiency. An important reform is the restructuring of the Zeravshan river irrigation systems into one basin administration under the control of a single operating agency. USAID works with the ministry and the basin's operating agency and is also collaborating closely with the government to implement substantial improvements to the main delivery canals of the Surkhandarya river irrigation system and the Zeravshan river basin. Over 3.5 million people are directly engaged in farming in these areas (USAID, 2003a).

In 2010, the World Bank launched the Fergana Valley Water Resource Management Phase-I Project, which deals with increasing water use efficiency and rehabilitating the irrigation and drainage infrastructure in Fergana Valley to promote economic development.

Finances

During the Soviet period, Uzbek cotton was among the most highly subsidized crops. Inputs were provided to collective farms at large discounts, and credits were allocated to state-owned enterprises by the government banking systems at concessional interest rates. The state still controls, monopolizes and subsidizes input markets. Starting in 1993, the government established a range of state-owned agencies for agricultural inputs, which provide inputs such as machinery and fertilizers. Credit subsidies, both through low rates and write-offs, especially for collectives, also existed. In 2004, the government provided approximately US$400 million in subsidies, equivalent to approximately 43 percent of the value of the cotton crop. It also provided subsidies to the agricultural sector of which $261 million or 65 percent went to irrigation service provision (Abdullaev *et al.,* 2009). In 1995 a land tax was introduced. The amount payable depends on irrigation and land quality, which is calculated by province on the basis of a soil fertility parameter. For example, in 1997, in Karakalpakstan, the tax varied from US$0.64/ha for the lowest fertility class to US$6.5/ha for the best fertility class. In the south of the country, the tax varied between US$1.1 and 11.2/ha. A WCA is in charge of operating and maintaining the on-farm water infrastructure through irrigation service fee (ISF) collection. However, most WCAs are still not able to take full responsibility and generate sufficient investment for the infrastructure maintenance.

Policies and legislation

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 legal framework is constantly being improved and in 2009 a new law was approved on 'Introducing amendments to some legislative acts of the Republic of Uzbekistan in connection with the deepening of economic reforms in agriculture and water management'. The law is said to be a successful in the water sector, because it clearly governs the relationship between water users, increases their responsibility concerning the rational and economical use of water, determines the status of water consumer associations (former water users associations) and reflects the basic principles of Integrated Water Resource Management (IWRM).

A policy framework for water supply and environmental sanitation is being developed, which besides providing water supply and sanitation to areas currently without, will contribute to a reduction in water-borne and water-related diseases and improve the nutritional status of the population in general and children in particular (UNICEF, 2003).

ENVIRONMENT AND HEALTH

From 1960 to 1992 the surface area of the Aral Sea was halved and its volume quartered, as the Amu Darya and Syr Darya rivers were channelled and dammed to provide irrigation for agriculture. The dry land has separated the remaining bodies of water into two main lakes (OrexCA, 2011). The areas most affected are Karakalpakstan and the neighbouring region of Khorezm, which together contain a population of over 2.5 million people at risk (UNICEF, 2003).

As the sea level drops by 1 m/year, more land is exposed, and chemical pesticides used in cotton production are concentrated in a crust on the newly-exposed land. Winds then disperse the crust as a cloud of lethal dust, causing health problems among the population and reducing agricultural productivity as a result of land and water salinization. The people in these regions suffer from high levels of anaemia, together with rising levels of tuberculosis, while children suffer from liver, kidney and respiratory diseases, micronutrient deficiencies, cancer, immunological problems and birth defects.

All existing wetlands are used for fishing. Environmental wetland problems are mainly associated with the unstable regime of water flow and the low level of its protection, thus limiting the possibilities of conservation of habitats and biodiversity of flora and fauna of this ecosystem.

In Karakalpakstan the fishing industry has disappeared and agricultural land is no longer productive, resulting in a rapid loss of employment opportunities for local people. Consequently, vulnerability to poverty has increased. Forty-percent of the rural population depend on small subsistence plots of land for their livelihoods, but these plots have been adversely affected by water shortages or pollution and the rural population consequently face increasing hardship, malnutrition and illness.

In 2001 and 2002, the situation in Karakalpakstan and Khorezm declined further as a result of two consecutive years of drought that brought water shortages. The drought had a negative impact on domestic and personal hygiene exposing the population to higher risk of water-borne diseases such as typhoid, diarrhea and worm infection. Although the government has made progress, in this region still only 54 percent of urban and 3 percent of rural populations have access to adequate sewage systems, the rest rely on very basic and unhygienic pit latrines. One of the major problems is salinization and although Karakalpakstan has 63 out of 80 functioning desalination units, most of these are working well below their capacity and need major repairs (UNICEF, 2003).

Intensive development of new irrigated areas in 1960–1980s was accompanied by land salinization, waterlogging, land degradation and increased discharge of highly salinized drainage water into the Amu Darya river through a system of collector drains. These led to increased salinization and pollution of the river, as well as negative impacts on the health of the population and on agricultural production. Waterlogging and/or salinization already affect 50 percent of irrigated areas in Uzbekistan.

Salinity of irrigation water in the middle reaches of rivers has become 1–1.1 g/litre with a low content of organic substances, and in the lower reaches at certain periods it becomes an average of 2 g/litre and more (compared to the original 0.2–0.3 g/litre), and organic substances 29.6 mg/litre. Sewage and municipal wastewater discharged into some rivers leads to increased pollution along the course from its source downstream. Pollution by petroleum products goes from 0.4 to 8.2 maximum allowable concentration (MAC), by phenols up to 6 MAC, by nitrates up to 3.7 MAC, by heavy metals up to 11 MAC. The contamination rate of groundwater has also increased.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

As population and industrialization increase, growing municipal and industrial water needs will compete with demands for irrigated agriculture. Increasing the efficiency of agricultural water use is essential for supporting rural livelihoods, producing sufficient food for the growing population, and producing commodity crops, that are important to the national economy, and continuing social and economic development (USAID, 2003a).

Economic deterioration in Central Asian countries, which had followed the disintegration of the USSR, resulted in less than normal water use. Also, the partial thawing of the Pamirs and Tien Shan glaciers, along with global warming, provided temporary relief for an inevitable water shortage. The situation is predicted to become more serious by 2020 when the glaciers feeding the Amu Sarya and Syr Darya rivers will have lost their critical mass (FIA, 2008).

Out of the countries located in the basins of the Amu Darya and Syr Darya rivers, Uzbekistan has the largest population and requires the largest amount of water. The population is growing by half a million people per year, meaning that there is a need for more products and expansion of irrigated lands, which requires even more water. Based on the data of the 'Vodoproekt' (Water project) association of the MAWR, in 10–15 years the population may reach 32–35 million and water requirements will far exceed those available in the country. Thus, the urgency of the problem is beyond question (Akhmadov, 2008).

Even if policy changes reduce cotton exports, it is much more likely that any water 'saved' from reduced cotton production will instead be used to produce other crops, as has been the pattern to date. Soviet planners made the initial decision to trade the viability of the Aral Sea for agriculture. There is currently no reason to think that present and future governments will reverse that decision. If water scarcity is to be a factor for the Uzbek cotton production, it is most likely to occur because of the regional trade-offs between downstream agriculture (Uzbekistan and Kazakhstan) and upstream energy production (Kyrgyzstan and Tajikistan), than between agriculture and environment, at least in the foreseeable future (Abdullaev *et al.*, 2009).

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The Aral Sea transboundary river basin

GEOGRAPHY, CLIMATE AND POPULATION

Geography

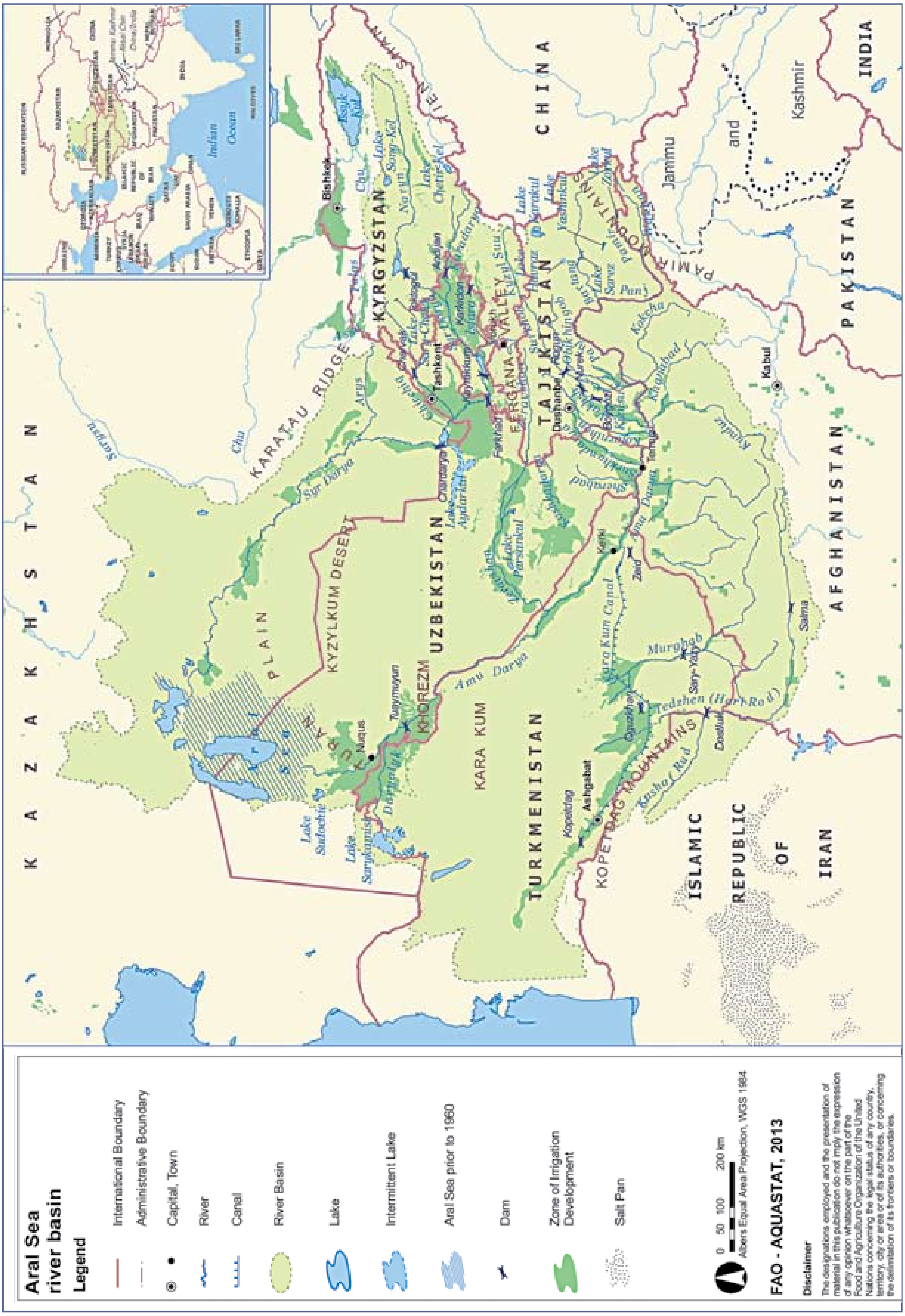
The Aral Sea basin, total area 1.76 million km^2, is a transboundary river basin at the heart of the Eurasian continent. Geographically it covers an extensive area of Central Asia, most of Tajikistan (99 percent), Turkmenistan (95 percent) and Uzbekistan (95 percent), Osh, Djalal-Abad and Naryn provinces of Kyrgyzstan (59 percent), Kyzylorda and South Kazakhstan provinces of Kazakhstan (13 percent), northern Afghanistan (38 percent) and a very small part of the Islamic Republic of Iran in the Tedzhen/Murghab basin (not included in Table 1) (Table 1).

The territory of the Aral Sea basin can be divided into two main zones: the Turan plain and the mountain zone. The Kara Kum covers the west and northwest of the Aral Sea basin within the Turan plain and Kyzylkum deserts. The east and southeast are in the high mountains of the Tien Shan and Pamir ranges. The remaining portion of the basin is composed of various types of alluvial and inter-mountain valleys, arid and semi-arid steppe. In all the regions the different forms of relief have created specific conditions that are reflected in the interrelation between water, land and people.

TABLE 1
Country areas in the Aral Sea basin

Basin	Area		Countries included	Area of country in basin (km^2)	As % of total area of the basin	As % of total area of the country
	km^2	% of Southeast Asia				
Syr Darya	531 650	11	Kazakhstan	345 000	64.9	12.7
			Kyrgyzstan	110 570	20.8	55.3
			Tajikistan	15 680	2.9	11.0
			Uzbekistan	60 400	11.4	13.5
Amu Darya	1 023 610	22	Afghanistan	166 000*	16.2	25.4
			Kyrgyzstan	7 800	0.8	3.9
			Tajikistan	125 450**	12.3	88.0
			Turkmenistan	359 730	35.1	73.7
			Uzbekistan	364 630**	35.6	81.5
Tedzhen-Murghab	182 010	4	Afghanistan	80 000	44.0	12.3
			Turkmenistan	102 010***	56.0	20.9
Aral Sea basin	**1 737 270**	**37**	**Afghanistan**	**246 000**	**14.2**	**37.7**
			Kazakhstan	**345 000**	**19.9**	**12.7**
			Kyrgyzstan	**118 370**	**6.8**	**59.2**
			Tajikistan	**141 130**	**8.1**	**99.0**
			Turkmenistan	**461 740**	**26.6**	**94.6**
			Uzbekistan	**425 030**	**24.5**	**95.0**

* Includes 75 000 ha of Northern basin
** Includes the Zeravshan basin
*** 55 155 ha of Tedzhen river basin and 46 855 ha of Murghab river basin


Aral Sea river basin
Legend
International Boundary
Administrative Boundary
Capital, Town
River
Canal
River Basin
Lake
Intermittent Lake
Aral Sea prior to 1960
Dam
Zone of Irrigation Development
Salt Pan
0 50 100 200 km
Albers Equal Area Projection, WGS 1984
FAO - AQUASTAT, 2013
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KAZAKHSTAN
KYRGYZSTAN
UZBEKISTAN
TAJIKISTAN
TURKMENISTAN
AFGHANISTAN
PAKISTAN
INDIA
CHINA
ISLAMIC REPUBLIC OF IRAN
Jammu and Kashmir
KARATAU RIDGE
KYZYLKUM DESERT
KARA KUM
FERGANA VALLEY
KOPETDAG MOUNTAINS
PAMIR MOUNTAINS
Aral Sea
Amu Darya
Syr Darya
Bishkek
Tashkent
Dushanbe
Ashgabat
Kabul
Nukus

About 90 percent of Tajikistan and Kyrgyzstan is mountainous. More than half the mean annual runoff in the Aral Sea basin is generated in Tajikistan and almost one-quarter in Kyrgyzstan. A significant feature of the region is the number of oases (Fergana valley, Khorezm, Tashaus, Mary, Zeravshan, Tashkent – Chimkent), which cover a small part of the overall area. Since ancient times these oases have been at the centre of human activity because of their favourable living conditions (water, precipitation, the best soils, etc.). More than 50 percent of Kazakhstan, Turkmenistan and Uzbekistan are covered by desert, less than 10 percent is mountainous. Just over 10 percent of the mean annual runoff in the Aral Sea basin is generated in these three countries.

The Aral Sea basin includes the Syr Darya and Amu Darya, the Tedzhen (known as Hari Rod in Afghanistan) and Murghab rivers, the Kara Kum canal linking the Amu Darya, Murghab and Tedzhen rivers, shallow rivers flowing from Kopet Dag and western Tien Shan, as well as the areas with no runoff between these rivers and around the Aral Sea. In Kazakhstan, the flows from the Torgai, Sarysu, Chu and Talas rivers are lost in the desert or are directed to natural depressions. These rivers are not considered part of the Aral Sea basin.

Before 1960, the Aral Sea ranked as the world's fourth largest lake, after the Caspian Sea, the Great Lakes in North America and Lake Chad, since then it has been progressively drying up (see river basin map).

Population

The Aral Sea basin is a diverse region with approximately 46 million people in 2006 while in 1960 and 1980 the population was 15 million and 27 million people respectively (Sokolov, 2009). In 2010, access to improved water sources varied from 50 percent in Afghanistan to 96 percent in the Islamic Republic of Iran (Table 2).

Climate

The climate is continental, determined by the landlocked position of Central Asia within the Eurasian continent. Large daily and seasonal temperature differences are characteristic of the region, with high solar radiation and relatively low humidity. Terrain and altitude range from 0 to 7 500 m above sea level (asl), leading to greatly diversified microclimates. Although this area is often subject to humid winds, the mountains trap most of the moisture, leaving little precipitation for the other areas of the Aral Sea basin (CAWaterInfo, 2011).

The average temperatures range from 0–4 °C in January and 28–32 °C in July. In some areas, summer temperatures may be as high as 52 °C and winters as cold as minus 16 °C, with an absolute minimum of minus 38 °C, creating a sharply contrasting overall climate, with hot summers and cold winters (Murray-Rust *et al.,* 2003).

TABLE 2
Access to improved water sources (Source: JMP, 2011)

Country	Access to improved water sources (% of population)		
	National	Urban	Rural
Afghanistan	50	78	42
Islamic Republic of Iran	96	97	92
Kazakhstan	95	99	90
Kyrgyzstan	90	99	85
Tajikistan	64	92	54
Turkmenistan	84	97	72
Uzbekistan	87	98	81

Annual precipitation in the lowlands and valleys is between 80 and 200 mm, concentrated in the winter and spring, while on the foothills precipitation is between 300 and 400 mm, and on the southern and southwestern sides of the mountain between 600 and 800 mm.

Because of the large differences in summer air humidity between the ancient oases and the newly irrigated areas, 50–60 percent and 20–30 percent respectively, water demands in the former desert – now under irrigation – are significantly higher than around the oases. The second factor, which particularly affects agricultural production, is the instability of spring temperatures and precipitation. Late frosts may occur at the beginning of May with hail in June, which sometimes destroys emerging cotton plants and vegetables over large areas (CAWaterInfo, 2011).

WATER RESOURCES

Mountains and glaciers play an important role in water storage. They can store precipitation as snow and ice in winter and deliver it as snow melt to rivers and associated alluvial aquifers during the dry summer season (July and August) (Rakhmatullaev *et al.,* 2009).

Surface water

The two major river basins in the Aral Sea basin are the Amu Darya in the south and the Syr Darya in the north. A third river basin, the Tedzhen-Murghab basin, is located in the southwest. Some thirty primary tributaries feed the basins. However, today, many of the tributaries only flow seasonally – drying up before reaching the main rivers.

The main rivers originate in mountainous regions – the Pamir and Tien Shan ranges – where there is surplus moisture (precipitation of 800–1 600 mm and potential evapotranspiration of 100–500 mm), resulting in permanent snowfields and glaciers (Murray-Rust *et al.,* 2003).

Amu Darya basin

The Amu Darya basin is divided into two unequal parts: the smaller upstream to the southeast, characterized by the high mountain ranges of Central Pamir and Tien Shan with an altitude of 5 000–6 000 m, and the larger area downstream to the northwest, where plains dominate the landscape and elevations are no higher than 200 m. Despite the very arid conditions of the region, the high mountain ranges facilitate the formation of important water-courses that behave as a huge feeding reservoir (Rakhmatullaev *et al.,* 2009).

The Amu Darya is the longest river in Central Asia and the second longest in Afghanistan. Six countries share the river Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Rising in Afghanistan, Kyrgyzstan and Tajikistan, the Amu Darya flows 2 540 km from the headwaters of the Panj (Pyandzh) to the Aral Sea. The river is named Amu Darya from the point where the Panj river joins the Vakhsh river in the Pamir mountains.

The Vakhsh river rises in Kyrgyzstan, where it is named the Kyzyl Suu. This is the longest river in Tajikistan, crossing from the northeast to the southwest, its catchment area lies at over 3 500 m in the highest part of Tajikistan. The Vakhsh river takes its name from the confluence of the Surkhob and Obikhingob rivers. The Panj river, the largest tributary of the Amu Darya, originates in the Pamir mountain ranges and forms the border between Tajikistan and Afghanistan for almost its entire length flowing from east to west. After the confluence of the Panj and Vakhsh rivers, it becomes the Amu Darya and about 100 km further downstream it leaves Tajikistan to become the border between Afghanistan and Uzbekistan.

The Kofarnihon river rises in Tajikistan and flows into the Amu Darya about 36 km downstream of the confluence of the Panj and Vakhsh rivers. The Kofarnihon river flows mainly in Tajikistan and forms the border between Tajikistan and Uzbekistan over a short distance before flowing into the Amu Darya. Two other large right tributaries, the Surkhandarya and Sherabad rivers, and two left tributaries, the Kunduz and Kokcha rivers, flow into the Amu Darya in the middle reach. Further downstream towards the Aral Sea, the Amu Darya has no tributaries.

Two rivers, the Zeravshan and Kashkadarya rivers, are similar to the Amu Darya for their water catchment characteristics however; they no longer discharge into the Amu Darya (Rakhmatullaev *et al.,* 2009). The Zeravshan, which rises in Tajikistan, used to be the largest tributary of the Amu Darya before it began to be tapped for irrigation, mainly by Uzbekistan. Now the Zeravshan evaporates in the Kyzylkum desert near the city of Bukhara. Total river flow from Tajikistan to Uzbekistan is 3.09 km^3/year; all these water resources are allocated to Uzbekistan.

In Afghanistan, the rivers of the northern basin originate on the northern slopes of the Hindu Kush and flow northwards towards the Amu Darya river. However, most of these rivers die out on the Turkistan plains before reaching the Amu Darya. From west to east, the main rivers include the Shirin Tagab, the Sarepul, the Balkh and the Khulm rivers.

The Amu Darya is fed largely by water from melted snow, thus maximum discharges are observed in summer and minimum in January-February. This year-round availability of the flow favours the use of the river water for irrigation during the dry summer. While crossing the plain, from Kerki in Turkmenistan to Nuqus in Uzbekistan, the Amu Darya looses most of its flow to evaporation, infiltration and irrigation withdrawal. The basin's total long-term average annual runoff is 78.46 km^3. The long-term average annual flow in the Amu Darya basin from Kyrgyzstan to Tajikistan – through the Kyzul Suu river – is 1.93 km^3 or about 2 percent of the total flow of the Amu Darya.

The main flow of the Amu Darya originates in Tajikistan: about 59.45 km^3, including 3.09 km^3 of the Zeravshan river, or 76 percent of the total flow. The Amu Darya then flows along the border between Afghanistan and Uzbekistan, across Turkmenistan and returns to Uzbekistan where it discharges into the Aral Sea. About 11.7 km^3 (not including 1.9 km^3 of the northern basin, which mainly evaporates before reaching the Amu Darya) or 15 percent of Amu Darya water is formed in Afghanistan. The internal contribution of Turkmenistan to the river is 0.68 km^3 or 1 percent. The internal contribution of Uzbekistan to the river is 4.7 km^3 or 6 percent.

The share of the Amu Darya flow allocated to Turkmenistan and Uzbekistan is 50 percent each of the actual river flow at the Kerki gauging station. This share is based on an agreement between Uzbekistan and Turkmenistan signed in January 1996, which supplemented the 1992 Agreement signed by the five Central Asian countries. The Turkmen and Uzbek allocation corresponds to 42.27 percent of the share of the Amu Darya surface water resources on which agreements have been concluded. The agreements are calculated based on about 67 percent of the total flow produced in the Amu Darya basin, which is on average 78.46 km^3/year. This is calculated by adding the long-term average annual internal renewable surface water resources (IRSWR) of the basin in the different countries: Kyrgyzstan 1.93 km^3, Tajikistan 59.45 km^3, Uzbekistan 4.70 km^3, Afghanistan 11.70 km^3 and Turkmenistan 0.68 km^3.

The actual surface water resources allocated to Turkmenistan and Uzbekistan are calculated every year, depending on the actual flow. On average, water resources allocated to Turkmenistan in the Amu Darya basin are about 22 km^3/year, including 0.68 km^3/year of IRSWR, and 22 km^3/year to Uzbekistan, which includes 3.09 km^3 of the Zeravshan river. Even though Afghanistan is not part of the five states of the Former Soviet Union, and therefore not part of the agreement, allocations between the five states include the flow of 11.7 km^3/year, which is measured at Kerki station in Turkmenistan.

Syr Darya basin

The Syr Darya is the second most important river in Central Asia for water resources it flows 3 019 km from the Naryn headwaters in Kyrgyzstan. The Syr Darya originates in the Tien Shan mountains, runs through the upstream countries of Kyrgyzstan and Tajikistan and then through Uzbekistan and Kazakhstan into the Aral Sea (Murray-Rust *et al.*, 2003). The river is known as the Syr Darya after the point where the Naryn joins with the Karadarya in Uzbekistan. Glaciers and snow melt feed the river, mostly the latter. The water regime is characterized by a spring-summer flow, which begins in April. Discharge is highest in June.

The total long-term average annual runoff of the Syr Darya basin is 36.57 km^3. About 27.42 km^3 or 75 percent is formed in Kyrgyzstan, which is the flow from Kyrgyzstan to Uzbekistan, of which 22.33 km^3 is secured by agreements. Of this, 11.8 km^3/year is transit flow to Tajikistan secured by agreements. Only 3 percent of the Syr Darya is generated within Tajikistan by the shallow rivers Khodzhabakirgan, Isfara and Isfana, with a total flow of 1.01 km^3/year. The annual flow at the border between Tajikistan and Uzbekistan, is 11.54 km^3 of which 10 km^3 is transit flow to Kazakhstan, as secured by agreements. On average, the contribution of Uzbekistan to the Syr Darya is 4.84 km^3 or 13 percent, and the contribution of Kazakhstan is 3.3 km^3 or 9 percent.

The largest tributaries of the Syr Darya within Kazakhstan are the Keles, Arys, Badam, Boroldai, Bugun and smaller rivers, flowing from the southwestern slopes of the Karatau ridge.

Tedzhen-Murghab basin

Afghanistan is the source of the Murghab and Tedzhen rivers of the Aral Sea basin. They terminate in Turkmenistan, although the Tedzhen also travels across the Islamic Republic of Iran (Horsman, 2008). The main flow of the Tedzhen and Murghab together is 3.1 km^3 in Afghanistan and 0.3 km^3 in Turkmenistan. The Tedzhen waters are covered by a treaty, signed in February 1926 between the Islamic Republic of Iran and Turkmenistan, which remains in force. This treaty stipulates that each year Turkmenistan receives a quantity equal to 70 percent of the total Tedzhen average runoff, which corresponds to an average of 0.75 km^3.

Aral Sea basin

The total mean annual flow of all rivers in the Aral Sea basin is an estimated 118.43 km^3 (Table 3). In accordance with flow probabilities of 5 percent (wet years) and 95 percent (dry years), the annual flow ranges from 108 to 47 km^3 for the Amu Darya river and from 54 to 21 km^3 for the Syr Darya river respectively.

TABLE 3
Mean annual runoff in the Aral Sea basin (km^3/year)

Country	River basin			Total Aral Sea basin	
	Syr Darya	Amu Darya	Tedzhen-Murghab	km^3	%
Kazakhstan	3.30			3.30	2.8
Kyrgyzstan	27.42	1.93		29.35	24.8
Tajikistan	1.01	*59.45		60.46	51.0
Turkmenistan		0.68	0.3	0.98	0.8
Uzbekistan	4.84	4.70		9.54	8.1
Afghanistan		11.70	3.1	14.80	12.5
Islamic Republic of Iran			n.a.	-	-
Aral Sea basin	**36.57**	**78.46**	**3.4**	**118.43**	**100.0**

n.a. not available
* Includes 3.09 km^3 of Zeravshan river

There are no significant anthropogenic changes in the upstream zone of flow formation. However, because of the construction of large dams on the border of this area, the downstream runoff regime is changing. Because of significant losses in the desert areas, and because of major agricultural water withdrawal, the flow reaching the Aral Sea is limited to a small percentage of these annual flows. In the driest years this corresponds to less than 10 percent for Amu Darya and less than 5 percent for the Syr Darya.

Groundwater

The groundwater resources of the Aral Sea basin can be divided into two parts: the natural flow or primary freshwater from the mountainous and water catchment areas, and groundwater filtrated from hydro-technical structures and irrigated land (secondary freshwater). Estimated reserves of Central Asia countries (Afghanistan not included) are about 31.1 km^3, of which 14.7 km^3 are in the Amu Darya basin and 16.4 km^3 in Syr Darya basin. Because exploitation of groundwater may impact surface water flows, the quantification of groundwater resources must be carefully carried out to identify the portion of the reserves that can be used without significantly diminishing surface runoff. The reserves confirmed for extraction are an estimated 13.1 km^3 per year (CAWaterInfo, 2011).

Average annual groundwater recharge in Afghanistan is an estimated 2.97 km^3 in the Amu Darya basin, 0.64 km^3 in the Tedzhen basin and 2.14 km^3 in the Murghab and northern basins. In Kyrgyzstan groundwater recharge is an estimated 0.23 km^3 in the Amu Darya basin and 5.25 km^3 in the Syr Darya basin. Average annual groundwater recharge in Uzbekistan, which is entirely located in the Aral Sea basin, is an estimated 8.8 km^3, while in Tajikistan it is 6 km^3. There are no detailed figures by basin for Kazakhstan and Turkmenistan. It should be noted, however, surface water and groundwater resources cannot be added to obtain total renewable water resources. This is because of the overlap between surface water and groundwater as a result of seepage from rivers into aquifers and groundwater drainage into rivers (base flow of rivers).

Natural lakes, reservoirs and non-conventional sources of water

There are many natural lakes in the mountainous areas and ravines of Central Asia. Most of the large lakes occupy basins that resulted from tectonic activity (Issyk-Kul, Song-Kel, Chetir-Kel, Karakul, Sarichelek). Lakes resulting from landslides, caused by earthquakes, are the Sarez and Yashinkul in the Pamir mountains. Numerous lakes are of glacial origin; one of the largest is the Zorkul, located at 4 125 m in the Eastern Pamir. Karst lakes are also present. In the mountains, lakes are usually freshwater or slightly saline, depending on the quality of inflowing water. Initial assessments of freshwater reserves in mountain and lowland lakes suggest a volume of 60 km^3 (CAWaterInfo, 2011).

Many artificial lakes have been created, most are shallow. The largest of these lakes in the region are Sarykamish, in the lower reaches of the Amu Darya and Aydarkul, in the middle reach of the Syr Darya. Large volumes of water are discharged into Aydarkul lake during high water years from the Chardarya reservoir, on the border between Kazakhstan and Uzbekistan. In the last few years, this has been common practice in winter to create energy from the Naryn-Syr Darya hydropower cascade. The volume of water resources found in artificial lakes is an estimated 40 km^3 (CAWaterInfo, 2011).

Return flow forms a high proportion of water resources in the basin and is a major source of pollution. In recent years, the annual mean values of return flow, comprised of drainage water from irrigation and wastewater from industry and municipalities have varied between 28 km^3 and 33 km^3. About 13–15.5 km^3 annually form in the Syr Darya basin, and about 15–18 km^3 in the Amu Darya basin. The total amount makes up about 95 percent of drainage water and about 5 percent of untreated municipal and industrial wastewater. The high percentage of drainage water demonstrates that irrigation actually consumes only about 45–50 percent of total agricultural withdrawals (CAWaterInfo, 2011). In 1993, about 6 km^3 of agricultural drainage water or wastewater were directly used for irrigation.

One of the principal goals of water managers is to minimize losses. Drainage water is highly saline: 2–3 g/litre from April to September and 5–12 g/litre during autumn and winter. The quality of the drainage effluent depends on the location of the irrigation scheme within the river basin – upper, middle, or lower reaches – and the leaching requirements of the irrigated area. It also depends on the use of agrochemicals. Local salt mobilization is determined in part by the type of drainage system (open, subsurface or vertical), seepage, drain spacing and drain depth. The poor quality limits the direct use of drainage water, especially for irrigation. Only about 15 percent of total return flow is directly used and more than 55 percent returns to rivers. About 30 percent ends up in natural depressions, from which the water evaporates (CAWaterInfo, 2011).

WATER-RELATED DEVELOPMENTS IN THE BASIN

Agriculture

The rural population in the Aral Sea basin is mainly employed in farming. Out of 60 million ha that are considered cultivable (Afghanistan and the Islamic Republic of Iran are not included) only about 10 million ha are actually used. Half of the actually cultivated land is located on the fertile soils of the oases, which are naturally drained. The other half requires complicated and expensive reclamation measures before it can be used, including drainage and land levelling and improvement of the soil structure. Land availability varies greatly between the countries. Kazakhstan and Turkmenistan have good land availability, while land is scarce in Tajikistan and Kyrgyzstan and in some areas of Uzbekistan, such as Khorezm, the Fergana valley and Samarkand provinces.

This situation, plus water scarcity, causes friction between the countries, provinces and tribes. The significance of large-scale development of desert areas during the Soviet period, such as Golodnaya steppe, Karshi steppe, areas along the Kara Kum canal, Asht and Lylak systems, was they allowed the resettlement of hundreds of thousands of people from more populated areas. Such enormous undertakings are no longer a viable option for these post-Soviet, independent and economically weak countries. Thus decision should be based only on the improvement of available resources and not on major new developments (CAWaterInfo, 2011).

Irrigation plays an important role in the economies of Central Asia. While some areas have been irrigated for centuries, central planning created many irrigation and drainage schemes in the 1950s–1980s. In the 1960s, Soviet policy assigned Central Asia the role of supplier of raw material, notably cotton. Irrigation was necessary because of the mainly arid climate in the lower reaches of the Amu and Syr Darya basins. The development of irrigation in the Soviet area of the Aral Sea basin was spectacular: from about 4.5 million ha in 1960 to almost 7 million ha in 1980. Huge schemes were constructed to irrigate desert or steppes and hundreds of thousands of people moved to the areas to work in agriculture. From 1970 to 1989 the irrigated area expanded by 150 percent in the Amu Darya basin and 130 percent in the Syr Darya basin (World Bank, 2003).

Some 32.6 million ha are considered suitable for irrigation in the Aral Sea basin. Currently, the total area equipped for irrigation is around 9.76 million ha (Table 4). The area equipped for irrigation in the Amu Darya basin is an estimated 6 million ha of which 1.3 million ha in northern Afghanistan, 0.1 million ha in Kyrgyzstan, 0.5 million ha in Tajikistan, 1.8 million ha in Turkmenistan and 2.3 million ha in Uzbekistan (Sokolov, 2009; Horsman, 2008; Rout, 2008).

More than 90 percent of the Aral Sea basin's crops are produced on irrigated land (Horsman, 2008). Currently, rainfed land does not play a significant role in total agricultural production in

TABLE 4
Irrigation in the Aral Sea basin (Adapted from: Sokolov, 2009; Horsman, 2008; Rout, 2008)

Country	Area equipped for irrigation (AEI)	As % of	Area actually irrigated (AAI)	AAI as % of AEI
	(million ha)	total	(million ha)	(%)
Afghanistan	1.30	13	0.77	59
Kazakhstan	1.30	13	0.83	64
Kyrgyzstan	0.42	4	0.42	100
Tajikistan	0.74	8	0.67	91
Turkmenistan	1.80	19	1.80	100
Uzbekistan	4.20	43	3.70	88
Aral Sea basin	**9.76**	**100**	**8.19**	**84**

the Aral Sea basin, with the exception of extensive (semi-nomadic) livestock husbandry (cattle and sheep). Nonetheless, increasing the productivity of non-irrigated land is an important goal. Some crops (e.g. cereals), which are grown increasingly in irrigated areas, could be moved to non-irrigated areas thus substantially reducing the volume of irrigation water withdrawn in the basin (CAWaterInfo, 2011).

Since independence, the irrigated land area has not changed significantly in Central Asian countries, with the exception of Turkmenistan where the area of irrigated land during 1995–1996 increased by about 400 000 ha. However, there have been major changes in cropping patterns. Cotton is still one of the most important crops, although between 1990 and 1998 its share of irrigated agriculture decreased from 45 to 25 percent. In the same period, the area under cereals (wheat, rice, maize and others) increased from 12 to 77 percent. Wheat became the dominant crop in the region, which covers about 28 percent of total irrigated area. Fodder crops in 1998 occupied less than 20 percent of the total irrigated area, compared to 27 percent in 1990, which is highly undesirable from the viewpoint of maintaining soil fertility and crop rotation (CAWaterInfo, 2011).

Large-scale irrigated farming in the Aral Sea Basin is based on a well-developed system of irrigation and drainage facilities. By the end of 1998, the overall length of main and inter-farm irrigation networks in the basin was 47 750 km and on-farm irrigation networks totalled 268 500 km. Irrigation in Central Asia, and particularly in Uzbekistan, relies on a system of pumps and canals that is among the most complex in the world. Since 1990, on-farm irrigation networks have deteriorated as a result of the poor financial situation of both state-owned and privatized farms, which are unable to reconstruct on-farm networks or maintain them in a satisfactory condition (CAWaterInfo, 2011).

In 1960, total water withdrawal in the Aral Sea basin was an estimated 64.7 km^3. In 2006, it was an estimated 107 km^3 of which irrigation withdrawal accounted for 96 km^3, or 90 percent of the total (Sokolov, 2009). Most of the Amu Darya water is withdrawn by Turkmenistan and Uzbekistan along the section of their common border (Stanchin and Lerman, 2006). Uzbekistan accounts for approximately 56 km^3 (50 km^3 in agriculture) and Tajikistan for 11 km^3 (10 km^3 in agriculture).

Withdrawal of water per irrigated hectare in the Aral Sea Basin is high, in the order of 11 000–14 000 m^3/ha or even more (World Bank, 2003).

During the Soviet period groundwater resources were not widely used for irrigated agriculture in the Central Asian Republics. This is because farmers received sufficient surface water, and had a reliable water supply and irrigation infrastructure. During this period groundwater resources were used primarily for the livestock sector and drinking water supply in both urban and rural areas. The Aral Sea basin countries began useing groundwater during the drought years (1998–2001) to sustain vital agricultural production. Groundwater is of relatively good quality and quantity and provides an alternative to highly salinized surface water.

Afghanistan has traditionally relied upon surface water and groundwater springs and *karezes* (constructed underground channels) for irrigated agriculture and the share of groundwater irrigation of the cultivated area is around 18 percent. During recent drought years in the Aral Sea basin, the use of deeper groundwater, abstracted from dug wells and boreholes increased rapidly. Private farmers drilled many new wells and boreholes and, in some areas, groundwater abstraction rates are already exceeding, or will soon exceed, sustainable groundwater resources (Rakhmatullaev *et al.,* 2009). Total groundwater extraction in the Aral Sea basin is around 10 km^3 (CAWaterInfo, 2011).

The largest and most important artificial waterway in Turkmenistan is the Kara Kum canal. This canal was constructed in the 1950s and is the longest canal in the world with 1 300 km. Canal capacity is an estimated 630 m^3/s. The canal's inlet on the Amu Darya is just after the river enters Turkmenistan from Uzbekistan. The Kara Kum canal pools the Amu Darya, Murghab and Tedzhen rivers into an integrated water management system. It supplies water to the densely populated south of the country and irrigates more than 1.2 million ha. The canal brings water to Ashgabat and to the oases in the south. Each year it takes 10–12 km^3 from the Amu Darya (Orlovsky and Orlovsky, after 2002).

During the Soviet period, water allocation and irrigation system infrastructure were well maintained and operated, with massive funding coming from the central government. Since the Central Asian countries gained independence, the situation changed dramatically, politically, institutionally as well as technically. The political transition from a planned economy to a market economy introduced 'new' concepts such as land tenure, water rights and different kinds of ownership. The institutional changes are described as a transition from former state collective farms – *kholkhoz* and *sovkhoz* – into smaller private farms. Many farmers, however, do not have the capacity to pump and irrigate land on an individual basis (Rakhmatullaev *et al.,* 2009).

Salinization and drainage

Climatic and hydro-geological conditions make the soil in the Aral Sea basin particularly vulnerable to salinization. Some land, especially in the inter-mountain valleys, is initially salt affected as a result of the arid climate. The process of salt accumulation is intensified under the influence of pressure from deep saline artesian water and the following two factors: (a) additional infiltration of irrigation water to the drainage network, (b) deterioration of downstream water quality. This is the result of natural evaporation processes, the use of overly saline irrigation water as well as naturally poor drainage conditions. The intensity of irrigation in Central Asia requires artificial drainage to control waterlogging and salinization. In 1994, about 40 percent of irrigated land in the basin was saline and groundwater salt content in the lower reaches of the river basins varied between 1 and 30 g/litre. Currently, about 5 million ha have drainage systems, of which about 60 percent is surface drainage, 26 percent subsurface, and 14 percent vertical drainage (tubewells). Uzbekistan has the largest area of artificially drained land in Central Asia.

Several innovations have been made to drainage design to address seepage from irrigation canals and upstream irrigation, percolation from excess irrigation water, groundwater fluxes to the root zone and the accompanying salts moving into the crop root zone. Deeper subsurface drainage depths are considered essential to control waterlogging and salinity. Significant investments were made in drainage in the region until the 1990s. However, with the demise of the Union of Soviet Socialist Republics (USSR), and the deterioration of economic conditions in Central Asia, investment in drainage declined. Drainage systems are no longer properly maintained and the areas suffering from salinization and waterlogging have been increasing (Dukhovny *et al.,* 2007).

Dams and hydropower

More than 80 water reservoirs were constructed in the Aral Sea basin, each with a capacity of over 10 million m^3. In order to modify natural river flow patterns to those needed for water supply, reservoirs were constructed either on rivers (off-stream and river-channel reservoirs) or on main canals (compensation reservoirs) (CAWaterInfo, 2011).

There are more than 45 hydropower plants in the Aral Sea basin, the total capacity of which exceeds 34.5 GW, ranging from 50 to 2 700 MW. The largest hydropower plants are Nurek in Tajikistan on Vakhsh river, with a capacity of 2 700 MW, and Toktogul in Kyrgyzstan on Naryn river, with a capacity of 1 200 MW. Hydropower makes up 27.3 percent of average energy consumption in the Aral Sea basin. Potentially, the region can meet more than 71 percent of its energy requirements from hydropower (CAWaterInfo, 2011).

Afghanistan has no dams in the Aral Sea basin, although the Salma Dam for hydroelectricity is under construction on the Hari Rod river. Originally constructed in 1976, it was damaged early during the civil war. In 2006, India committed to funding the completion of the Salma dam. On completion the hydroelectric plant should produce 42 MW in addition to providing irrigation to 75 000 ha, including stabilization of existing irrigation on 35 000 ha and development of irrigation facilities on an additional 40 000 ha.

In Kazakhstan, the Chardarya dam (5.2 km^3) is the only dam on the Syr Darya, located at the border with Uzbekistan and connected to hydroelectric power stations.

In Kyrgyzstan there are nine reservoirs in the Syr Darya basin, with a total capacity of 22.3 km^3. The Toktogul dam, with a reservoir capacity of 19.5 km^3, on the Naryn river, a northern tributary of the Syr Darya. The dam is multipurpose used for irrigation, hydropower production and flood protection/regulation. However, because it is located near the border with Uzbekistan, it does not play an important role in the irrigation of areas within Kyrgyzstan. In 1985, gross theoretical annual hydropower potential in Kyrgyzstan was an estimated 162 500 GWh and economically feasible potential about 55 000 GWh. The installed capacity of hydropower is about 3 GW, a number of hydropower plants are part of the Naryn-Syr Darya cascade, which are controlled by the Toktogul dam. Hydropower plays a key role in Kyrgyzstan and is the country's main source of energy (about 90 percent of electricity generation in 1995), given its limited gas, oil and coal resources.

In 2010, there were 17 dams in Tajikistan: four in the Syr Darya basin and 13 in the Amu Darya basin of which eight on Vakhsh river, two on Panj river and three on the Kofarnihon river. Their total reservoir capacity is about 29.5 km^3, including the Rogun reservoir on the Vakhsh river (13.3 km^3), which is under construction with completion of its first phase in 2012.

The largest reservoirs are: the Nurek on the Vakhsh river (10.5 km^3), the Kayrakkum on the Syr Darya (4.16 km^3), the Farkhad on the Syr Darya (350 million m^3), the Boygozi on the Vakhsh river (125 million m^3), the Kattasoy on the Kattasoy river (55 million m^3), the Muminabad on the Obi Surkh river (31 million m^3), the Dahanasoy on the Dahanasoy river (28 million m^3) and the Sangtuda 1 on the Vakhsh river (25 million m^3). The Sangtuda 2 reservoir (5 million m^3) on the Vakhsh river was inaugurated in 2011.

The Nurek headwork incorporates a unique rock-fill dam with a central core, 310 m high, there is a power plant with a capacity of 3 000 MW. Nurek and Kayrakkum reservoirs reserve water to irrigate Uzbekistan, Turkmenistan and Kazakstan. In 1999, Tajikistan ranked third in the world for hydropower development, after the United States and the Russian Federation. In 1994, total installed capacity was about 4 GWh, generating about 98 percent of the country's electricity.

In Turkmenistan, total dam capacity accounted for about 6.22 km^3 in 2004. All reservoirs were designed and constructed mainly for irrigation purposes, and are affected by heavy siltation. There are five dams with a capacity of more than 0.5 km^3: Zeid on the Kara Kum canal (2.20 km^3), Dostluk on the Tedzhen river (1.25 km^3), Oguzkhan on the Kara Kum canal (0.88 km^3), Sary-Yazy on the Murghab river (0.66 km^3) and Kopetdag on the Kara Kum canal (0.55 km^3). The Dostluk dam, on the border between the Islamic Republic of Iran and Turkmenistan, is designed for flood control, hydropower generation and flow regulation. In 1993, the gross hydropower potential was an estimated 5.8 GWh, while total installed capacity was about 0.7 GWh. The contribution of hydropower to general energy consumption in Turkmenistan is only about 1 percent.

Most of the large dams in the Aral Sea basin are in Uzbekistan. In the Syr Darya basin, the largest reservoirs are the Charvak reservoir, one of the largest hydropower plants in Central Asia is located on the Chirchiq river, which has a capacity of 1.99 km^3 and 600 MW, and the Andijan reservoir on the Karadarya river in the Fergana valley with a capacity of 1.90 km^3. In the Amu Darya basin, the largest reservoir is the Tuaymuyun, in Khorezm *vilayat,* with a storage capacity of 7.8 km^3, comprised of four separate reservoirs. In the future it is expected that one reservoir in this system (Kaparas) will be used to provide drinking water to Karakalpakstan. This area is experiencing severe environmental problems as a result of the shrinking of the Aral Sea. In Uzbekistan, total installed capacity in 1993 was 1.7 GW, which provided about 12 percent of the country's electricity.

Table 5 shows the existing major dams, larger than 0.1 km^3, with details on height and capacity, where information was available.

TABLE 5
List of major dams (> 0.1 km^3) in the Aral Sea basin

Country	Name	Nearest city	River (Major basin)	Year	Height (m)	Capacity (million m^3)	Main use*
Afghanistan	-	-	-	-	-	-	-
Kazakhstan	Chardarya	Chardarya	Syr Darya (SD)	1968	27	5 200	I,H,W,F
Kyrgyzstan	Toktogul	Tash Kumur	Naryn (SD)	1974	215	19 500	I, H
	Kurpsay	Tash Kumur	Naryn (SD)	1981	110	370	I, H
	Papan	Osh	Ak-Bura (SD)	1981	120	260	I, H
Tajikistan	Rogun**	Rogun	Vakhsh (AD)	2012	335	13 300	I,H,F
	Nurek	Nurek	Vakhsh (AD)	1980	300	10 500	I,H,W,F
	Kayrakkum	Khujand	Syr Darya (SD)	1959	32	4 160	I,H
	Farkhad***	Khujand	Syr Darya (SD)	1948	24	350	I,H,W,F
	Boygozi	Nurek	Vakhsh (AD)	1989	54	125	I,F,H
Turkmenistan	Zeid	Turkmenabat	Kara Kum Canal (AD)	1986	12	2 200	I,W
	Dostluk	Saragt	Tedzhen (AD)	2004	n.a.	1 250	I,H,W,F
	Oguzkhan	Mary	Kara Kum Canal (AD)	1975	n.a.	875	I,W
	Sary-Yazy	Tagtabazar	Murghab (AD)	1984	25.5	660	I,W,F
	Kopetdag	Geoktepe	Kara Kum Canal (AD)	1987	n.a.	550	I,W
	Tedzhen-1	Tedzhen	Tedzhen (Tejen) (AD)	1950	n.a.	190	I,W,F
	Tedzhen-2	Tedzhen	Tedzhen (Tejen) (AD)	1960	20.5	184	I,W,F
	Yolotan	Yolotan	Murghab (AD)	1910	n.a.	120	I,W,F
Uzbekistan	Tuaymuyun	Pitnak	Amu Darya (AD)	n.a.	n.a.	7 800	n.a.
	Charvak	Tashkent	Chirchiq (SD)	1977	168	1 990	I,H
	Andijan	Andijan	Karadarya (SD)	1980	121	1 900	I
	Pachkamar	n.a.	Guzar (AD)	1961	71	1 525	I
	Talimarjan	Jangi-Nishon	Karshi canal (AD)	1985	635	1 525	I
	Tudakul	Navoji	Tudakulskaya natural depression (AD)	1983	12	1 200	I
	Kattakurgan	n.a.	Zeravshan (AD)	1953	31	900	I
	Yuzhnosurkhan	Shurchi	Surkhandarya (AD)	1967	30	800	I
	Chimkurgan	Chirakchi	Kashkadarya (AD)	1963	33	500	I
	Tupalang	Shargun	Tupalang (AD)	2002	180	500	I
	Shorkul	Navoji	Zeravshan (AD)	1984	15	394	I
	Farkhad***	n.a.	Syr Darya (SD)	1948	24	350	I,H,W,F
	Kuyumazar	Navoji	Zeravshan (AD)	1958	24	310	I
	Tashkent	n.a.	Chirchiq (SD)		37	250	I
	Karkidon	Kuba	Isfayramsay along the Kuvasay channel (SD)	1967	70	218	I
	Akhangaran	Angren	Akhangaran (SD)	1989	100	198	I
	Gissar	n.a.	Aksu (AD)	1990	139	170	I
	Kasansai	n.a.	Kasansai (SD)	1968	64	165	I
	Uchkyzyl	n.a.	Zang canal, Termiz canal, Surkhandarya river (AD)	1957	12	160	I
	Aktepin	n.a.	Surkhandarya (AD)	n.a.	14	120	I
	Akdarin	n.a.	Akdarya (AD)	n.a.	20	112	I
	Jizzakh	Jizzakh	Gully of Djailmasay (SD)	1973	20	100	I

n.a.: Information not available; SD: Syr Darya major basin; AD: Amu Darya major basin
* I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection
** Under construction at the time of writing, 1st phase is expected to be finished in 2012
*** The Farkhad dam is shared by Tajikistan and Uzbekistan

ENVIRONMENT, WATER QUALITY AND HEALTH

Irrigation water withdrawal from both the Syr Darya and the Amu Darya continuously reduces the volume of the remaining runoff in the rivers and inflow into the Aral Sea. During the summer months, when demand for irrigation is at its highest, little water reaches the Sea. Diversions for irrigation, and relatively large amounts of water used for leaching and to upstream reservoirs to produce electricity, have reduced important winter flows to the sea (Murray-Rust *et al.,* 2003). The environmental consequences of the huge irrigation development in the Aral Sea basin 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. 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.
- At the end of the 1960s water salinity did not exceed 1 g/litre, even in the lower reaches. Currently, it varies from 0.3–0.5 g/litre in the upper reaches to 1.7–2.0 g/litre in the lower reaches. The highest values occur in March and April in the upper reaches, and around May in the lower (CAWaterInfo, 2012).
- 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. There is also pollution from industrial and municipal waste, especially from metropolitan areas.
- The traditional ecosystem of the two deltas of the Amu Darya and Syr Darya has perished. The marshes and wetlands, 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 sandy deserts. More than 50 lakes, covering 60 000 ha in the deltas, have dried up.
- The Aral Sea is drying up. 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 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 km^3/year compensated for the evaporation over the lake, estimated at about 60 km^3/year. The Aral Sea level was then fluctuating at around 50–53 m asl. The average mineral content of the Aral Sea's water was an estimated 10 g/litre in 1960. Fish capture was about 40 000 tonnes/year and many fish-processing industries were established on the shores of the Aral Sea. Together with fishing, these industries provided employment to many in the local population. In 1965, the Aral Sea received about 50 km^3 of freshwater per year – a value that had fallen to zero by the early 1980s. Consequently, concentrations of salts and minerals began to rise in the shrinking body of water causing severe soil salinity problems, especially in the downstream areas of the region (Murray-Rust *et al.,* 2003). The Sea's level dropped by 17 m, its surface area reduced by half and its volume by three-quarters. By the end of the 1980s, the Aral Sea no longer reached its former shores. Today, the sea is made up of three sections: the Small Sea or Northern Sea in Kazakhstan, the Central Sea, and the Western Sea, which is the deepest, mostly in Uzbekistan. The mineral content of the water has increased four-fold to 40 g/litre, preventing the survival of most fish and wild life in the Aral Sea. Fish capture has become negligible, leaving most people unemployed. All commercial fishing ceased in 1982. Moreover, the former seashore villages and towns are 70 km away from the present shoreline. A secondary effect of the reduction of the Aral Sea's overall size is the rapid exposure of the sea-bed. Strong winds that blow across this part of Asia routinely pick up and deposit tens of thousands of tonnes of exposed soil every year in neighbouring areas and up to a distance of 250 km. This process has not

only contributed to the deterioration of air quality for nearby residents, but has reduced crop yields because of the heavily salt-laden particles falling on arable land (Murray-Rust *et al.,* 2003). Salinization is even threatening the cultural heritage of Central Asia: high groundwater levels and salinity are affecting historic monuments in the famous towns of Bukhara and Khiva. The environmental crisis of the Aral Sea basin is a major disaster that has affected the territories of all five riparian Central Asian countries and has resulted in economic losses amounting to US$115 million and social losses of about US$28.8 million annually (Dukhovny and Schutter, 2003).

- With the reduced 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/year causing many farmers to switch from cotton to rice, demanding even more diverted water. Desert storms are frequent, occurring on average more than 90 days a year.
- Communities face appalling health conditions. In Karakalpakstan, drinking water supply is too saline and polluted. The high content of metals such as strontium, zinc and manganese cause diseases and prevent iron absorption, causing anaemia. Between 1985 and 2000, kidney and liver diseases, especially cancer, 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.

The Amu Darya carries the highest sediment load of all the rivers in Central Asia and one of the highest levels in the world. The sodium adsorption ratio (SAR) normally ranges from 0.5 7 milli-equivalent (meq)/litre at most gauging stations in the Aral Sea basin. These values indicate that, in general, the water is still suitable for irrigation. During the years since independence from the Soviet Union, strict limitation of water allocation between the countries has been implemented and increasing attention is being paid to ecological aspects. This has led to some improvement of water quality (CAWaterInfo, 2011).

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 asl. 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 asl) would require a total inflow of about 35 km^3/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 38–40 m asl would require an inflow of at least 6–8 km^3 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 km^3/year, with at least 5–11 km^3 of freshwater. Since 1989, a project has been implemented in Uzbekistan that 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 redevelopment of flora and wildlife in the abandoned areas and stopped the eolian (wind) erosion of the former exposed seabed. Another result of this project has been a higher fish capture, estimated at 5 000 tonne/year in 1993, compared with 2 000 tonne/year in 1988.

TRANSBOUNDARY WATER ISSUES

Afghanistan and the USSR had signed international agreements on the use and quality of Amu Darya transboundary water. In 1946 both nations reached the international water agreement, under which Afghanistan is entitled to use up to 9 km^3 of water from the Panj river. In 1954, the USSR offered US$240 million to Afghanistan and built 100 km of pipeline from Termiz, Uzbekistan. In 1955, the USSR announced further assistance, such as agricultural development, hydroelectric generation and construction of irrigation infrastructure. In 1956, Afghanistan signed a contract accepting Russian supervisors for the construction of water facilities.

At the beginning of 1958, Afghanistan and the USSR reconfirmed and signed the border agreement. The second international agreement on the use and quality of Amu Darya transboundary water was signed in 1958. These agreements founded an international commission to cope with the use and quality of transboundary water resources. After 1963, the relationship between the two nations gradually deteriorated. The Soviet invasion disrupted Afghanistan from 1979 to 1989. After the Soviet withdrawal from Afghanistan in 1989, the USSR collapsed in 1991. Nevertheless, this invasion left profound effects such as ethnic conflicts and the rise of the Taliban (Fuchinoue *et al.,* 2002; Favre and Kamal, 2004).

In the early 1970s, when the Aral Sea started to shrink rapidly, the USSR arrived at an understanding of the need to undertake some reclamation measures. At that time several governmental commissions were established. They concluded that it was necessary to undertake urgent measures, if not to prevent lowering of the Sea level, then to mitigate the negative socio-economic and ecological impacts related to this disaster. Transfer of water from Siberian rivers – from the Ob river to the Amu Darya through a 2 200 km-long canal or from the Volga river to the Aral Sea – in the amount of 18–20 km^3 annually was proposed to improve both water supply and environmental conditions in the Prearalie.

The government of the USSR rejected this proposal in 1986 and submitted a range of alternative measures approved by Resolution No 1110 of 1986. Eventually, two basin water organizations (BWOs), the 'Amu Darya' and the 'Syr Darya', a special organization 'Aralvodstroy', and the coordinator of the programme, the Consortium 'Aral', were established. During the Soviet period, the sharing of water resources among the five Central Asia republics was based on master plans to develop water resources in the Amu Darya (1987) and Syr Darya (1984) basins. From 1987 to 1990, works related to improving water conservation in the south Prearalie, the right bank drain, and the completion of the Tuaymuyun Reservoir Project were implemented (Dukhovny and Schutter, 2003).

The environmental problems of the Aral Sea, which previously had been an internal issue of the USSR, became internationalized after its demise in 1991. In 1992, the five newly independent countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) signed interstate agreements on water sharing, use, conservation, financing and management. In 1992, the first of these agreements established the Interstate Commission on Water Coordination (ICWC), appointing relevant deputy ministers for water as its members. The ICWC was entrusted with the responsibilities of policy formulation and allocating water to the five countries. The ICWC comprises leaders of water management organizations (deputy ministers for water) of the Central Asian countries and is the highest decision-making body concerned with the regional water supply.

The ICWC annual planning meeting is scheduled towards the end of each calendar year, with high-level government representatives (prime ministers or deputy prime ministers and relevant ministers) of the Central Asian countries participating to discuss preliminary plans and agreements for the following year's water supply. Plans for water supply and mutual agreements regarding all commodities are confirmed at an ICWC meeting in March of the following year. Subsequently, the ICWC conducts working meetings approximately once every three months to discuss the monitoring of water deliveries and any problems with water supply, as well as compliance with agreements (Murray-Rust *et al.,* 2003).

The ICWC operates through four executive bodies: the Amu Darya and the Syr Darya basin valley organizations (BVOs), the Scientific Information Centre (SIC), and the ICWC secretariat. The ICWC secretariat is responsible for facilitating the ICWC meetings, preparation of programmes and projects with the other sister organizations and financial control of the BVOs. The BVOs are responsible for the technical aspects of water allocation, distribution and management at the basin scale and among the countries. The SIC, with its 14 regional branches, is responsible for creating an information base, analysis, and supporting and carrying out programmes to enhance water conservation measures.

The 1992 agreement included the construction of Kambarata 1 reservoir in Kyrgyzstan and Rogun reservoir in Tajikistan.

In 1993, two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) and the International Fund for Saving the Aral Sea (IFAS). The ICAS was created to coordinate implementation of the Aral Sea Basin Programme approved in 1994 and developed by the World Bank, the United Nations Development Programme (UNDP) and the United Nations Environmental Programme (UNEP). The International Fund for Saving the Aral Sea (IFAS) was created to raise and manage its funds. The ICAS subsequently merged with the IFAS in 1997 (Murray-Rust *et al.,* 2003).

The IFAS is headed by one of the presidents of the five countries on a rotation basis. The executive committee of IFAS, comprising the prime ministers of the five states, carries out the functions. In the present context, the institutional framework for water management in the region is a hierarchy with five levels of authority/responsibility. The levels of management responsibility are interstate, state, provincial, district and farm. The interstate level organizations work on two different aspects: IFAS and ICWC handle macro-level water resources, environmental management, funding decisions and political decisions and the BVOs handle technical aspects of water regulation among the countries (Murray-Rust *et al.,* 2003).

Two international freshwater agreements were signed for the Amu Darya by the Central Asian countries. The first agreement was the 'Agreement on joint activities for addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and implementing the social and economic development of the Aral Sea region', signed in 1993. The second agreement was the 'Resolution of the Heads of States of the Central Asia countries on work of the Economic Commission of ICAS on implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin for the 3–5 years to come with consideration of social and economic development of the region', signed in 1995 (Fuchinoue *et al.,* 2002). As a result of conflicts, Afghanistan, a critical partner to any future transboundary water management agreement, has so far been unable to participate in any of the discussions or agreements (Favre and Kamal, 2004).

The most acute disagreement in the Syr Darya basin relates to the operation of the Toktogul reservoir (in Kyrgyzstan), which is the largest in the basin and in Central Asia. There is essentially a conflict of interest between Kyrgyzstan, Uzbekistan and Kazakhstan. The two downstream countries of the Syr Darya basin are interested in maintaining storage for summertime irrigation from the Toktogul reservoir, whereas winter energy generation from the reservoir is beneficial to Kyrgyzstan. Much money is required to keep the reservoir in operating condition, but Uzbekistan and Kazakhstan, which are water recipients, pay nothing to maintain the Toktogul reservoir. A similar set of issues may be observed between Tajikistan and Uzbekistan regarding the management of the Kayrakkum reservoir.

Changes in the operation of the Toktogul reservoir have led to negative developments such as insufficient water for irrigation, the population's deteriorating social, economic and living conditions, as well as flooding of populated areas and agricultural land in Uzbekistan and Kazakhstan. Furthermore, the environmental and sanitary situation in the basin has become more acute (UNDP, 2004). An agreement was reached between Kyrgyzstan, Uzbekistan and Kazakhstan in 1996, in which Uzbekistan and Kazakhstan will transfer energy, coal or gas to Kyrgyzstan in the period of power deficit, to compensate for the non-use of water for hydropower in the winter period.

In 1996 a permanent agreement was signed between Turkmenistan and Uzbekistan concerning cooperation on water management issues. This agreement is based on the principles that the Parties:

- recognize the need for the joint use of interstate rivers and other water sources;
- refuse to apply economic and other means of pressure when solving water issues;
- acknowledge the interdependence of water problems and the responsibility of rational water use;
- focus on increasing water inflow to the Aral Sea;
- understand the need to respect mutual interests and settling water-related issues through consensus.

This 1996 Agreement between Turkmenistan and Uzbekistan sets out that:

- land used by Uzbekistan and located within the borders of Turkmenistan is the sole property of Turkmenistan;
- waterworks and water management organizations on the Karshi and Amu-Bukhara canals and Tuyamuin reservoir, located in Turkmenistan, are the property of Uzbekistan;
- land for the Karshi and Amu-Bukhara canals and for the Tuyamuin hydrostation is placed at Uzbekistan's disposal on a chargeable basis;
- Parties will make all necessary attempts to provide normal operation of the interstate waterworks located within their territories;
- companies and organizations, including those dealing with interstate waterworks operations, that are located on the territory of the other Party act according to international rules and the laws of that Party;
- the flow of the Amu Darya at the Kerki gauging station is divided into equal shares (50/50);
- Parties should allocate a portion of their share to the Aral Sea;
- Parties should stop disposal of drainage water to the Amu Darya, independently of the quality of the drainage water;
- Parties jointly implement measures for land reclamation, reconstruction and operation of interstate collectors and irrigation systems, and for construction of water disposal canals;
- Parties will prevent channel deformation and flooding of adjacent areas, caused by operation of the Amu-Bukhara, Karshi, Sovetyab, Dashoguz, Tashsaka, Kylychbay and Shabat-Gazavat water systems;
- Parties will make necessary attempts to prevent flooding of land located along the Daryalyk and Ozerny collectors crossing Turkmenistan, and will bear the cost of the collectors' reconstruction and operation proportional to drainage flow;
- during the driest years limits for reduced water withdrawal are defined by the ICWC, which includes ministries of water economies of all five Central Asian countries.

In 1998, three agreements took place between Kazakhstan, Kyrgyzstan and Uzbekistan: i) on the use of water and energy resources in the Syr Darya basin, ii) on cooperation in the area of environment and rational use of natural resources and iii) on the joint and complex use of water and energy resources of the Naryn Syr Darya cascade reservoirs (OST, 2001).

In 1999, a protocol was adopted for the insertion of amendments and addenda into the agreement between the governments of Kazakhstan, Kyrgyzstan, and Uzbekistan on the use of water and energy resources of the Syr Darya basin (OST, 2001).

In 2002, the Central Asian countries and the Caucasus formed the CACENA Regional Water Partnership under the Global Water Partnership (GWP). Within this framework, state departments, local, regional and professional organizations, scientific and research institutes as well as the private sector and NGOs cooperate in establishing a common understanding of the critical issues threatening water security in the region (SIWI, 2010).

In 2002, the heads of the Central Asian countries developed a 'Programme of concrete action to improve the ecological and economic environment of the Aral Sea Basin for 2003–2010' (UNDP, 2004).

In 2004, experts from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan produced a regional water and energy strategy within the framework of the United Nations Special Programme for the Economies of Central Asia (UN-SPECA). In collaboration with the European Union Water Initiative (EUWI) and the United Nations Economic Commission for Europe (UNECE) integrated water resources management is being developed in Central Asian countries. In cooperation with Germany and other EU countries, UNECE may play a role in the implementation of the EU Strategy for Central Asia in the water and energy sectors (SIWI, 2010).

The Syr Darya Control and North Aral Sea Phase I Project, which is currently underway, is the first phase of the rehabilitation of the Syr Darya and was identified under the Aral Sea Basin Programme (1994). The objectives of the project are to sustain and increase agriculture (including livestock) and fish production in the Syr Darya basin in Kazakhstan; and to maintain the Northern Aral Sea and enhance ecological/environmental conditions for improved human health and conservation of biodiversity.

The project's components include: building water infrastructure to rehabilitate the Northern Aral Sea, improving hydraulic control of the Syr Darya, rehabilitating the Chardarya dam, restoring aquatic resources, promoting fisheries development, and building institutional capacity. To maintain the integrity of the Northern Aral Sea, the 13 km Kok-Aral dyke was constructed to separate the Northern Aral Sea from the South Aral Sea, completed in August 2005. To increase the flow capacity of the Syr Darya, several additional hydraulic structures were constructed on the river and existing hydraulic structures and the Chardarya dam were rehabilitated.

Successful restoration efforts, initiated by Phase I, provided a catalyst for approval of Phase II in 2009. Phase II will continue efforts to improve water resources management in the Kazakh part of the Syr Darya basin. Based on the results obtained during Phase I, Phase II should further improve irrigation water supply for agriculture, revitalize the fisheries industry, enhance public health, and ecosystem recovery in the Aral Sea (World Bank, 2008).

Afghanistan has used only about 2 km^3 of the 9 km^3/year of water it is entitled to use under the treaties. Meanwhile, the Panj river has an annual flow of 19 km^3, and Afghanistan's fresh involvement in the process of water use would radically change the Amu Darya flow if the Afghan government decides to develop agriculture in the north (Favre and Kamal, 2004).

Currently, tensions exist between Kyrgyzstan and Uzbekistan in the Fergana valley. The Andijan reservoir, lying in a border area and currently leased to Uzbekistan, increases tensions. Kyrgyzstan claims that it does not receive compensation for the lease while Uzbekistan has been reluctant to enter into negotiations (SIWI, 2010).

Residents of Vorukh in eastern Uzbekistan and Ravot in northern Tajikistan both have access to the Isfara river for most of the year. However, once the growing season begins, farmers from upstream Ravot irrigate their fields and unintentionally cut off access to water for Vorukh. The Community Initiative Group, a council of active citizens from all walks of life, undertook the design and implementation of a project, which required the repair and rehabilitation of three wells, in addition to the construction of a 3.5 km water pipeline. The total cost of the project was approximately US$17 000, with roughly half coming from the community itself. More importantly, this group has stressed the long-term management of this project (USAID, 2012).

Afghanistan is planning to construct dams and facilities on its rivers for flood control, electricity generation and irrigation expansion. Once implemented, such projects would impact the amount of water and timing of peak runoff to the Islamic Republic of Iran, Pakistan, Uzbekistan and Turkmenistan (Khurshedi, 2011). Uzbekistan doesn't agree with the construction of reservoirs in the mountainous area of Tajikistan and Kyrgyzstan. Kyrgyzstan and Tajikistan indicate that the Aral Sea problem is mainly because of inefficient water use for irrigation (<30 percent).

In 2010, the United Nations Secretary-General Ban Ki-moon called the diminishing of the Aral Sea "one of the worst environmental disasters in the world" and asked regional leaders to come together to solve the crisis (Seela, 2010).

Table 6 lists the main historical events in the Aral Sea Basin.

TABLE 6
Chronology of major events in the Aral Sea basin

Year	Plans/projects/treaties/ agreements/conflicts	Countries, agencies involved	Main aspects
1946	International water agreement	USSR, Afghanistan	Both nations reached the international water agreement, under which Afghanistan is entitled to use up to 9 km^3/year of water from the Panj river.
1954	Pipeline built	USSR, Afghanistan	The USSR offered US$240 million to Afghanistan and built 100 km of pipeline from Termiz, Uzbekistan.
1958	Agreement on the use and quality of Amu Darya	USSR, Afghanistan	The second agreement on the use and quality of Amu Darya transboundary water signed. These agreements founded an international commission to cope with the uses and quality of transboundary water resources.
1970's	Several commissions were established	USSR	When the Aral Sea started rapidly shrinking several governmental commissions were established.
1980's	Establishment of BWOs, Aralvodstroy and the Consortium Aral	USSR	Two basin water organizations (BWOs) 'Amu Darya' and 'Syr Darya', a special organization 'Aralvodstroy', and the coordinator of the programme - the Consortium 'Aral' – were established.
1984	Master plan Syr Darya	USSR	Master plan for the water resources development in the Syr Darya.
1987	Master plan Amu Darya	USSR	Master plan for the water resources development in the Amu Darya.
1992	Interstate agreements on water	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	The five newly independent countries signed interstate agreements on water sharing, use, conservation, financing and management.
1992	Interstate Commission on Water Coordination (ICWC)	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	The first of the 1992 agreements established the ICWC, which was entrusted with the responsibilities of policy formulation and allocating water to the five countries.
1993	Interstate Council for the Aral Sea (ICAS) and International Fund for Saving the Aral Sea (IFAS)	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	Two new organizations emerged: the Interstate Council for the Aral Sea (ICAS) and the International Fund for Saving the Aral Sea (IFAS).
1993	Agreement on the Aral Sea, Amu Darya and Syr Darya	Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan	Agreement on joint activities in addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and ensuring the social and economic development of the Aral Sea region.

TABLE 6
Chronology of major events in the Aral Sea basin (continued)

Year	Plans/projects/treaties/ agreements/conflicts	Countries, agencies involved	Main aspects
1994	Aral Sea Basin Programme (ASBP)	Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan	The Aral Sea Basin Programme was approved in 1994 and developed by the World Bank, UNDP and UNEP. The ICAS was created to coordinate implementation of the Programme.
1995	Resolution on the implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Resolution of the heads of states of Central Asia on work of the EC of ICAS on the implementation of the action plan on the improvement of the ecological situation in the Aral Sea Basin for the 3-5 years to come with consideration for social and economic development of the region
1996	Agreement on transfer of energy, coal or gas to compensate the non-use of water for hydropower in the winter period	Kyrgyzstan, Uzbekistan and Kazakhstan	Uzbekistan and Kazakhstan will transfer energy, coal or gas to Kyrgyzstan in the period of power deficit, to compensate for the non-use of water for hydropower in the winter period.
1996	Agreement on water management issues	Turkmenistan and Uzbekistan	A permanent agreement was signed between Turkmenistan and Uzbekistan on cooperation in water management issues.
1997	ICAS merged into IFAS	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	The ICAS merged into the IFAS.
1998	Agreement on the use of water and energy of the Syr Darya Basin	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on the use of water and energy resources of the Sry Darya Basin.
1998	Agreement on the Naryn Syr Darya cascade reservoirs	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on joint and complex use of water and energy resources of the Naryn Syr Darya cascade reservoirs.
1998	Agreement on cooperation in environment and rational nature use	Kazakhstan, Kyrgyzstan, Uzbekistan	Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan on cooperation in the area of environment and rational nature use.
1999	Amendments and addenda in agreement on the use of water and energy of the Syr Darya Basin	Kazakhstan, Kyrgyzstan; Tajikistan, Uzbekistan	Protocol on inserting amendments and addenda in the agreement between the governments of Kazakhstan, Kyrgyzstan, and Uzbekistan on the use of water and energy resources of the Syr Darya basin.
2002	Programme of concrete action to improve the ecological and economic environment of the Aral Sea Basin	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Central Asian states took a decision to develop a 'Programme of concrete action to improve the ecological and economic environment of the Aral Sea basin for 2003–2010'.
2005	Syr Darya Control and North Aral Sea Phase I Project	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Completion of the first phase of the project.
2009	Syr Darya Control and North Aral Sea Phase II Project	Kazakhstan; Kyrgyzstan, Tajikistan; Turkmenistan; Uzbekistan	Approval of the second phase of the project.

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AQUASTAT, FAO's global information system on water and agriculture, was initiated by the Land and Water Division with a view to presenting a comprehensive picture of water resources and irrigation in the countries of Africa, Asia, Latin America and the Caribbean and providing systematic, up-to-date and reliable information on water for agriculture and rural development.

This report presents the results of the most recent survey carried out in the six countries of the Central Asia region, and it analyses the changes that have occurred in the ten years since the first survey. Following the AQUASTAT methodology, the survey relied as much as possible on country-based statistics and information.

The report consists of three sections. Section I describes in detail the methodology used and contains a glossary of the terms used. Section II contains the regional analysis presenting a synopsis on water resources, water use and irrigation in the region and the trends over the last ten years. It also describes the legislative and institutional framework for water management as well as environmental issues and it presents prospects for agricultural water management from the countries' perspective. Section III contains detailed country profiles for Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and one river basin profile for the Aral Sea basin.

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