

Chapter 1:

Water, Development and Large Dams



Over 45 000 times in the last century, people took the decision to build a dam. Dams were built to provide water for irrigated agriculture, domestic or industrial use, to generate hydropower or help control floods. But dams also altered and diverted river flows, affecting existing rights and access to water, and resulting in significant impacts on livelihoods and the environment. Decisions to build dams are being contested increasingly as human knowledge and experience expand, as we develop new technologies, and as decision-making becomes more open, inclusive and transparent.



At the heart of the current debate on dams is the way choices are made, and the different opinions and perspectives that are expressed – or denied expression – in the process. The same question of decision-making is at the centre of the Commission's area of concern.

Dams are a means to an end, not an end in themselves. What is that end? How central are the challenges that large dams set out to meet? And how well can dams meet them?

The World Commission on Dams considers that the end of any dam project must be the sustainable improvement of human welfare. This means a significant advance of human development on a basis that is economically viable, socially equitable, and environmentally sustainable. If a large dam is the best way to achieve this goal it deserves our support. Where other options offer better solutions we should favour them over large dams.

Thus the debate around dams challenges our view of how we develop and manage our water resources.

Water has attracted the attention of political leaders at the highest level and has triggered a series of strategic global initiatives such as the World Commission on Water.¹ The most powerful players in development have placed water at the top of their agendas. Why this sudden attention to a resource that was, after all, central to

human needs long before the dawn of civilisation?

At one level, the water issue justifies the priority accorded it because demand for water is rapidly outstripping available supply in large parts of the world. As populations grow, and economic development leads to higher consumption, demand for water increases sharply putting intense pressure on available stocks. This can cause growing social tensions, or even lead to outright conflict. While commonly expressed predictions that future wars will largely be fought over water may be exaggerated, nobody doubts that access to both surface and ground water is an increasingly contentious issue.

Where co-operation gives way to unfair competition between different water uses or between communities and countries, a range of new issues come to the fore. These issues relate to the distribution of power and influence within societies and between countries. They concern the relative weight of the different factors that make up the decision-making mix. And they relate to how choices are made between available options.

The issues surrounding dams are the issues surrounding water, and how water-related decisions are made. There is little public controversy about the choice between an embankment dam or a gravity dam, or whether to use earth, concrete or rock-fill, possibly even over financing the development. The issues all relate to what the dam will do to river flow, to rights of access to water and river resources, to whether it will uproot existing human settlements, disrupt the culture and sources of livelihood of local communities and deplete and degrade environmental resources. Conflicts over dams are more than conflicts over water.

The World Commission on Dams considers that the end of any dam project must be the sustainable improvement of human welfare.

They are conflicts over human development and life itself.

If water is life, rivers are its arteries. Dams regulate or divert the flow through these arteries, affecting the life-blood of humanity. The fact that they aim to do so in the interests of humankind only makes the decision to build a large dam more sensitive, one that will trigger a range of apprehensions, hopes and fears, both rational and irrational.

This Chapter examines the context of the debate on large dams that led to the establishment of the Commission. It begins with a broad look at the past and present 'drivers' of the demand for water, and the role of large dams in meeting this demand. Then it presents general patterns and trends in the development of large dams during the 20th century, along with a brief description of the main purposes for building dams. The chapter also introduces the scale and significance of the benefits, costs and impacts of large dams, described in more detail in Chapters 2 to 6.

It goes on to look at the central issues in the large dams debate – the benefits and adverse impacts – and the positions taken by different constituencies on the past effectiveness of dams, and what may constitute good practice in future decision-making. Chapter 7 picks up many of these themes and also situates the dams debate in the emerging global development framework.

The final section of the chapter traces the establishment of the Commission and highlights the mandate given to it in response to the debate on large dams. It then lays out the methodology adopted and the process followed by the Commission.

Water and Development

Today, around 3 800 km³ of fresh water is withdrawn annually from the world's lakes, rivers and aquifers.² This is twice the volume extracted 50 years ago.

A growing population and a rising level of economic activity both increase human demand for water and water-related services. Development, technological change, income distribution and life-styles all affect the level of water demand.

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How much water do we need?

World population has passed 6 billion. Although the annual increase probably peaked at about 87 million around 1990, the high proportion of young people in most developing countries means that global population will continue to increase significantly well into this century.

Recent projections suggest a peak of between 7.3 billion and 10.7 billion around 2050 before total population begins to stabilise or fall.³ Predictions cannot be precise, because other dimensions of development such as access to health, education, income, birth control and other services influence the pace of population growth.

Despite the massive investment in water resource management and particularly in

Box 1.1 New paradigm for water use

Successfully meeting human demands for water in the next century will increasingly depend on non-structural solutions and a completely new approach to planning and management. The most important single goal of this new paradigm is to rethink water use with the objective of increasing the productive use of water. Two approaches are needed, increasing the efficiency with which current needs are met, and increasing the efficiency with which water is allocated among different uses.

Source: Gleick, 1998



dams, billions of children, women and men in rural areas lack access to the most basic water and sanitation services. Although problems of access are worst in rural areas, rapid urbanisation is also increasing the demand for water-related services. In 1995, 46% of the world's population lived in urban areas. If current trends persist (and they may accelerate), that figure could reach 60% by the year 2030 and over 70% by 2050.⁴ Most of this growth will take place in developing countries where an estimated 25 to 50% of urban inhabitants live in impoverished slums and squatter settlements. Lack of access to water in both rural and urban areas is not just a question of supply. It is partly due to inequitable access to existing supplies.

Urbanisation implies an increasing concentration on water and energy demand in mega-cities, a switch to different lifestyles and consumption patterns, and a loss of productive agricultural land through urban expansion. It is a widely held view that lack of attention to development in rural areas is fuelling unsustainable forms of urban growth, shifting poverty from rural to urban

areas, and contributing to rapidly growing demand for additional services. In heavily populated countries like China, India and Indonesia many question the sustainability of the high rates of urbanisation in mega-cities.

Economic growth and development

World economic activity has grown approximately five-fold since 1950 at a rate of about 4% per year.⁵ The regional balance is changing, with significant growth in Asia over the past 25 years. At present, OECD countries continue to account for the largest share, amounting to 55% of world production at purchasing power parity, nearly 80% at market prices.⁶

Economic growth has two implications for water demand. The first is that increased economic activity will increase the demand for water-related services – regardless of whether the demand is satisfied by more efficient use of the existing supply, or by increasing the level of supply. The second is that both the development brought about by economic growth and the technological changes that accompany it will lead to structural changes in the pattern of goods and services that society produces, and in the way these services are provided. The water demand per unit of Gross Domestic Product (GDP) will depend on how these two components of economic growth are combined. Countries with the same product per capita but different production characteristics – for example, with large scale irrigated agriculture or water intensive industries – may consume three or four times more water per dollar of GDP. This is evident when comparing the United States and Canada with Germany or France, or India with China.

Development and technological change can also save water per dollar of output. Between 1950 and 1990 the world economy grew by a factor of five while world water withdrawals only grew by a factor of 2.⁷ The last fifty years have seen a worldwide reduction in the amount of water per dollar of non-agricultural production as a result of improved technology, more recycling, enforcement of environmental standards, higher water prices, and industries moving away from natural resource intensive activities.⁸ However, the water management practices and technologies that enable such advances are not widely available or promoted and are often absent where they are most needed. Despite the increasing number of options available, the total number of people without access to clean water is growing.

Income distribution and life-styles

Economic activity and development affect income, income distribution and lifestyles. These in turn affect the demand for water through changes in the level and composition of household consumption in areas such as diet, the use of household appliances and standards of sanitation.

How much water is needed for one more person? Although climate and culture influence what constitutes an appropriate level of domestic water consumption, several international agencies and experts have proposed 50 litres per person per day (or just over 18.25 m³ a year) as an amount that covers basic human water requirements for drinking, sanitation, bathing and food preparation. In 1990 over a billion people were below that level.⁹

On the other hand, households in developed countries and better-off households in developing cities use from 4 to 14 times the threshold of 50 litres per person a day.

Drastically lower average figures for domestic consumption in developing countries reflect not only different life styles and lower incomes, but also a huge backlog of unsatisfied demand. The lower average also masks extremely high consumption among better-off urban households and acute deprivation among rural and urban poor.

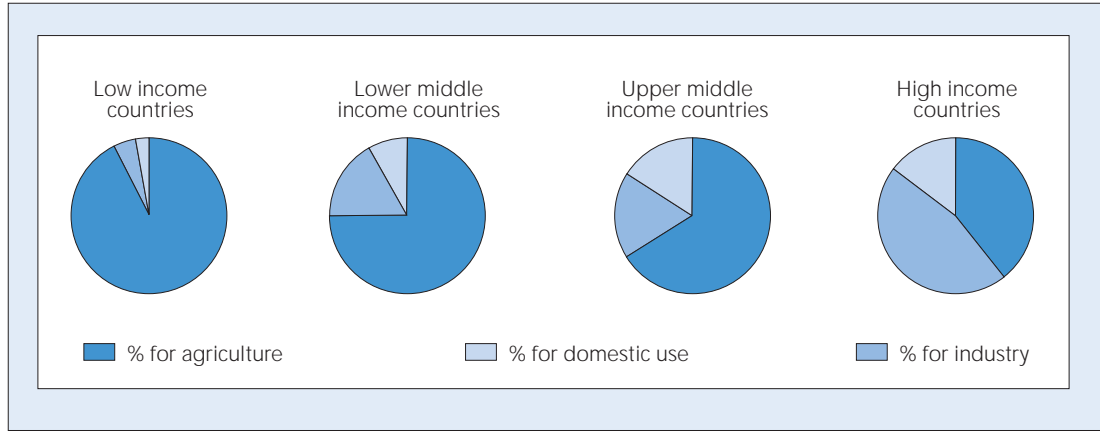
Competing uses of water

Water analysts foresee increased competition among water users in meeting the growing demand. They predict that competition will increase among the three largest water users in global terms. Agriculture accounts for about 67% of withdrawals, industry uses 19% and municipal and domestic uses account for 9%.¹⁰ Analysts foresee that these uses will continue to draw from the water needed to sustain natural systems. In dry climates, evaporation from large reservoirs, estimated at close to 5% of total water withdrawals, may also be a significant consumptive use of water.¹¹

In 1990 over a billion people had access to less than 50 litres of water a day.

Regional trends vary widely as shown in Figures 1.1 and 1.2. Despite increasing urbanisation in Africa, Asia and Latin America, agriculture is the dominant water user in these regions, accounting for approximately 85% of all water used. In all regions of the world except Oceania, domestic or household water consumption accounts for less than 20% of water use.¹² In Africa, Central America and Asia, this is nearer to 5%. In the more developed regions of Europe and North America, industry is the major water consumer. The water use breakdown in a specific country influences where water demand management opportunities exist.

Figure 1.1: Annual fresh water withdrawals as a percentage of total resources withdrawn (1996)



Source: World Bank 1999a.

For many water-stressed countries that are industrialising, and that have large urban populations, the present water crisis often revolves around industrial and domestic water supply and sanitation. This is evident in the significant trend over the past few decades towards diverting water from agricultural to municipal and industrial uses. As this is happening in the context of an overall increase in withdrawals, it will lead

to increased competition for water, unless more efficient water use in both sectors accompanies the transition from agricultural to industrial based economies.¹³

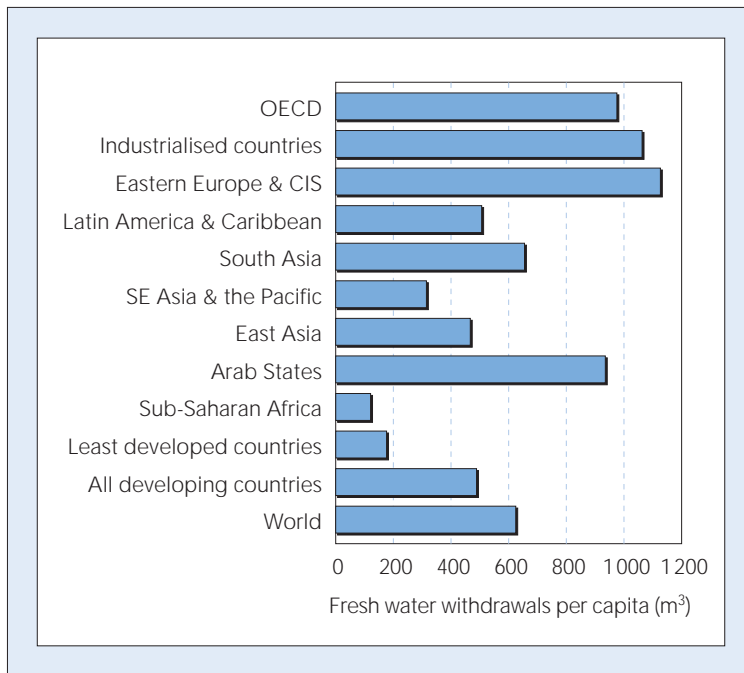
There are additional challenges. To meet food requirements, water used in agriculture may have to increase 15 to 20% by 2025 even with improvements in irrigation efficiency and agronomic potential.¹⁴ In addition to increasing food production in the face of water stress, distribution, equitable access, purchasing power and poverty are central issues in meeting food demand.

Beyond competing human demands, water for nature is an essential consideration. The fresh water ecosystems that provide the livelihoods of the world's riverine communities and many other goods and services to our societies depend on water. Arresting, and where possible reversing, the accelerating trend to increasing degradation of many of the world's watersheds caused by human activity have emerged as an urgent priority.

Availability and quality of water

Rainfall and other sources of freshwater (rivers, lakes, groundwater) are unevenly distributed around the world and are not

Figure 1.2: Annual fresh water withdrawals per capita average (1987-95)



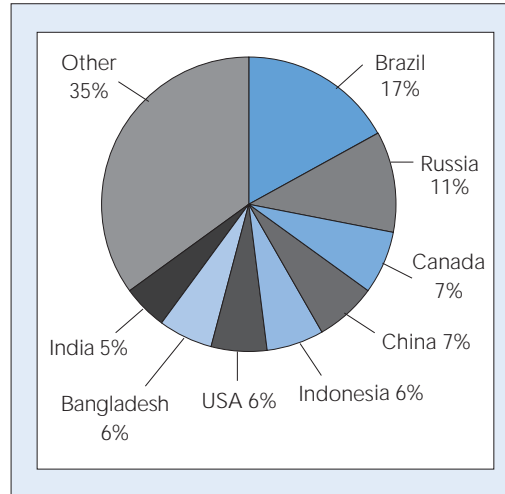
Source: UNDP, 1999.

always located where human water demand arises. Pollution threatens surface and ground water sources and may make them unfit for many uses, or require expensive treatment. Pollution is especially serious where ground water resources are over-exploited and suffer from reduced natural rates of recharge due to deforestation, land use changes and urbanisation.

Fully one third of the countries in water-stressed regions of the world are expected to face severe water shortages this century, and within these regions there are great disparities in access to fresh water. Not surprisingly, a significant number of less developed countries, including regions of India and China, are facing severe shortages.¹⁵ With population growth, the number of countries in this category is increasing, and by 2025 there will be approximately 6.5 times as many people – a total of 3.5 billion – living in water-stressed countries.¹⁶ Figures 1.3 and 1.4 show the distribution of world fresh water resources and selected water stressed countries. The uneven distribution of water supply means that countries may have water surplus and water deficit regions.

Not only surface water is under pressure. The growing rate of extraction of fresh water from rivers and lakes is matched by increasing extraction of ground water, with many aquifers now seriously depleted. The volume of ground water withdrawal, primarily for irrigation but also for municipal and industrial use, exceeds long-term recharge rates. In many parts of India, Pakistan and China, the water table is sinking at the rate of one to two meters a year.¹⁷

Climate change can also affect the seasonal distribution of rains and water availability. Studies and modelling exercises reviewed by the Commission, including those by the

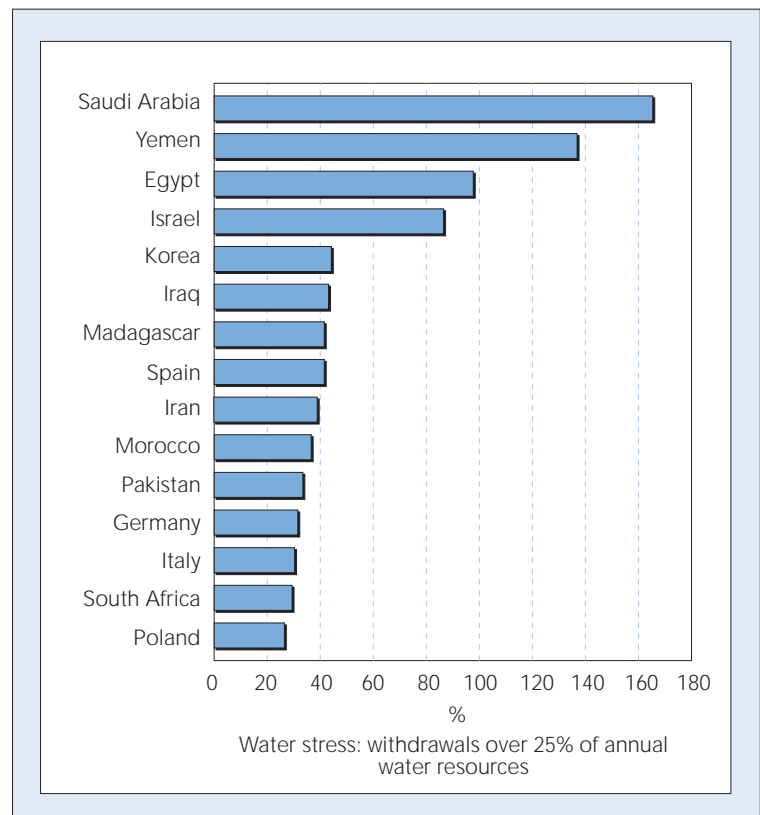


Source: Gleick, 1998.

Figure 1.3: Distribution of the world's water

Intergovernmental Panel on Climate Change (IPCC), strongly suggest that global warming trends could significantly increase the variability of weather patterns.¹⁸ Results could include a decline in rainfall in

Figure 1.4 : Selected water stressed countries



Source: Raskin et al, 1995.

arid and semi-arid regions, and an increase in seasonal variations in rainfall around the globe over the next 50 to 100 years.

Development and Large Dams

River basins are renowned as the cradles of civilisation and cultural heritage. Ancient and modern communities alike have depended on rivers for livelihood, commerce, habitat and the sustaining ecological functions they provide. Throughout history alterations to rivers – natural or human generated – have affected riverine communities in one way or another.

The earliest evidence of river engineering is the ruins of irrigation canals over eight thousand years old in Mesopotamia. Remains of water storage dams found in Jordan, Egypt and other parts of the Middle East date back to at least 3000 BC.

Historical records suggest that the use of dams for irrigation and water supply became more widespread about a thousand years

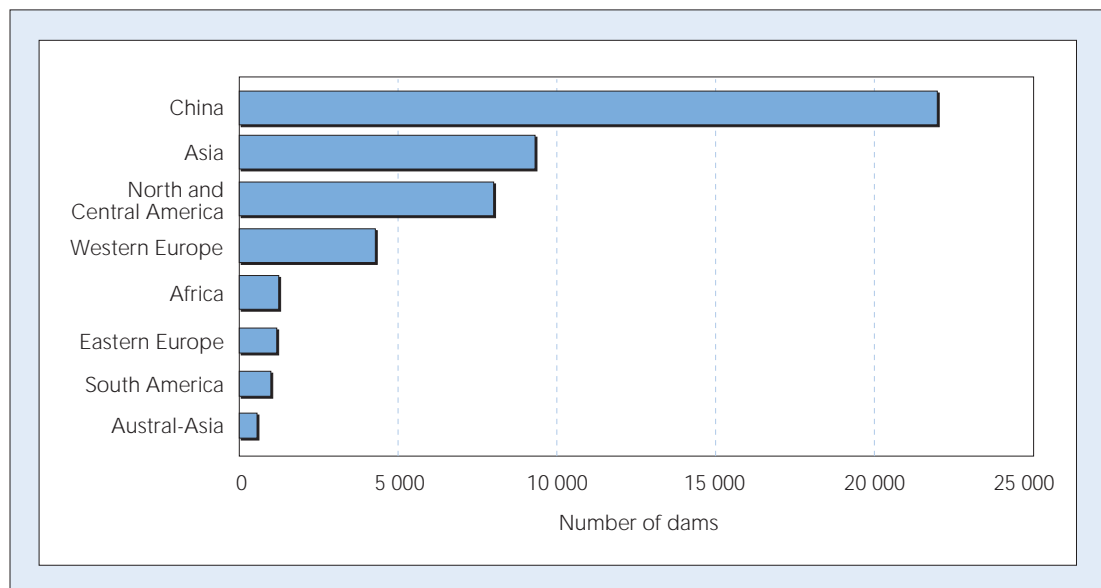
later. At that time, dams were built in the Mediterranean region, China and Meso America. Remains of earth embankment dams built for diverting water to large community reservoirs can still be found in Sri Lanka and Israel.¹⁹ The Dujiang irrigation project, which supplied 800 000 hectares in China, is 2 200 years old.²⁰ Dams and aqueducts built by the Romans to supply drinking water and sewer systems for towns still exist today.

The first use of dams for hydropower generation was around 1890. By 1900, several hundred large dams had been built in different parts of the world, mostly for water supply and irrigation.

Dams in the 20th century

The last century saw a rapid increase in large dam building. By 1949 about 5 000 large dams had been constructed worldwide, three-quarters of them in industrialised countries. By the end of the 20th century, there were over 45 000 large dams in over 140 countries.²¹

Figure 1.5:
Regional
distribution of
large dams at the
end of the 20th
century

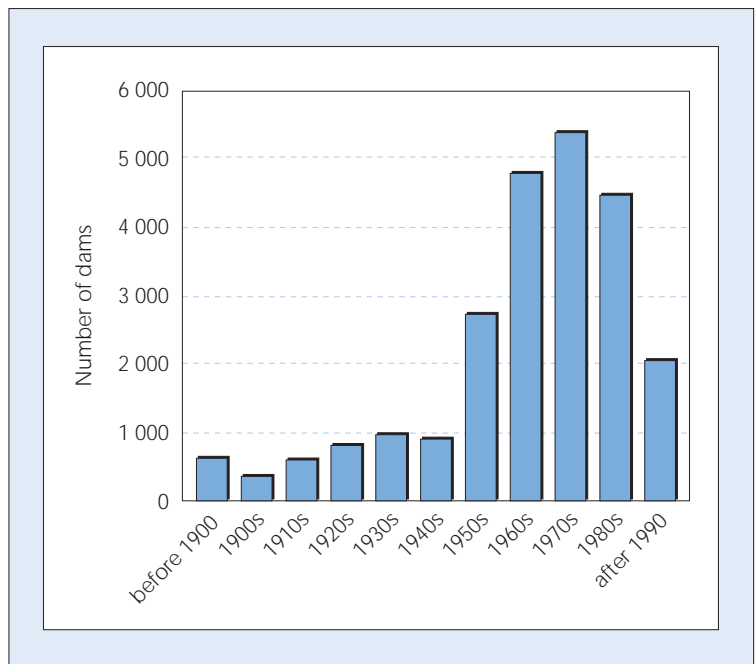


Source: WCD estimates based on ICOLD, 1998 and other sources (See Annex V).

The period of economic growth following the Second World War saw a phenomenal rise in the global dam construction rate, lasting well into the 1970s and 1980s. At its peak, nearly 5 000 large dams were built worldwide in the period from 1970 to 1975. The decline in the pace of dam building over the past two decades has been equally dramatic, especially in North America and Europe where most technically attractive sites are already developed. The average large dam today is about 35 years old.

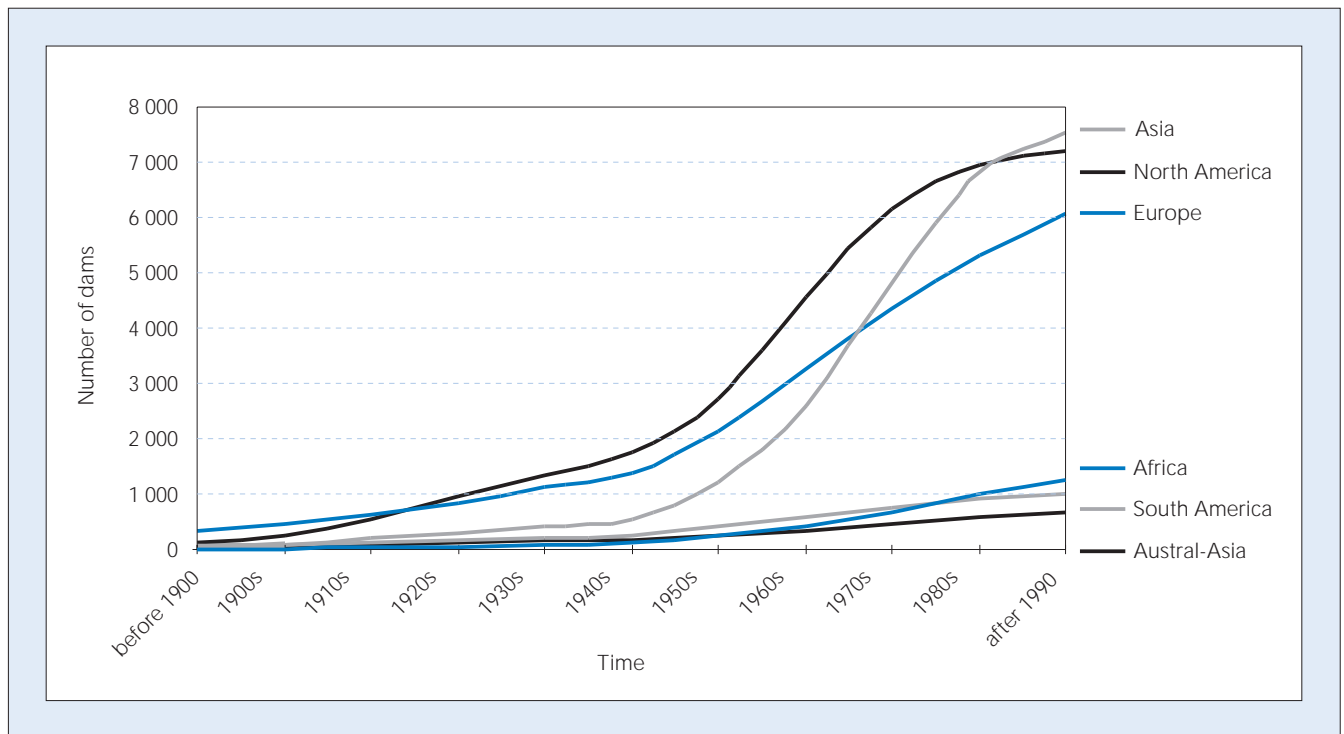
The top five dam-building countries account for nearly 80% of all large dams worldwide. China alone has built around 22 000 large dams, or close to half the world's total number. Before 1949 it had only 22 large dams. Other countries among the top five dam building nations include the United States with over 6 390 large dams; India with over 4 000; and Spain and Japan with between 1 000 and 1 200 large dams each.

Figure 1.6: Construction of dams by decade (1900-2000)



Source: ICOLD, 1998. Note: Information excludes dams in China.

Figure 1.7: Dams constructed over time by region (1900-2000)



Source: ICOLD, 1998. Note: Information excludes the time-trend of dams in China.

Figure 1.5 shows the proportional distribution of large dams in different regions of the world. Approximately two thirds of the world's existing large dams are in developing countries. Figures 1.6 and 1.7 show the cumulative and time-line trends in the construction of large dams in the last century. The time-trend figures exclude data on most of the dams in China and therefore differ slightly from the trends described in the text.

Current regional focus for large dam construction

Construction of large dams peaked in the 1970s in Europe and North America. Today most activity in these regions is focused on the management of existing dams, including rehabilitation, renovation and optimising the operation of dams for multiple functions. An estimated 1 700 large dams have been under construction in other parts of the world in the last few years. Of this total, 40% are reportedly being built in India (see Table 1.1 and Annex V for details).

Since average construction periods generally range from 5 to 10 years, this indicates a worldwide annual average of some 160 to 320 new large dams per year.

Table 1.1: Dams currently under construction

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 60m)	Irrigation, multipurpose

Sources: ICOLD, 1997; *International Journal of Hydropower and Dams*, 2000; WCD India Case Study, 2000; Japan Dam Almanac, 1999, National Register of Large Dams for India cited in WCD India Case Study.

Decommissioning of large dams

The end of the 20th century saw the emergence of another trend relating to large dams – decommissioning dams that no longer serve a useful purpose, are too expensive to maintain safely, or have unacceptable levels of impacts in today's view. Momentum for river restoration is accelerating in many countries, especially in the United States where nearly 500 dams, mainly relatively old, small dams have been decommissioned. Since 1998, the decommissioning rate for large dams has overtaken the rate of construction in the United States.

Experience in North America and in Europe shows that decommissioning dams has enabled the restoration of fisheries and riverine ecological processes. However, dam removals without proper studies and mitigation actions cause public concerns and environmental problems. These include negative impacts on downstream aquatic life due to a sudden flush of the sediments accumulated in the reservoir. Where there has been industrial or mining activity upstream, these sediments may be contaminated with toxic substances. Another option is to open the floodgates of dams where this is possible, either as a form of decommissioning, or to allow natural river flows and unrestricted fish passage at critical times of the year. While decommissioning efforts in the United States and France have received public support thus far, there may be local opposition where changes in the flow and water levels affect services previously provided by the dam, or where development has taken place around the reservoir and downstream.

There is comparatively little experience with the removal of larger dams. The bigger the dam, the more problems decommission-

ing or removal are likely to face, and the more expensive they are likely to be. More studies are needed to address the costs, benefits and impacts of decommissioning as the stock of dams ages and choices must be made between refurbishing and decommissioning.

Large Dams as Instruments of Development

Dams have been promoted as an important means of meeting perceived needs for water and energy services and as long-term, strategic investments with the ability to deliver multiple benefits. Some of these additional benefits are typical of all large public infrastructure projects, while others are unique to dams and specific to particular projects.

Regional development, job creation and fostering an industry base with export capability are most often cited as additional considerations for building large dams. Other goals include creating income from export earnings, either through direct sales of electricity, or by selling cash crops or processed products from electricity intensive industry such as aluminium refining.

Water-rich countries such as Canada, Norway, Brazil and parts of Russia have developed large dams for hydropower generation where suitable sites were available. Governments in semi-arid countries such as South Africa, Australia and Spain have tended to build dams with large storage capacity to match water demand with stored supply, and for security against the risk of drought. For example, in Spain – one of the top five dam-building countries – rainfall is highly variable between seasons and from year to year.

In East and Southeast Asia, during the monsoon season, rivers swell to over 10

Table 1.2: Estimated annual investment in dams in the 1990s (\$US billion per year)

	Developing countries	Developed countries	Total
Dams for hydro power	12-18	7-10	19-28
Dams for irrigation	8-11	3-5	13-18
Dams for water supply	1.5		
Dams for flood control	0.5-1.0		
Total	22-31	10-15	32-46

Source: WCD Thematic Review III.2, Financing Trends. Note that these figures include generating installations for hydropower dams but not canals and piped distribution systems served by irrigation and water supply dams.

times the dry season flow. In these settings dams have been constructed to capture and store water during wet seasons for release during dry seasons.

Large dams require significant financial investments. Estimates suggest a worldwide investment of at least two trillion US dollars in the construction of large dams over the last century. During the 1990s, an estimated \$32-46 billion was spent annually on large dams, four-fifths of it in developing countries.²² Of the \$22-31 billion invested in dams each year in developing countries, about four-fifths was financed directly by the public sector.

Today the world's large dams regulate, store and divert water from rivers for agricultural

Dams are promoted as an important way to meet water and energy needs and support economic development.

Box 1.2: Types of large dams

There are various definitions of large dams. The International Commission on Large Dams (ICOLD), established in 1928, defines a large dam as a dam with a height of 15m or more from the foundation. If dams are between 5-15m high and have a reservoir volume of more than 3 million m³, they are also classified as large dams. Using this definition, there are over 45 000 large dams around the world.

The two main categories of large dams are reservoir type storage projects and run-of-river dams that often have no storage reservoir and may have limited daily pondage. Within these general classifications there is considerable diversity in scale, design, operation and potential for adverse impacts.

Reservoir projects impound water behind the dam for seasonal, annual and, in some cases, multi-annual storage and regulation of the river.

Run-of-river dams (weirs and barrages, and run-of-river diversion dams) create a hydraulic head in the river to divert some portion of the river flows to a canal or power station.

production, human and industrial use in towns and cities, electricity generation, and flood control. Dams have been constructed to a lesser extent to improve river transportation and, once created for other purposes, the reservoirs of many large dams have been used for recreation, tourism, and aquaculture.

Figure 1.8 shows that about one third of large dams serve two or more purposes. Recent trends have favoured multi-purpose dams. As the figure shows, there is considerable regional variation in the functions served by large dams and these functions have also changed over time.

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 and South America, whereas single-purpose water supply projects dominate in Austral-Asia. North America

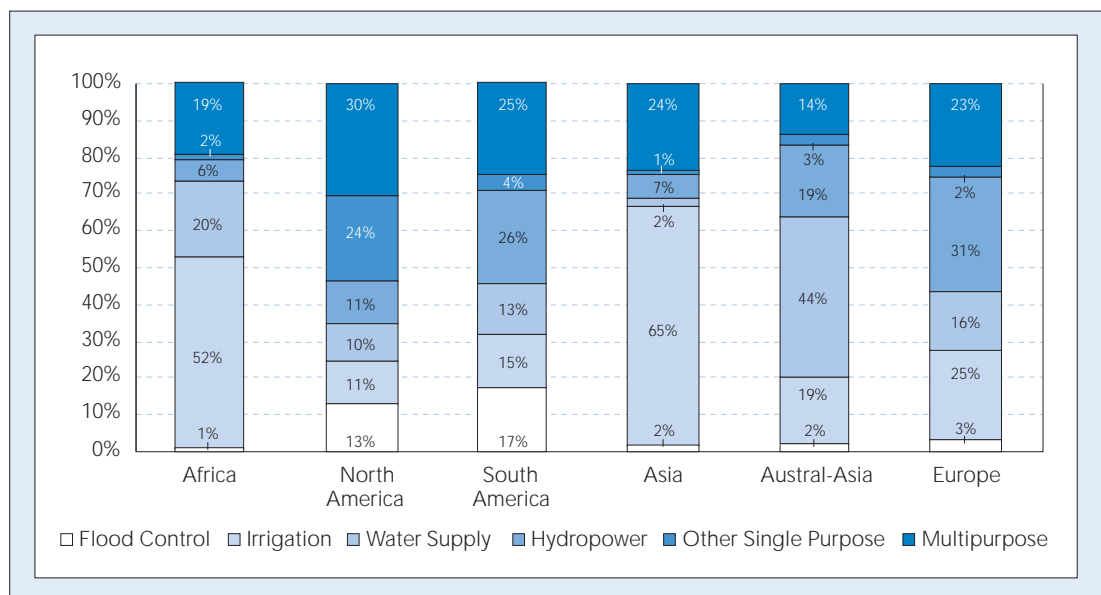
has a relatively even spread of large dam functions. All other potential purposes, including recreation and navigation, were found in less than 5% of projects. Overall, the proportional share of irrigation dams and multi purpose dams has been increasing over the last 20 years, while the share of hydropower dams has been decreasing.

Irrigation water supplied from large dams

Irrigation is the single largest consumptive use of fresh water in the world today. It is linked to food production and food security. About one fifth of the world's agricultural land is irrigated, and irrigated agriculture accounts for about 40% of the world's agricultural production.²³

The total area irrigated expanded dramatically during the first years of the green revolution in the 1960s, increasing yields and bringing down food prices. From 1970 to 1982, global growth in the irrigated area slowed to 2% a year. In the post green revolution period between 1982 and 1994 it declined to an annual average of 1.3%.²⁴

Figure 1.8:
Distribution of
existing large
dams by region
and purpose



Source: Adapted from ICOLD, 1998 (See Annex V).

Half the world's large dams were built exclusively or primarily for irrigation, and an estimated 30 to 40% of the 268 million hectares of irrigated lands worldwide rely on dams. Discounting conjunctive use of ground water and surface water, dams are estimated to contribute to at most 12-16% of world food production. Ground water irrigation typically has higher yields, for a given amount of water, than surface water irrigation because of better control of the resource at farm level.²⁵

Four countries – China, India, United States and Pakistan account for more than 50% of the world's total irrigated area. As Figure 1.9 shows, the scale and significance of large dams for irrigation varies significantly from country to country in terms of the percentage of agricultural land irrigated, and the proportion of the irrigation water supplied from large dams. Dams supply the water for almost 100% of irrigated production in Egypt – most coming from the Aswan High Dam – while in Nepal and Bangladesh dams provide only 1% of irrigation water. In the two countries with the largest irrigated areas – India and China – official statistics suggest large dams supply approximately 30 to 35% of irrigation water,

with the balance coming mainly from ground water sources. There is some controversy in calculating the percentage of food production attributable to dams, and particularly on the methods used to account for conjunctive use of surface and ground water.²⁶

Unsustainable irrigation practices have affected more than a fifth of the world's irrigated area in arid and semi-arid regions. As a result, soil salinity and waterlogging either make agriculture impossible, or limit yields and the types of crop that can be grown. In other regions, over-use of tubewells has depleted ground water aquifers, lowering water tables and making extraction increasingly expensive and especially difficult for small-holders. The absence of effective policies on conjunctive use of ground water and surface water resources is one of the most important concerns.

Water for industrial use and urban centres

Globally, urban water consumption accounts for 7% of total freshwater withdrawals from rivers, and 22% from lakes.²⁷ Many reservoirs

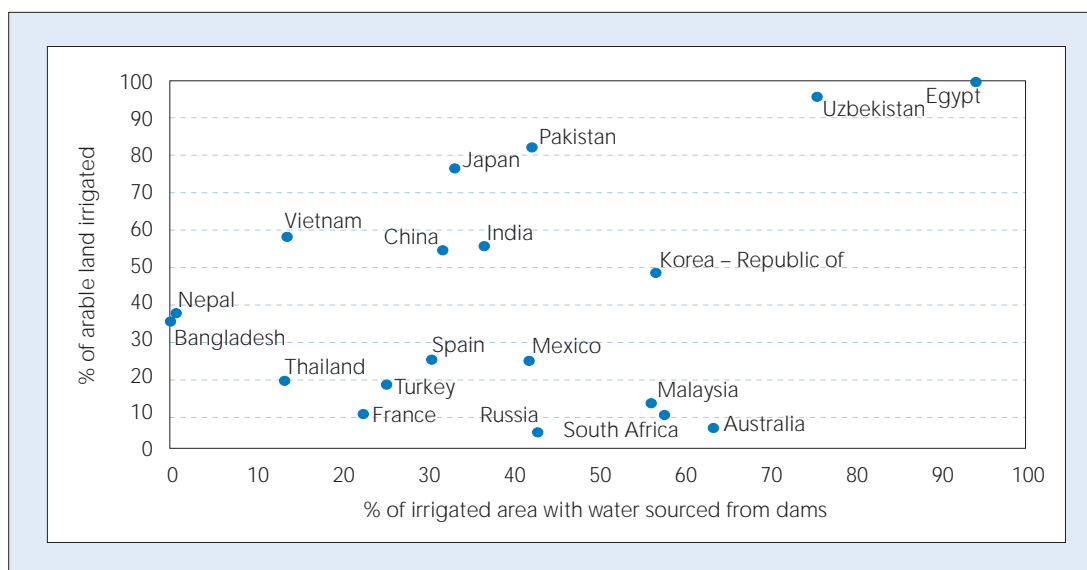


Figure 1.9: Agricultural land irrigated from dams

Source: WCD Thematic Review IV.2 Irrigation Options, Section 1.3.



were built to provide a reliable supply of water to meet rapidly growing urban and industrial needs, especially in drought-prone regions where natural ground water sources and existing lakes or rivers were considered inadequate to meet all needs.

Globally, about 12% of large dams are designated as water supply dams. About 60% of these dams are in North America and Europe.

The extent to which cities rely on dams and reservoirs for urban and industrial water varies greatly even within countries. In the Saxony region of Germany, reservoirs provide 40% of the water supplied to two million people, while Los Angeles derives 55% of its water supply from local ground water resources and 37% from a system of reservoirs and pipelines that bring water from more distant locations. Ho Chi Minh City in Vietnam gets 89% of its water from surface sources, whereas Hanoi gets 100% from ground water.²⁸

Electricity generation for the national grid

Electricity generation is an important reason for building large dams in many countries, either as the primary purpose, or as an additional function where a dam is built for

other purposes. Over the last 22 years, global electricity production has more than doubled, though access is highly skewed between and within countries.²⁹

Hydropower currently provides 19% of the world's total electricity supply and is used in over

150 countries. It represents more than 90% of the total national electricity supply in 24

countries and over 50% in 63 countries. About a third of the countries in the world currently rely on hydropower for more than half of their electricity needs. Five countries – Canada, United States, Brazil, China and Russia – account for more than half the world's hydropower generation. Between 1973 and 1996 hydropower generation in non-OECD countries grew from 29 to 50% percent of world production, with Latin America increasing its share by the greatest amount in that period.³⁰

Hydropower has been perceived and promoted as a comparatively clean, low-cost, renewable source of energy that relies on proven technology. Except for reservoir evaporation, it is a non-consumptive use of water. Once built, hydropower, like all renewable sources, is considered to have low operating costs and a long life, particularly for run-of-river projects and reservoir projects where sedimentation is no concern. In the past, hydropower was especially attractive to governments with limited fossil fuel resources, who would otherwise have had to import fossil fuels to sustain power generation. At the global scale, current levels of hydropower generation offset 4.4 million barrels of oil-equivalent (thermal electric generation) a day, roughly 6% of the world's oil production.

Protecting against floods

While natural floods have many beneficial functions they also pose a threat to life, health, livelihoods, and property. They remain among the world's most frequent and damaging disasters. Floods affected the lives, on average, of 65 million people between 1972 and 1996, more than any other type of disaster, including war, drought and famine³¹. During the same period, an estimated 3.3 million people were left homeless every

Hydropower provides 19% of world's total electricity supply with 24 countries depending on it for more than 90% of their supply.

year as a result of floods. In terms of its regional significance, flood-related economic losses in Asia exceeded those in North America and Europe between 1987 and 1996.³²

About 13% of all large dams in the world – in more than 75 countries – have a flood management function.³³ Although dams have historically been extensively used as a defence against floods, recent approaches see flood protection as more than building defences against rising waters. For instance, reporting on the 1998 flood, Chinese authorities acknowledged that its severity was partly due to long-term environmental degradation and heavy logging throughout the affected watersheds.³⁴ There are also cases where dams have created or worsened floods due to dam breaks, poor reservoir operation and changed downstream sedimentation patterns that reduce river channel capacity.

The last two decades have seen a thorough re-evaluation of what constitutes the appropriate mix of prevention, defence and mitigation against flood disasters. As a result, the focus on controlling floodwaters, dominant in the 1950s–1960s, has lost ground to more environmentally based and integrated approaches. The reasons include frustration at floods occurring despite structures being in place, the high cost of engineering solutions, and a better understanding of how natural systems work.

Problems Associated with Large Dams

While dams have contributed to economic growth in the 20th century, the services they provide have come at a cost. This section gives an overview of the problems associated with large dams.

Physical transformation of rivers

Large dams have fragmented and transformed the world's rivers. The World Resources Institute (WRI) found that at least one large dam modifies 46% of the world's 106 primary watersheds.³⁵ The extent to which river flows have been changed varies around the world. The United States and the European Union regulate the flow of 60–65% of the rivers in their territories, though the amount varies from basin to basin. Spain's 53 km³ of storage behind large dams regulates 40% of its river flow, varying from 71% in the Ebro river basin, to 11% in the basins on the Galicia coast.³⁶ In Asia, just under half the rivers that are regulated have more than one large dam.³⁷

Large dams have fragmented and transformed the world's rivers, modifying 46% of primary watersheds.

The modification of river flows on trans-boundary rivers has particular implications. There are 261 watersheds that cross the political boundaries of two or more countries³⁸. These basins cover about 45% of the earth's land surface, account for about 80% of global river flow and affect about 40% of the

Box 1.3: Changing physical attributes and impacts of large dams

The volume of the reservoir relative to the annual river flow is important in relation to the purpose of the dam and how it is operated. It is also a major factor in the scale of the ecological effects. The surface area of the reservoir, or the area flooded, points to the potential resettlement impact. The majority of large dams have reservoir surface areas of 0-1 km² (more than 60%). This includes run-of-river dams with no reservoir. A small percentage of dams (2%) have reservoir areas greater than 100 km².

During the first half of the 20th Century, the average height, reservoir volume and reservoir area increased in all regions. The average height of new dams was 30-34 meters from 1940 through 1990, but has increased to about 45 meters in the 1990's, largely due to trends in Asia. The average reservoir area dramatically increased from 1945 into the 1960's to 50 km²; declined through the 1980's to an average of 17 km²; and has again increased in the 1990's to around 23 km².

Source: WCD analysis of ICOLD, 1998

The construction of large dams has led to the displacement of some 40 to 80 million people worldwide.

world's population.³⁹ Issues and concerns facing riparian countries in these basins range from water quality to flow volumes.

The aggregate storage capacity of large dams, based on dam design, is about 6 000 km³.⁴⁰ Assuming that half the design storage is achieved in reality, the aggregate real storage capacity of large dams globally is similar to total freshwater withdrawals estimated at around 3 800 km³.⁴¹

An estimated 0.5–1% of the total fresh water storage capacity of existing dams is lost each year to sedimentation in both large and small reservoirs worldwide.⁴² This means that 25% of the world's existing fresh water storage capacity may be lost in the next 25 to 50 years in the absence of measures to control sedimentation. This loss would mostly be in developing countries and regions, which have higher sedimentation rates.

Riverine ecosystems impacts

Growing threats to the ecological integrity of the world's watersheds come from rising populations, water pollution, deforestation, withdrawals of water for irrigation and municipal water supply and the regulation of water flows resulting from the construction of large dams. Among the many factors leading to the degradation of watershed ecosystems, dams are the main physical threat, fragmenting and transforming aquatic and terrestrial ecosystems with a range of effects that vary in duration, scale and degree of reversibility.

The watersheds of the world are the habitat of 40% of the world's

fish species, and provide many ecosystem functions ranging from nutrient recycling and water purification to soil replenishment and flood control. At least 20% of the world's more than 9 000 fresh water fish species have become extinct, threatened or endangered in recent years.⁴³

Fish are a critical source of animal protein for more than 1 billion people. In Africa, fish protein is 21% of the total animal protein in the diet, and in Asia it is 28%. While rivers supply about 6% of fish protein consumed by humans globally, it is often 100% of the supply for many inland riverine communities.

Ecosystem transformations do not only occur in the upper, lower and mid-reaches of watersheds, they also impact on river estuaries, which are frequently complex ecosystems. Closing the mouths of major rivers, salt intrusion, destruction of mangroves and loss of wetlands are among the many issues at stake.

Social consequences of large dams

While many have benefited from the services large dams provide, their construction and operation have led to many significant, negative social and human impacts. The adversely affected populations include directly displaced families, host communities where families are resettled, and riverine communities, especially those downstream of dams, whose livelihood and access to resources are affected in varying degrees by altered river flows and ecosystem fragmentation. More broadly, whole societies have lost access to natural resources and cultural heritage that were submerged by reservoirs or rivers transformed by dams.

The construction of large dams has led to the displacement of some 40 to 80 million



people worldwide, as shown in Chapter 4.⁴⁴ Many of them have not been resettled or received adequate compensation, if any.⁴⁵ Between 1986 and 1993, an estimated 4 million people were displaced annually by an average of 300 large dams starting construction each year.⁴⁶ These figures only give an idea of the size of the problem, since there are enormous variations from case to case.

The scale and range of social issues encountered in the river basins altered by large dam construction vary from region to region. The number of people deriving their livelihood directly from the river and its ecosystem, and the overall population density in the river basin, gives an indication of the potential impacts. As table 1.3 illustrates, population density can vary significantly.

The world's two most populous countries – China and India, have built around 57% of the world's large dams – and account for the largest number of people displaced. In the late 1980s China officially recognised some 10.2 million people as 'reservoir resettlers', though other sources suggest the figure may be substantially higher.⁴⁷ Large dams and reservoirs already built in the Yangtze basin alone have led to the relocation of at least 10 million people.⁴⁸ In India, estimates of the total number of people displaced due to large dams vary from 16 to 38 million people.⁴⁹

Resettlement caused by large dams has been a significant part of total resettlement for all public infrastructure development. In China, large dams are estimated to have displaced an estimated 27% of all people displaced by development projects (the total includes people displaced by urban expansion, roads and bridges).⁵⁰ In India the figure is 77% (this total excludes people displaced by urban development).⁵¹ Among

World Bank funded projects involving displacement, dams and reservoirs accounted for 63% of people displaced.⁵² These figures are only estimates and do not include people displaced by other aspects of the projects such as canals, powerhouses, project infrastructure and associated compensatory measures such as bio-reserves.

These are not the only problem areas and Chapters 2 to 6 examine other reasons for dissatisfaction.

Understanding the Large Dams Debate

The huge growth of dam building in the 20th century took place against a backdrop of tremendous political, economic and technical transformations – while the world's population grew from 1.65 billion in 1900, to 6 billion by the end of the century. The last three decades especially have seen dramatic and wide-reaching changes in perceptions of development and concepts of interdependence with other people and with nature. This dynamic of change is also redefining the roles that governments, civil society and the private sector play in water

The last three decades especially have seen dramatic and wide-reaching changes in perceptions of development and concepts of interdependence with other people and with nature.

Table 1.3: Population density of selected river basins

Country	River basin	Population density (person/km ²)
China	Yangtze	224
Brazil	Tocantins/Amazon	6
India	Ganges	375
Norway	Glomma and Laagen	26
South Africa	Orange River Basin	12
Thailand	Mun/Mekong	78
United States	Columbia/Snake	9
Zimbabwe and Zambia	Zambezi	35

Source: Revenga et al, 1998.

As dam building accelerated after the 1950's, opposition to dams became more widespread, vocal and organised.

and energy resource development planning. And while the wider transformations have spurred the debate on large dams, that debate itself has become a major catalyst of change.

We begin by looking at the genesis of opposition to large dams from the perspective of social and environmental movements, before considering the main issues in the debate that the meeting in Gland Switzerland handed down to the Commission.

Genesis of the opposition to dams

In the previous section we saw that dam building has a long history. Conflicts too have a long history, though it is only in recent years that they have come to command wider attention. Conflicts over water and dams are probably as ancient as dam building itself. In medieval England, boat owners opposed millers blocking rivers to create millponds to turn their water wheels.



Records from the 17th century tell of Scottish fishermen trying to destroy a newly completed weir. In the 1910s, conservationist John Muir unsuccessfully lobbied public opinion and the US Congress against the building of O'Shaughnessy dam in Yosemite National Park in California.

Populations affected or threatened by dams have fiercely resisted dam building throughout the last century. Because they were often isolated, without help from outside sympathisers, affected people's resistance to dams often went unnoticed internationally and, in some cases, the states concerned used intimidation and violence to suppress it. Eight people died and over 30 were injured when colonial government forces fired on Tonga people resisting removal to make way for the Kariba dam reservoir. But international attention focused on the mission to rescue wildlife stranded in the impoundment area.⁵³ At around the same time in Mexico, the Papaloapan River Commission set fire to the houses of indigenous Mazatecs who refused to move for the Miguel Aleman dam. In 1978 police killed four people when they fired at an anti-resettlement rally at Chandil dam in the state of Bihar in India. In Nigeria in April 1980, police fired at people blocking roads in protest against the Bakolori dam.⁵⁴ And in 1985, 376 Maya Achi Indians, most of them women and children, were murdered in the course of clearing the area to be submerged by the Chixoy dam in Guatemala⁵⁵.

As dam building accelerated after the 1950's, opposition to dams became more widespread, vocal and organised. Conservationists in northern countries, especially in the United States, led the first notable successes for campaigns against large dams.⁵⁶ There, conservationists were able to stop

the 175 metre-high Echo Park dam on a tributary of the Colorado River in the 1950s and two dams planned for the main stem of the Colorado River in the Grand Canyon in the following decade. A series of new laws (notably the 1969 National Environmental Protection Act, and the 1974 Endangered Species Act), together with growing public concern about environmental conservation, public subsidies and budget deficits served increasingly as grounds for halting expensive dams, canals and channelisation projects through the 1970s and early 1980s.

Over the past thirty years, the alliance of northern activist groups (environmental and human rights groups) with NGOs and affected groups' associations in the South has resulted in more vigorous and more coordinated opposition to dams worldwide. In many cases, the strength of these coalitions has had a major impact on dam-related planning and policy and at the level of individual dams. As a result of these concerted pressures the planning process, which until the 1970s was the restricted preserve of government agencies, engineers and economists, began to include environmental impact assessments and some public reviews. By the late 1980s environmentalists and sociologists began to play a more important role in the planning process, and by the mid-1990s the involvement of affected peoples and NGOs in the process became more significant.⁵⁷

It is only fair to note that popular action has also supported dams. Farmers in Madrid recently marched to demand more water and more dams for irrigation.

The last few decades have seen a number of significant policy steps in response to civil society demands and changing values. The World Bank offers a good illustration. It is a

priority target of dam critics, as it is often the first and single largest financier of large dams. In 1982, the Bank adopted an internal directive on indigenous peoples. Revisions of policies on resettlement and environmental assessment are other important milestones. More recently, in 1993, the World Bank established an appeals mechanism, the Inspection Panel. This allows citizens adversely affected by Bank funded projects to file claims regarding violations of its policies, procedures and loan agreements. At the same time the Bank promoted more flexible approaches to information disclosure.⁵⁸

Often, these policy reforms have been closely related to the impacts of resistance from affected groups and international NGO campaigns around individual projects. In 1973-77, the resistance of indigenous peoples to four dams along the Chico River in the Philippines led the World Bank to withdraw from the project and resulted in the government postponing it indefinitely.⁵⁹ Other important milestones include the World Bank's withdrawal from the Sardar Sarovar project in India in 1993, and then from Arun III in Nepal in 1995 (although in the latter case public pressure may not have been the deciding factor)⁶⁰. Sardar Sarovar, still on the agenda despite the World Bank withdrawal, continues to be the focus of local opposition and international support. More recent examples of campaigns include the Three Gorges dams in China, the Pak Mun in Thailand, Ilisu in Turkey, Ralco in Chile, Epupa in Namibia, the Lesotho Highlands Water



The last few decades have seen a number of significant policy steps in response to civil society demands and changing values.



Project involving Lesotho and South Africa, and Nam Theun II in Laos.

As earlier sections of this chapter showed, the pace of dam construction has slowed significantly in recent years. This is partly because industrialised countries have used most of their attractive sites, and

because of other factors, such as shifts in dam financing from public to private sources, matched with the decline in donor funding and increasing costs of large dams. However, it also reflects the effectiveness of anti-dam strategies developed by environmental and human rights activist groups worldwide.

One frequently asked question is why the debate focuses so centrally on dams. The issues being debated, such as environmental sustainability, equitable development, transparent and participatory decision-making also apply to other large infrastructure projects and can only be addressed in the context of broad societal change.

The view that environmental and human rights groups have singled out large dams as their main target is misleading. One assessment found that, of the 36 World Bank supported projects that NGO activist groups have targeted with some success, only 12 are dam projects, compared to 14 forest and natural resource management projects, five mines or industrial management projects, and two urban infrastructure projects.⁶¹ In fact, large dams, like many other industrial, commercial, and governmental facilities are increasingly contentious and difficult to site and build, as are hazardous waste decontamination facilities, solid waste landfills,

hospitals, conservation areas, shopping complexes, highways, parking areas, and many more.

If dams are not the only infrastructure projects subject to rising criticism, why do they seem to be often at the centre of controversy, dispute, and even violent confrontation? There are many reasons largely related to the scale and scope of the dams and the impacts.

- Large dams represent major investments, and in some cases may be the largest single investment in a country. These investments are essentially irreversible and often highly politically charged.
- Large dams are generally justified by national or regional macro-economic benefits while their physical impacts are locally concentrated, mostly affecting those within the confines of the river valleys, and along the river reaches. The mismatch of benefits and costs translates easily into confrontational attitudes.
- Resettlement for large dams tends to be on a larger scale than resettlement for other types of physical infrastructure. Roads and thermal power stations can be sited on marginal land whereas dams generally flood rich and fertile agriculture land.
- Those resettled from dam or reservoir sites very often lose not only their homes but also their livelihoods. Relocation in rural settings where good land is already occupied can be problematic.
- Large dams affect critical, life sustaining resources, such as land, fisheries and the quality and allocation of freshwater, an increasingly scarce and coveted resource.
- Lack of adequate and accepted solutions to the social and environmental impacts of large facilities has resulted in increased social mobilisation around these issues.

- The lower than anticipated economic performance of many projects.

These factors aside, the perceived injustice in the distribution of the benefits and impacts, and the increased concern about the environmental implications indicate that the debates, controversies and conflicts surrounding large dams are not about dams alone. They are part of a wider debate about development, a debate where diverging views on the use of natural resources and public financial resources confront each other.

Disaggregating the debate

Clearly the dams debate has many layers and many interconnected issues. The debate is partly about what occurred in the past and continues to occur today, and partly about what may happen in the future if more dams are built – or are not built. The extent to which the debate is driven by social or environmental concerns, or by broader development considerations, varies from country-to-country. The dams debate in the United States, where the rate of decommissioning dams is greater than the rate of construction, is perhaps as intense as, but qualitatively different from, the debate in India which, along with China, is now building more dams than any other country.

The two principal poles in the dams debate, much in evidence at the Gland Workshop in 1997, help to define the range of views on past experience with large dams. The first focuses on the gap between the promised benefits of a dam and what happens on the ground. The review of global experience with dams set out in Chapters 2-6 confirms that these concerns are justified. Dams have often not met their targets.

The other pole looks at the challenges of water and energy development from a

perspective of ‘nation building’ and resource allocation. To its proponents, the answer to the question of past performance is self-evident. Dams have generally performed well as an integral part of water and energy resource development strategies in over 140 nations and, with a few exceptions, dams have provided an indispensable range of water and energy services.

Beyond this rough characterisation, it is possible to disaggregate the debate along a few central themes. The way the debate is structured largely determines how it is conducted at national and international levels.

Performance: costs and benefits

Performance is often measured in terms of whether the project delivered the benefits that were the basis for approval and funding of the project. But there is more to judging performance than this. An assessment of overall performance, or performance over the full life-cycle of a dam, often yields many different results. So too with costs, much depends on how completely costs are internalised, and who bears particular costs compared to how the benefits are shared. There is no easy formula for calculating the costs and benefits to yield a quick and easy judgement on the overall balance.

Environmental impacts and sustainability

At one level, the debate revolves around how to measure the scale of the impacts, whether these impacts can be avoided or successfully mitigated, and whether they are reversible or irreversible. A more fundamen-

Box 1.4: Central issues in the dams debate: past and present

- Performance: costs and benefits
- Environmental impacts and sustainability
- Social impacts and equity
- Economics and finance
- Governance and participation
- Wider development impacts of dams
- Alternatives to dams
- Cross-cutting issues



tal controversy centres on how environmental considerations are valued against immediate human development needs. For communities who depend directly on river resources for their livelihoods, the environment is the basis for meeting their needs. An example is the value placed on biological diversity, or on the ecosystem functions that may be lost when the river flow is regulated. This debate becomes especially heated where other options are available. Other controversies concern wider regional or global environmental impacts, for example whether dams emit greenhouse gases or reduce acid rain, under what

conditions, and to what extent relative to the alternatives. This aspect of the debate extends to whether large dams should be included in climate change protocols, and whether and how dams should be treated in future carbon emission trading schemes.

Social impacts and equity

This includes both the scale of the impacts and the distribution of costs, benefits and impacts, including those borne by relocated families, host communities where families are resettled, and riverine communities affected by the change in river flows and access to resources. Social issues go beyond equity in the distribution of benefits and impacts and relate to fundamental rights. They include:

- the burden placed on indigenous peoples and ethnic minorities and the degree of recognition of their distinctive status;
- the impact on gender and basic human rights; and
- the loss of livelihood and health impacts in rural areas.

Dealing with the legacy left by forced relocation under both authoritarian and democratic regimes and the need to allocate responsibility for redress are other issues in the debate. An issue that has caused a great deal of tension in the past concerns the basis on which trade-offs, such as the potential benefits to many at the cost of hardship for a few, are invoked and decided.

Economics and finance

Controversy also surrounds the limits and the ability of methods for economic assessment to fully capture and reflect the various social and environmental impacts and values. Governments and financial institutions continue to use traditional economic and financial analysis – rate of return, discount rates, sensitivity tests and the exclusion or inclusion of indirect costs – as primary decision criteria. The debate is how adequately these are applied in practice and how they are balanced against other development objectives or criteria. Related issues include the cost recovery levels for all types of dam projects, the implications for subsidised use of water and the equity dimensions of these subsidies.

Governance and participation

The principal considerations related to these issues centre on the transparency and openness of options assessment, and how planning and decision-making processes are conducted. Other issues relate to the methods used to reconcile local or community-led planning and consensus-building processes with more traditional and centralised planning approaches, access to information, and the dominance of single agencies in planning with multiple responsibilities for designing, construction and operating large infrastructure projects. At the heart of the debate on these issues is the degree of involvement of affected people and wider

groups of stakeholders in needs assessment and project-level decision-making. Implementation creates its own set of governance challenges, including whether agreed standards are followed for social and environmental mitigation, compensation and enhancement.

Wider development impacts of dams

Many of the controversial issues go beyond the impact of the project itself and touch upon wider regional or national development choices. Examples include the proportion of the development budget allocated to large dams as opposed to other uses of public funds, the impact of an investment in a dam on the country's debt burden, and competitiveness considerations linked to subsidies. There are also more positive considerations, including the potential of dams to contribute to export earnings.

Alternatives to dams

The degree of even-handedness applied in considering alternatives to large dams is, perhaps, one of the most contested issues. It raises the question of whether dams are selected over other options that may meet the water development or energy objectives at lower cost, or that may offer more sustainable and equitable development benefits. This aspect of the debate extends to whether, and on what basis, dams should be considered complementary to, or mutually exclusive of other options of different scales and types. Whether to give primacy to options such as demand-side management or improving the efficiency of existing supply assets, and under what conditions, are also debated. The options debate connects with the political economy of decision-making, and therefore to the distribution of power and influence within societies. This includes how choices are made between available options, and the extent to which market or other institutional factors create barriers and

incentives for different options that provide the same service.

Cross-cutting issues

A range of cross-cutting issues turn on the role and influence of various public and private sector interests in the planning and decision making process. This includes the roles and influence of industry groups ranging from domestic and international consultants, to developers, contractors and suppliers, and extends to the financial service providers. The financing role is especially critical and includes the multilateral and bilateral development banks, insurers and export credit agencies, as well as the commercial banks. Issues raised in the debate range from harmonising standards for financing dam construction to steps to address corrupt practices that can distort decision-making. There are numerous other cross-cutting issues such as the transboundary implications of dams on shared rivers.

These examples illustrate the terrain, scope and complexity of the debate, and how it has become intertwined with wider development concerns.

Economic development during the first half of the 20th century was dominated by an approach that emphasised harnessing and appropriating water and other natural resources for economic activities. Since the United Nations Charter (1945) and The Universal Declaration on Human Rights (1948), a globally accepted development framework setting out universal goals, norms, and standards has been gradually emerging. These declarations have been augmented over time by the Convention

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Since the United Nations Charter (1945) and The Universal Declaration on Human Rights (1948), a globally accepted development framework setting out universal goals, norms, and standards has been gradually emerging.

Concerning the Protection and Integration of Indigenous and Other Tribal and Semi-Tribal Populations in Independent Countries (1959), the International Covenant on Economic, Social, and Cultural Rights, (1966), the UN Declaration on the Right to Development (1986), and the Rio Declaration on Environment and Development (1992), among others. Together they form the current framework for sustainable human development.



This framework has been widely ratified by the world's nations, although differences emerge in setting priorities and emphases, and in fulfilling, implementing, and resolving conflicts between competing rights. The realisation of these rights presumes recognition of conflicts between competing rights and the setting up of mechanisms for negotiation and conflict resolution. We discuss the development framework as it relates to the WCD's analysis and methodologies later in this chapter, and Chapter 7 presents an approach for designing mechanisms to resolve and negotiate competing rights.

Where international laws, norms and aspirations are reflected in national legal and policy frameworks, a number of obstacles often prevent their translation into reality. These obstacles include lack of political will or incentive, especially where the democratisation process has not reached a level where citizens and civil society organisations are strong enough to influence decision-making. Another major obstacle, especially facing poor countries, relates to the lack of capacity (financial and human resources but also institutional capacity) to

ensure that basic human rights and aspirations are fulfilled for their citizens. Compliance with existing laws and policies is another important issue.

Is there a way forward?

All parties involved in the debate have their own views on what needs to be done to address the problems that they have identified. Some of the main suggestions made by dam critics and proponents in various declarations and statements are as follows.

Dam critics point to:

- the need for more sustainable and appropriate alternatives to dams;
- the imperative for improved transparency, accountability and public participation in the planning of water and energy projects;
- the importance of prior project approval by potentially affected groups;
- the need for protecting and promoting the rights of potentially affected peoples, and for setting in place measures to reduce inequities; and
- the necessity of reparation measures to address the legacy of unfulfilled commitments and unresolved problems.

Dam proponents underline:

- the evolution and change in practices over time;
- the recognised need for social and environmental concerns to be elevated to the same level as safety concerns. (They believe these environmental and social costs must be avoided, or minimised and properly mitigated when they occur.);
- the importance of ensuring that affected people are better off as a result of dam development, and of considering them as

shareholders, partners, and therefore project beneficiaries;

- the imperative of participatory decision-making;
- the need to promote the principles of equity, efficiency and economic viability; and
- the importance of balancing the need for development with the requirement of ensuring environmental sustainability.

This broad taxonomy indicates that there are many areas for potential convergence, especially regarding what needs to be done in the future. All agree on the need:

- to take environmental and social costs of dams more seriously;
- for more systematic consultation with affected people;
- to ensure that affected people are better off as a result of the dam development; and
- to ensure that the costs and benefits of dams are shared more equitably.

However, unresolved issues still separate positions on a number of financial, economic, social, and environmental issues. The most intractable include:

- the extent to which alternatives to dams are viable for achieving various development goals, and whether alternatives are complementary or mutually exclusive;
- the extent to which adverse environmental and social impacts are acceptable;
- the degree to which adverse environmental and social impacts can be avoided or mitigated; and
- the degree to which local consent should govern development decisions in the future.

One of the central problems – and certainly one of the main causes of stalemate in the

debate – is the lack of mutual trust between the key parties involved. For opponents, dams promoters too often agree to new policies and guidelines, but fail to comply with them.

Toward the establishment of the WCD and its mandate

The WCD can trace its roots back to the origins of the dams debate. In addition to the debate, two other related factors painted the backdrop to its conception. The first is the accelerating shift in accepted notions of the appropriate relationship between the State and its citizens. The second is the increased recognition of the negative environmental and social outcomes experienced with large dams. The result has been growing controversy and consequent delays in development decisions.

In Chapter 7, the section on development trends explores the shift in public support away from centralised decisions often taken on the basis of abstract notions of the greater common good. Instead the public is focusing more sharply on notions of equity in the distribution of the costs and benefits of development and participation in decision-making.

Growing disaffection by many groups in society with the way decisions are taken, with the distribution of costs and benefits, and with compliance and recourse mechanisms has provoked growing resistance to large dams and escalating tension and conflicts around individual dam projects. While much of this conflict has centred on the developing world, it nevertheless strikes at the dams industry as a whole. Because many of the most appropriate dams sites in

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the developed world have already been exploited, the future of the industry lies principally in the developing countries, whether the industry itself is based there or in the developed countries. Linked to this are considerations about the image of international companies, their standing in the community, their relationship with shareholders and their reputation for corporate social responsibility.

New approaches are not always well received by developing country governments. They often see them as a case of developed countries, having benefited from cutting corners themselves, turning to insist that

By the early 1990s, it was becoming clear that the cost of controversy could seriously affect future prospects for dams and stall efforts to finance other non-dam water and energy development projects to serve rural or urban communities.

developing countries meet higher standards. However, to obtain international financing – public or private – developing countries find themselves having to comply with new approaches, norms, and policies as a condition of financing or partnership.

The net effect of opposition and the controversy over outcomes has been to increase the level of risk associated with projects – especially those that fail to

recognise the need for a change in the way things are done. This has increased delays on dam projects in cases where controversial elements are contested in the courts. Both these factors directly or indirectly increase the costs of dams.

By the early 1990s, it was becoming clear that the cost of controversy could seriously affect future prospects for dams and stall efforts to finance other non-dam water and energy development projects to serve rural or urban communities. The stalemate did not benefit governments, dam builders,

communities or the environment, as no actions or investments were considered attractive given the ongoing conflict. A new way had to be found.

The need of both dams proponents and opponents to negotiate a new, agreed basis for assessing options and for planning, deciding, implementing and operating them – created the conditions for setting up the WCD and giving it a mandate.

Beyond these general considerations, several specific milestones mark the road leading to the establishment of the WCD. These include:

- The 1992 Morse report.⁶² This was an independent review of the Sardar Sarovar project, commissioned by the World Bank as a result of growing controversy over Bank funded projects and criticism of these projects at grassroots level and internationally. Instead of tempering the controversy, the Morse report fuelled deep criticism of the World Bank's internal decision-making.
- The Manibeli Declaration, signed in June 1994 by 326 activist groups and NGO coalitions from 44 countries, calling among other things for a moratorium on World Bank funded large dams until a comprehensive, independent review of all Bank funded dam projects had been conducted.⁶³
- The 1996 report of the World Bank's Operations Evaluation Department (OED).⁶⁴ An internal review of the performance and impacts of a sample of 50 Bank funded large dams. This desk study observed that 90% of dams reviewed met the Bank's standards for resettlement at the time they were built, but 75% failed to meet the Bank's most recent standards. Another important

finding was that proper mitigation of the adverse environmental and social impacts of most of the dams reviewed would have been feasible without compromising the economic feasibility of the projects. The report and the process by which it was prepared were highly criticised by the NGO community.

- The soul-searching was not confined to the development finance community. Professional water and energy development associations also began assessing the causes of the growing controversy and reaching conclusions on what needed to be done. The International Commission On Large Dams (ICOLD) published its *Position Paper on Dams and the Environment* in 1997.⁶⁵ Similarly the International Commission on Irrigation and Drainage (ICID) initiated a process that resulted in a major statement, *The Role of Dams for Irrigation, Drainage and Flood Control*, in 2000.⁶⁶
- The NGO community was also active in gathering case material on experience with large dams and drawing conclusions from it. Building on Goldsmith and Hildyard's 1984 report, *Silenced Rivers* by Patrick McCully of the International Rivers Network, published in 1996, depicts a particularly bleak record of the social and environmental impacts of dams and their underlying political dimensions.

By 1997, suspicion and mistrust between proponents and critics of large dams threatened to dominate and undermine wider discussion needed to reach agreements on ways to improve access to water and energy services. In response to this the World Bank and the World Conservation Union (IUCN), a global union of more than 800 governments, government agencies and NGOs – sponsored a meeting between the

champions and the critics of large dams in Gland, Switzerland in April 1997. While the Gland workshop was focused on bringing a range of opinion around the table to discuss the implications of the World Bank/OED review of 50 Bank funded dams, it found sufficient common ground to set in motion the process that led to the formation of the WCD.

The Gland workshop brought together 39 participants representing governments, the private sector, international financial institutions, civil society organisations, and affected people in a balance later mirrored in both the WCD and the Stakeholders Forum. In addition to assessing the OED report, they addressed three issues:

- Critical advances needed in knowledge and practice in relation to energy and water resources management.
- Methodologies and approaches required to achieve these advances.
- Proposals for a follow-up process involving all key players.

The workshop participants identified key issues relating to the social, environmental, technical, and financial aspects of dams that had to be addressed in reviewing the role of dams and their alternatives in sustainable development. They also formed an Interim Working Group composed of workshop participants and entrusted this group to establish the WCD. This task proved to be long and complex, in part because of the decision of the working group to consult all of the key stakeholder groups at each step, and also because of the time needed to build confidence in the good faith of all the parties.

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The WCD was finally announced in February 1998, and began its work the following May, under the Chairmanship of Professor Kader Asmal, then South Africa's Minister of Water Affairs and Forestry and later Minister of Education. Its 12 members were chosen through a global search process to reflect regional diversity, expertise, and stakeholder perspectives. The Commission was independent, with each member serving in an individual capacity and none representing an institution or a country.

As defined by the Gland workshop, the Commission's two objectives were to:

- Review the development effectiveness of large dams and assess alternatives for water resources and energy development.
- Develop internationally acceptable criteria, guidelines and standards where appropriate, for the planning, design, appraisal, construction, operation, monitoring and decommissioning of dams.

The dual objectives are deliberate, reflecting to some extent the priorities of the different participants in the dams debate. The champions of large dams, while wishing to draw useful lessons from the review of past experience, tend to lay the emphasis on practical tools that will help overcome the controversy and set a foundation for more predictable scenarios. The opponents of large dams, on the other hand, tend to underscore the importance of the review, convinced that it will reveal the depth and persistence of the negative impacts that dams have caused. They want to see evidence that dams can be an acceptable option before giving too much attention to developing guidelines for building better dams in the future.

Fulfilling the WCD Mandate: Process and Methodology

To respond to both parts of the mandate it was given in Gland, the Commission began by developing an analytical framework and work programme to assemble a consolidated, shared knowledge base on the worldwide experience with large dams, that:

- is grounded in the accepted international norms of sustainable and equitable human development;
- aims to explore the key themes at the centre of the dams debate, especially those that are unresolved; and
- compares the planned performance and expectations of dams with the actual experience after project completion.

The Commission used both quantitative and qualitative methods to objectively evaluate and answer the key questions posed.

It did not set out to judge decisions on dam projects from 50 or 100 years ago, but rather to learn lessons about the outcomes of dams and how these lessons could work to change or affect outcomes in the future.

In order to ensure a solid foundation of material on which to base its analysis and conclusions, the WCD commissioned, organised or accepted:

- in-depth Case Studies of eight large dams on four continents, together with two country review studies;
- a Cross-Check Survey of large dams located in 52 countries across the globe;
- 17 Thematic Reviews grouped along five dimensions of the debate;
- four regional consultations; and

- over 900 submissions from interested individuals, groups and institutions.

Recognising the value of the perspectives provided by representatives attending the Gland meeting, in the first few months of its work the Commission decided that the group should be retained as a consultative body for the Commission process, to be known as the WCD Forum. It was composed of a mix of former Reference Group members from the Gland meeting, and new stakeholders and interest groups. In selecting the new members of the Forum the WCD was guided by criteria such as relevance, balance and representation of a diversity of perspectives and interest groups.

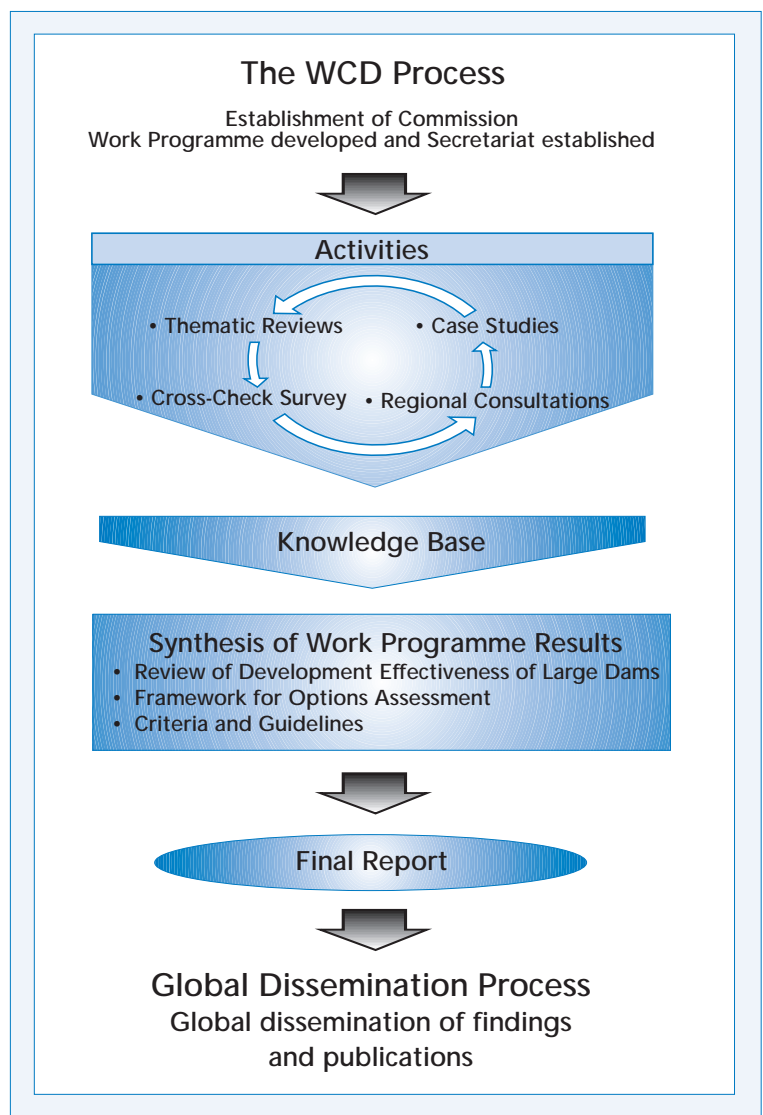
The Forum offers a consultation model that works at a somewhat different level than other forms of consultation. It has around 70 members and operates as a 'sounding board' for the work of the Commission. It is primarily a mechanism for maintaining a dialogue between the Commission and the constituencies of Forum members.

Since the Commission was facilitating debate on the complex issue of the development effectiveness of dams, input derived through consultation with these constituencies was essential for the understanding and acceptance of the Commission's final products. The Forum was one means of achieving these objectives.

Chapter 10 looks ahead to the dissemination and the adoption of the Commission's recommendations. It provides suggestions on the post-Commission role of stakeholder groups such as the Forum.

Developing the knowledge base

The Commission set out to develop a knowledge base that would give it access to the full range of issues and perspectives concerning large dams. The goal was to go beyond the realm of experts and intergovernmental processes to include constituencies with very different entry points into the dams debate. The process was designed to offer the opportunity for dialogue among the different interest groups, while providing a solid foundation for the Commission's findings.

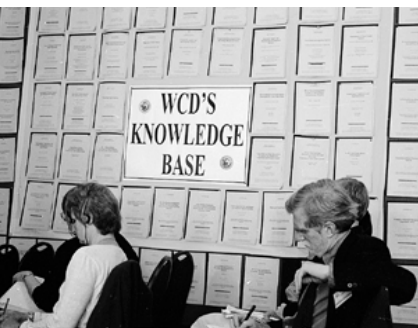


Main elements of the work programme

The Commission has based its report on a synthesis of information on past experience across all elements of the WCD work programme. A brief description of these main elements follows. Further details on the methodology are shown in Annex III.

Case Studies and Country Studies

The Commission undertook two case studies in OECD countries and six in developing countries. It prepared country review studies for India and China, and an issue paper for the Russian Federation and Newly Independent States. The case studies provide a thorough understanding of the challenges and dilemmas associated with specific dams set in the context of the development situation in specific countries, and the river basins. They were implemented in stages with stakeholder participation.



The Commission followed a standard framework for each case study, based on the model developed by the Secretariat. At the core were six questions:

- What were the projected versus actual benefits, costs and impacts?
- What were the unexpected benefits, costs and impacts?
- What was the distribution of costs and benefits – who gained and who lost?
- How were decisions made?
- Did the project comply with the criteria and guidelines of the day?
- How would this project be viewed in today's context in terms of lessons learned?

These questions served a much wider purpose than merely orienting the case

studies. They helped to shape the global review, the element of the work programme used by the Commission to evaluate the key issues in the overall debate. The Commission also used the studies to focus more specifically on the development effectiveness issue from the viewpoints of the stakeholder group for each case study.

Cross-Check Survey of dams

The Commission developed the Cross-Check Survey to extend the analysis provided in the case studies to target a broader set of dams. Completed survey forms were received for 125 dams in 52 countries. The 125 dams included the case study dams, additional dams from the case study basins, dams from existing databases and a random selection of dams from the larger population to contribute to the overall diversity of the sample. The analysis aimed to detect broader patterns and trends in performance and decision-making relating to dams.

A variety of dams of different types (storage, run-of-river); ages (the 1930's through the 1990's), functions (water supply, irrigation, power, flood management, recreation and other); ownership structures (public, corporate and private); and regional locations were included in the survey. Data was verified by an internal review and by submitting contested and randomly selected data sets for review by constituencies other than the dams owners and operators. Annex III sets out the methodology and summary statistics. Figure 1.10 shows the location of the case study dams and cross-check survey dams.

Thematic Reviews

A total of 17 Thematic Reviews and some 130 papers were commissioned to address five major areas of concern identified in the WCD strategy and objectives paper:



South Asia Consultation,
Colombo, December 1998



Latin America Consultation, Sao
Paulo, August 1999



East and South-East Asia
Consultation, Hanoi, February
2000



Africa-Middle-East Consultation,
Cairo, December 1999

- social and distributional issues;
- environmental issues;
- economic and financial issues;
- options assessment; and
- governance and institutional processes.

The Thematic Reviews provided the baseline information, analysis and recommendations on issues that cut across the central elements in the large dams debate. They consider past and current experience, as well as the forward-looking context, by synthesising the state-of-the-art knowledge, practices and key viewpoints on each topic. Within limits set by available resources and the Commission's schedule, the level of effort involved in preparing these review papers varies according to the complexity of the issue and the level of controversy surrounding it. Preparation of the review papers included setting up panels and procedures for broader peer review. This helped to bring together a wide spectrum of perspectives and ap-

proaches on the topic and to clarify the areas of potential agreement, and persistent disagreement, on highly controversial issues.

Regional Consultations

Over the course of two years, the Commission held four regional consultations, one each in South Asia, Africa and the Middle East, Latin America, and East and South East Asia. For each of the regional consultations, governments and non-government organisations, project-affected communities, financial institutions, industry and private sector representatives were invited to submit proposals on all aspects of their experience with dams and alternative options, and with water and energy resource development. Over 30 presentations were made at each consultation and participants engaged in debates on the issues raised. They gave the Commission a unique and unprecedented exposure to the many voices and perspectives in the dams debate in a number of countries and regions.

The Commission also had the benefit of listening to NGO and affected community presentations at two hearings organised by NGOs from Europe and from Southern Africa, as well as obtaining a wider range of inputs through attending and participating in meetings, workshops and conferences organised by a wide range of organisations and networks.



Endnotes

- 1 World Commission on Water in the 21st Century, 2000. Other examples of strategic initiatives in water include the United Nations Comprehensive Assessment of Freshwater Resources of the World, the United Nations Food and Agriculture Organisation Aquastat programme, and the World Water Vision conferences.
- 2 Gleick, 1998, p43.
- 3 UN, 1999, p1; also Raskin et al, 1998. Medium projection in 2050 was 8.9 billion.
- 4 UN, 1998, p2–29. In 30 years the largest population growth is projected to be in urban conglomerations; the 10 largest population centres in descending order of size would be Mumbai (Bombay), Shanghai, Chennai (Calcutta), Beijing, Delhi, Karachi, Tianjin, Metro Manila, Jakarta, and Dhaka.
- 5 IPCC, 1999. Purchasing power parity (PPP) uses accounting exchange rates to compare or add country economic data and avoid distortions introduced by market exchange rates. In 1995 world Gross Product reached a figure of US\$33.4 trillion at purchasing power parity (PPP).
- 6 Raskin et al., 1998, p9. OECD Data; 78% at market prices and 55% at purchasing power parity.
- 7 Shiklomanov, 1998 in Gleick 2000, p51–54; Raskin et al, 1995; based on United Nations, World Bank, and World Health Organisation data.
- 8 Raskin et al, 1995.
- 9 Gleick, 1998, p44–45.
- 10 Seckler et al, 1998.
- 11 Shiklomanov, op cit.
- 12 WRI et al, 1998, p304–305.
- 13 Shiklomanov, op cit. Municipal and industrial use increased from 17 to 28% of fresh water withdrawals globally between 1950 and 1990.
- 14 Van Hofwegen and Svendsen, 2000.
- 15 Raskin et al, 1995, p9; Countries are considered to be water stressed when the annual renewable water supply drops below 1700 m³ per capita, and water scarce when it drops below 1000 m³.
- 16 Raskin et al, 1998.
- 17 Brown and Halweil, 1999.
- 18 WCD Thematic Review II.2 Global Change.
- 19 Schnitter, 1994; McCully, 1996.
- 20 Zhang, 2000, WCD Regional Consultation Paper.
- 21 ICOLD, 1998; see also Annex V; Compilation of estimates of the number of dams in the main dam building countries suggest there may be as many as 48 000 large dams.
- 22 WCD Thematic Review III.2 Financing Trends.
- 23 WCD Thematic Review IV.2 Irrigation Options. Yields from irrigated areas are on average double that of rainfed agriculture, and are generally higher on land irrigated by ground water than on land irrigated with surface water.
- 24 Cosgrove and Rijsberman, 1999, p40.
- 25 Ibid.
- 26 The WCD India Country Study noted that the official figures of the Central Water Commission indicate that 30% of irrigated land is supplied with water by dams; however, the study also suggested an alternative figure of 10%.
- 27 Shiklomanov, op cit.
- 28 Roo, 2000, pp1–31; McIntosh and Yñiguez, 1997, p189.
- 29 IEA, 2000. The UN estimates that 2 billion people have no access to electricity. Electricity consumption per capita varies by more than a factor of 10 among different regions of the world: from approximately 10 000 kWh/year in North America to less than 1 000 kWh/year in Africa.
- 30 IEA, 1998.
- 31 IFRCRCS, 1998.
- 32 Berz, 2000.
- 33 ICOLD, 1998.
- 34 Lu, 2000.
- 35 Revenga et al, 1998. The WRI's 1998 study of the conditions of the major watersheds in the world focused on 150 watersheds, representing 55% of the world's land area.
- 36 Berger et al, 2000.
- 37 ICOLD, 1998; WCD Analysis.

- 38 Wolf, 2000, Contributing Paper for WCD Thematic Review V.3 River Basins.
- 39 Wolf et al, 1999.
- 40 Lecornu, 1998.
- 41 A considerable portion of the aggregate storage of large dams may be for non-consumptive hydropower releases. Analysis of all large dams in the ICOLD Register (1998), but excluding single purpose hydropower dams, shows 4 373 km³ of designed storage capacity. This data set excludes many of the large dams in China, estimated to provide 451 km³ of storage (IJHD, 1999)
- 42 Keller et al, 2000, p6-7.
- 43 Revenga et al, 1998.
- 44 The World Bank based on the review of resettlement experience estimated that between 1986-1993, an estimated 4 million people were displaced annually by the 300 large dams that entered on an average into construction every year. In the late 1980s some 10.2 million people were officially recognised as "reservoir resettlers" in China. This figure would be substantially higher if it is officially updated to include new figures of population resettlement. For example, dams and reservoirs already built on the tributaries and the main course of the Yangtze River alone have caused relocation of at least 10 million people. In India the estimates of people displaced due to large dams vary, from 21 million to 33 million people. Dams account for 34% of all people displaced by development projects in China (displacement due to city construction included in the total), 77% in India (urban displacement not included to total displaced) and 65% among the projects funded by the World Bank involving displacement. All these figures are at best only careful estimations and certainly do not include the millions who may have been displaced due to several others aspects of the projects such as canals, powerhouses, project infrastructure and associated compensatory measures such as bio-reserves etc. (See end notes 7 to 10 in chapter 4 for references to this endnote.)
- 45 Fox and Brown, 1998b.
- 46 World Bank, 1996a, p77.
- 47 Jing, 1999, Contributing Paper for WCD Thematic Review 1.3 Displacement, p2.
- 48 Wang, no date.
- 49 WCD Thematic Review I.3 Displacement.
- 50 ADB, 1999b, p1-2.
- 51 Fernandes and Paranjpye , 1997, p15-17.
- 52 World Bank, 1996a, p90-92.
- 53 WCD Kariba Case Study.
- 54 The protestors included both those to be resettled and farmers who were supposedly beneficiaries of the Bakolori irrigation scheme. According to the Nigerian government, 23 protestors were shot dead; unofficial estimates put the death toll at more than 126.
- 55 Stewart et al, 1996; World Bank, 1996b; Chen, 1999, WCD Regional Consultation Paper. At the WCD Regional Consultation at Sao Paulo one of the survivors narrated how his wife and children were shot dead before his eyes when he merely enquired of the authorities 'where do you want us to move to?' The answer came in the form of four rapid bullets.
- 56 McCully, 1996, p281-282.
- 57 Goodland, 2000.
- 58 Udall, 1998, p392.
- 59 Gray, 1998, p269-270.
- 60 Moore and Sklar, 1998, p286, WCD Submission eco048.
- 61 Fox and Brown, 1998a, p489.
- 62 Morse and Berge, 1992.
- 63 Manibeli Declaration, 1994.
- 64 OED, 1996a and 1996b.
- 65 ICOLD, 1997.
- 66 ICID, 2000.

Part One:

The WCD Global Review of Large Dams



The World Commission on Dams was charged with reviewing the development effectiveness of large dams and assessing alternatives for water and energy resources management. Part One of the report contains the results of our Global Review of large dams. It consists of five chapters.

- Chapter 2 provides the findings of the Commission's independent review of the technical, financial and economic performance of large dams.
- Chapter 3 examines the environmental performance of large dams, including ecosystem and climate impacts.
- Chapter 4 evaluates the social performance of large dams, looking especially at the displacement of people, and the distribution of gains and losses from dams projects.
- Chapter 5 assesses the scope of various alternatives to large dams for meeting the needs of irrigation, drinking water, electricity, and flood management in terms of both the opportunities they provide and the obstacles they face.
- Chapter 6 considers the planning, decision-making and institutional arrangements that guided the development of water and energy resources and the selection, design, construction and operation of dams.