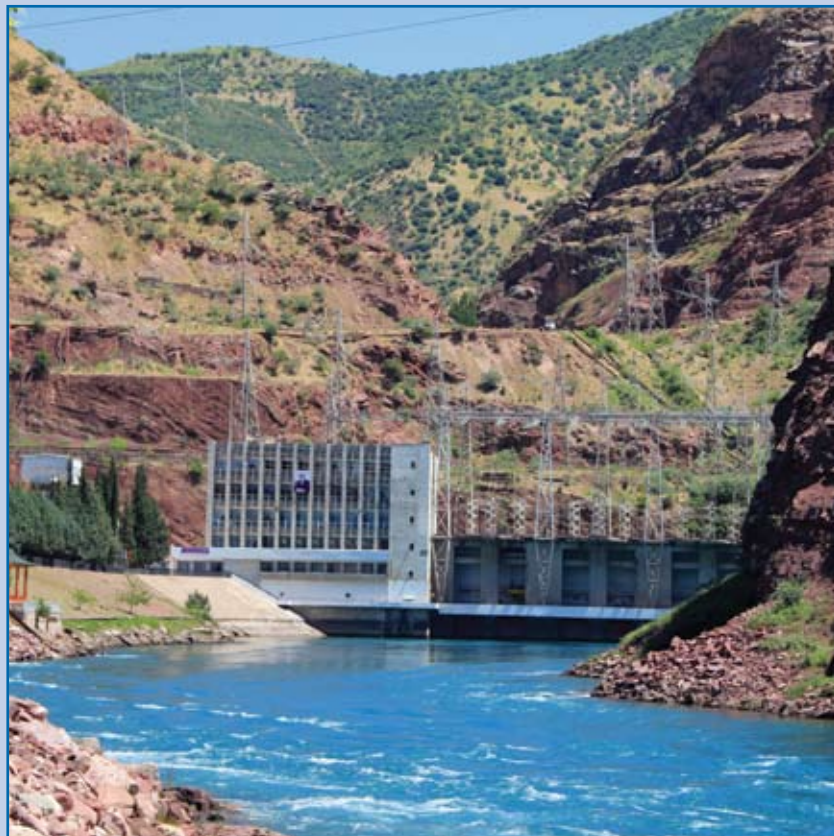




Eurasian Development Bank

The Investment Aspect of the Region's Water Sector Development



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Electric power, water and energy, transportation infrastructure and high-tech and innovative industries are the key areas for the Bank's investment activity. In line with its Charter, the Bank views information and research support for integration in Eurasia as a priority of its analytical work.

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Abbreviations

ADB – Asian Development Bank

CIS – Commonwealth of Independent States

EDB – Eurasian Development Bank

GDP – gross domestic product

IDB – Islamic Development Bank

IDWA – index of drinking water adequacy

OECD – Organisation for Economic Cooperation and Development

R&D – research and development

WCD – the World commission on dams

Main conclusions

Water is one of the few natural resources that bear heavily on both environmental and socioeconomic processes, particularly, international relations.

Demand for water is on the rise, and the task of satisfying the growing needs of the population and various economic sectors is becoming increasingly challenging. One needs to take into account the natural factors that determine the formation and distribution of water resources (uneven territorial distribution, natural seasonal runoff fluctuations, climate change, etc.). Furthermore, the impact of the population's effect on water resources, particularly, the growing water withdrawal and contamination, also need to be addressed. Economic activity has reached such a scale that control of the negative economic, social and environmental effects it produces in river basins must be made an international effort.

Climate change, contamination and depletion of water sources, and uncontrolled construction of water withdrawal structures in river basins lead to negative qualitative and quantitative changes in river runoff patterns, resulting in inadequate water supply to the population and various industries, difficulties with water economy planning, and higher investment risks.

The adequacy and quality of water resources is a prerequisite to sustainable development. Water falls into water belongs to the category of finite resources, as global water consumption outstrips natural renewal of fresh water reserves. In addition, the depletion of river systems' potential and increasing water contamination resulting from economic activity and climate change seriously threaten the water security of many regions. As climatic differences become more and more distinct, droughts and floods will become more frequent and severe. This will affect the adequacy of water supply even further. To address the issues of water and food security, the overall investment structure should be reviewed, with a shift of emphasis to drinking water, quality protection, irrigation, and hydropower. Water resources management must be comprehensive, so that the interests of water users are balanced at the river basin level.

The declining accessibility of quality drinking water in many parts of the world and shrinking water resources call for new approaches to water resources management. Adequate funding is required to improve access to safe drinking water and sewage systems, and to switch to water and energy saving in production and consumption. Measures to adapt to climate change (regulation of river runoff, protection of water quality, etc.) also require additional financial resources. In this context, the role of international development institutions and donors in creating and implementing water supply and sanitation programmes becomes pivotal.

One of the preconditions for keeping investment risks down in water use and water protection projects is a preliminary study of water sector conditions including the justification of development outlooks. This should include reviewing international water management practices and innovative developments on a regular basis, and foresight studies aimed at developing a methodology of investment support for the water sector. Any projects capable of producing effects on the environment must be subject to environmental impact assessment and notification procedures meeting international standards. Bearing in mind the potential social and economic risks relating to cross-border changes in environmental conditions and management of natural resources, an environmental impact assessment must be viewed as an essential part of a project cycle.

Introduction

River runoff constitutes a significant proportion of all water being consumed practically in all parts of the world, irrespective of whether it is formed within a national territory or comes from sources possessed by neighbouring countries. The latter are critical for downstream countries, as their water security depends on water management practices and contamination levels existing in upstream countries.

In the present conditions, river basins are being extensively used for various economic purposes, and are covered by networks of interrelated facilities (reservoirs with dams and hydropower plants, withdrawal facilities, canals, dykes and water protection zones), which together make up water economy systems. These may be interstate or international (in the case of a river, these are referred to as cross-border watercourses). The main task of the joint management of these systems is to secure optimum and safe conditions for the formation, distribution, use and protection of water resources on a legally, technically and environmentally acceptable footing.

International water basins are special in that their river runoff formation conditions depend on natural and geographic factors, whereas water consumption depends on geopolitical factors. A major threat to international security is not the increasing water deficiency, but frictions and potential conflicts between stakeholders and a lack of cooperation between them in addressing water and environmental problems. The political and economic interests of countries lying within the same river basin may differ seriously; they do not coincide just like national borders do not coincide with river watersheds. Downstream countries find themselves scarcely dependent on upstream users, whereas the latter may barge into difficulties trying to satisfy the demands of the former.

The global economy development strategies emphasising investments in environmental protection recommended in Rio de Janeiro (1992) and Johannesburg (2002) laid down the foundations for a green economy. Transition to it requires heavy investment, and this was the main theme of the UN report *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – a Synthesis for Policy Makers* presented at the UNEP ministerial forum in Nairobi, Kenya, on February 21, 2011. This report was prepared specially for the Rio+20 world summit scheduled for 2012 in Brazil. The report outlines a new world economy development philosophy that prioritises investing in natural and human resources.

A solution to the problem of water for the future must be based on certain priorities put forward by the international community. On December 20, 2010 the UN General Assembly adopted a resolution declaring 2013 the International Water Cooperation Year. The resolution stresses the importance of cooperation in water management for sustainable development globally.

The increasing water shortages in cross-border river basins in Central Asia warrant taking measures to modernise and expand water sector infrastructure and enhance the efficiency of water use and water saving in various industries. These will require heavy long-term investment and, accordingly, legal provisions for protecting the investment and reducing project risks.

In this paper used materials from the EDB's 2010 monograph *Water and Energy Resources in Central Asia: Utilisation and Development Issues*. Comprehensive study the issues of assessment and outlooks in Central Asia, with due regard for the contemporary requirements for water economy investment projects and environmental sustainability in cross-border river basins.

Chapter 1. Modern trends in water management

The use of water exceeds the use of all most consumed natural resources in both scale and growth rate. Total world fresh water consumption is one thousand times greater than that of all industrial raw materials: it makes up 10 km³ daily, an equivalent of annual production of all extractable resources. Over three past centuries global water consumption has increased more than 35 times, doubling every 20 years, and now reaches 3,900–4,000 km³ a year, or even more, according to some sources (Gleick, 2003). This volume can be considered «available water resources», which characterises the level of world economic development and modern engineering and technological capacity in water use.

Economic activities and demographic processes lead to extensive extraction and use of natural resources including water, thus bearing on the condition of the environment. This bearing is especially pronounced in water-stressed regions. Population determines world demand for water. In the 20th century the world's population grew 3.7 times and consumption of natural resources 7 times. In 1804 the world's population totalled 1 billion people, in the beginning of the 20th century 1.6 billion, and in 1927 2 billion – a double increase over 123 years. From 1950 to 2000, the population grew 2.4 times from 2.5 billion to 6.1 billion – that is, the period of population doubling became more than twice as short.

These regions already suffer fresh water shortages. By 2050 the world's population is expected to reach 9.1 billion people (OECD/IEA, WWF, 2007).

Guaranteed water and energy supply is the basic precondition for economic stability and development. Climate change, water and energy security issues, growing water and energy consumption in developing countries are the most pressing challenges to water management and energy. Investments, innovations, efficient use of existing technologies and adoption of new ones all have a role to play in tackling these problems.

Sector/year	1900	1950	2000	2010 *	2025 *
Population (million people)	1,600	2,542	6,181	7,113	7,877
Irrigated area (million ha)	47.3	101	264	288	329
Agriculture (km ³ /year)	513	1,080	2,605	2,817	3,189
Industry (km ³ /year)	21.5	86.7	384	472	607
Utilities (km ³ /year)	43.7	204	776	908	1,170
Others (km ³ /year)	0.3	11.1	208	235	269
Total (km ³ /year)	579	1,382	3,973	4,431	5,235

Table 1.1.
Dynamics of global water consumption by sector

Source: UNESCO, 1999
Note: * forecast

Countries and regions possessing less than 500 m³ of water per person a year fall into the «absolute scarcity» category; possession of 500–1,000 m³ indicates «scarcity», 1,000–1,700 m³ – «stress», and over 1,700 m³ – «no stress».

Unit (1 m ³ per person)	Category
> 1,700	no stress
1,000–1,700	stress
500–1,000	scarcity
< 500	absolute scarcity

Table 1.2.
Water adequacy categories

Source: Falkenmark, Widsrand, 1992

Over 1 billion people (1/6 of the world's population) live in water-stressed areas, and 1/3 of the world's population in more than 50 countries experience water scarcity. About 700 million people in 43 countries live below the water-stress threshold.

Table 1.3.
Indicators of global water availability and consumption

Indicator/year	1900	1950	2000	2010	2025
Population (million people)	1,600	2,542	6,181	7,113	7,877
Fresh water supply (m ³ /person/year)*	56,813	35,759	14,706	12,779	11,540
River runoff (m ³ /person/year) **	29,375	18,489	7,604	6,608	5,967
Available fresh water resources (m ³ /person/year) ***	9,375	5,901	2,427	2,109	1,904
Fresh water consumption (m ³ /person/year)	361.6	543.6	642.8	623.1	664.6
% of available resources	4%	9%	26%	30%	35%

Source: Land Market Indicators, 2008

Note: * – total less glaciers, groundwater, swamps, etc.,

** – main source of water supply,

*** – less river runoff to the ocean

With 1950 as a benchmark, the distribution of global population growth has dramatically reshaped the per capita availability of water. Because available water resources presumably remain constant, it is per capita availability that will shrink.

Water availability per capita

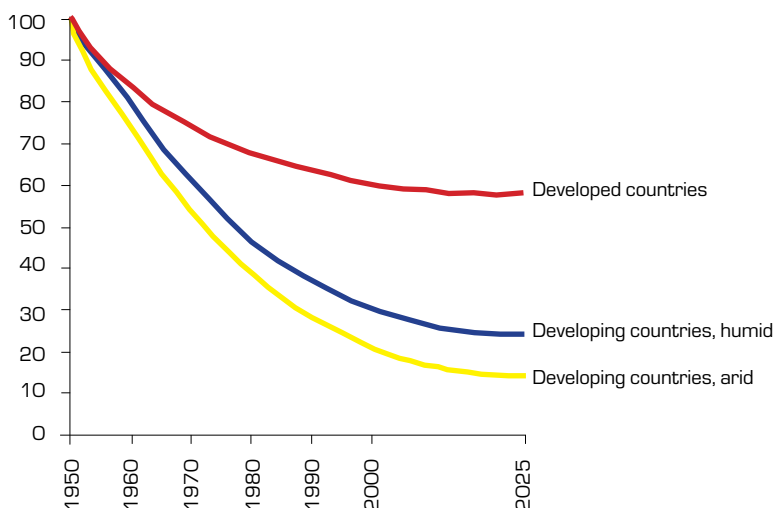


Figure 1.1.
Water availability in decline (%)

Source: UNDP, 2006: 136

While availability stabilised in rich countries in the 1970s, the decline continued in developing countries. In 1950 it averaged at 33,000 m³, but by 1993 it slid to 8,500 m³ per capita a year. By 2005 annual per capita availability dropped from the 1950 benchmark as follows: from 20,600 to 5,000 in Africa; from 9,600 to 3,000 in Asia; from 5,900 to 4,200 in Europe; from 37,200 to 17,100 in North America; and from 105,000 to 28,000 m³ in South America. The high and rapidly growing levels of water pollution aggravate this sustained downward trend. This is particularly true for regions with arid climate and high population growth rates. These areas are now suffering a sharp decline in per capita water availability and increased pollution of water sources. If this trend continues, by 2025 more than 3 billion people will live in water-stressed countries and 14 countries will slip from water stress to water scarcity (UNDP, 2006).

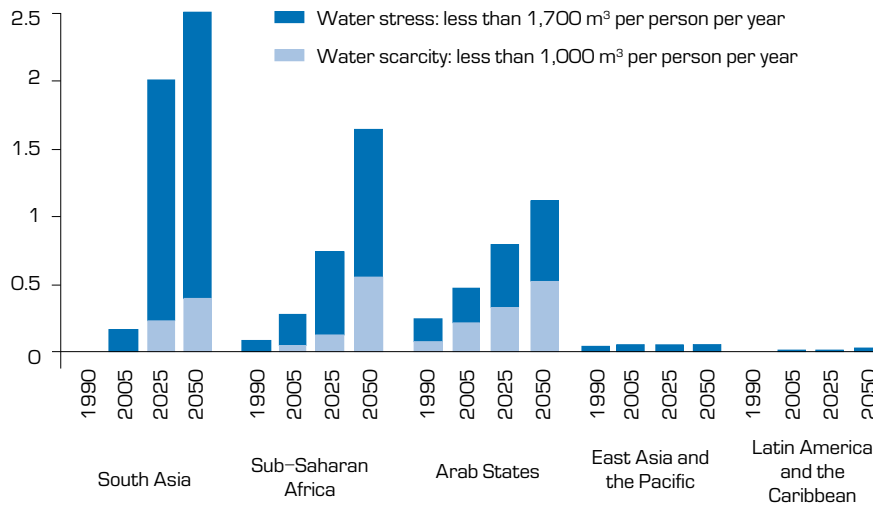


Figure 1.2. Population of countries facing water stress or scarcity (billions)

Source: UNDP, 2006: 136

The existing water use technology and population growth lead to serious ecological restrictions. Water resources management needs radical changes at the global, regional, national and local levels. According to expert forecasts, today's water-stressed regions will face a severe water deficiency in several decades.

Globally, 67–70% of all water withdrawal is attributable to agriculture, 20–23% to industry, and 8–10% to domestic consumption and drinking.

In rich countries, industries consume water most extensively. Industrial development is largely responsible for increasing water consumption in Europe. Industrial use accounts for 88% of all water consumption in Belgium, 86% in Finland, 79% in the UK, and 71% in France. Access to quality drinking water is an indicator of the population's standard of living. Developed societies have efficient water supply and sewage systems which safeguard public health and allow high levels of household water consumption to be maintained.

The correlation of water consumption and economic development is shown in *Table 1.4* in which countries are grouped by income level. In highly developed economies, annual per capita water consumption reaches 1,167 m³, with industrial use having the largest share in the total consumption structure.

Population's income	Per capita consumption (m ³ /person)	Consumption by sector (%)		
		Household	Industry	Agriculture
Low	386	4	5	91
Medium	453	13	18	69
High	1,167	14	47	39

Table 1.4. Correlation between water consumption and the population's income

Source: UNDP, 2006: 138

In low-income countries water consumption is only one-third of that of rich countries – 386 m³ a year per person. Low-income countries spend 91% of all water on agriculture, and household consumption stands at 4%. These figures paint a clear picture of water supply in developing countries where most people are deprived of access to quality drinking water and sanitation services. Inadequate water supply is becoming an increasingly pressing problem, one that threatens public health in many regions.

Intensive water consumption by the industrial sector and the resulting pollution with specific contaminants and harmful substances make wastewater treatment particularly expensive. Treatment methods and technology and protection of water sources and river ecosystems

are all subject to special requirements. On the other hand, pollution, a lack of quality drinking water, poor sanitary conditions and insufficient water supply to agriculture are the main causes of social tension and regional conflicts. Therefore, many countries view measures to improve water supply and sanitation services and develop irrigation as a strategic direction in eradicating social and economic inequality.

Water consumption at the current rate will inevitably lead to a global water deficiency. The development of new water resources requires more and more investments in maintenance of water economy systems. Each cubic metre of water produced will cost more, making access to water for developing countries even more difficult. As is expected, the growth of global withdrawal from water sources will slow down, and the current rate will constitute the available quantity in the near future. Given the current water use model and increasing per capita consumption, the downward spiral of water availability will continue.

By 2050 the world's population will reach 9.1 billion people. Of this figure, 58% will have unrestricted access to water; 24% will have limited access; and 18% will face insurmountable problems with uncovered water deficiency. Under a scenario in which the current per capita consumption is preserved, the use of global fresh water may increase by 70% in 2050 due to household consumption alone. On the other hand, if contamination of water sources continues at the current rates, the use of global freshwater sources will reach its limit in 2030.

According to forecasts, in 2050 per capita availability of water will average at one-quarter of the quantity that was available in 1950. Improving standards of living in developed countries will bring about higher nutritional standards and better sanitary conditions. At present, normal daily per capita water consumption in developed and developing countries is 400–500 litres and 20 litres, respectively.

Household consumption takes a priority place in the use of water resources. It averages at 10% of all water consumption, and this figure is much higher in developed countries. Water supply to households is subject to two compulsory conditions: it must be uninterrupted and meet health standards.

Modern urban water supply serves many diverse needs. Water consumption by the industrial and energy sectors exceeds consumption by the population. Accordingly, if we take these needs into account, daily per capita consumption will reach high figures: 450 litres in Paris, 600 litres in Moscow, 600 litres in New York, 700 litres in Washington, and 1,000 litres in Rome. The actual water consumption for drinking and household purposes is much lower: for example, 170 litres in London, 160 litres in Paris, 85 litres in Brussels, etc.

The human development index is now a universally accepted indicator for overall national progress. Based on the this index computation method, the Asian Development Bank (ADB)

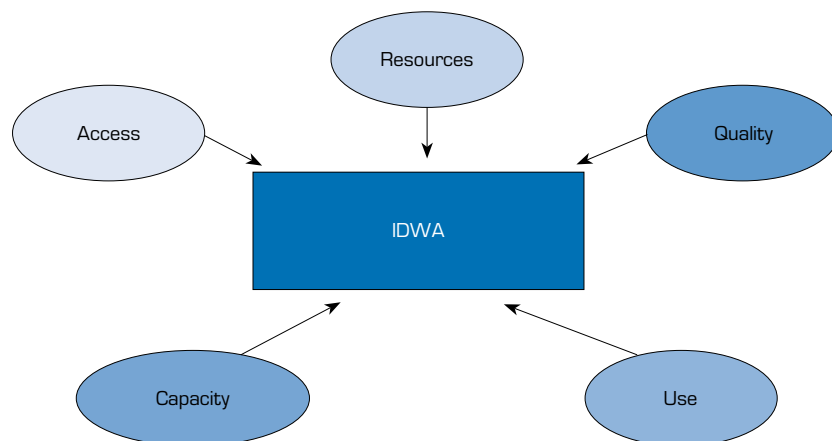


Figure 1.3.
Index of drinking water adequacy (IDWA)

Source: ADB, 2007: 51

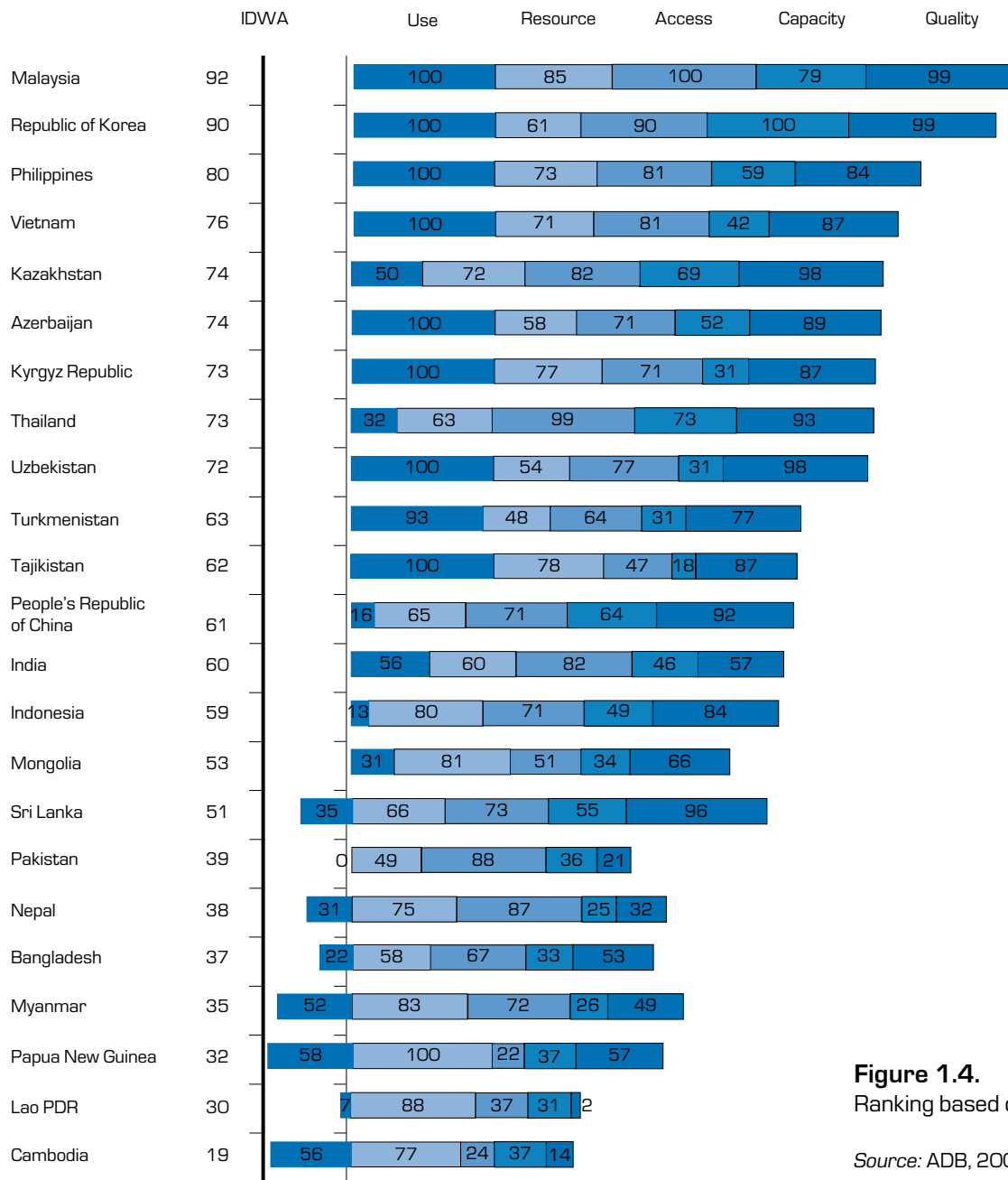


Figure 1.4.
Ranking based on IDWA

Source: ADB, 2007: 52

proposed a new index of drinking water adequacy. Index computation methodology is essentially the same as the one adopted to compute the water poverty index, which was the method used to compute the human development index over the years. The method simply involves taking the variable, for example resource per capita, R_j for country j , and then estimating the percentage as follows $'j' = [(R_j - R_{min}) / (R_{max} - R_{min})] \times 100$.

IDWA is an average of the five most important variables:

- 1) per capita internal renewable fresh water resources;
- 2) percent of population with general access to a sustainable «improved» water source, which is one of the target indicators in the Millennium development goals;

- 3) national capacity to purchase water, based on the proxy measure of per capita gross domestic product in purchasing power parity dollars (PPP \$);
- 4) the extent of use of water by the domestic sector on a per capita basis measured against a norm;
- 5) diarrheal deaths per 100,000 people (used as an indirect measure of water quality, due to a lack of reliable water quality data from almost all developing member countries).

This has been applied to 23 developing member countries of ADB, which together account for 3.4 billion people (2004 estimates), and covers nearly 99% of the population of all 44 developing member countries. It should be noted that the IDWA, in its present form, is not intended to provide a reliable ranking of countries with regard to access to safe drinking water on a sustained basis. Thus, the Index should not be used for intercountry ranking. IDWA provides a much better picture of the national situations than do access-only indicators. In fact, each of the five components could trigger a message, depending on the country-specific situation. IDWA can assist development policy, programmes, and projects as a tool for assessment, monitoring, and benchmarking.

For national policy makers and external support agencies, it could also be an instrument to make a good case for additional improvements and investments in water supply systems. IDWA can also assist countries in targeting one or more of its components to move further up the scale. IDWA not only enables country comparison, but also shows what component in a particular country is weak and should receive priority attention. In its present stage, IDWA is limited to water only. Conceptually, IDWA can be extended to incorporate wastewater management, if reasonable data for at least two additional indicators become available. These could be access to sanitation facilities and the extent of collection, treatment, and disposal of wastewater. Unfortunately, such data are not presently available at national levels.

The world's agriculture consumes over 2,600 km³ of fresh water annually – up to 70% of the total global consumption or seven times industrial consumption. The majority of this is used for irrigation. Apart from irrigated farming and animal breeding, water is also required for the processing of crops, milk and meat.

Table 1.5.
Use of water for irrigation

Source: Land Market Indicators, 2008

	1900	1950	2000	2010	2025
Irrigated area (million ha, % of all farmland (arable land, hayfields and pastures)	47.3 3.5%	101 7.5%	264 19.7%	288 27.5%	329 24.5%
Per capita irrigated area (m ²)	296	397	427	405	418
Global water consumption in agriculture (km ³)	513	1,080	2,605	2,817	3,189
Water consumption in agriculture (m ³) per:					
1 ha of irrigated land	10,846	10,693	9,867	9,781	9,693
1 person	321	425	421	396	405

Irrigated land accounts for about 20% of global farmland and produces about 40% of all food and 60% of all cereals. The high productivity of irrigated areas is an incentive to expand them even further, and now they total 280 million ha globally. Despite the 40% increment in productivity per ha achieved in recent two decades, water consumption per ha has remained practically unchanged throughout the past century.

Large portions of farmland are irrigated in China (68%), Japan (57%), Iraq (53%), Iran (45%), Saudi Arabia (43%), Pakistan (42%), Israel (38%), India (27%), Indonesia (27%), Thailand (25%), Syria (16%), Philippines (12%) and Vietnam (10%). Irrigated areas occupy large proportions in Africa (except Egypt): 22% in Sudan, 20% in Swaziland and 17% in Somalia; and in the Americas: 62% in Guyana, 46% in Chile, 22% in Mexico and 18% in Cuba. In the US, about

10% of all farmland is irrigated, especially in the west. In Europe, irrigated farming is practiced in Greece (15%), France (12%), Spain (11%) and Italy (11%). About 9% of farmland is irrigated in Australia and about 5% in the Commonwealth of Independent States (CIS). In Egypt, where rainfall is particularly scarce, all farming relies on irrigation. In the UK, all crops are rain-fed, but additional watering is also practiced. One of the most pressing challenges of the modern world is food shortages in developing countries resulting from insufficient water supply and limited opportunities to make use of additional sources of water. Crop productivity in arid areas can be improved only if adequate water supply is secured. Threats to food security associated with the rapid population growth must be addressed through additional food production. This requires the development of new areas and construction of irrigation systems, as more intensive use of the limited land resources is only possible with irrigation. Accordingly, maximum use must be made of the available water and energy resources.

Irrigated farming is one of the most water-intensive sectors. The production of one tonne of irrigated wheat requires 1,500 m³ of water (gross), depending on local irrigation conditions. One tonne of cotton requires 3,000 to 4,000 m³ and one tonne of rice over 5,000 m³. Irrigated farming is concentrated in regions with warm climate and a short growing period. About 40% of all irrigated land under rice produces one harvest a year, 40% two harvests, and 20% three harvests. The production of the simplest plant food requires about 350 m³ of fresh water per person a year. Even a slight improvement in living standards leads to changes in nutritional habits, and meat products start to occupy 20% of the once purely vegetable rations. Animal breeding triples annual fresh water consumption to 980 m³ per person. Per capita consumption of food produced in irrigated areas averages at 0.2 tonnes a year. According to forecasts, when the world population reaches 8 billion people, production by irrigated farming will have to be increased to 3 billion tonnes, or 0.3 tonnes per person.

Water requirements for the production of a food unit can be evaluated on the basis of the physiological and evapotranspiration characteristics of the foods comprising a ration. Depending

Water productivity				
Farm product	kg/m ³	\$/m ³	Protein, g/m ³	Kcal per m ³
<i>Cereals</i>				
Wheat (\$0.2 per kg)	0.2–1.2	0.4–0.24	50–150	660–4,000
Rice (\$0.31 per kg)	0.15–1.6	0.05–0.18	12–50	500–2,000
Maize (\$0.11 per kg)	0.30–2	0.03–0.22	30–200	1,000–7,000
<i>Legumes</i>				
Lentils (\$0.3 per kg)	0.3–1	0.09–0.3	90–150	1,060–3,500
Beans (\$0.3 per kg)	0.3–0.8	0.09–0.24	100–150	1,260–3,360
Groundnuts (\$0.8 per kg)	0.1–0.4	0.08–0.32	30–120	800–3,200
<i>Vegetables</i>				
Potatoes (\$0.1 per kg)	3–7	0.3–0.7	50–120	3,000–7,000
Tomatoes (\$0.15 per kg)	5–20	0.75–3	50–200	1,000–4,000
Onions (\$0.1 per kg)	3–10	0.3–1	20–67	1,200–4,000
<i>Fruit</i>				
Apples (\$0.8 per kg)	1–5	0.8–4	–	520–2,600
Olives (\$1 per kg)	1–3	1.0–3	10–30	1,150–3,450
Dates (\$2 per kg)	0.4–0.8	0.8–1.6	8–16	1,120–2,240
<i>Others</i>				
Beef (\$3 per kg)	0.03–0.1	0.09–0.3	10–30	60–210
Pond fish*	0.05–1	0.07–1.35	17–340	85–1,750

Table 1.6.
Water productivity by farm product

Source: UN, 2009: 107

Note: * Including fish products not requiring intensive technologies

on local climate, crop variety and farming practices, water requirements are commonly thought to be 400–2000 litres per kg of wheat and 1,000–20,000 litres per kg of meat (depending on animal species, fodder type and management practices). Taking these values into account, researchers estimate a daily nutritional water requirement at 2,000 to 5,000 litres per person. The UN FAO uses the lowest threshold of food security of 2,800 kcal per person a day at a national level, assuming that production of 1 kcal takes 1 litre of water (UN, 2009). Production of foods reach in energy and protein requires much more water than computed for the FAO's lowest threshold ration. Given the world trend towards better rations and greater protein consumption, water requirements will rise.

A principal cause of food shortages in many developed countries is inadequate water resources rather than a lack of farmland. To satisfy the growing demand, global food production must be increased by 60% and use of water for irrigation by 14% by 2030. To this end, the investment structure must be revised and an emphasis must be put on the water economy. Conditions must be created for adoption of inexpensive irrigation technologies by farms and raising the efficiency of land and water resources.

Financing is the main problem for irrigated farming. Inadequate investment in the maintenance of irrigation systems results in salinisation and water-logging of soil, excessive water losses and low crop productivity. In countries where irrigated farming receives government support the condition of irrigation systems is much better than in countries where farmers do not receive these subsidies. The increasing cost of maintenance of irrigation systems in the absence of public compensatory policies reduce the efficiency and profitability of irrigation, hence deterioration in the farmers' economic standing.

Table 1.7.
Irrigation costs and their share in the product cost structure in Asia

Country	Average water fee (\$ per ha)	Average water fee in the product cost structure (%)
Pakistan	7.4 (4.6–10.6)	2.5 (1.7–3.9)
India	10 (10)	2.8 (1.6–4.3)
China	46.5 (26–67)	3.6 (1.8–5.1)
Vietnam	59.5 (58–61)	5.5 (4.6–6.3)

Source: UNDP, 2006: 191

Note: these are average values of individual districts of the counties; the range is given in parentheses

In developing countries, irrigated farming is a critical sector that guarantees food security. Any improvement in production depends directly on farmers' access to water. These countries possess over 240 million ha of irrigated land, or 85% of the world's total. Limited land resources warrant efforts to enhance productivity, especially in the light of the poor outlook of new lands coming into use. Productivity can be improved by melioration and irrigation. Since food security closely relates to water and energy resources, we can assume that countries experiencing food shortages will attempt to expand areas under crops, which in turn will lead to increased water withdrawal for irrigation and water tensions. It should be remembered that in cross-border river basins these tensions can be very dramatic and even grow into open conflicts. Therefore, addressing food and other issues associated with the use of water resources must be based on the principles of cooperation, international division of labour and integration.

Over-abundance and scarcity of water are the causes of the most severe natural disasters. The frequency of extreme weather conditions (droughts and floods) has increased notably with global climate change. As a result, diversification and sustained operation of the water economy become strategic issues. This includes, first of all, securing the availability of water resources by constructing facilities to control surface runoff. Reservoir storage capacity is an indicator used for comparing the overall capacity of the water economy in different countries. For example, reservoirs in the US hold 6,000 m³ of water per person, and in Australia 5,000 m³. By contrast, per capita reservoir storage in Ethiopia is 43 m³. The comparison of water reserves by country

enables the assessment of opportunities to reduce risks associated with water scarcity and over-abundance (droughts and floods). Countries such as Ghana or Zambia have ample water resources but limited means to reduce risk, as reservoir capacities are inadequate. Typically, projects to construct reservoirs and dams are considered from the perspective of possible interference with ecosystems, especially in the case of large dams (UNDP, 2006: 158).

An increase in reservoir area altered the face of nature in a territory of 700,000 km², and the entire global infrastructure. The impact of reservoirs on the environment, economy and livelihoods cannot be described in simple terms; it is diverse and contradictory.

To secure water supply for irrigation and other purposes, over 45,000 dams have been constructed all over the world. The need to control river runoff is dictated by various factors, but principally the uneven seasonal and year-to-year distribution. Reservoirs for seasonal and perennial runoff control allow the water requirements of the population, the industry and agriculture to be met adequately at any time.

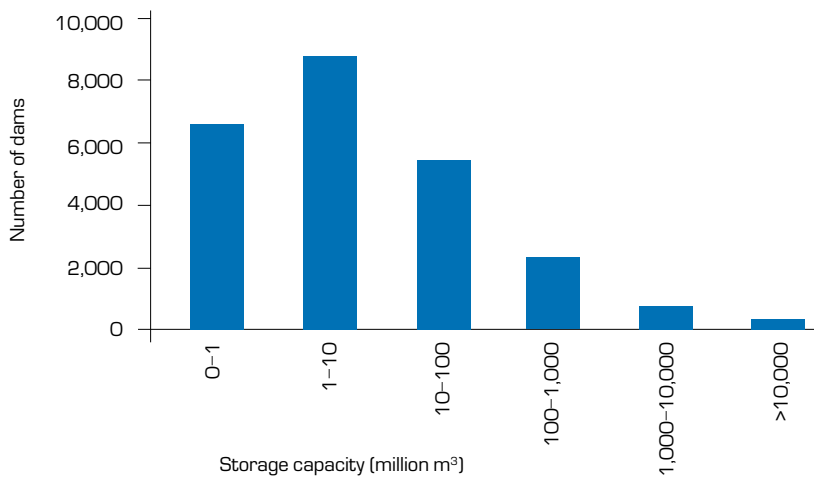


Figure 1.5.
Distribution of dams by storage capacity

Source: WWF, 2009: 17

Two-thirds of all large dams are built in developing countries, and half of them are exclusively for irrigation. In 24 countries, including Brazil and Norway, most dams are built for hydropower, which accounts for more than 90% of total power generation.

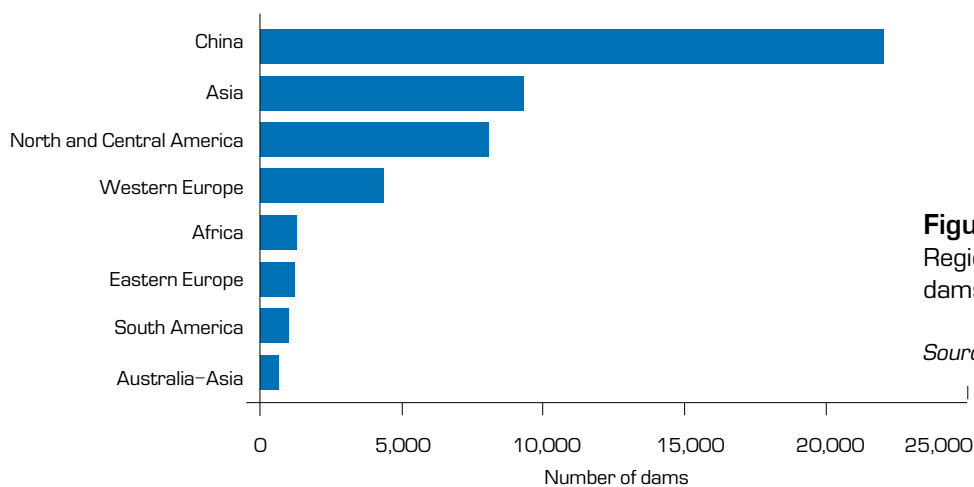


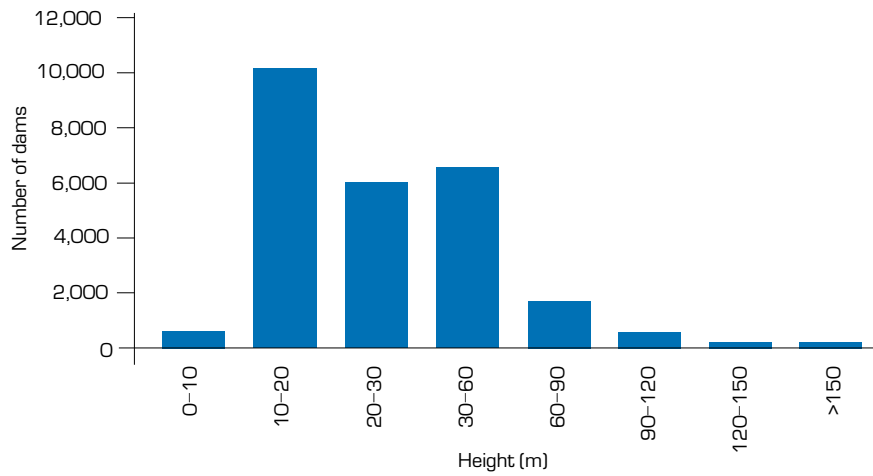
Figure 1.6.
Regional distribution of large dams

Source: WWF, 2009: 18

China has 22,000 large dams, or 45% of the world's total. The US has 6,575 dams (14%), India 4,291 (9%), Japan 2,675 (6%), Spain 1,196 (3%), Canada 793 (2%), South Korea 765 (2%), Turkey 625 (1%), Brazil 594 (1%), and France 569 (1%).

Figure 1.7.
Distribution of dams by height

Source: WWF, 2009: 16



Country data on reservoirs, especially small-capacity ones, is incomplete in many cases. Reservoirs with a storage capacity over 0.1 km³ (100 million m³) are all entered in the world dam register. Their total capacity and surface area are in excess of 95% of the world's total figures.

Figure 1.8.
Distribution of dams by reservoir surface area (km²)

Source: WWF, 2009: 16

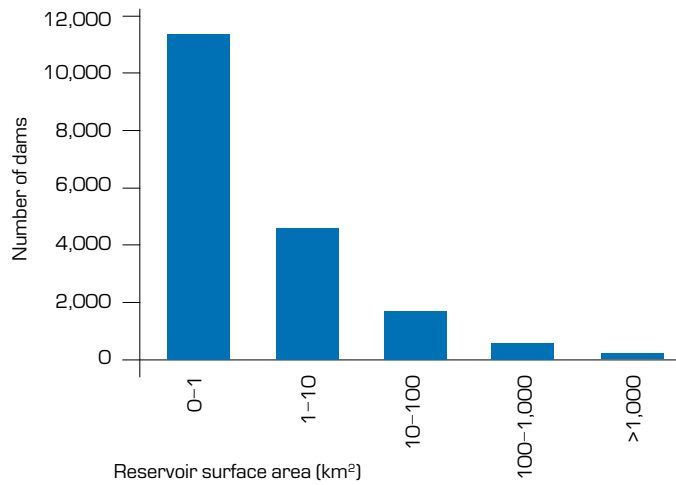
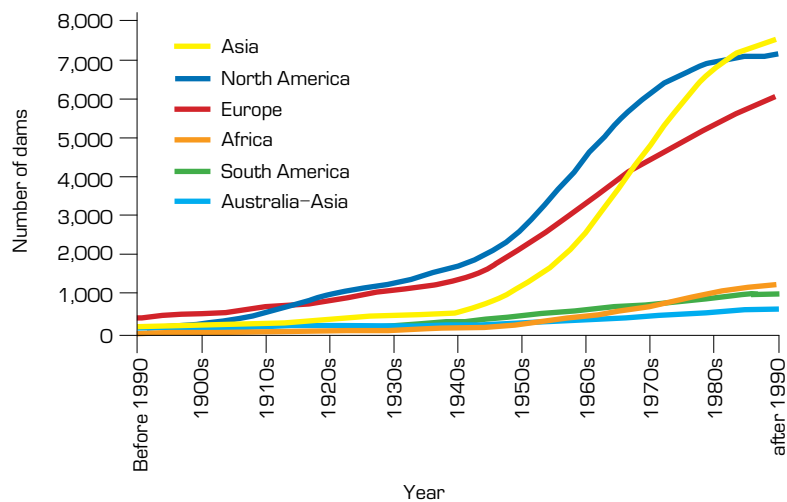


Figure 1.9.
Dams constructed over time by region (1900-2000)

Source: WWF, 2009: 19



Most in dam construction slowed in the past three decades, especially in Europe and North America. The storage capacity of the ten largest reservoirs commissioned in the 1960s exceeds that of the ten largest 1990s' reservoirs by 5.6 times. In this century, mainly small and medium-capacity reservoirs will be built.

Country	Number of dams	Purpose
India	Varies from 695 to 960 depending on the source of information	Irrigation, multipurpose
China	280	Flood control, irrigation, hydropower including pumped storage
Turkey	209	Irrigation, hydropower, water supply
South Korea	132	Irrigation, hydropower, flood management, water supply
Japan	90	Mainly flood control
Iran	48 (above 60 m)	Irrigation, multipurpose

Table 1.8.
Dams currently under construction

Source: WWF, 2009: 17

The majority of large dams in Africa and Asia are for irrigation, though large dams are more often than not multi-purpose. There is growing interest in dams for flood protection and in pumped storage dams for power generation to meet peak demand in Asia.

Single-purpose hydropower dams are most common in Europe, South America and Central Asia, whereas single-purpose water supply projects dominate in AustralAsia. North America has a relatively even spread of large dam functions. Overall, the proportional share of irrigation dams and multi-purpose dams has been increasing over the last 20 years, while the share of hydropower dams has been decreasing.

Hydropower uses renewable energy resources. The harnessing of global hydropower resources is illustrated in *Table 1.9*. hydropower plants have been operated for more than a century in all parts of the world, and now hydropower is the second largest provider of electricity. From 1996 to 2006 hydropower plants generated a total of 3,137.3 TW/h of energy, or 16.6% of all power generation. Hydropower accounts for 89% of all electricity produced from renewable sources.

Region	Capacity (TW/h per annum)	Used (%)
Africa	1,150	3
South Asia and the Middle East	2,280	8
China	1,920	6
CIS	3,830	6
North America	970	55
South America	3,190	11
Latin America	350	9
Europe	1,070	45
Oceania	200	19

Table 1.9.
World hydropower resources

Source: Belyakov, 2008

Only a few countries employ hydropower on a large scale: China, Canada, Brazil, the US and Russia, generating 51.8% of the world's electricity. In late 2006 three major hydropower-using regions generated comparable percentages of the world power output: North America – 21.1%, South America – 20.8%, and East and Southeast Asia – 20%. Western Europe contributed 16.1%, and on the whole these four regions generated 78.1% of the world output.

In the next few years Asia's contribution to the global hydropower is forecast to increase even further: of the 150.61 GW of all hydropower capacity to be commissioned, 126,044 MW belong to Asian countries. A large increment in hydropower capacity is also expected in South America (10.5 GW) and Africa (6.22 GW). In 2006 the total installed capacity of all world hydropower plants was estimated at 807 GW.

Country	Generation (TW/h)	Share in global generation (%)
China	443.2	14.1
Canada	355.4	11.3
Brazil	347.8	11.1
USA	307.8	9.8
Russia	169.6	5.4
Norway	119.8	3.8
India	112.2	3.6
Japan	97.5	3.1
Sweden	61.7	2
France	61.1	1.9
Others	1,061.1	33.3
Total	3,137.3	100

Table 1.10.
Major hydropower countries
in 2006

Source: Belyakov, 2008

Large hydropower reservoirs with a surface area comparable to that of a large natural lake seriously alter runoff patterns over vast territories, thus affecting the interests of neighbouring countries. Reservoirs have long become an influential component of ecosystems and a major factor in river systems behaviour. Therefore, the construction of reservoirs in cross-border river basins is a geopolitical matter that directly bears on international security.

Global industries are a major polluter of water sources, as they generate wastes with high concentrations of pollutants and consume huge quantities of water per unit of production – in many instances, tens and hundreds times the weight of the product. Thus, an increase in water consumption by industry is attributable not only to rapid industrial development but also increasing water intensity. Water is essential to many technical processes. All industrial water uses, despite their differences, can be classified by the role of water in the process, i.e. coolant, solvent, absorbing or transporting medium, or component of the final product. The first three uses account for up to 90% of all industrial water consumption.

Chapter 2. Strategy of transition to a green economy as a factor in water sector development

In the late 1980s the concept of «sustainable development» became widely recognised; it was used as a basis for the 21 Century Agenda, a programme document of the UN Conference on the Environment and Development in Rio de Janeiro in June 1992. As a follow-up, the UN formed the Commission on Sustainable Development.

In 2002 Johannesburg hosted the World Summit on Sustainable Development which named the key sectors requiring urgent investments and reform: fresh water, sewage, energy, health, agriculture, biodiversity and ecosystems management. The Summit adopted the *Plan of Implementation of the World Summit on Sustainable Development*, which aims to prevent social and environmental crises and foster sustainable development.

The global economy development strategies emphasising investments in environmental protection recommended in Rio de Janeiro (1992) and Johannesburg (2002) laid down the foundations for a green economy. This term means an economic system in which environmentally clean, efficient technologies and sustainable agriculture are given the role of the main factors in economic growth and environmental safety, employment, and social prosperity. A green economy, as defined by the UNEP, maintains and rebuilds natural capital or reduces environmental threats and risks. Whereas a traditional economy combines labour, technology and resources to produce final products and wastes, a green economy strives to return wastes to the production cycle in order to minimise environmental impact.

A green economy relies on clean or green technologies («cleantech» and «greentech») and new business models that offer investors and consumers competitive income whilst simultaneously addressing the associated environmental problems. The clean technology market offers a wide range of products, services and processes capable of enhancing productivity at lower costs (and reducing or eliminating negative impact on the environment), resulting in more efficient and responsible natural resources management and higher economic rewards. Cleantech Group (USA) forecasts the clean technology market to grow to \$2 trillion in 2020.

In March 2009 the UNEP issued a report entitled *Global Green New Deal* in which it outlines the rationale of ecosystem-oriented investing in the global economy (UNEP, 2009). Investments in sustainable development, reads the report, must prevent future economic crises and maintain stability in the medium and longer term. It is argued that that an investment of 1% of global GDP (\$750 billion) over the next two years could provide the critical mass of green infrastructure needed to seed a significant greening of the global economy. The objectives of this initiative are to:

- make a major contribution to reviving the world economy, saving and creating jobs, and protecting vulnerable groups;
- reduce carbon dependency and ecosystem degradation, putting economies on a path to clean and stable development; and
- further sustainable and inclusive growth, achievement of the Millennium development goals, and end extreme poverty by 2015.

The achievement of these goals will require both direct investments in key sectors and reforms enabling concerted global efforts aimed at the promotion of:

- retrofitting public buildings to be energy efficient, and providing incentives for greening and weatherising homes and offices;
- developing more energy-efficient, less polluting transport modes;

- financing renewable energy projects and off-grid technologies;
- investing in sustainable agriculture and water systems;
- reforming inappropriate subsidies, providing the right incentives and implementing tax reforms; and
- perfecting environmental laws.

Providing access to electricity in developing countries will require investment of \$756 billion in 2010–2030, or \$36 billion a year. Investing in the water sector is also a good business for international and national financial institutions. Globally, the market for water supply, sanitation, and water efficiency is estimated to be \$253 billion and estimated to grow to \$658 billion by 2020. The estimated investment of \$15 billion per year towards meeting the Millennium development goals of halving by 2015 the proportion of people (counted in 1990) without sustainable access to safe water and basic sanitation could generate global economic benefits worth \$38 billion annually.

Efforts are already being made to target this sector in a number of stimulus packages. The 2009 American Recovery and Reinvestment Act provides for investments of \$4 billion for clean water infrastructure and \$2 billion for drinking water infrastructure. In the \$38 billion South Korean economic stimulus package, nearly \$12 billion is allocated for improvements to four major river systems.

The report also names ecological infrastructure as one of the top priorities for public spending, as it is closely related to livelihoods. Ecological infrastructure refers to healthy ecosystems like water catchments and river systems, wetlands, soil, forests, oceans, which form a resource base for the economy. Their contributions to the economy, however, are often unappreciated because their services are seen as being provided naturally and thus not accounted for nor priced. Evidence, however, is accumulating to show that it makes economic sense to invest in ecological infrastructure. A global marine protected area system, accounting for the closure of 20% of total fishing areas and resulting in a lost profit of \$270 million per year, would help sustain fisheries worth \$70–80 billion per year while creating one million jobs. The world's wetlands, covering 6% of the earth's land-mass, produce 25% of the world's food through fisheries, agriculture and hunting.

The report points out that, in the medium and long-term, liberalisation of trade in environmental goods and services should be given priority as it will provide further impetus to green investments. These goods and services include renewable energy technologies, zero carbon vehicles, equipment for public transport, energy- and resource-efficient construction materials and designs, waste treatment facilities, recycling technologies, water conservation and waste water treatment technologies and facilities, sustainable agriculture production, and related consultancy services. Expanding trade in farm produce is an opportunity to cover water deficit in water-stressed countries: thus, water-rich exporters can indirectly «sell» water to them. Thus, water-stressed economies can save water on agriculture and divert it to their pressing needs, e.g. household consumption.

Developing countries should be provided with access to the new technologies and professional skills that are required in order for them to enhance green production and services and efficient water management.

International financial institutions are being encouraged to design innovative financing mechanisms to support the efforts by developing countries and countries with economies in transition to shift their economies onto a «green» path. The beneficiary countries are receiving recommendations to factor potential environmental risks as well as environmental gains into the standard asset valuation and credit rating procedures of banks and financial institutions.

Transition to a green economy will require heavy investment, and this was the main theme of the UNEP report *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – a Synthesis for Policy Makers*. This report is among UNEP's key contributions to the Rio+20 world summit scheduled for 2012 in Brazil.

The report makes a compelling economic and social case for shifting to a green economy and unleashing public and private capital flows to a low-carbon, resource-efficient path. Production processes should be made harmless to ecosystems and human health. Essentially, the report outlines a new world economy development philosophy that prioritises investing in natural and human capital.

Investing 2% of global GDP (\$1.3 trillion a year) in greening ten central sectors coupled with efficient national and international policies can catalyse economic activity of at least a comparable size to business as usual, but with a reduced risk of the crises and shocks increasingly inherent in the existing model. The investment structure by sector within the said framework (\$1.3 trillion, given the current global GDP value) would be as follows:

- agriculture including small farms – \$108 billion;
- retrofitting buildings (improving heating and illumination) – \$134 billion;
- energy supply – \$360 billion;
- fishery and vessels decommissioning – \$110 billion;
- forestry and climate change mitigation – \$15 billion;
- industry, including processing – \$75 billion;
- tourism – \$135 billion;
- transport – \$190 billion;
- wastes management and utilisation – \$110 billion; and
- water and sanitation services – \$110 billion.

In many developing countries, transition to a green economy can be accelerated by policies to increase investments in improving water supply and efficiency and sanitation services. The provision of freshwater of sufficient quality and quantities needed is a basic ecosystem service. The management of, and investment in, ecosystems is therefore essential to address water security for both people and ecosystems in terms of water scarcity, the over-abundance of water (flood risk) and its quality. Business as usual is projected to lead to a large and unsustainable gap between global supply and water withdrawals, which can only be addressed by investments in infrastructure and water policy reform. The latter may focus on improving the institutional and economic mechanisms of water management. In green investment scenarios of \$100–300 billion per year between 2010 and 2050, increased efficiency in agriculture, industrial and municipal sectors would reduce demand for water by about a fifth by 2050, as compared to projected trends, reducing pressure on groundwater and surface water in both the short and long term. Under the «as usual» scenario the demand for fresh water will remain unmet.

A green investment scenario of 2% of global GDP delivers long-term growth over 2011–2050 that is at least as high as an optimistic business as usual case, while avoiding considerable downside risks such as the effects of climate change, greater water scarcity, and the loss of ecosystem services. Training and skill enhancement programmes are needed to prepare the workforce for a green economy transition. There is also a pressing shortage of skills for manufacturing in the renewable energy industry, particularly for engineers, operation and maintenance staff and site management. International environmental agreements can facilitate and stimulate a transition to a green economy. For instance, multilateral environmental

agreements that establish the legal and institutional frameworks for addressing global environmental challenges can play a significant role in promoting green economic activity.

The rapid growth of capital markets, the growing green orientation of these markets, the evolution of emerging market instruments such as carbon finance and microfinance, and the green stimulus funds established in response to the economic slowdown of recent years, are opening up the space for large-scale financing for a global green economic transformation. Concentrated pools of assets, such as those controlled by long-term investors, including public financial institutions, development banks, sovereign wealth funds as well as some pension funds and insurance funds whose liabilities are not due for payment on a short-term basis, will be needed to transform the economy.

The financial services and investment sectors control trillions of dollars and are in a position to provide the bulk of financing for a green economy transition. Long-term institutional investors such as pension funds and insurance companies are increasingly seeing the potential for minimising environmental, social and governance risks by building up «green» portfolios. In the renewable energy sub-sector, for example, around \$627 billion of private capital had already been invested between 2007 and mid-2010. This market saw a three-fold increase in investment from \$46 billion in 2004 to \$173 billion annually in 2008. Public financing, however, is essential in order to jump-start a green economic transformation. For example, during the 12th five-year plan period starting 2011, the Chinese government will invest \$468 billion in green sectors compared to \$211 billion over the last five years, with a focus on three sectors: waste recycling and reutilisation; clean technologies; and renewable energy. With this amount of public investment, China's environmental protection industry is expected to continue growing at an average of 15–20% per year and its industrial output is expected to reach \$743 billion during the new five-year period, up from \$166 billion in 2010.

In 2009, multilateral development finance institutions committed \$168 billion in development assistance, whereas national development banks and bilateral agencies provided over \$350 billion in 2008. These institutions will play an increasingly important role in supporting transition to a green economy. For example, the ADB in its long-term strategy for 2008–2020 declares the intention to shift an emphasis in its activity to five key green economy issues: infrastructure; ecosystems, including climate change; regional cooperation and integration; finance; and education (ADB, 2008). Sustainable development could wipe out poverty, as many poor people's livelihoods depend on nature. To this end, the ADB will encourage the use of clean technology, promoting environmental safety, and building an enabling institutional capacity. To improve public health, the ADB will invest in water supply, sewage and sanitation services. Investments in agriculture including irrigation, water management, rural roads and electricity will continue. The ADB will support efficient ecosystems management and mitigation of unavoidable consequences of climate change such as damage to human health by assisting national and municipal level planning and investing in protective measures, insurance and other risk sharing mechanisms, and climate-resistant projects. Particular attention will be paid to the risks related to natural disasters.

Chapter 3. Assessment of water sector investment needs

Inadequate access to water for drinking, agriculture and irrigation create social tension and undermine economic growth in many regions of the world. To address this universal problem, investments in water and related sectors should be boosted and water management improved.

Investments in water are repaid directly or indirectly at different levels and in different sectors: health, agriculture, industry, hydropower, recreation, and so on. For example, each \$1 invested in safe drinking water and basic sanitation yields returns of \$3–34. Underinvestment in water can lead to a GDP decline. Over 80% of wastewater in developing countries is not treated and pollutes rivers, lakes and littoral areas. Therefore, the level of investment in treatment facilities directly affects health and the protection of ecosystems.

Replacement of obsolete water supply and treatment systems in highly industrialised countries alone may cost \$200 billion annually (UN, 2009). Investments required for sustained operation of water supply systems are estimated at \$360–480 billion globally; however, according to other estimates, these investment requirements are much higher.

According to the UN, in the recent 50 years annual surface and ground water withdrawal exceeded 2%, and is forecast to average at 3% in the next few years. In 1950, per capita annual water consumption averaged 580 m³. This figure had already risen to 660 m³ by the year 2009. Demand for water will escalate faster than in previous decades. This trend is mainly attributable to rapid population growth and continuous improvements in living standards following urbanisation. In 1950 there were only 86 cities with a population of more than 1 million, but this figure rose from 387 to 431 cities between 2000 and 2007. The number of megacities is increasing rapidly in Asia, Africa and Latin America, in particular. The cities are growing not just in number, but also in size: In 2007, the world's 100 largest cities had an average population of more than 7 million people. The rise in the world's population and demand for food and energy fuels competition for water not only between countries and regions but also between different sectors of the economy. The rapid growth of cities is creating a huge challenge for the water sector and will require a more efficient investment mechanism of investing to infrastructure modernisation and development.

A good balance between the needs of the utilities and agriculture sectors is critical to efficient water demand management and water saving. Investment requirements largely depend on the tariff policies in water supply and sewage. These policies vary across world cities and cannot be brought to a universal solution. Water tariffs must fully cover the costs and future development needs of water systems. Therefore, switching to economy-oriented tariffs is the cornerstone of utilities and sanitation reform.

In OECD (Organisation for Economic Cooperation and Development) countries, centralised water supply and sewage tariffs charged on a per person basis range from \$0.42 to \$7.58 and from \$0.17 to \$3.49 per m³, respectively (assuming one person consumes 15 m³ a month). A total tariff of water supply and sewage charged on a per person basis is \$0.42–\$7.58 per m³. Water supply and sewage costs account for 1–5.5% of GDP, as of June 2007.

In some non-OECD countries, centralised water supply and sewage tariffs charged on a per person basis range \$0.01 to \$1.25 and from \$0.01 to \$1.01 per m³, respectively (assuming one person consumes 15 m³ a month). A total tariff of water supply and sewage charged on a per person basis is \$0.01–\$2.26 per m³, as of June 2007 (GWI, 2007).

Rapid urbanisation, which is expected to pass 4 billion by 2025, changes the water consumption structure. This opens up opportunities for lucrative investment projects such as selling bottled water: this business currently yields up to \$1 trillion annually, which is 40% of world oil companies' income. Growth in this industry has been very strong for many years now, averaging

8% by volume per annum for the last ten years, even though the growth rate is now slowing or even negative in some countries (such as the USA). On the other hand, demand for bottled water is growing faster in developing countries, driven by contaminated and unsafe drinking water. During the period 2003 to 2008, demand for bottled water in China grew by 15.6%, while consumption in the US grew by 6.7%. The cost of desalination has come down significantly over recent years, and it plays an increasingly important role in drinking water supply and sanitation. Among the industrial wastewater treatment technologies, the reverse osmosis market is expected to be one of the fast-growing areas. For desalination plants using reverse osmosis membrane technology and advanced management practices, operating costs are now three times lower than they were 30 years ago. This technology is especially economic for island countries such as Singapore. The cost of desalination does not exceed \$0.20–\$0.35 per m³ for low-mineralised water. These technical solutions bring about new alternatives in addressing water quality and quantity issues, but also have other implications, especially for hydropower and technology management, which need to be scrutinised prior to any practical use (Gleick, 2009: 314–323).

The investments requirements of irrigation infrastructure are comparable to those of water supply. Typically, irrigation systems are fed from multi-purpose reservoirs. The possession of vast hydropower resources and pressing fuel and energy deficiency prompt many countries to increase investment in hydropower and improve water management practices. The benefits of hydropower plants compared to thermal plants are the low operational and reequipment costs, longer lifetimes (40–50 years), and efficient use of water resources.

In the coming decades the largest increase in hydropower capacity is expected to occur in Asia and South America; and a boom in hydropower plant construction is expected in Africa. Developed countries do not consider building large hydropower plants, focusing instead on reconstruction and reequipment of existing installations (new turbine types, pumped storage, etc.), which is more economic than building new dams. Hydropower output is expected to increase 1.7–1.8 times in 2050 and 2.2–2.4 times in 2100. On the whole, hydropower will account for about 16% of the global energy throughout the 21st century.

Global energy consumption has risen by 70% since 1971, and this growth is continuing at about 2% per annum (with a slowdown in the crisis period that affected both developed and developing economies). Renewable sources are responsible for 16% of global power generation. Hydropower is the most technically perfect and flexible among them; its share in renewable power is 87% (World Energy, 2007: 271–314).

The era of large hydropower installations fell on the first decades of the 20th century; many of them are still operational. Large hydropower projects were pioneered by North America, and were also implemented in many other regions: the former Soviet Union, China, India, Turkey, Iran, Iraq, Canada, Africa and Latin America. North and Latin America and Europe possess significant hydropower potential; much of it is already harnessed. In East and South Asia and Africa there is still much room for hydropower development. Hydropower has important long-term advantages – namely, the potential for diversification and use of smaller rivers. This branch of hydropower is rapidly growing, especially in rural and remote areas. Small hydropower plants are also a promising option for cross-border river basins; they are free from many shortcomings inherent in large plants, economic, and environmentally friendly. The benefits of small plants are numerous: low carbon dioxide emission, reliable technology, independence from fuel imports, diversification of energy sources, no need for land, stimulus for local and regional development, assistance in river basin maintenance, guaranteed rural electricity, quick payback, and so on. The construction and operation of a small hydropower plant does not change the natural landscape and exerts minimum pressure on the ecosystem.

The level of small hydropower plants in power generation has reached 8.3% in Switzerland, 2.8% in Spain, 3% in Sweden, and 10% in Austria. The leaders in this respect are China (47 GW), Japan (4 GW) and USA (3.4 GW), followed by Italy and Brazil.

Chapter 4. Support for innovation and projects in the water sector

An investment cycle comprises activities necessary for commissioning a facility. The investment process includes concept design, engineering survey and design, building and installation, and commissioning. Concept design typically accounts for 5–10% of project time and less than 1% of investment. Engineering survey and design account for 10–20% of project time and 2–6% of investment. Building and installation account for 70–85% of project time and 93–97% of investment (including the cost of equipment). Commissioning accounts for 10% of project time and 2–3% of investment.

In aggregate, concept design and engineering survey and design take 15–30% of project time and 3–7% of investment. Although these two phases are not very lengthy and relatively inexpensive, they are the most important part of an investment cycle, determining the level of innovation and technology, reliability, and performance characteristics of the water facility.

In the Soviet period there was an extensive network of design institutions of diverse specialisations that were responsible to different ministries. These institutions did all the design work and typically were affiliated with research institutes and laboratories; some of them had the status of policy-making body and issued rules and regulations.

After the disintegration of the Soviet Union most design and research organisations in CIS countries were reorganised into cooperatives or limited liability or joint stock companies, i.e. denationalised. Many of these split into smaller companies, some ceased to exist, and some started to engage in non-core businesses. The investment activity in the economy declined, and so did the scale of construction, reconstruction and modernisation in energy and related design work. Frequent reorganisations of regulatory agencies, denationalisation of design and research institutes and the ensuing brain drain and loss of corpora of scientific and technical data, project designs and findings, had a grave effect on safety in energy. For example, the absence of archive data makes rehabilitation projects far more expensive and lengthy as existing facilities need to be re-understood, let alone resulting in poorer accident management.

These problems with project activity persist in all post-Soviet countries. A fully-fledged project services market that would feature quality supply on the one hand and solvent demand on the other is yet to emerge. The existing public regulation of this process based on licensing of project activities helps ensure that design organisations meet certain qualification requirements. However, this is where the state's involvement with this sector effectively stops. At the same time, most water and hydropower management initiatives are exceptionally science-intensive and require decisive government support. Design work should be viewed as a technical aspect of national security, as is the case in developed economies. Research and design for hydropower should be put on a modern managerial footing orchestrated by the state.

In so doing we should learn both from our own past and the practices of developed countries. For example, in Japan support of any new industry starts at a ministry level with scrutiny of its current status, prospects, resource requirements and need for protectionist policies. All issues related to administering research and development (R&D), commercial industrial technology and support for innovative small and medium-size businesses are the domain of the Ministry of the Economy, Trade and Industry. Most leading national research centres have been released from the control of respective ministries and made independent government-funded institutions. Notably, in Japan's traditional standardisation system, ministries responsible for various aspects of entrepreneurship have equal authority to impose standards in respective fields.

Public and private spending on R&D in Japan exceeds 3% of GDP; of this figure, 80% is contributed by the private sector. A high degree of interaction between private businesses and the state has existed for decades, due to a network of special liaison organisations. These include

public corporations, special-status entities, combined private-public companies, industry associations, and numerous government advisory councils and groups examining government policies.

Practically all private companies, from the smallest ones to giants, are united in associations by industry, product or function. This network provides a convenient vehicle for ongoing exchange of information, discussions and consultations between government officials and the banking and industrial elite, the mass media, scientists, and trade unions. Associations convey members' proposals to the government and the government's recommendations and requests for the members to support its line and ensure discipline in this respect.

Decision-making on important economic matters is always preceded by consultations with business circles, and decisions normally represent a compromise by stakeholders. The Japanese state is special in that it actively interferes with the economy at all levels using various informal mechanisms. This specific regulation is particularly present in industry. Whereas in other developed countries the state confines itself to regulating the cycle and monetary circulation and leaves the formation of industry structure to the private sector, in Japan long-term regulation of the industry structure is central to the overall public policy.

Throughout the post-war period, the basic functions of the Japanese state were economic programming, choosing a general direction for the national economy for the next 5–10 years, and implementing industrial policies to that end. Public programmes are indicative, however, i.e. recommendatory rather than mandatory.

Development programmes do exert regulatory force on governmental agencies and the parliament, particularly, as far as annual budgets are concerned, because economic targets set in the programmes are the main guidelines in the budget preparation and approval process. Individual ministerial programmes draw heavily on summary government programmes. Dedicated funds are then made available directly to various public corporations for investment purposes. The finance reaches the private sector through the Japan Housing Finance Agency, the Development Bank of Japan, the Export-Import Bank of Japan, Japan Finance Corporation for Small Businesses, and other institutions.

Japan maintains systemic monitoring and statistics of the financial and economic performance of companies in which the government has a major stake. These companies are subject to regular financial inspections, and the results are presented in summary reports.

In Germany, the state exerts influence on individual sectors of the economy through fiscal, credit, financial, customs, investment, antitrust and employment policies. Sector and structural policies also play a prominent role in the German economy.

In recent years investment in education, professional training, research and innovative developments was increased dramatically. Since 2004 private investors, including foreign ones, have the opportunity to invest in so-called hedge funds. Basically, a hedge fund is an investment pool made up by individuals and institutional investors and entrusted to professional managers. It employs a wide range of instruments, from bonds to the most risky investments.

Flexible mechanisms for stimulating investment enabled Germany to quickly advance to leading positions. The German economy makes out a strong case for R&D as a pivotal factor in achieving competitiveness internationally. The foundations of the country's industrial power were laid by R&D contributions to mechanical engineering and other industries. Germany's expenditure on R&D from all sources totals 3% of GDP, with the public sector contributing one-third of that.

Venture capital is highly developed in Germany. The federal government has modified the system of stimulating venture companies by establishing an investment fund for financing new innovative companies from private sources, an initial investments fund for small-scale research projects (implemented mainly by young people) with capital requirements not exceeding €600,000, and

a number of regional funds for pilot projects. The state is represented in these funds by federal banks. Germany's current practice of supporting innovation indicates that support for R&D should ultimately benefit the state, higher education and the private sector.

The UK is a historical leader in science and technology. Policy-making in these areas is the prerogative of the Parliament, the government, ministries and leading national organisations. R&D is the direct responsibility of the industrial sector, research institutions and universities. The key importance attached to R&D is dictated by the need to retain top positions in competitive production and advanced research management, i.e. it is in both the corporate and public interest.

Spending on R&D by the public and private sectors exceeds 2% of GDP. The UK is a European leader in terms of economic efficiency of R&D. The main factors in keeping research costs low are good organisation of labour of scientists and technical staff, well-adjusted mechanisms of ongoing assessment and correction of the R&D process, flexible financing systems, and efficient tax incentives. The body responsible for identifying R&D priorities and implementing respective policy is the Ministry of Trade and Industry.

Brazil has emerged as a new economic leader and is actively developing hydropower. The country has an efficient hydropower and safety administration system and over 1,596 generating facilities using hydraulic, thermal, nuclear, wind and solar energy. Since 2004 Brazil has been implementing a programme of stimulating the development of alternative sources with the support of the National Bank of Economic and Social Development. The Bank has a facility that supplies up to 70% of investment requirements of projects to build power plants using alternative sources, with the remaining 30% being provided by private investors. Under this programme, 16 biomass thermal plants with a total capacity of 600 MW, 43 wind plants with a total capacity of 1,300 MW and 15 small hydropower plants with a total capacity of 1,200 MW will be commissioned.

CIS countries still lack a system that would allow project work to be organised efficiently, not only in the water sector but also in other sectors. New approaches to financing R&D need to be developed, new organisational forms need to be found for design institutions, and more R&D professionals need to be raised. The legal framework for design and construction needs urgent revision, as many existing standards, rules, instructions and recommendations are obsolete. The role of the state in strengthening the project industry and preserving the corpora of project findings irrespective of the developer's status and accessibility of data need to be clearly defined.

Notably, the project industry no longer receives new specialists, as educational institutions in the CIS do not train them. Raising a highly professional designer takes 15–20 years. Given the current workforce shortage, the project industry may face major problems with future application of investments. Therefore, an urgent designer training programme should be adopted within the EurAsEC or CIS framework, and Russia would assume the role of originator of this process. The problem of R&D support for energy in EurAsEC and CIS countries has many facets and cannot be discussed in full within the framework of our publication.

In Central Asia, 80–85% of all water resources are used by irrigated agriculture, which provides two-thirds of GDP and employs most of the population. Hydropower accounts for 27.3% of all electricity consumption. The industry and agriculture are the most energy-intensive sectors. Therefore, the policy of hydropower resources management in cross-border river basins must be based on the premise that food safety cannot be achieved without sustained energy development. To Central Asia, hydropower and agriculture is an interrelated regional complex. If the perception of these two sectors as contradictory continues, competition for water will become bitterer. The lengthy attempts over many years at creating a hydropower consortium in Central Asia were inconclusive. Most experts attribute this failure to the specific features of economic cooperation between the region's countries and weak integration mechanisms rather

than political frictions. This warrants considering other mechanisms for managing the potential of Central Asian cross-border rivers.

A possible solution is to create agrarian-energy clusters at local, national and international levels, which would enable mutually beneficial management of existing river basin organisations without disrupting the hydrographic unity of the basin.

The basic preconditions for such clusters, i.e. interdependent water and energy infrastructures, are already there. In relevant literature a cluster is defined as association of economic entities from closely related industries that can promote each other's competitiveness. A cluster is an interindustry rather single-industry complex covering an area in which specialised suppliers, producers and consumers united by a common technological chain are all concentrated.

Over time, clusters can expand and even grow into other integration forms. This flexibility creates an important advantage over other forms of economic organisation. The cluster form of integration requires taking account of natural factors such as climate change and its impact on water resources. The negative consequences for hydropower and irrigation can be mitigated by modernising equipment and irrigation methods and improving water and energy saving.

An agrarian-energy cluster is based on the premise that the water and hydropower services are ultimately consumed by a common user, namely, irrigation. A cluster unites a region's water, agricultural and hydropower organisations, which typically share common water and energy infrastructure. Regional development requires constructing new water facilities, and not only for hydropower – these will help to better cope with natural disasters such as droughts and floods and mitigate water stress. These measures must be well coordinated and not detrimental to water availability in neighbouring states and river basin ecosystems, and be in line with international law and obligations related to protection and management of cross-border river resources.

Chapter 5. The role and involvement of international financial institutions in water sector development

International financial institutions are positioned to provide the bulk of finance for harnessing the hydropower potential of the cross-border rivers Syrdarya and Amudarya. Bearing in mind that the issues of cross-border water and energy regulation in Central Asia are highly sensitive, these institutions must adopt a well-balanced, transparent and consistent policy on involvement in projects with cross-border effects.

Many developing countries have difficulties harnessing their available hydropower potential due to a lack of funds for the construction of dams, as access to credit for these purposes is subject to strict international legal and environmental requirements.

One the whole, there has been a sharp decline in investment in water infrastructure since the mid-1990s. International financial institutions effectively ceased to finance large hydropower projects in developing countries bowing to the pressure of organisations and the public who believed that large dams and reservoirs cause irreparable damage to ecosystems and livelihoods.

However, the construction of large dams (with a height of 15 m or higher, according to the International Commission on Large Dams classification) continued in many countries even after the withdrawal of international financial institutions. In recent years, there have been 245 large dams under construction in China, 475 dams in India, 88 dams in Iran, 230 dams in Turkey and 110 dams in Japan. However, in countries that had not sought external borrowings the level of investment in dam projects fell dramatically.

The report *Dams and Development: A New Framework for Decision-Making* (2000) sponsored by the World Bank and World Wildlife Fund elaborates on the importance of dams for power generation, irrigated agriculture, prevention of floods and droughts, and water supply improvement. Constructing a dam is often considered the most economic option. However, any dam project should be accompanied by measures to prevent damage to the environment and livelihoods.

The report reviews the performance and social and environmental impacts of dams, the decision-making process and the available options for providing water and energy services. Decision-making on dams must be based on the following principles:

- Gaining Public Acceptance;
- Comprehensive Options Assessment;
- Addressing Existing Dams;
- Recognising Entitlements and Sharing Benefits;
- Ensuring Compliance;
- Sharing Rivers for Peace, Development and Security;
- Sustaining Rivers and Livelihoods.

Based on these priorities, five critical decision points have been identified as having a particularly strong influence on the final outcome and enable progress evaluation. The first two relate to water and energy planning. These five points represent a plan of action for the planning of new dam construction or addressing existing plans:

- 1. Needs assessment:** validating the need for water and energy services. Confirmation is required that plans for water and energy development adequately reflect local and national needs.

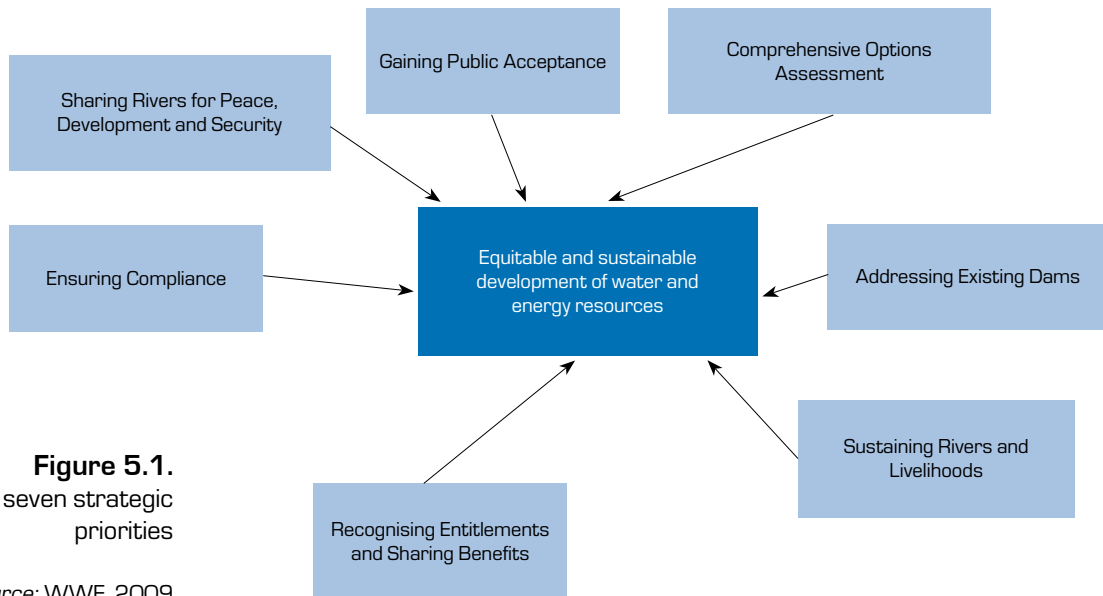


Figure 5.1.
The WCD's seven strategic priorities

Source: WWF, 2009

2. **Selecting alternatives:** identifying the preferred development plan from among the full range of options. The preferred development plan is selected through a participatory multi-criteria assessment that gives the same significance to social and environmental aspects as to technical, economic and financial aspects and covers the full range of policy, programme, and project options. Within this process, investigations and studies are commissioned on individual options to inform decision-making as required; for example, demand-side management studies or feasibility studies. Where a dam emerges as a preferred option, the following key decision points occur for project preparation, implementation and operation.
3. **Project preparation:** verifying agreements are in place before tender of the construction contract. Licences issued for development of a project incorporate any conditions that emerge from the water and energy options assessment process. Tendering the construction contract is conditional upon reaching negotiated agreements for benefit sharing mechanisms and for mitigation, compensation, and so forth.
4. **Project implementation:** confirming compliance before commissioning. Issuing the licence to operate is contingent on implementation of specific benefit sharing, mitigation and compensation measures at the construction stage.
5. **Project operation:** adapting to changing contexts. Any decisions to modify facilities, operating rules, and licence conditions to meet changing contexts are based on a participatory review of project performance and impacts.

These points ensure a transparent decision-making process and can be supplemented with additional criteria. They cover the entire large dam planning and implementation cycle and the issues of existing dams operation. Currently a large number of dam projects are at various stages of planning and development. These dams should also be assessed by the above criteria in order to identify opportunities for optimisation. The criteria are of a general nature and should be applied with due regard for local planning process peculiarities.

The World commission on dams (WCD) report made a valuable contribution to reviving interest in hydropower and changing the stance of international financial institutions on investing in large dams on internal and international rivers.

The World Bank began financing large dams in the 1950s, committing on average over \$1 billion per year to this purpose. For the period from 1970 to 1985 this amount had risen to

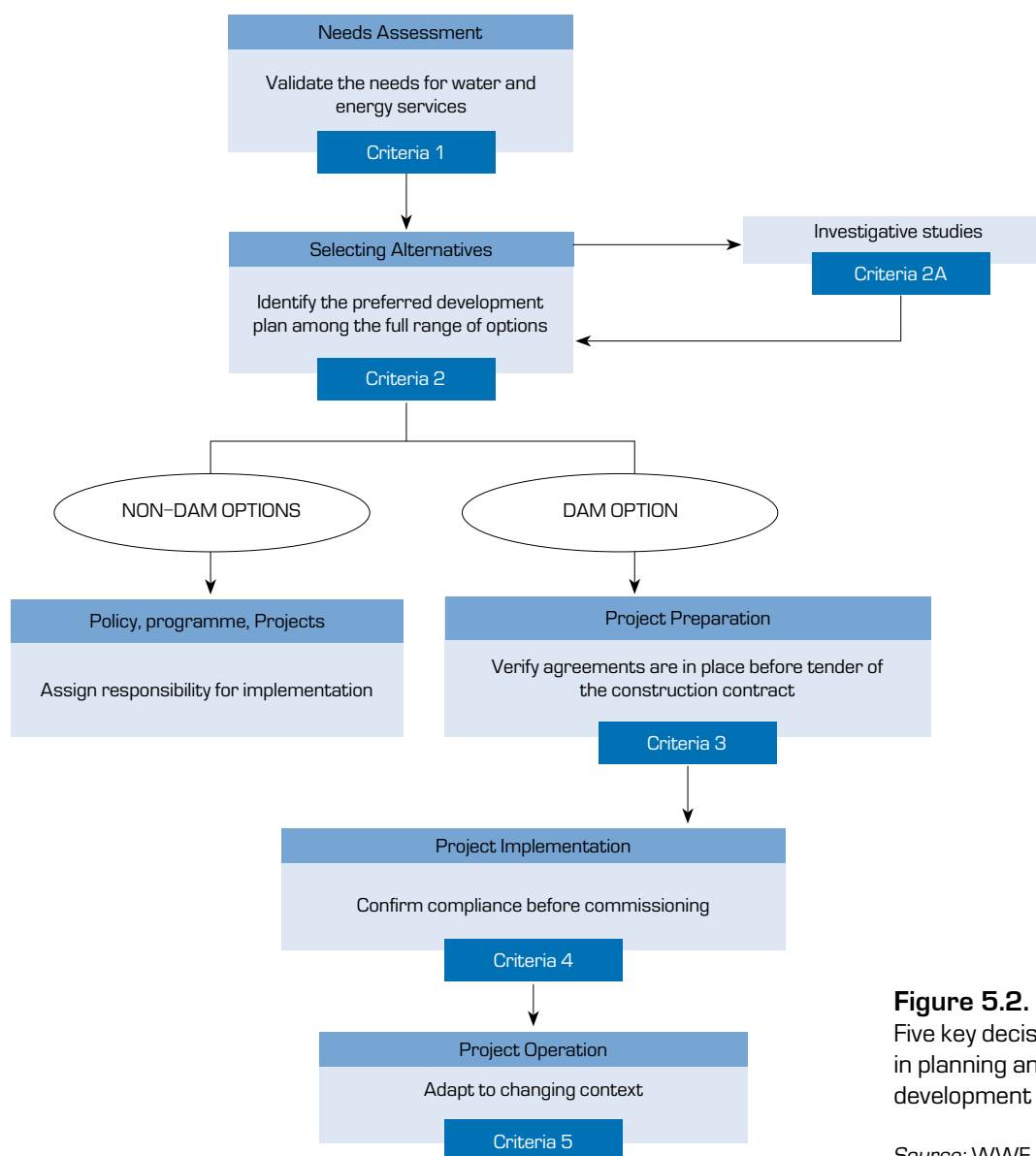


Figure 5.2. Five key decision points in planning and project development

Source: WWF, 2009

\$2 billion per year. Adding in finance by the Asian, InterAmerican, and African Development Banks, as well as bilateral funding for hydropower, suggests total financing for large dams from these sources of more than \$4 billion annually at the peak of lending during 1975–1984. Although the proportion of investment in dams directly financed by bilaterals and multilaterals was perhaps less than 15%, these institutions played a key strategic role globally in spreading the technology, lending legitimacy to emerging dam projects and training future engineers. Since the 1990s there has been a decline in investments in this sector that was only reversed in 2003, as food security considerations began to prevail.

More recently, a gradual shift towards an increased role for private sector finance in hydropower has also led the banks to move into a facilitation role with the emphasis on public–private partnerships and risk guarantees. Part of the financing has now been taken over by export credit guarantee agencies in donor countries that finance and underwrite risks taken by home–country engineering firms and equipment suppliers participating in projects abroad.

Figure 5.3.
Development assistance for large dams (1950–1999)
Source: WWF, 2009: 125

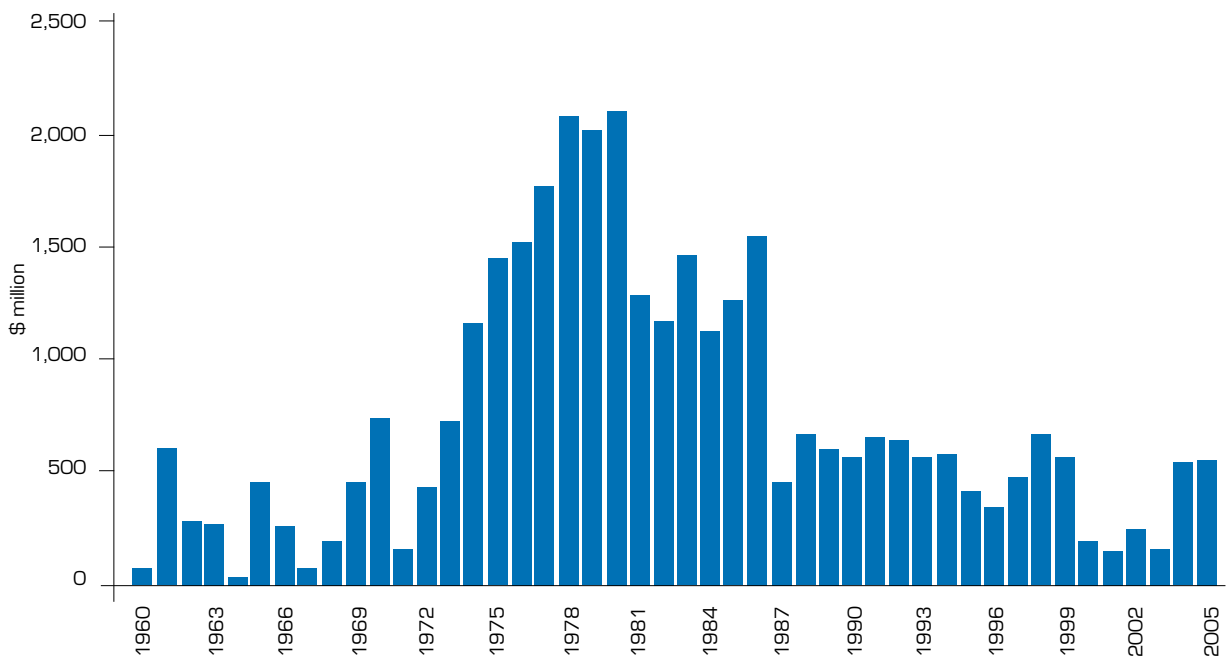
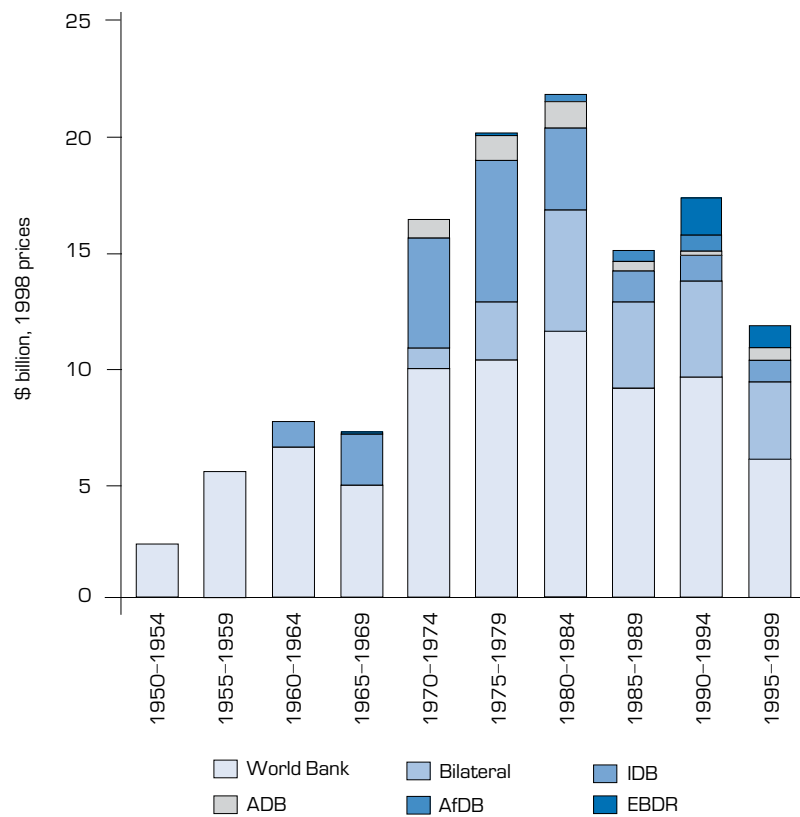


Figure 5.4.
World Bank investment in irrigation (1960–2005)
Source: UN, 2006: 261

The World Bank has contributed to the funding of several large hydropower projects on international rivers. The most well known of these is the construction of a series of dams and canals in the 1960s to divide the river Indus between India and Pakistan.

Long-running disputes between countries regarding the utilisation of the resources of a number of international rivers, and the lack of precise and unequivocal international laws, led the World Bank to conclude that it should adhere to very strict criteria when financing projects on international rivers. In 1956, the Bank adopted guidelines for bank personnel on issues relating to projects on international rivers. These have been reviewed several times since then; the latest revision of the guidelines was in 2001.

In the process of considering funding applications for projects located on international watercourses, the Bank firstly verifies whether countries bordering the river have drafted all necessary agreements relating to the whole watercourse or any of its parts. If there are no such agreements in place, the Bank is often prepared to assist the relevant parties in preparing them. If disputes between the state which is proposing the project (the beneficiary state) and other countries bordering the river cannot be settled, before allocating any funds to a project, the Bank requires that the beneficiary state acts as the initiator of negotiations with the other countries on the river in order to reach necessary agreements or arrangements.

If existing agreements between the countries located on the river as to the terms on which the river is to be shared are deemed to have inadequate provision for the possible consequences of the project, the Bank requires that changes or additional agreements are drafted accordingly.

The Bank requires the beneficiary state to notify the other states bordering the river of its intention to execute the project located on the international river and to circulate available data. If the potential borrower informs the Bank of its refusal to notify other countries along the river, then the Bank undertakes this notification process. If the beneficiary state objects to this, the Bank refuses to consider the project.

The Bank also defines the scope of activity and the function of existing cooperation institutions regarding cooperation in the international water basin.

If countries bordering the river object to the proposal, the Bank may appoint independent consultants to study the reasons for this. If the Bank decides to continue evaluating the project, the Bank informs the states on the river of its decision.

An exception to the aforementioned procedure is only made when changes to a project are relatively minor and do not involve actions that may expand the original project, change its nature or increase its scale so that it becomes, in practice, a new or different project. In addition, no element of the plans should have an adverse impact on the quality or volume of water flowing into other countries along the river, and the project itself must not be subject to any negative effects of water utilisation in other countries bordering the river.

World Bank procedures relating to projects located on international watercourses also establish the approval process and other internal procedures of the Bank according to how countries along the river respond to the notification of the project they receive. World Bank policy on projects located on international watercourses is based on the two principles enshrined in international law, i.e., the right to fair and reasonable use and the principle of causing minimal prejudice. The first principle is based on the premise that every country situated on the river has the same rights as any other to reasonable and fair use of international watercourses. The second principle is that all countries have the right to use the rivers within their territory only as long as that does not cause significant harm to other countries using the river. The principle of causing minimal prejudice has priority and is fundamental to the Bank's policy.

The principle of causing minimal prejudice, selected as the World Bank's fundamental criteria, does to a degree favour countries located downstream of international rivers. However, in the

Bank's opinion, this principle is more easily and appropriately applied without diminishing the importance of the principle of fair and reasonable use.

The fundamental prerequisite to gaining World Bank financing for any project is the completion of an ecological impact assessment.

Securing World Bank financing for projects located on international watercourses, or for even a small part of these projects, opens the door to further investment from other sources, as the project will then be considered to have met international legal requirements. Investors do not need to assess the project for themselves because they trust the conclusions of the World Bank. Over the last 15 years, the World Bank has not participated in the financing of any new hydropower installations on international rivers and only recently granted a modest loan to the Nam Teun II dam on the Nam Teun international tributary of the river Mekong in Laos.

Commercial banks must exercise prudence to ensure that their participation in the project does not complicate relations with other countries situated on the river. In the case of the Nam Teun II project, nine European commercial banks and seven commercial banks in Thailand created a consortium to invest more than \$1 billion even before the World Bank, the ADB and the European Investment Bank had issued loans to Laos for this project. The determining factor was a long-term agreement between Laos and Thailand that the latter would purchase almost all the electricity generated by Nam Teun II.

The Asian Development Bank's program entitled Water for All: the Asian Development Bank's policy on Water Resources identifies the promotion of regional cooperation as its primary goal. Emphasis is placed on supporting activities to regulate cross-border water resources, creating the mechanism for cooperation, the evaluation of resources and the exchange of information. With regard to projects on international rivers, the ADB generally follows the operational policy and procedures of the World Bank. In 2003, the ADB allocated \$700,000 to the Central Asian states to improve the regulation of cross-border watercourses. With this financial assistance, work to prepare several regional agreements on water resources is under way. The Draft Agreement on the Utilisation of the Water and Energy Resources of the Syrdarya River Basin is also in preparation thanks to this money, and it has helped to support the recently created commission of the Republics of Kazakhstan and Kyrgyzstan on the utilisation of water conservation installations as part of their joint exploitation of the Chu and Talas Rivers.

Since the mid-1990s, neither the ADB nor the World Bank have granted loans for the construction of new hydropower units on international rivers. After a long interval, in April 2005, the ADB issued a credit to Laos to finance the construction of Nam Teun II.

The European Union finances a small number of projects beyond its borders. Credit is extended via the European Investment Bank, which usually acts as co-investor in a project together with other financial institutions. For example, the European Investment Bank is part of the consortium of investors in Nam Teun II. In selecting projects to finance, the European Investment Bank requires that the project should be subject to a thorough ecological audit.

The Islamic Development Bank (IDB), in which all the countries of Central Asia have interests, is considered as one potential source of financing for international river projects. The purpose of the IDB is to assist in the economic and social development of the IDB member states and Muslim communities according to Shariya principles. The IDB's international legal and ecological requirements with regard to projects on international rivers may be different from those of the World Bank and the ADB.

Conclusion

In today's world, economic and social development and environmental safety heavily rely on water. Cross-border rivers make the stakeholder countries hydrologically interdependent. Therefore, joint water management is concerned not only with political issues relating to water distribution but also economic implications: each stakeholder must see clear benefits from this cooperation.

All large rivers in Central Asia are cross-border and have the interstate status. Runoff in these river basins is formed and used almost exclusively in the stakeholder countries. The existing water stress in the region is the result of poor organisation of water supply to the industry and agriculture, neglect of infrastructure, and a lack of finance for addressing these shortcomings and jumpstarting future development. The priority investment targets are the reconstruction and modernisation of water treatment facilities, adoption of water saving technologies, and improving drinking water quality and sanitation services.

Both natural and geopolitical factors inherent in the region call for closer integration that would enable joint water management based on the principles of international law. The principles of water management should be harmonised throughout the region to ensure that all stakeholders target the same goals in water development and protection. For adopting such an approach is pivotal to the achievement of the strategic tasks of ensuring efficient use and fair distribution of water resources and sustaining ecosystems. Concerted efforts are also required in order to preserve the quality of water and ensuring safety of hydrological installations on cross-border rivers.

Water tensions between countries can have grave effect on regional economic integration, trade, transport and labour markets. Example, over 40% of cross-border agreements in the world contain provisions on investing in water infrastructure and joint construction of hydropower plants.

Investment flows in the water sector can only be sustained through public-private partnership mechanisms and policies aiming to encourage external investments in water supply, sanitation, irrigation, recreation and protection of ecosystems.

Just as importantly, Central Asian countries must cooperate in the research and training of new generation scientists and engineers capable of solving the region's water and environmental problems.

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Journal of Eurasian Economic Integration

The Journal of Eurasian Economic Integration is a quarterly academic and analytical journal published in Russian by the Eurasian Development Bank. The members of Editorial board and Advisory council are distinguished academicians, practitioners and experts in regional integration. Eurasian Economic Integration brings together academic and analytical articles, reviews of books relating to regional integration, interviews and quarterly chronicles of regional integration. With its focus on economics, the journal is a rich source of material addressing a broad range of issues specific to Eurasian integration. These include integration theory and its relevance to the development context; economic integration (trade, investment, financial institutions); institutional integration; cooperation issues in the post-Soviet space; and international experience of regional integration. The first issue was published in the third quarter of 2008.

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- Development banks' operations and activities in the CIS countries and issues of cooperation.

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