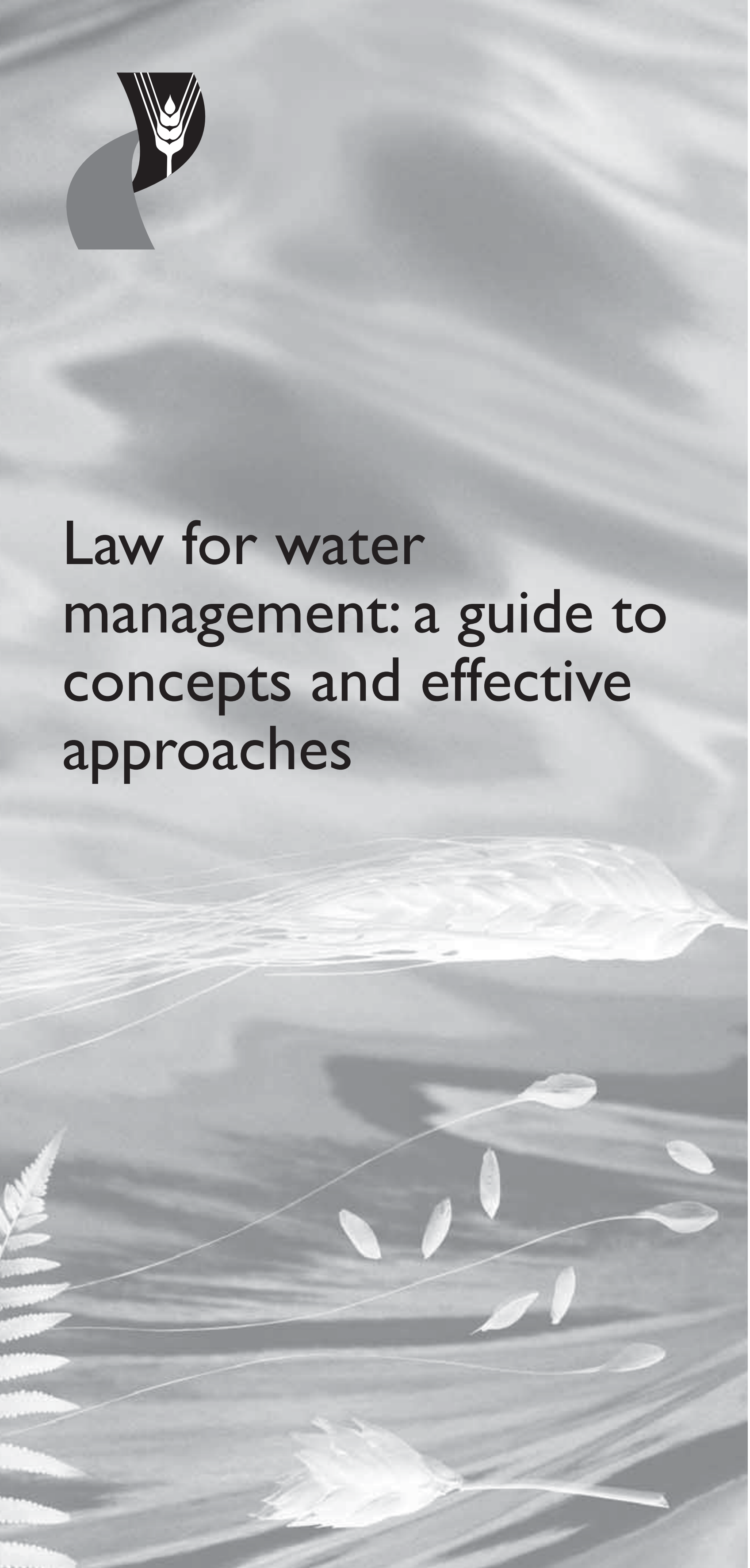

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Law for water management: a guide to concepts and effective approaches

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for the
Development Law Service
FAO Legal Office

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ABBREVIATIONS

BAT	Best Available Technology
BATNEEC	Best Available Technology Not Entailing Excessive Cost
BEP	Best Environmental Practices
BMP	Best Management Practices
BOD	Biological Oxygen
BOT	Build-Operate-Transfer
CESCR	United Nations Committee on Economic, Social and Cultural Rights
CRP	Conservation Reserve Program (United States)
DNR	Department of Natural Resources (Indiana, United States)
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
FAO	Food and Agriculture Organization of the United Nations
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
HIA	Health Impact Assessment
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICJ	International Court of Justice
ILA	International Law Association
ILC	International Law Commission of the United Nations
IRPTC	International Register of Potentially Toxic Chemicals
IWRM	Integrated Water Resource Management
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
LVFO	Lake Victoria Fisheries Organization
M&I	Municipal and Industrial
MDGs	Millennium Development Goals
NGO	Non-Governmental Organization
NEPA	National Environmental Policy Act (United States)
NWI	National Water Initiative (Australia)

OECD	Organisation for Economic Co-operation and Development
OKACOM	Permanent Okavango River Basin Water Commission
PCB	Polychlorinated Biphenyl
POP	Persistent Organic Pollutant
POTW	Publicly Owned Treatment Works
SFRA	Stream Flow Reduction Activity
TMDL	Total Maximum Daily Load
TSA	Trail Smelter Arbitration
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
UNICEF	United Nations Children's Fund
UWWT	European Council Directive Concerning Urban Waste Water Treatment
WHO	World Health Organization
WPWP	Working Party on Water Problems (Helsinki Convention)
WQS	Water Quality Standards
WSP	Water Safety Plan
WSRA	Wild and Scenic Rivers Act (United States)
WTO	World Trade Organization
WUA	Water Users' Association
WWAP	United Nations World Water Assessment Programme

GLOSSARY[*]

aquifer: a geological area that produces a quantity of water from permeable rock.

annual water yield: the total volume of water produced by a watershed on an annual basis.

appurtenant: belonging or attached to; constituting a legal accompaniment.

atmospheric deposition: the processes, excluding precipitation, by which materials are removed from the atmosphere and deposited on the surface of the earth.

baseflow: the sustained or dry weather flow of a stream resulting from the outflow of permanent or perched groundwater and from the drainage of lakes and swamps during dry weather; also included are water from glaciers, snow and other sources not resulting from direct runoff.

bioaccumulate: the process by which an organism absorbs a toxic substance at a rate greater than that at which the substance is lost.

blue water: freshwater found in river basins, lakes and aquifers.

cap and trade system: a system that sets an aggregate rather than individual cap on pollution (or resource use), issues individual emission (or use) permits matched by an equivalent number of allowances or credits and then allows the trading of individual credits in an amount equal to or less than the permits held.

catchment (watershed): a discrete area of land with a common drainage system; includes both the water bodies that convey the water and the land surface from which water drains into those bodies.

club good: an excludable, non-rival good or resource, or a resource to which access may be limited and the use of which does not generate competition.

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[*] This glossary was prepared by Julia Rogers.

command and control regulations: regulations that establish the type or amount of permissible resource use, or require that certain technologies be employed for such use.

common pool resource: a non-excludable, rival resource subject to congestion or overuse.

concession contract: an agreement between a government and a private company granting the latter the exclusive right (and sometimes obligation) to operate, maintain and invest in a public utility for a given number of years.

conjunctive management: the joint or coordinated management of surface water and groundwater, in particular regarding the inflow and reservoir functions of aquifers, for the sustainable extraction of groundwater.

connectivity: the physical connection between tributaries and rivers; surface water and groundwater; and wetlands and both surface water and groundwater.

consumptive water use: water that evaporates or transpires, or is incorporated into a product or a crop, consumed by humans or animals or otherwise removed from the immediate environment.

customary international law: rules of law derived from the consistent conduct of states acting out of the belief that the law requires them to act that way; a general, international practice accepted as law.

diversion weir: a barrier or dam constructed on the reaches of a canal or navigable river to retain the water and regulate its flow.

drawdown: the change in head or water level relative to background conditions.

ecosystem: a system of dynamic interdependent relationships among living organisms and their physical environment; a bounded entity that has evolved to contain self-stabilizing mechanisms and an internal equilibrium.

ecosystem water: the water that is made available naturally by the water cycle and freshwater ecosystems.

effluent: liquid waste, whether treated or untreated, that flows from a process or facility into the environment.

effluent requirements: measure of the amount of waste material that may be discharged into the environment.

environmental flow: the amount of water needed in a watercourse to maintain healthy, natural ecosystems.

ephemeral stream: a stream that exists only in periods of heavy rainfall.

equitable utilization: the principle that each state within an international drainage basin has the right to a reasonable and equitable share in the beneficial use of the basin waters.

eutrophication: the enhancement of the natural process of biological production in rivers, lakes and reservoirs caused by an increase in the level of nutrients, usually phosphorus and nitrogen compounds.

evapotranspiration: the sum of water moving through physical evaporation and plant transpiration from the earth's surface to the atmosphere.

flood flow: see stormflow response.

fossil groundwater: water stored over geologic time in aquifers located at great depths with little or no connection to groundwater recharge; once extracted, these groundwater reserves are difficult to replenish.

freshwater in transit: freshwater molecules moving actively through the water cycle.

fund pollutants: pollutants that decompose and are therefore more readily assimilated by the environment.

general principle of international law: a principle common to the domestic laws of many nations which, because of its broad acceptance, may be considered a part of international law when neither customary nor conventional laws cover a particular legal issue.

green water: water that moves through evapotranspiration, cycling largely through plants.

groundwater discharge: outward flow of groundwater into surface waters.

groundwater recharge: replenishment of groundwater supply in the saturated zone, or addition of water to groundwater storage by natural processes or artificial methods for subsequent withdrawal for beneficial use or to check saltwater intrusion in coastal areas.

halophyte: a plant that naturally grows in locations where it is affected by salinity in the root area or by salt spray, such as in saline semi-deserts, mangrove swamps, marshes and sloughs and seashores.

headgate: a barrier that controls the flow of water into a channel.

helminth: a worm, either parasitic or free-living.

hydrograph: a record of the discharge of a water body over time.

hydrosphere: the combined mass of water found on, under and over the surface of the earth.

improved water source: a source with some form of improvement on, or protection from, groundwater, such as household connections, public standpipes, boreholes, protected dug wells, protected springs or rainwater collection.

infiltration: precipitation that enters the ground and goes into the water table.

leachate: liquid that drains from a landfill, usually composed of both dissolved and suspended waste materials.

lease affermage: a lease that gives a company the right to operate and maintain a public utility whilst investment in the utility remains a public responsibility.

macrophyte: an aquatic plant that grows in or near water and is either emergent, submergent or floating.

Millennium Development Goals: eight international development goals agreed in 2000 amongst 189 United Nations member states and at least 23 international organizations, to be achieved by 2015: eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development.

mine tailings: the materials left over after the process of separating the valuable fraction from the worthless fraction of an ore.

non-point source pollution: pollution from multiple or unidentified sources that is delivered to water systems through runoff, infiltration or other unchanneled means, as well as through precipitation that has bonded with pollutants in the atmosphere.

nutrient outflow: the amount of nutrients (fertilizer) flowing from an agricultural watershed into a body of water in a given amount of time.

parastatal: an organization or industry with political authority that serves a state indirectly.

perched aquifer: an aquifer that is stored above an impermeable layer and has no outlet.

point source pollution: pollution conveyed to water systems by a discrete and identifiable outlet.

prior appropriation doctrine: a system that gives the first person who makes beneficial use of a quantity of water from a given source the right to continue to use such quantity for the same purpose; subsequent users may use the remaining water for their own beneficial purposes, provided they do not impinge on the rights of the prior user(s).

public good: a non-excludable, non-rival resource.

recharge pit: a means of capturing rainwater runoff to recharge groundwater supplies; typically consists of a pit filled with stones and sand through which water percolates.

return flow: see groundwater discharge.

riparian rights: the rights of land owners to access and use the water that borders their property.

rivalry: the degree to which the use of a unit of a good by one individual reduces the potential for others to use the same unit.

run-of-river hydropower facility: a facility in which the river current applies the needed pressure to generate electricity through either a diversion or a barrage system, the former using only the force of gravity, the latter using a barrier to increase force by creating a backup of water.

saturated zone: the area below the water table where all open spaces are filled with water.

self-executing treaty: a treaty that comes into effect immediately upon ratification and does not require national implementing legislation.

soil water: water that occupies the unsaturated zone directly above the water table, rests in the spaces between particles of soil and is immediately available to plants.

static storage: water in static storage is water that does not move through the water cycle.

stock pollutants: pollutants that accumulate with little or very slow degradation because the capacity of the environment to assimilate them is very small.

stormflow response (flood flow): stream discharge during a flood.

streamflow: the flow of water in streams, rivers and other channels, and the main mechanism by which water moves from land to the oceans.

total maximum daily load: the maximum amount of pollutants a water body can receive and still meet water quality standards.

unsaturated zone: the shallow layer of earth located directly above the water table.

vadose zone: the unsaturated layer above the water table.

water abstraction: the process of taking water from any source, either temporarily or permanently.

water quality standards: benchmarks established to determine whether water quality is sufficient for certain uses; typically expressed as maximum allowable concentrations of pollutants.

watershed: see catchment.

water table: the top of the saturated zone; the depth from which water can be extracted.

water yield: total volume of water produced by a watershed on an annual basis.

wellhead: the structure built over a well to protect the water.

wetland: an area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres.

PREFACE

Water is a fundamental resource for life and plays an essential role in agriculture, power generation, social development and health. Increases in human population and demographic shifts towards more urban areas have heightened demand for water, creating new challenges in managing water resources, water supply and sanitation infrastructure. Increased demand has also created conflicts over national and international water resources. The future will call for improved management of water resources to address these and other challenges.

Effective water management relies on a wide range of institutions and actors playing distinct but inter-connected roles. Coordination and cooperation are essential to ensure effective water management, health protection and sustainable development. Good water policies implemented by nationally tailored water legislation and other tools can facilitate coordination and help governments achieve their water management objectives.

Close cooperation will be needed between those with technical water expertise and those with expertise in legislation and regulation. The legal profession has a suite of tools that may provide a better or worse "fit" to a specific water management issue. The community of water managers, for its part, has a suite of technical tools that it uses to respond to regulatory challenges. Although communication between these two groups is vital in order to assess potential design and implementation issues, it is often constrained by different perspectives and vocabularies. A common lack of understanding can impede innovation and identification of the most effective solutions to water management problems.

This text was conceived by staff of FAO and WHO as a resource to bridge the gap between these disparate groups. It is intended to support legal experts, policy experts and other interested individuals in understanding the scientific and technical issues associated with water, health and development, whilst raising awareness on the part of scientists and technical experts regarding the legal and policy issues surrounding water management.

FAO and WHO address water-related issues according to their respective mandates and perspectives. FAO, in its role as an advisor to governments and neutral forum for inter-governmental consultations on issues of food and agriculture, is concerned with water as a resource and as an integral element of sustainable agriculture and rural development. WHO, on the other hand, was created for the purpose of ensuring health for all people and, accordingly, approaches water from a global health perspective. Marrying these two important objectives will be an important step toward improving water management practices.

The complexity of the task has meant a lengthy and sustained effort on the part of many people in FAO, WHO and elsewhere. Jessica Vapnek, FAO Legal Officer, and Jamie Bartram, formerly Coordinator of the Water, Sanitation and Health Programme at WHO, conceived the text and its companion website, www.waterlawandstandards.org, and led the editing of the text. Bruce Aylward and Christie Popp completed the editorial team. Many other people have participated in aspects of this project, and the editorial team would like especially to thank Bo Appelgren, Jeremy Bird, Robert Bos, Jake Burke, Rich Carr, David Coates, Ariella D'Andrea, Susan Davis, Megan Dyson, Maj Fiil, Jared Gardner, Hiroki Hashizume, Federike Jansonius, Charlotta Jull, Donald Kaniaru, Rachael Knight, Julia Lenney, Meg Mahoney, Kerstin Mechlem, Jennifer Mercer, Deana Nassar, Jane O'Farrell, David Percy, Claudia Sadoff, Jim Salzman, Jackie Sims and Melvin Spreij. These many individuals provided administrative, editorial or research support, or offered expert reviews of draft chapters. The project could not have been completed without them.

The books' authors represent or represented FAO, WHO, universities, government agencies, NGOs and the private sector. The views expressed in the various chapters are personal to the authors and do not necessarily represent those of their respective organizations.

We hope that this text will prove useful to government policy-makers, law-makers and researchers alike.

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Chief, Water Development and
Management Unit
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1

INTRODUCTION[*]

Contents

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[*] This chapter was prepared by Bruce Aylward, Jamie Bartram and Sasha Koo-Oshima.

Ancient and fundamental, water is inextricably a part of us and one of the few essential requirements for life. From the very first settlements, the health, welfare and development of societies have been predicated on readily available, safe sources of drinking water. Scholars have found that ancient civilizations declined and at times collapsed because of misuse of water resources. Other commentators have suggested that the economic gains of the nineteenth and twentieth centuries were founded upon major advances in the provision of water. Today is no different. Water resources development has altered the natural functioning of the water cycle to better meet human needs, particularly the major human consumptive uses (irrigation, municipal and industrial) and non-consumptive uses (hydropower and navigation). Humankind's ability to re-work river systems and plumb aquifers has allowed civilization to flourish.

Water is essential to human development. Freshwater and inland water bodies underpin national economic and social development by providing essential goods and services for households and producers. The water cycle is also vital to ecosystem health, and supports not only basic human needs but also cultural uses of water including tourism and recreation. In the modern era, population growth and social and economic development have rapidly increased the demand for water and placed escalating pressures on the world's natural resources. Unfortunately, laws and institutions have often not adapted quickly enough to ensure that this development is sustainable – meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.

Despite technological advances, many regions of the world suffer from serious water shortages. The world's poor are most affected by water scarcity. Today, 1.1 billion people lack access to safe drinking water, and more than twice that number lack access to adequate sanitation, mostly in Africa, Asia, Latin America and the Caribbean (WHO/UNICEF, 2004). When affordable piped water is not available, citizens use lakes, rivers or shallow wells that may be polluted or contaminated with faecal matter. Without progress, the numbers of people without access to water and sanitation will likely increase sharply with urban and rural population growth. Indeed, social scientists have introduced the term "water deprivation" – the inability reliably to obtain water of adequate quantity and quality to sustain health and livelihood – as a basic index of poverty.

I. CHALLENGES IN WATER MANAGEMENT

The challenge facing governments is not only to provide clean water and sanitation but also to oversee how that water is provided. Water supplies must be safe, sufficient for people's needs, regular (number of hours per day), convenient and affordable. Much progress has been achieved. Global figures suggest that more than five billion people are routinely provided with clean water, and three billion have access to sanitation (WHO/UNICEF, 2004). In the last 20 years alone, more than 2.4 billion people have gained access to water supply and more than 600 million have gained access to sanitation (WHO/UNICEF, 2004).

The Millennium Development Goals (MDGs), agreed on in the year 2000, challenge governments to improve economic growth, health and agriculture and to alleviate poverty. Recognizing the importance of water to human well-being, the MDGs call on the international community to halve the proportion of people without access to safe drinking water and hygienic sanitation facilities by 2015. This would require that from now until 2015, an additional 100 million people per year (or 274 000 per day) be afforded access to water – a formidable challenge. For sanitation the challenge is even greater, with services to be provided for an additional 125 million people each year (or 342 000 per day). Although many governments have committed to the task, much remains to be done. This section sets out some examples of current water management challenges.

1.1. Health

The availability of clean water and sanitation is a key determinant of human health. Its absence causes or contributes to many diseases which lead to high rates of morbidity and mortality. Millions of people, particularly in developing countries, die each year from water- and sanitation-related illnesses.

The most common water-related ailment is diarrhoea. An estimated 1.6 million people die every year from diarrhoeal diseases (including cholera), and 5.4 billion cases of diarrhoea every year are attributable to poor water, sanitation and hygiene (Hutton and Haller, 2004). A range of parasitic infections caused by poor sanitation could be addressed through improvements in water management. Skin and eye infections are also common health problems related to water and sanitation. One example is trachoma, which is spread by eye-seeking flies that breed in areas with poor environmental sanitation. Trachoma has infected 146 million people worldwide, including 6 million who have been made completely blind by the disease. It is the leading cause of preventable blindness in the world (UNDESA, 2006). Vector-borne diseases, including Japanese encephalitis, filariasis, schistosomiasis, dengue fever and malaria, also infect and kill millions every year. Malaria infects 300 million people annually, the majority in Sub-Saharan Africa (UNDESA, 2006). Malaria, filariasis and dengue fever are all spread by mosquitoes, which breed in stagnant water. Other health dangers related to water include water pollution caused by industrial contamination and agricultural practices, leading to the leaching of pesticides, fertilizers and other chemicals into water sources.

1.2. Agriculture

Despite a quadrupling of the world's population during the twentieth century, world food production at the end of the century was sufficient to meet global caloric needs (Shah and Xepapadeas, 2005). Water stored and diverted for irrigation played a particularly important role in this achievement, irrigating 40 percent of global crop production (WWAP, 2003). In the last century, intensification of irrigation created a 13-fold increase in the world's consumptive use of water and today, irrigated agriculture is the single largest user of water. Estimates vary, but the general figure quoted is that agricultural uses make up 70 percent or more of total water withdrawals.

Population and food needs will continue to increase as the world's population increases to nine billion or more by the middle of this century. The International Food Policy Research Institute and the International Water Management Institute examined the impact of the growing human population on water and food and projected an expected increase of 17 percent in water withdrawals for irrigation (Rosegrant *et al.*, 2002). Nonetheless, with appropriate technologies, significantly less water could be consumed in meeting future needs. For example, farmers currently lose half of the water they abstract due to seepage in the delivery of water to their fields. Technology and improved water use efficiency could increase the reliability of water supply to agriculture and increase water availability.

1.3. Hydropower

The energy harvested from water as it moves through the water cycle is an important component of the world's energy supply. In the last century, hydroelectric power harnessed through large dams provided almost one-fifth of the world's electric power production. In some countries, hydropower makes up over 90 percent of electric power (e.g. Brazil, Honduras, Laos, Mozambique, Norway, Tajikistan) (WWAP, 2003). However, more than two billion people still have no access to electricity, whilst electricity consumption has grown rapidly – doubling in the last 20 years. As a result, local pressures to continue developing hydropower potential remain. Although industrialized countries have seen a rapid drop in new dam construction (having reached capacity in earlier decades), in many regions much of the potential for hydropower remains unexploited.

Structural and capital-intensive engineering solutions – particularly large dams and associated irrigation and power schemes – have provided communities with massive amounts of water, food and power and have caused improvements in human development. On the other hand, dam construction has destroyed critical ecosystems, endangered certain species and displaced millions of people (WCD, 2000). In 2000, the World Commission on Dams released a report, *Dams and Development: A New Framework for Decision-Making*, which noted that over the past 50 years, dams have fragmented and transformed the world's rivers, displaced 40 to 80 million people in different parts of the world and caused significant adverse impacts on human health and the environment (WCD, 2000). The report also found that by creating standing bodies of water, hydroelectric facilities may have increased the incidence of water-related diseases such as malaria, dengue fever and schistosomiasis.

1.4. Ecosystems

Efforts to harness and develop water resources for the sake of human development have indisputably degraded the environment. Changes to the hydrograph and related physical, chemical and biological processes have substantially degraded inland water ecosystems throughout the world. The impacts of water resource development on ecosystems occur in a number of ways, but the main effects arise from the removal of water from inland water systems, which alters the distribution and availability of the remaining waters.

The amount of water withdrawn from inland water systems has increased an estimated 15 times over the past 200 years (Vörösmarty *et al.*, 2005). Changes in river flow resulting from infrastructure development and land conversions have also had ecological impacts on watersheds, water temperatures and upstream and downstream ecosystems, particularly in terms of nutrient load and sediment transport. These activities may negatively affect deltas and fish migrations, destroy or degrade fish and waterfowl habitats and harm the livelihoods and food security of local delta populations (WCD, 2000). Poorly managed watersheds can also degrade the level and value of ecosystem services such as water purification and erosion control.

Recognition of the extent and severity of the effects of water resource development on ecosystems has led to efforts to avoid, minimize and mitigate the consequences (WCD, 2000; Vörösmarty *et al.*, 2005; Aylward *et al.*, 2005). This has led to proposals to create environmental flow regimes, employing a number of engineering, economic and legal tools to restore the ecosystem function of river systems (Dyson *et al.*, 2008).

1.5. Social development

Unlike the situation in most OECD countries, in many developing countries neither water quality nor quantity can be assumed. Because water supply infrastructure is not provided in the poorest urban areas or in many rural areas, obtaining water is regarded as an individual or domestic responsibility. In contrast to the ease of turning on a faucet, lack of infrastructure means a high labour input as members of the household (generally women and girls) must collect each day's water, whether from a communal pond or well, tanker or kiosk. One billion people do not have water within a 15-minute walk of where they live (Vidal, 2003). The average daily time spent on collecting water in 1997 across East Africa was 91.7 minutes per day, triple the time spent 30 years earlier (Thompson *et al.*, 2000).

Where communal or free water sources are too far away or contaminated, poor people purchase their water from street vendors or tanker trucks. Forty percent of those surveyed in an East African study used water vendors (Thompson *et al.*, 2000). The price of water from vendors is always higher than the price from municipal supply systems – on average 12 times higher (Segerfeldt, 2005) – with the tragic irony that the poorest in society are paying the most for their water. The resulting social and economic impacts are immense. With a significant proportion of women and girls' time and family income dedicated to procuring domestic water, opportunities for productive activities such as education or employment are reduced. It is no exaggeration to say that the introduction of piped water and improved infrastructure can transform the social and economic fabric of a community.

II. MANAGING WATER RESOURCES

In its natural state, freshwater varies considerably in terms of its availability. Water resource development efforts (construction of dams and irrigation channels, widening of river embankments to improve navigation, drainage of wetlands for flood control, etc.) have resulted in the replacement of naturally occurring and functioning systems with highly regulated and modified human-engineered systems. These "developed" systems have typically been designed solely for the satisfaction of the major human consumptive uses (irrigation, municipal and industrial use) or non-consumptive uses (hydropower and navigation). Although such large-scale projects may have improved efficiency in the collection and provision of water for a number of important human needs, they may also have caused harm to human health and the environment.

Unforeseen adverse impacts of past water development efforts and ongoing shifts in ecological, social and political forces have changed the landscape of water management in the early twenty-first century. A number of forces influence and drive change in the management of water resources (Aylward *et al.*, 2005; Finlayson and D'Cruz, 2005; Vörösmarty *et al.*, 2005). Population growth, increased urbanization, industrialization, political instability, conflict and climate all play a role in the drama of water scarcity. Responding to current and future water management challenges will require careful consideration of these different influences, in order to balance water resources development with the management of ecosystems.

Population growth is directly linked to increased water pollution, higher demand for water for domestic purposes and an escalating need for water to irrigate the crops necessary to supply greater amounts of food. Increasing wealth with its concomitant rise in the standard of living in certain regions puts pressure on water resources as wealthier populations use more water and pollute more (Aylward *et al.*, 2005; Finlayson and D'Cruz, 2005; Vörösmarty *et al.*, 2005).

Industrial development strains both the quantity and quality of existing water resources and affects water management. Low production costs in developing countries have attracted investors, although regulatory frameworks and enforcement capacity may be weak. Activities such as mining and chemical production can directly and negatively affect water resources. Industrial compounds, agricultural pesticides, fertilizers and industrial wastes have entered key water sources, polluting them and aggravating water scarcity. The poor and disadvantaged are disproportionately affected by water scarcity and water pollution, placing livelihoods, health and security at stake.

Increasing urbanization is another challenge to water management. Approximately half of the world's population now lives in urban areas, compared to around one-third in 1972. The total urban population is projected to swell by 2030 to nearly five billion people, with the greatest urban growth taking place in Asia and Africa (UNFPA, 2007). High concentrations of urban residents increase local water demand and water pollution, overload sanitation infrastructures and harm groundwater sources. On the other hand, urbanization can provide options for urban and peri-urban farmers to rely on the nutrient loads in wastewater for improved nutrition and household savings.

Over-exploitation of underground aquifers near major urban centres has resulted in sinking water tables in many cities. The remaining groundwater is often degraded from inadequate wastewater treatment, anthropogenic pollution and saltwater intrusion (in coastal areas). Poor sanitation leads to contamination of water by pesticides, nitrogen, phosphorus and raw organic matter containing undesirable residues. Sustainably managing water consumption and waste discharges in urban areas is therefore one of the major issues for the future. Clean, safe and sustainable urban water flow is necessary not only for the survival and health of city populations but also for the smooth functioning of industry, hospitals and municipal infrastructure.

Global climate change poses additional challenges for successfully managing water resources. Climate change may increase the frequency of extreme weather events such as floods, fires, drought, cyclones and hurricanes (hydro-meteorological events). Extreme weather events may increase the prevalence of outbreaks of infectious disease; lead to loss of land (as a result of rising sea levels); damage fish stocks and agricultural outputs; threaten water supplies; damage infrastructure and communications; interrupt economic activities; and magnify social problems such as poverty and overcrowding. The annual impact of climate change is projected to be more than US$ 300 billion (Munich Re Group, 2000).

As the climate changes, current patterns of water scarcity, drought and floods will shift and have consequent effects on river flows and groundwater recharge. Natural ecosystems may suffer potentially irreversible effects. Climate change may also degrade water quality through increasing pollutant loads as river systems suffer from low flows and water stress. Water planners and managers will have to accommodate the resulting changed availability of water resources for ecological and human needs.

Efforts to address population growth, urbanization, industrial development and climate change are beyond the scope of this book, as they are not within the purview or control of the water resources community. However, the impacts of these forces on water resources must be brought to the attention of policy-makers working toward sustainable water resources management.

"Water resources management" can be defined as all efforts related to the use of water to meet human and ecosystem needs. Water resources management is not the same as water resources development. Development can include the construction of dams for water storage, channels for irrigation and river embankments for navigation; the draining of wetlands for flood control; and the establishment of inter-basin connections and associated water transfers. Water resources management, by contrast, is both a scientific and a political undertaking, occurring within the context of national laws and regulations, international treaties and biological and ecological technologies. Water resources management activities range from planning water resources development to monitoring and evaluating water contamination.

Lack of access to water, sanitation, power and adequate nutrition, as well as the degradation of ecosystem function and biodiversity, suggest an emerging crisis in the water resource field (Rijsberman and Scott, 2005). However, a central factor of the "water crisis" is lack of proper resource management. At its core, improper water management is often a failure of governance – a failure at the level of policy, legislation, regulation and the application of economic incentives. More specifically, it is a failure to create adequate institutional arrangements (rules, regulations, norms and incentives) for governing freshwater ecosystems, water and water-related services.

A variety of interventions and tools can positively address water resource management problems. Regulatory interventions directly influence decisions on water governance and management. For example, rules can regulate how water is abstracted from rivers, assess fines for discharge of pollutants and control how new dams are constructed. Rules may mandate that when a wetland is converted, another wetland be protected or restored as mitigation. Scientific understanding of the water cycle must be linked to the legal and regulatory tools necessary to provide incentives to individuals and groups to manage water sustainably.

Proper water governance will be critical to meeting human and ecosystem needs and avoiding water-related crises. The world's freshwater must be shared sustainably among individuals, economic sectors and sovereign nations, whilst respecting the environment. Minimizing threats whilst striking a balance between equity and efficiency in the allocation and use of water is the goal of water resources management and regulation.

III. THE ROLE OF LAW IN WATER MANAGEMENT

Well-designed water legislation creates an enabling environment for effective water resources management. Good legal frameworks may enhance peaceful cooperation and resource-sharing, allowing governments to implement and enforce policies to ensure sustainable and equitable allocation of water.

3.1. National water legislation

Although the role of law in society varies from country to country, the central importance of water law is widely recognized. Through water legislation, governments seek to ensure that water resources are readily available to meet the needs of each sector of society. Yet many nations' legal provisions on water are scattered throughout laws related to different uses, such as irrigation, industry, municipalities or hydropower. For example, legal provisions concerning water supply, quantity and quality may be located in separate pieces of legislation addressing energy, the environment and public health. The policies and objectives of these sectoral laws may be redundant, inconsistent or even contradictory, placing various stakeholders at odds and making effective management difficult. The net result may be gaps, inefficiencies, an overlap of powers or a fragmentation of water management efforts, leading to inefficient and unsustainable water use. Instead of this patchwork approach, many countries are rigorously reviewing the national legal frameworks that govern their water sectors and making appropriate changes to achieve more effective water management.

Comprehensive water legislation will be effective if it reflects the political and cultural structure of a nation and integrates all water-related concerns. Each country has unique politics, traditions, international obligations, institutions, resources and history, all of which affect the development and implementation of water legislation. Any new water law should account for these factors to ensure that it is closely tailored to national circumstances and local capacities. Moreover, modern water legislation must consider domestic water uses and management against the backdrop of international and regional agreements. The ultimate goal is an integrated national legal framework that respects international commitments, incorporates all aspects of water use and rights and takes into account human health and sustainable development.

National water legislation has traditionally focused on administration and enforcement efforts, for example by establishing rules and procedures for water use and imposing penalties for breaches and violations. More recently, governments have also adopted economic instruments – such as effluent taxes, abstraction charges, tradeable abstraction and pollution permits and subsidies – to influence individual and corporate behaviour in order to achieve policy objectives. These economic tools complement classic regulatory instruments such as maximum pollution-load limits or permits for water abstractions and wastewater discharges.

A wide range of stakeholders must be consulted throughout the process of drafting and adopting water law. Governments should consult professionals in the fields of law, health and environmental protection; scientists; NGOs; local government administrators who will face the practical challenges of implementation; and citizens representing a variety of water uses. Elites, donors, "experts" and other groups must not overpower or ignore the inputs and voices of the water users themselves, who may be poor, unable to speak the official language of the state or otherwise disenfranchised. As noted earlier, it is often the poor whose access to water is most at risk.

True consultation requires a commitment to listen to and understand the needs, objectives, insights and capacities of the intended users and others potentially affected by the law, and to find ways to accommodate the multiple interests at stake. By helping create a broad-based consensus in favour of the law, participation improves compliance and fosters a wide sense of “ownership”. Laws that reflect stakeholders’ perceptions and views may stimulate organized support and active pressure for the laws’ enforcement, as opposed to indifference or even passive resistance. At the very least, public participation publicizes the legislation to society at large.

3.2. International developments

The need for regional and global water management grows stronger each year. Some transboundary water conflicts are longstanding, whilst new and increasingly volatile water-related conflicts can be expected to arise as water scarcity increases. International water resources – whether lakes, rivers or groundwater – face increasing pressure from abstractions and pollution. Because of the expansive geographic network of water flow and currents, even when national water policies appear to be addressing purely local problems, the ramifications may be regional or worldwide. Nations will have to work in concert to find lasting solutions.

National water legislation is frequently inspired and guided by agreements signed at international or regional level. Some treaties or conventions cover many countries and watercourses, whilst others cover a particular transboundary river, lake, basin or aquifer. Nations’ new or revised legislation should be informed by those agreements to which they are signatories. To best address emerging international water concerns, governments should establish joint water management plans, surveillance and early warning systems and contingency plans with neighbouring countries, and should exchange information and knowledge.

IV. BOOK OVERVIEW

The ten chapters of this book are designed to bridge the gap between the practice and science of water resources management on the one hand, and the law of water resources management on the other. The chapters describe the legal and regulatory frameworks for water management in a manner comprehensible to scientists and health professionals, whilst discussing the science of water management in a manner comprehensible to policy- and law-makers. The book identifies how law and science may be applied to water-related challenges, amongst them pollution, water scarcity, use of wastewater and access to drinking water.

An increasing number of countries are reviewing their water policies, water management strategies and legislative frameworks. This book can serve as a resource not only for water management professionals and water lawyers, but also for policy-makers interested in learning about water law, water resources management and emerging water-related issues.

The book contains the following chapters:

Chapter 1: Introduction

This introductory chapter explains how water and water management affect health, social and economic development and environmental sustainability. It describes current trends in water resource management, focusing particularly on the challenge of meeting the competing water needs in society. It then turns to the role of law in water management, demonstrating how good legal and regulatory frameworks underpin sustainable, effective and integrated water management, and arguing that water law and policy should reflect users' real needs and priorities and be tailored for each specific national context. It concludes with an overview of the remaining chapters.

Chapter 2: Water Resources and Their Management

Chapter 2 provides an introduction to basic water management concepts and terminology. The chapter describes the classifications of fresh water bodies (surface water, groundwater, reservoirs and others), presents the types and sources of water resources and outlines the water cycle. It discusses the relationship between human and ecosystem demands and explores the principal water uses, including domestic water supply, agriculture, industry, transportation, energy production, recreation. The chapter also explores the concepts of blue and green water, which are increasingly used to understand water scarcity and to determine how best to fulfil human and ecosystem water needs. It concludes by introducing the main objectives and concepts of water management and the currently available tools and technologies.

Chapter 3: Water Governance: Policy and Legal Frameworks

Effective water legislation must be grounded in sound policy. Countries may need to revise existing policies or create new ones to reflect the changing conditions of national water resources. Chapter 3 introduces water policy and explains its role in the governance of water. The chapter then examines the laws, regulations and standards through which national water policy may be implemented. It describes best practices and desirable features of modern water laws, provides examples of water legislation from around the world and suggests ways of addressing the challenges of water resources management and water services provision.

Chapter 4: International Water Law

Just as water should not be managed and legislated by disparate sectors within a particular country, individual countries should not manage water in isolation. Coordinated, multinational responses to water scarcity and water problems are critical to achieving effective management of shared water resources. Chapter 4 provides a brief overview of international law and then describes international water law in detail. It introduces binding and non-binding sources of international water law, including water-related treaties, conventions and agreements, basic principles of international customary law and guidelines for water management and water services formulated by international organizations. The chapter concludes with a discussion of emerging principles in international water law.

Chapter 5: Water Resource Quantity: Allocation and Management

Chapter 5 explores the challenges of water allocation and management. The timing and location of water availability affect water quantity: water is often unavailable in the right quantity at the right time and place and is therefore considered “scarce” relative to the demands placed on it for human use and consumption. Moreover, human alteration of the landscape and natural water flows has routed water away from ecosystems upon which many species of animals and plants depend, endangering their survival.

This chapter describes management of three essential water resources: watersheds, groundwater and surface water. It outlines the complex challenges – technical, economic, institutional and regulatory – that must be addressed in order to allocate and manage water sustainably. In particular, there is a tension between the desire to manage water as a private good and the growing recognition that leaving the allocation and management of water to the market can have adverse effects on the social and environmental values of water. The chapter concludes by reviewing examples of national regulatory approaches to managing water quantity addressing real and potential conflicts.

Chapter 6: Water Resource Quality

Water pollution reduces the quality of water, making it unsuitable for many uses, most notably drinking water and ecosystem health. Chapter 6 addresses water quality problems. It reviews the hydrology of freshwater systems and the nature and sources of water pollution. It then looks more closely at two principal categories of water pollution: point source pollution (pollution of water systems by discrete and identifiable facilities and outfalls) and non-point source pollution (pollution delivered to water systems through surface water runoff, infiltration and other unchanneled means). The chapter also considers the social, economic and health effects of water pollution, the principles that inform government responses to pollution and the legislative and regulatory tools and strategies typically deployed in water pollution control.

Chapter 7: Drinking Water

Ensuring access to clean, healthy drinking water is one of the principal challenges of water management. Lack of access to clean drinking water results in the deaths of millions of people every year and harms the health of many millions more. Chapter 7 discusses the effects of lack of access to safe drinking water, both in social and economic terms. It describes policy and regulatory efforts to increase access to water and to improve its safety and quality. The chapter concludes with a detailed discussion of legislative and regulatory options for drinking water quality standards and laws, drawing on the World Health Organization's *Guidelines for Drinking-Water Quality*.

Chapter 8: Water and Agriculture

Chapter 8 explores the relationship between water and agriculture. Globally, more than two-thirds of all freshwater goes towards food production. The world's expanding population will require even more water to produce food, yet there are limited freshwater supplies. On the other hand, increasing urbanization can be expected to produce greater quantities of wastewater, which represents an opportunity since the nutrients in wastewater can increase food production whilst enabling farmers to spend less on fertilizers. The chapter presents the legislative and regulatory frameworks that govern irrigation practices and explores policy options and good practices for making irrigation more efficient whilst protecting public health and the environment.

Chapter 9: Integrated Management of Water for Human and Ecosystem Needs

The failure to effectively manage water resources has caused problems related to both water quantity and quality. Addressing the need to balance water use for human development and ecosystem protection, Chapter 9 outlines the significant benefits of improved watershed and groundwater management, introducing the concepts of environmental flows, watershed services and conjunctive management of surface waters and groundwater. It then considers how regulatory and market-based tools can meet future water resource management challenges. These tools include limits on water use and pollution, land use zoning, cap and trade systems, water taxes and subsidies, irrigation water pricing and demand management, incentives for agricultural water conservation and water quality trading.

Chapter 10: Conceptions of Water

The concluding chapter outlines three conceptions of water that can be expected to remain on the international stage in the coming years. These are water as a commodity, water as a service and water as a human right. International debate will continue on whether and how water should be covered under international trade rules, and international and national efforts will continue to recognize and define the human right to water. These conceptions of water should be weighed and considered by those who manage water quantity and quality, elaborate water policy and craft legislative solutions to global and local water problems.

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2

WATER RESOURCES AND THEIR MANAGEMENT [*]

Contents

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[*] This chapter was prepared by Bruce Aylward, Nila Petralli, Jessica Vapnek and Benjamin Kiersch.

This chapter provides a foundation for understanding the biophysical aspects of water management. It introduces the concepts, objectives and tools used in water management and provides the relevant terminology. It begins by describing the characteristics of the water cycle. It then sets out the types and sources of water resources. The chapter classifies the principal types of water uses, estimates their demand and discusses the relationship and potential conflicts between human and ecosystem needs. The chapter concludes by outlining the need to adopt integrated water resource management strategies.

I. THE WATER CYCLE

Water is a renewable but finite resource. It is neither created nor destroyed; it only moves from place to place and changes in quality. Under current estimates, the earth has about 1 386 million km^3 (cubic kilometres) of water. However, the vast majority of this is of little direct use to us. Over 97 percent of available water is saline and only 2.5 percent is freshwater. Moreover, much of this freshwater is locked in the polar icecaps and glaciers.

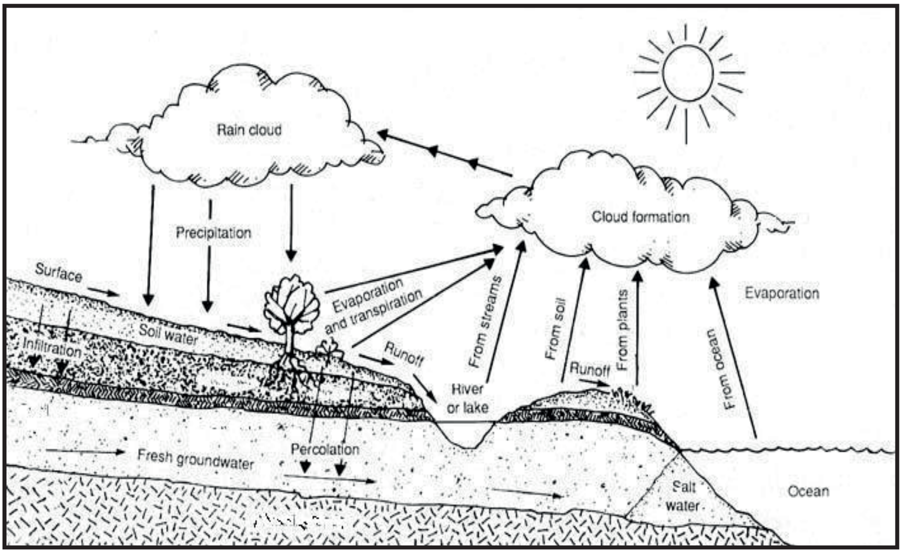
Freshwater can be defined as water having a low concentration of salts, or water that is generally accepted as suitable for abstraction and treatment to produce potable water. Salt water is generally defined as water containing more than 1 000 parts per million of dissolved salts of any type. This book focuses on freshwater and its uses.

The movement of water on the earth's surface and through the atmosphere is known as the hydrologic cycle or water cycle. As illustrated in Figure 2.1, the atmosphere takes up water as vapour from the earth's surface through evaporation from the soil and from water bodies, and through transpiration from plants. Evapotranspiration is the term used to describe the return of water from the surface to the atmosphere.

Wind moves water vapour from place to place until it condenses to form rain clouds. Water returns to the surface of the earth as either liquid or solid precipitation. Liquid precipitation includes rain, dew, drizzle and fog-drip. Solid precipitation comprises snow, sleet, hail and hoarfrost (the solid equivalent of dew).

Most precipitation is either intercepted by vegetation or infiltrates the soil. The precipitation that is not absorbed by plants or soil is called runoff, and it flows downhill over the ground surface until it reaches a river or other surface water body.

Figure 2.1 - The Water Cycle



Source: FAO, 1993.

The precipitation that does enter the ground, adding to the underground water table, is called infiltration. Infiltration may first replenish soil water, serving as a source of water for plant transpiration. Infiltration percolating further downwards (by means of gravitational or capillary forces) enters underground geological water systems called aquifers, which hold groundwater. This process is known as aquifer recharge or groundwater recharge. Aquifers usually have an outlet to surface waters (rivers and lakes) or the sea. The outward flow of water from groundwater into surface waters is called groundwater discharge or return flow. These terms are defined in greater detail in Box 2.1.

If groundwater levels fall, so, too, will most surface waters. Water in rivers and lakes then flows to the oceans from which water evaporates in an ever-repeating cycle. Indeed, our world's water systems are best understood not as a series of discrete and separable water bodies, but rather as a complex and inter-related network within which many natural cycles and processes are constantly in motion. For example, through the cycle of evaporation and precipitation, water molecules from surface moisture become airborne and then return to the earth as rain and snow, feeding the streams, tributaries, rivers, lakes and oceans that provided the bulk of the evaporate in the first instance. Groundwater and surface water are also inter-connected. Groundwater bodies generally both discharge to and are recharged by surface waters. In times of drought, pumping groundwater contributes to depletion of the remaining surface waters as well.

Box 2.1 - Subterranean Definitions

Soil water rests in the spaces between particles of soil and is immediately available to plants. The amount of water in the soil depends on the soil texture. Soil water occupies the shallow layer of earth, called the *unsaturated zone*, which is located directly above the water table.

The *water table* is located at the top of the groundwater and indicates the depth from which water can be extracted. When the water table falls, wells run dry and extracting water becomes more difficult. The water table rises after groundwater recharge, and declines with seasonally dry weather, drought, reduced infiltration caused by compaction and other factors.

Aquifers are rock formations, usually composed of sandstone, chalk and limestone, that are sufficiently porous to contain water and through which water may percolate. Aquifers may be *confined* or *unconfined*. Aquifers are unconfined when the rock formation that contains the aquifer is at the surface or is overlaid by permeable soils. Water may enter the aquifer directly from the surface or after passage through the soil, and the water levels are subject to seasonal fluctuations. Clays and other types of impermeable rocks or soil overlie confined aquifers.

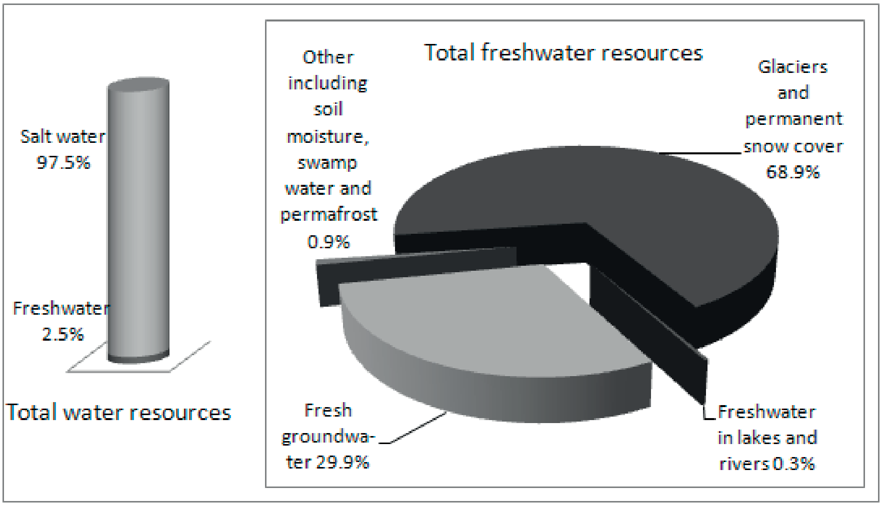
Water does not enter confined aquifers directly from the surface but through unconfined aquifer outcrops. Water levels in confined aquifers are not subject to seasonal fluctuations and may be almost completely depleted by excessive pumping. In a *perched aquifer* the water is stored above an impermeable layer and has no outlet; once full it spills water to the aquifer below.

Fossil groundwater is held in aquifers located at great depth that have little if any connection to groundwater recharge. Once extracted (or "mined"), these groundwater reserves are difficult to replenish.

The water cycle takes place within the earth's ecosystem. Without water, plants wilt, shrivel and die. Even viruses, which may not even be alive, go dormant and "turn off" without water. Because of the inter-relatedness of natural resources and systems, it is difficult to effectively manage the use of one natural resource without damaging the planet's subtle and fragile equilibrium. Human interventions can cause a series of reactions in the environment; for example, changes in vegetation and land use affect the quality and the availability of water resources. This is true with respect to surface water, groundwater and precipitation.

The ways in which environmental changes affect water resources may be loosely classified according to whether they are primarily related to water quality or water quantity. Soil erosion, sedimentation and nutrient outflow affect water quality in downstream runoff or surface water. Changes in annual water yield, seasonal flow, stormflow response and groundwater recharge affect the quantity of water received downstream (the stream hydrograph). Changes in local or regional vegetation may lead to localized or basin-wide shifts in rainfall and precipitation. For example, elimination of certain forest areas may reduce precipitation previously captured from fog in upland cloud forests. Regional climate also has an important influence on the hydrologic system and is affected by a wide range of human activities.

Figure 2.2 - Global Water Resources



Source: Shiklomanov, 1998.

II. SUPPLY OF WATER RESOURCES

2.1. Freshwater resources

Roughly 2.5 percent of the earth's water resources are freshwater. The total stock of freshwater is equivalent to a volume of water over 70 metres high spread across the land surface area of the earth. Much of this water, however, is locked up in long-term storage, leaving very little available to humans and the environment. In fact, more than 68 percent of this freshwater is in the form of ice and permanent snow cover in the Antarctic, the Arctic and mountainous regions. A further 30 percent of freshwater is stored underground as groundwater, although estimates of the amount of water in aquifers vary. Ice in the permafrost zone makes up the next largest amount, at just less than 0.75 percent of the world's freshwater. Finally, approximately 0.3 percent of freshwater is concentrated in lakes, reservoirs, wetlands and river systems, and an even lower percentage (0.1 percent) of water is retained at any given time as soil moisture.

There are two types of freshwater resources: freshwater in static storage and freshwater in transit. Freshwater resources in static storage include freshwater in the form of glaciers, permafrost and ice, whose complete renewal takes place over many years or decades. Freshwater resources in transit are those water molecules moving actively through the water cycle. Freshwater resources are both renewable and exhaustible. Both types of freshwater are fully replenished during the hydrologic cycle, but at very different rates. The complete recharge of permafrost and ice takes roughly 10 000 years, and the complete recharge of deep groundwater and mountainous glaciers about 1 500 years. Intensive use depletes stored waters and disturbs the natural systems that depend on these freshwater sources. In some circumstances, these ecosystems cannot be restored once disrupted.

The hydraulic connection between groundwater and surface water (rivers and lakes) must also be recognized. The influence of groundwater recharge or groundwater discharge is felt both in terms of volume changes (for example in static storage) and in terms of pressure within the hydraulic system. Just as additions (or not) to one end of a garden hose will affect the water emerging from the other end, groundwater recharge and withdrawal affect the rate and volume at which groundwater rejoins surface waters.

Table 2.1 - Stocks and Flows in the Hydrosphere

Type of Water	**Stock of Water**			**Flows**
	Volume ('000 km^3)	Fraction of Hydrosphere (%)	Fraction of Freshwater (%)	Annual Volume ('000 km^3/yr)
1. Saline Waters				
Seawater (oceans)	1 338 000.0	96.5	-	452
Groundwater – saline	12 870.0	1.7	-	
2. Freshwater				
Glaciers/permanent ice	24 100.0	1.74	68.7	
Groundwater – freshwater	10 530.0	0.76	30.1	
Ice in permafrost	300.0	0.022	0.86	
Lakes (fresh)	91.0	0.007	0.26	
Soil moisture	16.5	0.001	0.05	80
Wetlands	11.5	0.0008	0.03	
Rivers	2.1	0.0002	0.006	39
Biological water	1.1	0.0001	0.003	
Atmosphere	12.9	0.001	0.04	525
3. Totals				
Hydrosphere (all water)	1 385 935.1	100	-	
Freshwater	35 065.1	2.53		525
Blue water	105.7	0.008	0.0030	39
Green water	16.5			80

Sources: Shiklomanov and Rodda, 2003; Shiklomanov, 2000; and L'vovich, 1979.

The quantity of freshwater moving through the earth's surface is regenerated by precipitation. Estimates of total global annual precipitation vary between 525 000 and 577 000 cubic kilometres (km^3) (Shiklomanov, 2000; UNESCO, 2000). Of this, around 119 000 km^3 falls on land and the rest falls into the oceans

(Shiklomanov, 2000; UNESCO, 2000). This is the annual flow-through volume of freshwater potentially available for human and ecosystem needs.

The difference between rainfall and total runoff from rivers (including groundwater discharge) represents total terrestrial evapotranspiration (the evaporation of water from the earth's surface and from the transpiration from plants). The volume of terrestrial evapotranspiration is estimated at roughly 73 000 km^3/yr (Falkenmark and Rockström, 2004). Water that moves through evapotranspiration is often referred to as green water (in that it cycles largely through plants). This water is different from blue water, which includes all freshwater discharged from river basins (Falkenmark and Rockström, 2004).

The amount of water that percolates through to aquifers is estimated at 7 500 km^3/yr – the difference between evapotranspiration (72 500 km^3/yr) and the annual soil moisture turnover (80 000 km^3/yr) (see Table 2.1). In equilibrium, groundwater recharge naturally discharges to surface waters, as described above.

Many efforts have been made to calculate annual flows of freshwater. Vörösmarty *et al.* found that the different estimates range from 33 500 km^3 to 47 000 km^3 for long-term renewable runoff from land surfaces. These are large numbers and one might conclude that such a large amount of freshwater should more than satisfy human demands. The problem, however, is that insufficient freshwater is available to humans *in the amounts and at the time and location needed*. Thus the global supply of freshwater can prove a misleading statistic. What matters is not the total amount of freshwater on earth but, rather, whether a community has access to enough freshwater when it needs it.

2.2. Sources of freshwater

Precipitation, surface waters and groundwater are the main types of water sources from which freshwater is available for human or ecosystem use.

2.2.1. Precipitation

Precipitation is largely composed of rain and snow. It (along with the resulting soil moisture) feeds plants and animals and makes human life possible. It is estimated that 60 to 70 percent of global food production comes from rain-fed agriculture, and that 90 percent of evapotranspiration (or green water vapour) is related to plant production in terrestrial ecosystems (Falkenmark and Rockström, 2004). When rainfall exceeds the soil's capacity to absorb, excess water (runoff) flows downhill over the ground surface until it reaches a river or other surface water body. Of total stream runoff available each year, 30 percent is available on a generally constant basis, whilst 70 percent occurs through flood flows (Falkenmark and Rockström, 2004).

Humans have long harvested rainwater to meet personal, household, agricultural and livelihood needs. Today, new technologies are being devised whilst old and indigenous techniques are being explored and renewed to reduce human dependence on surface waters and groundwater extraction. In remote and rural areas, investments in rainwater collection from rooftops and in small tanks or ponds are increasingly part of small-scale development strategies. In areas where fog or low clouds are prevalent (such as coastal Angola, Central America or Chile), water may be harvested from water vapour through vegetation (forests) or human-erected structures. Scientific advances have led to new technologies to alter precipitation patterns. For example, cloud seeding can induce solid or liquid precipitation over target lands.

2.2.2. Surface water

Surface water resources include rivers, streams, lakes, channels and ponds. Although the freshwater in rivers and lakes accounts for only 0.3 percent of freshwater on earth, it is the most accessible to humans and vital for freshwater ecosystems. Rivers can be classified according to their catchment size, flow volume or other criteria. Perennial rivers carry water year-round, whereas intermittent streams flow irregularly throughout the year and ephemeral streams exist only in periods of heavy rainfall. The duration and rates of precipitation, infiltration and evapotranspiration in river drainage basins and the extent and rate of groundwater discharge affect a river's volume.

Lakes are inland bodies of water occupying a hollow in the earth's surface, where water is relatively stationary and is stored for a prolonged period. Lakes, like rivers, are usually freshwater bodies. Lakes are supplied with water through precipitation that falls directly on the lake surface, through the flow of streams and rivers into the lake, through runoff from adjacent lands or through groundwater discharge. However, many lakes, especially in arid regions, become saline because the high rate of evaporation concentrates salts.

Lakes are transient features on the earth's surface: they can appear and disappear in a relatively short period of geologic time. The rate at which a lake ages depends on several factors, including erosion and climatic changes. Moreover, a lake may gradually fill with organic and inorganic sediment, becoming first a swamp or bog and then a meadow.

The area drained by a stream, river or lake is called a watershed, catchment or basin, depending on the size of the area and local parlance. Every stream, tributary or river has an associated watershed, and small watersheds are often part of larger ones.

2.2.3. Groundwater

Groundwater consists of all waters found beneath the surface of the earth. It flows naturally to the earth's surface via springs, or can be collected and brought to the surface in wells or tunnels. Groundwater is an important source of drinking water: anywhere from one-quarter to one-half of the world's population depends on groundwater for drinking (WWAP, 2003). As noted above, groundwater constitutes roughly 30 percent of total freshwater, but makes up nearly all of the freshwater stored in the earth in liquid form. The true extent of groundwater resources is uncertain: estimates vary from 7 to 23 million km^3, with 10 million km^3 generally accepted as an intermediate amount (Vörösmarty *et al.*, 2005; Falkenmark and Rockström, 2004).

Only a fraction of groundwater is renewable on an annual basis. As described above, the potential annual groundwater recharge (percolating down through the earth from precipitation) is just 7 500 km^3/yr. The replacement rate for the global stock of groundwater would therefore be once every 1 400 years (Falkenmark and Rockström, 2004). However, transit times for groundwater vary tremendously. Fossil groundwater is the result of water storage over geologic time and is therefore an exhaustible resource, whereas the flow of groundwater into headwater areas may have a transit time measured in days or months.

In addition to the water that naturally percolates through the ground, groundwater may be artificially recharged by a range of human actions including injection of water deep into the ground through wells; infiltration into the ground by directing water into recharge pits; and infiltration through spreading water on fields. Intentional aquifer recharge serves two purposes: storing excess water for later use and improving water quality by using the soil's filtration capacity.

Although the soil's ecosystem service of water purification often filters groundwater so that it is safe to drink, the slow movement of groundwater also means that once groundwater becomes polluted it may remain polluted for decades. Groundwater clean-up is complex and expensive. As a result, source protection – prevention of groundwater pollution – is a central focus of water resources management.

2.2.4. Wetlands

Wetlands play a fundamental role in preserving the environmental balance of the earth and provide habitats for myriad species of flora and fauna. Wetlands are "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (1971 Ramsar Convention, art. 1). Scientists recognize five major wetland systems: marine (coastal wetlands, including coastal lagoons, rocky shores and coral reefs); estuarine (including deltas, tidal marshes and mangrove swamps); lacustrine (wetlands associated with lakes); riverine (wetlands along rivers and streams); and palustrine (marshes, swamps and bogs).

Wetlands are among the world's most productive environments, serving as cradles of biological diversity, storehouses of genetic material and producers of food and resources necessary for human survival. For example, rice – a common wetland plant – feeds half of the world's population (Ramsar Convention Bureau, 1997). Wetland ecosystems provide several crucial ecosystem services. They serve as natural filters for many pollutants, which are absorbed by wetland plant species and soil. Flood plain wetlands soak up and store water when rivers flood their banks, thus reducing downstream damage. And wetlands provide critical habitat for the young of many aquatic species. The importance of wetlands to the environmental health of the earth is widely recognized, and therefore the management of wetlands aims to protect and conserve these precious ecosystems.

2.2.5. Seas and oceans

Seas and oceans play an important role in the freshwater cycle, through evaporation. Unless it is desalinated, salt water cannot be used by humans. Although desalination processes are generally expensive and energy-intensive, technological advances have lowered costs. In some regions with limited water supply, desalination costs are now increasingly competitive with the costs of water conservation or water transfers. At the same time, desalination raises concerns both about the energy required to operate desalination plants and the difficulty of disposing of the heavily saline brine water discharged.

2.2.6. Artificial water sources

Reservoirs are artificially created by the construction of dams or impoundment barriers on rivers. These artificial water bodies allow for hydropower generation and facilitate seasonal water distribution for agriculture, industry and other uses. The total water stored in reservoirs behind dams is estimated to be between 6 000 and 7 000 km^3, and the total reservoir surface area has reached 500 000 km^2 (Shiklomanov, 2000; Vörösmarty *et al.*, 2005).

Box 2.2 - The Great Man-Made River

In 1984, Libya began to move water from fossil aquifers in the desert to the densely populated coastal areas, so as to ensure a sufficient supply of water for the nation’s industrial, domestic, municipal and agricultural needs. The Great Man-Made River Authority was established in 1983 to direct and implement this massive civil construction work. The project, whose final cost will be close to US$ 30 billion, has entailed drilling more than 1 000 wells varying in depth from 450 to 650 metres. The conduit, which is four metres in diametre, is about 1 600 km long. This huge pipeline supplies water to the cities of Tripoli, Benghazi, Sirte and other settlements, and the amount of water transferred daily is over 6.5 million m^3. The project’s scope and scale have led some commentators to call the resulting river “the eighth wonder of the world” (UNESCO, 2001).

Dams and related water impoundments and reservoirs significantly alter hydrology and often negatively affect the environment. Dams have destroyed aquatic habitats and fisheries, caused the loss of downstream flood plains, riparian zones and adjacent wetlands and degraded river deltas. Moreover, the diminution of downstream river flows impairs water quality (because pollution is less diluted) (Rosenberg, 2000) and deprives downstream communities, regions or nations of water that may previously have been a critical component of their water resource supply.

Human control of water flow is not limited to dams: artificial watercourses may be built for uses such as water management, irrigation and transportation. For example, in Libya the so-called "great man-made river" project is bringing drinkable water to the coast (see Box 2.2).

III. DEMAND FOR WATER RESOURCES

The preceding section introduced the types of water sources that provide freshwater for human and ecosystem needs. This section introduces the types of water uses, and estimates current and future demands of humans and ecosystems for water resources.

3.1. Classification of water uses

As freshwater cascades through the water cycle, pulled by gravity towards the sea, it is used and reused in various ways. The term "consumptive use" denotes a use that partially or totally "uses up" water. After upstream consumption, there is less water remaining for downstream users. Alternatively, consumptive uses may change the characteristics or lower the quality of water, making it unfit for other uses. Examples of partially or totally consumptive uses include water for domestic and municipal needs, irrigation and industry. In a sense, this categorization is imperfect because water never disappears from the water cycle; the amount of water on the planet cannot be increased or decreased (Falkenmark and Lindh, 1976). In reality, consumptive uses either return water to vapour or otherwise remove it from the terrestrial part of the water cycle.

Non-consumptive uses do not reduce the volume of water available in a given source, which means that this volume is still available for downstream uses. Non-consumptive uses include inland navigation, recreation and water sports, fisheries, hydropower production and ecosystem maintenance.

To illustrate the difference between consumptive and non-consumptive uses, consider water storage. Water can be stored for future use through mechanisms that are either consumptive or non-consumptive. Water storage in reservoirs for future diversion is a consumptive use, since a percentage of stored water is typically lost through evaporation. The shallower the reservoir, the more consumptive the water storage. Water injected into groundwater, however, is generally non-consumptive.

Water usage can also be classified by where the water is used. Water is used *in situ* (on the land where it falls as precipitation) or instream (where it falls, collects or flows). Alternatively, water may be abstracted, diverted or withdrawn and moved to where it is needed ("abstractive" water use). For example, flood plain agriculture is an instream water use because it provides water to crops using natural flood cycles; no water is diverted or withdrawn from natural water flows. In contrast, agricultural irrigation is an abstractive use, as it requires diverting water from its natural course in rivers or underground to bring it to the fields where the crops are growing. The different classifications of water use for human and ecosystem purposes are set out below in Table 2.2.

Table 2.2 - Classification of Human and Ecosystem Uses of Water

	Location of Use			
Nature of Use	Terrestrial uses	Instream uses	Abstractive uses	Storage
Consumptive: quantity and quality	Ecosystem Primary production Agriculture Domestic		Domestic Industrial Irrigation Aquaculture	Domestic Industrial Irrigation Storage Hydropower Flood control
Consumptive: quality only	Waste discharge	Aquaculture Waste discharge		Aquaculture
Non-consumptive		Capture fisheries Recreation Ecosystems Barrage run-of-river hydropower	Diversion run-of-river hydropower	Aquifer recharge Recreation Capture fisheries

3.2. Human consumptive uses

A review of the different human consumptive uses of freshwater begins with the three major consumptive uses: domestic, industrial and agricultural.

3.2.1. Domestic use

Domestic water uses are essential for survival and for hygiene. Domestic water use includes drinking, washing, sanitation, cooking and other activities, including the watering of gardens or domestic animals. Generally, these are abstractive uses (i.e. withdrawal of water from a source for use). Domestic uses may be urban or rural.

The World Health Organization (WHO) has not issued guidelines on the amount of domestic water necessary to promote or preserve good health. However, it is estimated that the minimum amount of water for domestic use per person must be 20 litres per person per day to fulfil basic needs, whilst optimal access requires 100–200 litres per person per day to meet consumption and hygiene needs (Howard and Bartram, 2003).

Although people everywhere need and use water for domestic purposes, the confluence of population growth and increased urban migration has made cities the largest users of domestic water. Water is delivered to houses, apartment buildings, public buildings (such as offices, hospitals and schools) and also to businesses and small industries located in urban areas. Water is also used by cities to wash streets and to maintain public gardens and parks. The amount of water withdrawn for municipal uses depends on the size of the population served and the services and utilities provided. Urban water use may also hinge on the regional climate and the efficiency of the public water supply system, in particular how much water is lost to leakage as a result of cracked pipes and aging infrastructure.

Most of the water withdrawn by urban water supply systems is returned as wastewater to the hydrologic system. Sewerage systems collect wastewater from private and public buildings and may treat and process the sewage before it is discharged into receiving water bodies. Treated sewage water may be released either directly to surface waters or to groundwater through recharge systems. In some cities, treated sewage water (so-called "grey water") may be used to water plants in urban parks and gardens or to irrigate agricultural land. In some countries, cities and regions, however, wastewater is not treated before being discharged back into the hydrologic system, creating public health risks.

Domestic water use in rural areas is generally lower than in municipal areas for a variety of reasons, including lower population density, fewer public water services provided and lower per capita water use by the poor, amongst other factors.

Table 2.3 - Per Capita Requirements for Water Service Level to Promote Health

Service Level	**Access Measure**	**Needs Met**	**Level of Health Concern**
No access (quantity collected often below 5 litre/capita/day [l/c/d])	More than 1000 m or 30 mins. total collection time	Consumption: cannot be assured Hygiene: not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000 m or 5 to 30 mins. total collection time	Consumption: should be assured Hygiene: hand washing and basic food hygiene possible; laundry/bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered thru one tap on plot (or within 100 m or 5 mins. total collection time	Consumption: assured Hygiene: all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption: all needs met Hygiene: all needs should be met	Very low

Source: Howard and Bartram, 2003.

WHO reports that of the global total of 1.07 billion people without access to improved drinking water, 84 percent live in rural areas (WHO/ UNICEF, 2006). Access is defined as being able to collect at least 20 litres per day of safe drinking water from a source located no more than one kilometre from the home. Improved drinking water is defined as access through household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collection. There is a clear relationship between access to safe drinking water and public health: the lower the access to water, the higher the potential for ill health. Indeed, as noted in Chapter 1, development economists have introduced the term water deprivation – "the inability reliably to obtain water of adequate quantity and quality to sustain health and livelihood" – as a basic index of poverty (see Table 2.3 above).

Globally, water for domestic purposes accounts for 9 percent of total water withdrawals, although this varies by region from 5 to 15 percent (see Table 2.4). Withdrawals for domestic use vary widely by region (driven primarily by service level) with a global per capita average of 148 litres/day. Sub-Saharan Africa has the lowest per capita average at 41 litres/day and OECD countries the highest at 422 litres/day. Domestic use in relation to other human consumptive uses is proportionally higher in OECD countries (15 percent of total water uses) and Latin America (12 percent), whilst Asia, with much larger agricultural withdrawals, uses only 5 percent of its water withdrawals for domestic use.

It is worth bearing in mind that the absolute amount of water withdrawn and used for domestic purposes is relatively minor as a proportion of overall human consumptive uses and the total water resource base. The majority of human water consumption goes towards agriculture and industry.

3.2.2. Industrial use

Industries use water to transport both inputs and outputs, to cool industrial machinery (water is the most efficient means to lower a machine's temperature), to produce energy, to make products and to clean and wash machinery and goods; it is also used as a solvent and as a part of the goods produced. Industries and commercial establishments also require water for their air conditioning. Cooling accounts for up to 70 percent of water use in industry. Power generation accounts for most of the water that industries use, due to the massive amounts of water needed to cool assemblies.

Table 2.4 - Withdrawals of (Blue) Water for Domestic Use, by Region/Grouping (1995–2000)

Region/ Grouping	Population (billions)	Total Domestic Water Use (km^3/yr)	Domestic Use as % of Total Withdrawal	Daily Domestic Water Use (litres/ capita/day)	% of Global Average
Asia	3.23	80	5	68	46
Former Soviet Union	0.29	34	10	323	218
Latin America	0.51	33	12	177	120
North Africa/ Middle East	0.40	22	8	153	103
Sub-Saharan Africa	0.67	10	10	41	28
OECD	0.97	149	15	422	284
GRAND TOTAL	6.06	328	9	148	100

Source: Vörösmarty *et al.*, 2005.

Forty percent of the water withdrawn for industrial use comes from groundwater (WWAP, 2003). The volume of industrial water withdrawal varies across regions, sectors, manufacturers and factories. The quality of the good produced and the technology employed in the manufacturing process affect the volume of water used. In addition to water withdrawal, industries often dump industrial by-products into nearby water bodies, sometimes using surface and groundwater systems as receptacles for the pollution and waste generated by industrial activities.

Globally, just over one-fifth of water withdrawals are for industrial purposes – roughly twice domestic uses (see Table 2.5). Not surprisingly, industrialized countries, including the OECD countries and the former Soviet Union, withdraw a much higher per capita rate of water for industrial use than do developing regions.

Table 2.5 - Withdrawals of (Blue) Water for Industrial Use, by Region/Grouping (1995–2000)

Region/ Grouping	Total Industrial Water Use (km³/yr)	Industrial Use as % of Total Withdrawal	Daily Industrial Water Use (litres/capita/day)	% of Global Average
Asia	99	6	84	25
Former Soviet Union	115	34	1 094	321
Latin America	31	12	167	49
North Africa Middle East	15	5	104	31
Sub-Saharan Africa	4	4	16	5
OECD	489	48	1 384	407
GRAND TOTAL	753	21	340	100

Source: Vörösmarty *et al.*, 2005.

3.2.3. Water in agriculture

Agriculture, including animal husbandry, is the largest human consumptive use of freshwater. Worldwide, about 70 percent of abstracted freshwater is diverted for agricultural irrigation. Irrigation is considered highly productive in terms of food produced per unit of land: 7 percent of the world's cultivated land is supported by human-made irrigation systems, and this produces 40 percent of the world's total food supply. Much of the dramatic increase in food production of recent decades has required high-yielding plant varieties (combined with fertilizers and pest control) that rely on irrigation that ensures an adequate and timely supply of water. Part of the water withdrawn for irrigation is used for crop production, and part is used to flush salts out of the soil to prevent a reduction in soil fertility over time. Of total agricultural irrigation withdrawals, 20 percent is estimated to come from groundwater pumping (WWAP, 2003) (see Table 2.6).

Some agriculture is supported by naturally occurring water flow alone. According to one estimate, rain-fed agriculture and permanent grazing are responsible for the consumption of 25 400 km³/yr of freshwater (Falkenmark and Rockström, 2004). The natural flow of the water cycle produces about 60 percent of the world's food supply and supports a range of additional ecosystem uses, particularly in grass and rangeland areas where livestock is just one of many species taking advantage of the feed, water and landscape.

World water withdrawals for irrigation have increased by over 60 percent since 1960 (UNDSD, 1999). This trend is expected to continue, particularly in countries with a high rate of population growth. Water withdrawals for irrigation do not vary as markedly from region to region as do domestic and industrial water use. The exception is Sub-Saharan Africa, where withdrawals are just 339 litres/capita/day, roughly one-third of the global average.

Table 2.6 - Withdrawals of (Blue) Water for Irrigation, by Region/Grouping (1995–2000)

Region/ Grouping	**Total Irrigation Use (km³/yr)**	**Irrigation Use as % of Total Withdrawal**	**Daily Irrigation Use (litres/capita/day)**	**% of Global Average**
Asia	1373	89	1 165	104
Former Soviet Union	188	56	1 788	160
Latin America	205	76	1 101	98
North Africa Middle East	247	87	1 713	153
Sub-Saharan Africa	83	86	339	30
OECD	384	38	1 087	97
GRAND TOTAL	2 480	70	1 121	100

Source: Vörösmarty *et al.*, 2005.

As currently practised, irrigation is not nearly as efficient as it could be. In certain instances, as a result of unlined canals or leakage from pipes, much of the water diverted for irrigation does not reach the intended crops.

Unchecked water evaporation also contributes to irrigation inefficiencies. Currently, more than half of irrigation water returns to river basins and to groundwater aquifers, but its quality has been degraded by pesticides, fertilizers and salination. With modern engineering and water technologies – such as the use of water sprinklers or drip irrigation – a considerable amount of water can be conserved. These methods can help increase crop productivity (by ensuring that water reaches each plant) whilst decreasing the volume of abstracted water.

Water used for irrigation and other agricultural uses does not need to be of the same quality as water used for domestic purposes. Treated wastewater can be used safely to irrigate agricultural land: growing plants can process the organic substances found in sewage and treated wastewater. Moreover, some of the nutrients found in wastewater support plant growth. It is necessary to ensure, however, that heavy metals are not also present in the treated waste. the risks for human health must be balanced against the benefits of wastewater use (see Chapter 8).

3.3. Human non-consumptive uses

3.3.1. Inland capture fisheries and aquaculture

Inland fisheries consist of capture fisheries (fishing) and aquaculture (fish farming). The value of inland fisheries is often underestimated. Developing countries depend on inland fisheries for food security, nutrition, income and livelihoods, especially in rural areas. The catch from inland fisheries provides almost 12 percent of total fish consumed by humans and, in many countries, freshwater fish make up the majority of total animal protein intake, particularly among the poor (FAO, 1999). Freshwater fish also provide vitamins and minerals essential to the human diet. Fish farming's role as a source of food and income, in both developed and developing countries, is increasing in importance, partially in response to the growing global crisis in marine capture fisheries. In developed countries, where food security is less of an issue, sport fishing plays a significant economic role, generating income, affecting water resource use and driving demand to restore and rehabilitate fish habitats.

Both the quantity and the quality of fresh water must be maintained to sustain inland fisheries. In fisheries, "quantity" refers to the area of aquatic habitats and the physical volume of water, whereas "quality" refers to water chemistry and the quality of aquatic habitats, including the surrounding catchment and vegetation. Inland fisheries are biologically diverse in different parts of the world, but they all depend on a healthy environment and are influenced greatly by environmental changes.

Water for inland fisheries or aquaculture may be naturally available, as in lakes or rivers, or made available (abstracted) through the construction of reservoirs and other artificial fish habitats. Whether human-made or natural, water is “consumed” in lakes and reservoirs by evaporation (760 km^3/yr) and changes in water quality. Freshwater management strategies must explicitly incorporate inland fisheries – and the lakes and reservoirs in which they are located – into their planning and consider fisheries managers and fishing communities as stakeholders in multi-use strategies.

3.3.2. Hydropower

Hydropower is the use of the potential energy in surface waters to generate electricity and create energy. Hydropower generation is an important use of water in many countries. Although water is not “consumed” in the strict sense by hydropower facilities, it is usually stored in reservoirs that affect the timing of river flows and can alter downstream flow and volume.

Hydropower facilities are divided into “run-of-river” and “storage” facilities. In a run-of-river system, the force of the river current applies the needed pressure. Run-of-river projects depend on river flows and are affected by seasonal flows and hydrology. Run-of-river facilities come in two types: diversion or barrage. A diversion run-of-river hydropower project harnesses the natural gravity from the river flow to produce electricity. It does not require an impounding dam with a large reservoir. Diversion run-of-river projects have four major components: a diversion weir, a pond or other mechanism that removes sediment from diverted water, a high pressure tunnel through which the water travels and the power plant itself. Water is then discharged either much lower in same river system or into a different system.

Barrage run-of-river facilities do not divert water from the river. Instead, they rely on a dam (called a barrage), which backs water up to achieve a greater height from which to harness potential energy. Water is not stored in this system; the incoming flow never stops moving through, over or around the facility.

In a storage system, water is stored in dam-created reservoirs, which then release the water when the demand for electricity is high. Storage facilities consist of a dam, a powerhouse with turbines and generators and a tailrace for returning water to the river. Depending on inflow and storage capacity, such plants can store and release water on a daily, annual or other basis. Storage facilities store water when electricity is less valuable (off-peak) and release water for power when it is needed most (peak). Some facilities also use "excess" energy at off-peak periods to pump water up into a reservoir in order to generate hydropower at later peak periods.

3.3.3. Navigation

For hundreds of years, humankind has been using the paths of natural rivers and also creating waterways for navigation. This involves diverting water for canals, creating channels, dredging rivers and building locks and other structures to facilitate the use of waterways for transport. Rivers are an important means of moving goods and people across distances, in both developing and developed countries.

3.3.4. Recreation

Freshwater bodies are often used for recreational purposes such as boating, rafting, kayaking, swimming and sport fishing. Many of these activities are central attractions of the tourist industry, which has the potential to generate local and national economic growth. Because these activities call for certain water quantity and quality requirements, the demands posed by recreational uses should be considered when formulating water and environmental management policies.

3.4. Ecosystem and biodiversity uses

Water is integral to the earth's ecology and biodiversity. A wide range of ecosystems are based on and depend on rivers, lakes and wetlands; ecosystems require water to function and to exist. Freshwater-dependent ecosystems – such as mangroves, inter-tidal zones and estuaries – sustain millions of plant and animal species. Effective management of an ecosystem's ecological functions requires addressing the full range of physical, chemical and biological demands of a healthy ecosystem.

Ecosystems provide myriad benefits and services that both directly and indirectly support economic activity and contribute to human welfare. Direct ecosystem services include human consumption of fuel, food, fibre, water and other natural resources from the ecosystem. Ecosystems also provide indirect services that support human welfare: they regulate the atmosphere and climate; purify and retain freshwater; form and enrich the soil; cycle nutrients; detoxify and re-circulate waste; and pollinate crops. Freshwater ecosystems support and provide for all of these needs, as well as others that enhance biodiversity, sustain animal and plant species and improve the human quality of life. A purely market approach to water management may not consider these non-monetized benefits, yet they unquestionably provide great value.

Box 2.3 - Freshwater Ecosystem Services

Provisioning services

- Water (quantity and quality) for consumptive use (for drinking, domestic use and agriculture and industrial use)
- Water for non-consumptive use (for generating power and transport/navigation)
- Aquatic organisms for food and medicines

Regulatory services

- Maintenance of water quality (natural filtration and water treatment)
- Buffering of flood flows, erosion control through water/land interactions and flood control infrastructure

Cultural services

- Recreation (river rafting, kayaking, hiking and sport fishing)
- Tourism (river viewing)
- Existence values (personal satisfaction from free-flowing rivers)

Supporting services

- Role in nutrient cycling (role in maintenance of flood plain fertility), primary production
- Predator/prey relationships and ecosystem resilience

Source: Adapted from Aylward *et al.*, 2005.

Freshwater and the hydrological cycle sustain inland water ecosystems, including rivers, lakes and wetlands. The Millennium Ecosystem Assessment (MA) was launched by the United Nations in 2001 to examine the consequences of ecosystem change for human well-being and to evaluate the state of scientific knowledge of ecosystem conservation. The MA provides a framework for classifying ecosystem services, in which freshwater is a "provisioning" service – providing for humanity's domestic, agricultural, energy and transportation needs. In the MA lexicon, ecosystems also provide "regulating", "cultural" and "supporting" services that directly and indirectly contribute to human well-being. Box 2.3 sets out the types of services provided by freshwater ecosystems.

A drawback of the MA lexicon is that it does not distinguish between the natural and human-made components of ecosystem services. However, it does encompass all the potential uses of freshwater and is therefore a useful tool to highlight the challenges society faces in choosing how to enhance or protect the range of services provided by water resources.

3.5. Balancing ecosystem protection and water resources development

The need to maintain ecosystem health is grounded both in ethics and in the practical benefits ecosystem goods and services provide to humans (UNDSD, 1999; MA, 2003; UNECE, 2006). As a result of the growing attention given to the benefits of ecosystem services, increasing priority has been given to ecosystem requirements, or "environmental flows", in water management decisions (UNDSD, 1999). Too often there had been an over-emphasis on the benefits of water resource development to humans, without considering the impacts of these efforts on ecosystems or the complicated inter-relationship between water management and ecosystem health (WCD, 2000; Aylward *et al.*, 2005).

Over time, water management practices have increasingly focused on developing surface water and groundwater resources through investment in physical infrastructure, so-called "built capital", such as dams, canals, wells and power plants rather than through the "natural capital" and ecosystem services of flood control or water quality provided by wetlands and flood plains. Built capital necessarily affects ecosystem health. A key issue for water management professionals is how best to balance human water needs with ecosystem needs. Understanding ecosystem water requirements – and thus defining the "supply" needed by ecosystems – is a challenge.

Society may need to choose which natural resources and ecosystem services to take advantage of. For example, a town that relies on clean water that is naturally filtered by a heavily forested watershed may need to choose between the livelihood and economic benefits of logging the forest versus the naturally occurring clean water. In this example, foresters and water resource professionals must collaborate to assess and make choices regarding the impacts of logging and the costs of water treatment. Ecosystem service professionals need to clarify the tradeoffs between different "services" provided by natural resources and the resulting effects on human welfare and ecosystem health if those natural resources are used. In such instances, parties may be able to craft a "win-win" solution where logging continues in the watershed but is conducted in a manner and on a scale that preserves the ecosystem service of water purification.

In regions where there has been little development of water resources, the challenge is how to balance protecting and capitalizing on free or low cost naturally occurring ecosystem services with the potential to develop human-made services to provide for human water needs. In regions where heavy investment in water management infrastructure has already occurred, the water management challenge is often how to recover the welfare-enhancing ecosystem services that have been degraded without unnecessarily imperilling the water supply benefits of development.

When making water management decisions, it may be constructive to evaluate the costs and benefits of each alternative, choosing the level of ecosystem protection and water resources development that optimizes human welfare whilst creating the fewest adverse impacts on ecosystem health. It is not always possible to do so using monetary values, particularly for public goods. As a result, the tradeoffs between the many types of services are often very difficult to calculate in a common currency. At the same time, it may still be better to have a mix of monetary estimates and biophysical measures than no measure of ecosystem service provision at all (i.e. a value of zero), which is clearly incorrect.

IV. FRESHWATER AVAILABILITY, ALLOCATION AND PRODUCTIVITY

A comprehensive analysis of the sources and uses of freshwater is integral to future water resources management, but it can prove difficult. Most efforts to date have focused purely on withdrawals from groundwater and water bodies. Increasingly, water management professionals are using a more holistic approach that takes into consideration the totality of terrestrial precipitation and accounts for both blue and green flows (Falkenmark and Rockström, 2004). These analyses are being undertaken to better project future water scarcity and to determine how best to fulfil human and ecosystem water needs as the world's population grows. The blue and green water approaches are reviewed in the next sections.

Table 2.7 - Total Withdrawals of (Blue) Water, by Region/Grouping (1995–2000)

Region/ Grouping	Popula-tion (billions)	Total With-drawal (km^3/ yr)	Total Daily With-drawal (litres/ capita/ day)	% of Global Aver-age	Access-ible Water (km^3/yr)	Use Relative to Access-ible Supply
Asia	3.23	1550	1 315	82	9 300	17
Former Soviet Union	0.29	337	3 206	199	1 800	19
Latin America	0.51	269	1 445	90	8 700	3
North Africa Middle East	0.40	284	1 970	123	240	118
Sub-Saharan Africa	0.67	97	397	25	4 100	2
OECD	0.97	1020	2 887	180	5 600	18
GRAND TOTAL	6.06	3557	1 608	100	29 740	12

Source: Vörösmarty *et al.*, 2005.

4.1. Blue water

Recall that water that moves through evapotranspiration is often referred to as green water (in that it cycles largely through plants), whereas freshwater discharged from river basins is referred to as blue water. As part of the Millennium Ecosystem Assessment, scientists calculated that of the 40 000 km^3/yr of blue water flow available, only 30 000 km^3 (or 75 percent) is accessible to humans in downstream areas (Vörösmarty *et al.*, 2005). Total withdrawal is estimated at 3 600 km^3/yr, or 12 percent of the accessible flow. However, withdrawal varies tremendously by region. The Middle East and North Africa use 118 percent of their renewable supply, meaning that they use 100 percent of their blue water flows and are actively drawing from groundwater stocks – depleting them, potentially permanently. Asia, OECD countries and the former Soviet Union use between 15 and 20 percent of their accessible supply, whilst Sub-Saharan Africa and Latin America withdraw only 2 to 3 percent of theirs (see Table 2.7).

Despite the apparent availability of freshwater, a significant portion of these withdrawals may be locally unsustainable. Localized areas of water stress (the population is high relative to supply) and water crowding (water use is intensive relative to supply) may contribute to regional water shortages. Indicators of water scarcity for human purposes also suggest that there are increasing water shortages relative to the needs of aquatic ecosystems, particularly given that few countries provide protection for instream flows. Moreover, these estimates do not account for the accompanying degradation of water quality, which affects the utility of remaining flows for human and ecosystem uses. (See Chapter 6.)

4.2. Green water

An alternative formulation considers green water flows in addition to blue. This analysis considers the full terrestrial water cycle as the resource base with which to meet human and ecosystem water needs. It distinguishes between water consumed directly for human needs and water that contributes more to ecosystem needs, which may or may not indirectly provide additional services to humans.

Falkenmark and Rockström (2004) estimate that direct human uses of water are on the order of 28 500 km^3/yr, after including evapotranspiration from rain-fed agriculture and livestock grazing (see Table 2.8). Nearly twice this amount goes to indirect human and ecosystem uses. Humans use just a part of total blue water flows, with the bulk of blue water going to ecosystem maintenance. The authors conclude that current human consumption (3 100 km^3/yr) and the amount of stable river flow that goes undiverted (9 400 km^3/yr) suggest that 12 500 km^3/yr is currently available for human uses, without the need to construct more storage reservoirs. It must be kept in mind, of course, that diverting water can have ecological costs as well, depending on how much water is returned to the ecosystem and its quality.

Table 2.8 - Global Water Balance for Blue and Green Flows

		Consumptive Use of Freshwater (km^3/yr)		
		Direct Human Use	Ecosystem Use and Indirect Human Use	Totals
Blue Flow				
Direct	Irrigation	1 800		1 800
	Domestic and industrial	1 300		1,300
Indirect	Stable		9 400	9 400
	Flood flows		30 150	30 150
Subtotal Blue Flow		*3 100*	*39 550*	*42 650*
Green Flow				
Direct	Crops	5 000		5 000
	Grazing	20 400		20 400
Indirect	Grasslands		12 100	12 100
	Forests		19 700	19 700
	Arid lands		5 700	5 700
	Wetlands		1 400	1 400
	Lake evaporation		600	600
	Reservoirs		160	160
	Urban		100	100
	Unaccounted for			5 690
Subtotal Green Flow		*25 400*	*39 760*	*70 850*
GRAND TOTAL			79 310	113 500

Source: Falkenmark and Rockström, 2004.

Using available data, Falkenmark and Rockström estimate future needs for a planet expected to have nine billion people by mid-century. In order to adequately feed this population, an increase in consumptive water use of 5 600 km^3/yr is expected. One of the most significant variables in this projection is growth in per capita meat consumption as incomes rise, since a much larger amount of water is required to produce meat than crops, as noted in Chapter 1. Falkenmark and Rockström project that in the future, food will be supplied from expansion of rain-fed agriculture in savannah areas rather than from increased irrigation of existing areas. In total, they project that the new requirements will draw 800 km^3/yr from blue sources and 4 800 km^3/yr from green sources.

The authors conclude that there remains considerable room to reallocate green water that ecosystems presently use, in order to expand agriculture into arable lands not currently devoted to food production. In other words, future food needs need not be met just from blue water flows, but from green water flows as well. Just as with blue water, green water uses can be made more efficient by moving green water from waste (pure evaporation) or ecosystem use to human use for food production. At the same time, to ensure a healthy ecosystem and a reliable flow of valuable ecosystem services, care must be taken to ensure that sufficient water remains accessible for environmental needs.

V. WATER RESOURCES MANAGEMENT

Water management consists of allocation, distribution and conservation decisions for water resources. Making these decisions requires addressing present challenges whilst preparing for future ones.

5.1. Water management and its challenges

For freshwater, the water cycle can be divided into three components: what happens from the ground up, what happens below the ground and what happens in surface waters. Water management can therefore be grouped into: (1) watershed management; (2) groundwater management; and (3) surface water management. The quantity and quality of water stocks and flows are affected by a range of land use and water management decisions. For example, vegetation management can affect precipitation and runoff whilst watershed management can affect evapotranspiration, infiltration and soil moisture. Similarly, the level of the water table is affected by the rate of percolation and groundwater extraction. Direct interventions in surface water bodies (such as diversions, abstractions and water storage) can affect runoff and return flows from groundwater. Accordingly, several key issues must be borne in mind when making water management decisions.

First, water resources must be managed at the appropriate scale. For watershed and surface waters, the watershed is the appropriate management unit. By contrast, the appropriate management unit for groundwater is the aquifer. Second, water management issues and responses may take place at different hydrologic levels, since some watersheds lie within each other and are connected through upstream-downstream interactions. The issues that arise or the effects of management responses at one part of the water cycle may or may not have effects at others. For example, changes in land use in a headwater area may affect flood flows immediately downstream, with important consequences for land owners or people who make their livelihoods in the immediate area. Further downstream in the basin, however, the impacts are likely to be attenuated or reduced, as streams draining other headwater areas converge, each with its own distinct flood peak based on watershed hydrology and the timing of precipitation (for example, as a storm moves across the basin). Understanding the relationships amongst watershed function, groundwater recharge and discharge, as well as surface flow patterns across the extent of a watershed or basin, is important for effective water planning and management.

Finally, water management needs to be integrated in the temporal dimension. Although some water moves through the water cycle over a course of weeks or years, other water, particularly groundwater, has a much longer cycle which may be measured in hundreds or thousands of years. Water management must therefore recognize that different components of the system react at different time scales.

In the past, water resources management primarily focused on making water available. Today, the focus is increasingly on maximizing water's overall productivity (rather than merely water supply or efficiency) and acknowledging water's dual role in providing for both human and ecosystem needs (Molden and Falkenmark, 2003). As the world population grows and the climate changes, water will continue to grow scarce in areas where water resources are already crowded and stressed, and water scarcity will emerge in areas where water is now plentiful. Data suggests that there is enough water available for human and ecosystem needs. The main constraints on water availability are quantity, timing and quality. Water will continue to be plentiful, but may not be in the necessary location at the necessary times to adequately serve human and ecosystem needs. Addressing this challenge lies at the foundation of water resources management.

Given the variety and scale of competing uses for water – domestic, industrial, agricultural and environmental – moving water to where it is needed is inescapably a mix of economics, engineering and socio-political concerns. Moreover, the management of water resources is often linked to other environmental and resource issues, such as climate change. It may be possible to mitigate climate change through conservation of existing forests, reforestation of degraded forests or afforestation. However, forests have high rates of evapotranspiration. Planting forests for wood and carbon increases the amount of green water used by forests which, in some circumstances, could reduce the green water available for food production, possibly depleting groundwater and surface water stores as well. It is thus essential to look at land and water management simultaneously.

5.2. Integrated water resources management

Water management professionals are increasingly using a methodology called integrated water resources management (IWRM) (or integrated river basin management) to best address and balance these issues. The Global Water Partnership (a joint initiative of the World Bank, the United Nations Development Programme and the Swedish International Development Cooperation Agency) has defined IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2007).

IWRM requires effective frameworks for the cooperation of all interested stakeholders. The fundamental goals of IWRM depend on harmonizing the institutional frameworks for water management and promoting the participation of water users. IWRM will only succeed if it is a multi-disciplinary undertaking that uses all available knowledge and experience, both scientific and traditional. Successful IWRM also depends on a supporting policy, legal and regulatory environment. The legislative framework is the subject of the next chapter, whilst IWRM is discussed in greater detail in Chapter 6.

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3

WATER GOVERNANCE: POLICY AND LEGAL FRAMEWORKS [*]

Contents

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Good governance is essential to effective water management. Although some countries face genuine water scarcity, in many countries the roots of many water management problems lie in poor governance. As a United Nations Development Programme report has bluntly stated, "power, poverty and inequality" are far more to blame for water management problems than physical availability (UNDP, 2006). Improved water governance coupled with effective policies will be critical to managing the world's freshwater resources and avoiding a water crisis (UNDESA, 2003).

The primary tools with which public authorities govern water and implement policy are national laws, regulations and standards. This chapter examines these tools and sets the context for the water management strategies examined in later chapters. The first section introduces the concept of water governance, followed by an introduction to water policy. The remaining sections of the chapter outline how to evaluate current water laws and create strong legislative frameworks that can more effectively implement national water policy whilst addressing the challenges facing water resources management and water services provision.

I. WATER GOVERNANCE AND WATER POLICY

1.1. Governance

The systems that develop and manage water resources and water services delivery fall under the broad umbrella term of "governance" – an evolving concept without a universally accepted definition. Governance is perhaps best understood as the "exercise of economic, political and administrative authority to manage a country's affairs at all levels" (UNDESA, 2003). Governance specifically concerns the "political and administrative elements of solving a problem or exploiting an opportunity" (Rogers and Hall, 2003) and broadly encompasses tools such as laws and regulations, economic instruments, public expenditure and any other initiatives a government uses to implement its decisions (UNDESA, 2006). Effective governance results in improved development and human well-being – higher per capita income, higher literacy rates, lower infant mortality rates and reduced poverty, amongst others (Rogers and Hall, 2003).

Water governance has not always been recognized as important. The connection between governance and management first received wide recognition in 2000 at the Second World Water Forum in The Hague, where members of the international community specifically acknowledged the significance of water governance and its key elements: ownership, development and management of water resources. At the Forum, leaders identified "governing water wisely" as the principal challenge for water resource management.

The United Nations has established several criteria against which decision-makers and policy-makers may evaluate their policies, laws and management decisions to determine whether they create an effective governance model (UNDESA, 2003):

- the system encourages *participation* of all citizens;
- decisions are *transparent* and open to public scrutiny;
- all groups in society have *equitable* access to water to improve their well-being;
- all organizations (whether governmental or non-governmental) and the private sector are *accountable* to the public;
- government policies and actions are *coherent* and understandable;
- water institutions are *responsive* to stakeholders' needs and demands;
- water governance is *integrative*; and
- the governance system is "based on the *ethical principles* of the societies on which it functions" (UNDESA, 2003).

In view of increasing global water scarcity and the emergence of new technologies, many countries have already begun to assess and transform their water governance structures. Although each nation's reforms vary, the efforts share common elements. Most reforms decentralize decision-making; increase stakeholder participation in water management decisions; promote and improve public/private partnerships; incorporate principles of integrated water resources management (or integrated river basin management); and clarify institutional roles and responsibilities through formal legislation and informal customary water rights (UNDP, 2006).

Specific national goals for governance reform vary according to a number of factors, including a nation's level of development and industrialization. Developed countries often have a more established rule of law – i.e. national laws and regulations are more rigorously implemented and enforced – as well as the political will, administrative authority and resources necessary to change the governance structures. On the other hand, developing nations often have more flexibility to overhaul water laws and policies in their entirety and re-draft them according to current needs and emerging trends. As will be emphasized throughout this book, each country has a unique combination of geography, resources, history, laws and needs for economic growth. Thus, each government must determine what works best in its particular circumstances.

1.2. Policy

Broadly speaking, water governance is carried out through water policies for the administration and management of water uses. Policies may be national, international or local, although this chapter focuses mainly on the national ones. National policies reflect a country's values and objectives, determining the laws and other strategies that the government uses to implement its goals. A policy may consist of broad social objectives – such as ensuring universal access to water – or narrower objectives for mitigating specific problems, such as decentralizing water management for greater efficiency. Policies often focus on long-term objectives and act as a framework for future government actions.

Due to the complex nature of water systems, water policies are generally most effective when they are created within a larger, inter-disciplinary framework that includes economic, social and natural resources management concerns (see Salman and Bradlow, 2005; FAO, 1995c). Important objectives for water policies may include integrating the management of water and land; defining goals for the different water sectors; creating procedures for identifying, measuring, presenting and evaluating the costs and benefits of development projects; and designing long-term use strategies for each sector and river basin, including conservation strategies (see Salman and Bradlow, 2005).

Since the Rio Declaration on Environment and Development, which was adopted at the United Nations Conference of the same name in 1992, the international community has embraced a sustainable development agenda. Accordingly, nations have committed to ensuring that economic and social development are accompanied by environmental protection measures. Good water policy should therefore give equal consideration to water not only as an economic but also a social and environmental "good".

Since national circumstances and technologies change over time, policies should also be dynamic. They must be flexible enough to address current national and international issues and government's evolving objectives, although not so malleable that they change too often, causing uncertainty amongst the regulated community (FAO, 1995c). Importantly, as new policies are created or current policies amended, existing laws and initiatives must also be reviewed to ensure consistency and harmonization at national level.

Although water policies are unique to each country, successful policy development shares common features. After establishing its policy, a government must craft strategies to bring the policy to fruition. Such strategies may consist of legal tools (such as laws and regulations), economic tools (such as taxes or tax deductions) and other means (such as education and awareness-raising initiatives). These building blocks of water governance are described below.

II. LEGAL FRAMEWORK FOR WATER

2.1. National and international overview

The primary tool to implement policy is legislation, i.e. laws and regulations. Legislation, like policy, can exist at different levels of government: local/municipal, regional/provincial, national and international. As a general matter, laws set forth rights, obligations and institutional roles. They also establish a broad framework for more detailed requirements elaborated in subsequent subsidiary instruments such as ministerial regulations. Within a country, the Constitution or national laws generally set out the substantive boundaries of what regional or local governments may legislate on. This will vary depending on the country's legal system and legal traditions.

The two most common legal systems are common law and civil law. Common law regimes draw from the Anglo-Saxon legal tradition. Laws may initially start with the legislature but the corpus of law is mainly developed through court cases and judicially created doctrines. Courts follow *stare decisis*, meaning that judges follow precedent (prior judicial decisions and the decisions of higher courts). Common law countries also have statutory laws, and courts play an important role in interpreting both codified laws and non-codified legal doctrines. Civil law countries, by contrast, have long had codified laws, mainly descended from or influenced by the early Napoleonic Code. Courts in these countries generally play a less important role in legal interpretation. Customary laws, laws derived from the customs and habits of the people, are prevalent in both common law and civil law countries.

In addition to national laws, most countries are subject to a variety of international obligations. There are four sources of "international law": treaties, customary laws, general principles and judicial opinions.

- *International treaties* and other binding obligations take effect upon ratification by a designated number of nations, and those nations must honour the signed agreements.
- *International customary law* emerges from the consistent conduct of multiple states. A marker of customary international law is consensus among states, exhibited both by widespread conduct and a sense of legal obligation to act in a certain way. In other words, customary law derives power from the customs and practices that states recognize as obligatory.
- *General principles of international law* are principles common to the domestic laws of many nations, and when neither a customary law nor a conventional law covers a particular legal issue, these principles may come into effect.
- *Judicial opinions* applicable to international law include judgments and advisory opinions of international courts, awards rendered by arbitral tribunals and decisions by national tribunals.

It is important to note that international law derives its power from the consent of the sovereign, signatory nations and often has no monitoring or enforcement mechanisms. International law and its instruments as they relate to water will be described further in Chapter 4.

2.2. Traditional and evolving approaches

National water legislation has often distinguished between different water resource sectors without considering their inter-connectedness. For example, water pollution is affected by water quantity (as greater river flows dilute pollution concentrations), and yet pollution control is often regulated and managed separately from water allocation. Similarly, groundwater levels affect surface water systems and yet groundwater is often regulated without consideration for the surface water systems to which the groundwater sources are often linked. By the same token, some water sources, such as springs, exhibit features of both groundwater and surface water and so may be duplicatively regulated or not regulated at all.

Despite these hydrological realities, in many nations separate laws deal with surface waters, groundwater, water resources abstraction, water pollution, irrigation and drinking water. As a result, water-related provisions are often scattered throughout a wide range of laws, regulations or decrees. The legal framework for water may have overlaps, duplications of responsibility among various authorities, ambiguities and gaps in coverage – grey areas left unregulated in the absence of a specific law, or fragmented policy areas that are ignored or under-emphasized. Moreover, laws may skew policies, for example protecting surface water at the expense of groundwater. Water laws should accommodate rather than ignore the realities of the water cycle.

In the past, many nations drafted their water policies and water laws under the assumption that water was inexhaustible. Accordingly, the existing framework may inadequately address the challenges of water scarcity and the need for sustainable water resource management. The legislative framework may not permit authorities to implement water policies that incorporate advances in knowledge and technology. Nor may the legislation allow government to play a more interventionist role aimed at ensuring fairness of resource allocation among users and an integrated approach to the development, management and conservation of water resources.

In an environment of greater scarcity and the need to balance competing uses, many governments are in the process of revising their national water legislation. Many circumstances and issues may drive reform of the national legislative framework for water. Jurisdictions may change their water laws after determining that water resource deficiencies were largely attributable to conflicts between sectors (Chile), in response to widespread frustration with government bureaucracy and unsupervised spending (State of Victoria, Australia), in order to address and resolve past injustices (South Africa) or to bring a new level of consistency of direction and purpose to water policies and provincial water programmes (Argentina). There are many other reasons as well.

In the process of revising their national legal frameworks for water, governments will have to assess and review a host of related legislation that has an impact on water resources management, such as legislation on land use, agriculture, forestry, biodiversity or species protection and air quality. Such a broad perspective is called for because of the nature of water flow: unwise land use and zoning can degrade water quality and wreak economic and social devastation on those living downstream; over-harvesting of forests may increase erosion and sedimentation; and air pollution may contain elements such as sulphur dioxide that cause acid rain, which leads to the acidification of lakes and ponds, or mercury which contaminates fish and eventually harms consumers.

Good water laws, rather than being fragmented across different sectors, address the full range of issues connected to the management, development, use and protection of the resource. Many recent laws also directly address the regulation of water services and encompass management and planning, issues generally absent in traditional water laws. The only significant regulatory area that often continues to be regulated separately is the provision of water supply and sanitation services, due to its complexity and importance (see Chapter 7).

2.3. Features of good water laws

Good water legislation should reflect three main characteristics. It should be clear; it must provide secure rights; and it must contain enforcement mechanisms that are both adequate and feasible and that can be applied consistently. These features are reviewed in more detail below.

2.3.1. Simplicity and clarity

Although the argument that "laws should be simple" may be attractive, creating simple laws is not always possible or desirable. Unlike a policy document, a statute must follow a certain format to create binding obligations. Moreover, the hydrologic cycle is complex, as are the rules that govern it. Complicated laws and regulations are often perceived as pursuing arcane legal goals and ignoring the practicalities of implementation, but if all of the relevant issues are to be addressed comprehensively (including those related to health and development), water legislation may not be as simple as policy-makers might like. For example, the idea of "simplicity" was aired frequently during South Africa's water policy review process, but the South African Water Act contains more than 100 pages of detailed provisions. Similarly, the 2000 Water Act of the Australian State of Queensland consists of some 1 100 sections and fills a 400-plus page book.

Nonetheless, law-makers should strive to make laws as basic as possible, leaving the details to implementing regulations which can be more easily changed. Rather than having to proceed through the lengthy legislative or law-making process, regulations are usually elaborated, issued and amended by a particular agency, ministry or department.

More critical than simplicity, however, is clarity. Regulated parties – as well as the regulators – must know what their legal obligations are. Laws must clearly describe the basic principles behind the legislation so that subsequent implementing regulations can build on the original intent of the law. The law must also clearly define the process and procedures for rule-making, including the degree of transparency and participation.

2.3.2. Security of rights

Water rights attempt to confer on the right-holder a degree of legal security which thereby promotes investment in the resource. Security of water rights is linked not only to water abstraction and use but also to wastewater disposal, since the right to use water implies that the water maintains a certain quality. Because the actions of upstream users have an impact on the quality and quantity of the water source and therefore affect downstream users, water legislation must strike a balance between the security needed to encourage investment and the need for administrative flexibility to re-allocate water resources from one use and user to another. Furthermore, since water availability can vary seasonally and from year to year, and since a water right can be exercised only if a source contains sufficient water, legislation should clarify whether government has the authority to curtail water rights during droughts or low-river flows or to accommodate a competing use. Licensing requirements for water abstraction and wastewater disposal should be structured so that they may be easily adapted to new circumstances, even in emergencies such as shortages or contamination. If properly designed, they should also permit changes to be made in less pressing circumstances, such as the need to accommodate technological advances in water management.

2.3.3. Implementation and enforceability

Implementation and enforcement issues are often left unaddressed during the preparation of legislation, which can severely undermine the law's efficacy. Failure to consider implementation issues may result not only in misallocation, over-exploitation or inequitable distribution of water, but also degradation of water resources. The government's administration and enforcement capacity, as well as users' capacity to comply with the new legislation, should be assessed during the drafting process and duly accounted for in the procedures set out in the law. The experiences of several countries reveal that considering implementation requirements while preparing new legislation improves the quality and realism of the legislation elaborated (FAO, 2001). The reverse also holds true, i.e. that lack of foresight regarding feasibility of execution can delay the implementation of new legislation.

Legislation must also resolve several questions regarding enforcement. First, who is subject to the law's restrictions? Second, the legislation must define which agencies and actors can enforce the law. Enforcement may be solely the obligation of government agencies – federal, provincial or local – or, as in some countries, the public may also enforce legislation directly through "citizen suits". Third, legislation needs to designate the correct forum for enforcement: do parties have to go through an administrative process, pursue mediation or arbitration or seek enforcement through the judicial system? Legislation must also designate the applicable appeals process. This is particularly important in federal republics where the proper appeals forum could be in state or federal court. Legislation must settle these questions to avoid confusion and allow for an efficient and just judicial process.

Finally, legislation should designate the proper remedies for violations. Remedies may include injunctions, restitution, fines, damages or imprisonment. An injunction is a court order stopping the violator from continuing the actions that are causing the violation, and may be temporary or permanent. Restitution orders the violator to restore the situation to its pre-injured state (e.g. cleaning a river into which wastewater was illegally dumped). Alternatively, restitution may require the violator to pay the equivalent of returning the water resources to their pre-injured state, for example where clean-up is not physically possible.

Fines and damages are both financial remedies, but their applicability depends on who is harmed. A fine is generally a remedy for violating a statute, and the proceeds go to the government (sometimes to help regulate and enforce the law, sometimes to the general treasury). Damages, by contrast, are awarded to an individual who has been injured by the violator's neglect or misconduct. These may be personal harms, such as illness or injury, or property harm.

The most extreme remedy is imprisonment. Except in countries where all offences are set out in a Criminal Code, the water legislation should specify the degree of *mens rea* (mental state) that must have been present in the violator to result in imprisonment. In other words, what was the violator's intent? Did he or she intend to cause the harm and knowingly violate the law, or was the damage caused by recklessness or negligence? For example, the United States' Clean Water Act has a maximum imprisonment of 15 years depending on many factors, including whether the violation was negligent or intentional.

III. SUBSTANCE OF NATIONAL WATER LAWS

The remainder of this chapter focuses on water legislation, outlining how water is regulated and describing key elements of water laws. It introduces important areas of inquiry such as ownership of water and abstraction rights; environmental protection; administrative structures for water management; and regulation of drinking water.

The discussion is intended to provide an analytical model for use in assessing a country's national legal framework for water. Employing this analysis should assist jurisdictions in identifying strengths, weaknesses and gaps in their water laws, and in elaborating an integrated legislative framework that includes environmental and human health and development concerns. To see this analysis applied with respect to specific countries and to make comparisons among them, visit the online database of national water laws at www.waterlawandstandards.org, a system that was designed and implemented by FAO and WHO alongside the development of the present text.

After analysing the enumerated substantive areas of water laws, the chapter concludes with an examination of some other key issues of water legislation, including the role of customary law, market-based regulations and government institutions, and suggestions for incorporating planning, integrating environmental, ecosystem, health and development concerns into water legislation and, finally, involving water users.

3.1. Ownership or other status of water resources

Water resource ownership and water rights allocation are two essential and related aspects of water law. To identify the legal framework related to ownership of water resources, public rights to water and the importance of water relative to other natural resources, the first step is to determine whether water is addressed in the national Constitution or Bill of Rights and to identify all water-related statutes. The extent of the state's ownership and regulatory role may vary, ranging from outright state ownership (in some constitutions or statutes) to a less direct approach, such as the "public trust doctrine", which considers water the property of all and which the government holds as a guardian or trustee. Furthermore, state ownership or trusteeship may embrace all water resources or leave some under private ownership or control. For indigenous communities, the government may establish forms of communal ownership. The applicable approach or approaches to the ownership of water resources may be explicitly stated in the constitution or law or implicitly result from the structures that the legal framework establishes.

3.2. Abstraction of water

A fundamental role of water law is to provide a mechanism for allocation of the resource amongst competing users, regardless of whether water is held under public ownership, public trusteeship or state custodianship. A formal allocation system gives water users some security that they will be able to access sufficient water to meet their needs, whilst maximizing the benefits of water across a certain region or country. A well-defined water rights system encourages responsible water use and facilitates sustainability of the resource.

Legislation may address whether the government will regulate the right to abstract water by granting licences (also referred to as permits or rights) and whether those rights are linked to land ownership. Under a licensing scheme, water may be allocated among diverse users and diverse water use sectors in accordance with the government's priorities and plans. Criteria for the grant of water abstraction licences represent the practical application of a government's environmental and public health priorities, amongst other concerns. The administering authority may prioritize use permits or licences based on a balance of societal, economic and ecological needs. Governments may wish, for example, to prioritize providing water for drinking, the environment, irrigation or industry, and must take steps to ensure that each water source can support these abstractions.

A state may consider a range of factors before granting water abstraction licences, such as the hydrology, the current and future demand for and availability of water and the likely impact the licensed use will have on water resources. The criteria employed to evaluate applications and grant or deny licences should be transparent, and should be applied to all applications in the same manner so as to ensure consistency and fairness.

An administrative structure should be in place to implement, monitor and enforce the system of water abstraction licences. Monitoring is particularly important for effective enforcement. For example, irrigation typically uses the greatest amount of water, and poorly managed irrigation schemes can over-abstract and inefficiently use water which may harm the ecosystems that also need the water. An effective monitoring system would evaluate how irrigation licence holders are using their water in order to make any needed changes. Where the licensing scheme allows for the suspension or variation of licences during their period of validity, the administering authority might suspend a valid existing licence and reallocate the water to another user where circumstances have changed or water needs and priorities in the region have shifted. Because such government action compromises the security of the licence holder's rights, the legislation needs to clarify which circumstances could lead to loss, suspension or variation and what compensation is payable, if any.

Water legislation may also identify uses that are exempt from water licensing requirements (such as household or stock water uses) and should provide for the recording of the water abstraction licences. The legislation should also indicate whether water abstraction licences are subject to specific terms and conditions. For example, licences may be issued subject to restrictions on the amount, rate or timing of abstractions or on the type of water use to which they apply. The administering authority may also impose time limitations on the licence period.

Water abstraction charges may help regulate use. If policy-makers choose this method of economic regulation, then legislation must clearly establish how charges will be calculated for the abstraction of water from streams, lakes, underground aquifers and other water bodies so that users can calculate their overall costs before proceeding. This is particularly important for businesses making investment decisions.

Legislation may provide that licences are tradeable, as this can foster efficiency in water allocation and use. However, it may also mean that water rights may not necessarily rest with those who will put the water resources to the best use. On the other hand, prohibiting water rights trading may cause water shortages, since once water supplies are fully allocated, new water users cannot easily be accommodated and existing users may have little incentive to conserve water. Economic development policies may be impaired if water cannot gravitate towards higher-value uses.

Finally, as demand for water increases, the hydraulic connection between surface water and groundwater must be taken into account. As groundwater is a particularly vulnerable resource subject to over-exploitation, it must be carefully managed. Legislation should regulate groundwater resource development, including prospecting (borehole drilling for groundwater exploration purposes). Furthermore, as surface water and groundwater approach full allocation, the legal regime may need to consider the right to capture rainwater. As rural land owners or urban dwellers install rainwater harvesting systems, these will have a greater impact on existing downstream water rights and users (see Chapter 9).

3.3. Environmental protection

Water legislation must address not only water quantity but also water quality. Starting with water pollution control, water legislation must address whether permission is required to directly or indirectly discharge effluents (waste materials) into streams, lakes, underground aquifers and other water bodies. As with abstraction, legislation must clarify the criteria for considering applications and granting permits and mandate that written records be kept of permits to discharge waste.

Furthermore, water resources legislation must specify whether wastewater discharge permits are subject to any exceptions or any terms and conditions, including duration, and whether there are applicable standards for effluent or ambient water quality. Legislation should set out how any such standards are set and reviewed, and by whom.

Legislation should also address whether wastewater discharge permits are tradeable on the market; whether they can be revoked, suspended or varied during their period of validity (and if so under what circumstances and whether compensation is payable); whether "vested" rights for wastewater disposal activities will be protected when any new legislation takes effect (an issue that also arises with water abstraction licences); and whether the government has the authority to declare certain regions or areas subject to additional restrictions on wastewater discharge (for example, where there is a risk of contamination of a drinking water source) and the procedures for making such declarations.

Legislation on wastewater disposal should also establish a system to monitor and enforce permits, for example by levying charges for wastewater disposal into water bodies. Provisions to control pollution of water resources from "diffuse" sources – for example, from the drainage and runoff of cultivated land where nitrates are used – should also be addressed (see Chapter 6).

To ensure the greatest environmental protection, the legislative framework must effectively address the full range of water-related ecosystem needs. Legislation may do this by setting instream flow requirements; enforcing instream flows; setting up a regulatory framework for payments for watershed services; and providing incentives for conservation of resources. Each of these regulatory strategies is discussed below.

Setting minimum flow requirements. Legislation may account for the environment's needs by setting a minimum necessary flow and then requiring maintenance of that minimum. However, maintenance of minimum flows often does not provide for a fully functioning ecosystem. As a result, increasing attention is being paid to defining environmental flows as a series of hydrological parameters that permit variability through the years (and across years) to better mimic the natural hydrograph.

Enforcing instream flows. Countries that choose to maintain instream flows for environmental and recreational uses have several options. For those rivers that remain relatively wild and free-flowing, placing restrictions on infrastructure development and use may be sufficient. However, many rivers are already developed and the applicable water licences already allocated. Legislation must then account for ecosystem needs within an already existing allocation and licensing scheme, determining the needs of both the water users and the ecosystems that rely on water. Experience in many countries indicates that reaching an allocation that satisfies the competing uses can be politically challenging. It is therefore essential that ecosystems have a representative or that other legal safeguards ensure that ecosystem interests are defended during allocation decisions.

Regulating payments for watershed services. Watershed service payment schemes enable downstream beneficiaries to contract with upstream land owners for improved land use and land management practices. Such schemes can be an effective way to protect watersheds for drinking water, agriculture and ecosystems. A solid legal framework for the enforcement of contracts and land tenure, as well as strong government oversight, are important. If parties to a contract know that the legal system will support and uphold the contract terms, they will be more likely to enter into contracts and this can improve environmental protection.

Similarly, the greater security of land tenure in the region, the greater the likelihood that service payments will emerge. Watershed service payment schemes are also being implemented through legislation imposing a system of water charges on users of the resource, where the water charges explicitly incorporate an environmental services component. An example of this can be found in recent Costa Rican legislation (see Box 3.1).

Providing incentives for conserving resources. Incentives for conserving water generally involve pricing water so that more use results in higher cost to the user. Fees may be applied to domestic, agricultural and/or industrial uses. Other incentives for water conservation include tax reductions, tax credits or cash rebates to individuals and businesses that implement water conservation measures (such as by installing water conservation fixtures in homes or repairing irrigation canals).

Box 3.1 - Charging for Environmental Services in Costa Rica

Under a presidential decree of 2005 in Costa Rica (No. 32868), all concessions and authorizations for the abstraction and utilization of water resources – including those held by government institutions – are subject to a charge. Water charges include an environmental services component which reflects the cost of conserving, maintaining and restoring ecosystems and basins in areas of importance to the hydrological balance (such as protected state forests). Charges are calculated on a volumetric basis in accordance with the decree.

This charging scheme was designed for gradual implementation over a period of seven years. From the eighth year on, charges will be automatically adjusted for inflation. Half of the proceeds from the collection of water charges will be destined for the integrated management of water resources at the national level and for a number of projects. The remaining half will be earmarked for investment in the resource's basin-of-origin, and will be used for the conservation, maintenance and restoration of protected state forests, national parks, biological reserves and private property located inside state lands, in recognition of the environmental water protection services provided.

The balance will go into a National Forestry Fund, which will provide the necessary resources to finance the Environmental Services Payment Programme. This programme will compensate private land owners for the environmental service of protecting and conserving water resources – especially sources of drinking water in areas significant to water resource sustainability. Part of these funds can also go to municipalities to fund the purchase of private land to protect groundwater recharge areas and water sources of local importance. Public and private providers of drinking water supply services, irrigation and aquaculture water services and electricity services must reflect their water charges in the tariff structure of the services they provide. These transparent charges are borne by customers, who are the final beneficiaries of the environmental services.

Source: Burchi, 2006

3.4. Government water administration

Many water bodies extend across multiple national or sub-national jurisdictions. Accordingly, the legislative review should determine how responsibilities are allocated at the national/federal level and at all subordinate levels of government, notably at the river basin level. For example, in countries with federal systems, the water resource management responsibilities of the states/provinces should be identified, as well as how water resource management powers are shared between the federal and state governments. Unclear allocation of authority increases the likelihood of ineffective governance.

In some cases, legislation may create a special-purpose governmental administration at the river basin level that cuts across jurisdictions. The administration may have its own responsibilities and structure in addition to, or in place of, those existing at the federal and state level. Legislation may also specify whether local governments have any responsibility in water resources management and whether the establishment of associations or other water user groups will be provided for and regulated.

3.5. Drinking water and water services

Water resources legislation should ensure sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. However, because of the complexity of regulating drinking water provision and sanitation services, it is often regulated in separate legislation.

Legislation on drinking water should address both access and quality. It should clearly delineate roles and responsibilities of all parties, empowering authorities to manage drinking water from source to consumer, including surveillance for and response to potential drinking water contamination and water-borne illness events. Legislation may designate the minimum volume of water that must be provided for drinking water and may set explicit priorities ensuring that the highest-quality water resources are set aside and protected for that purpose. Legislation may identify responsibilities for setting water quality standards and establish guidelines for monitoring adherence to and enforcement of these, alongside penalties for non-compliance. Legislation should provide authority for third-party oversight and monitoring and should require public reporting by drinking water purveyors, public health professionals and other stakeholders to ensure accountability.

Legislation must establish controls over the state entities and private corporations that supply drinking water. Such controls should outline the responsibilities of suppliers both during normal operation and during emergencies. These controls normally also provide for licensing, certification and approval of chemicals and materials used in the treatment, filtration and distribution of drinking water. Legislation may also provide for tariff structures and controls, including connection costs, water use charges, subsidies and mechanisms for dealing with non-payment of tariffs (see Chapter 7).

IV. OTHER KEY ISSUES IN THE LEGAL FRAMEWORK FOR WATER

4.1. Integrating customary law

Customary law plays an important role in water management in many countries, particularly at the community level. Like international customary law, local customary law develops from the traditions and norms of a certain society that come to be accepted as rules or law. These rules have often evolved over hundreds of years and may be best adapted to local water situations and cultural, social and livelihood practices. Customary water laws are rarely a single and unified body of rules and can vary widely from region to region, sometimes even between villages in the same region. Customary rules governing access to water have been documented in many countries, the best-known example perhaps being the allocation system of irrigation water and water rights on the island of Bali, Indonesia (Caponera and Nanni, 2007).

For most countries, the goal of revising water laws is to establish a formal system that will facilitate the most rational use of available water, guarantee access to safe water and support the administrative system governing water resources. A subsidiary goal in many countries is to replace and integrate existing traditional and customary systems. To that end, it is important that when establishing a formal water use regime (with its emphasis on legality and written rules), the new system does not penalize, harm or deprive water users who have relied on unwritten customary rights of water access and use. Otherwise, enforcement will prove challenging and often impossible.

One way to address customary rights in water legislation is simply to recognize them formally, for example by providing that traditional water rights shall apply so long as they do not conflict with written legislation. The 1994 Guinea Water Code, for instance, provides that customary rights of local communities are valid unless contrary to the provisions of the Water Code. The legal frameworks of Côte d'Ivoire, Namibia and Papua New Guinea establish similar accommodations and integrations of customary water law. Papua New Guinea's 1982 Water Resources Act states that customary water rights prevail over written law, and Namibia's Water Resources Management Act of 2004 explicitly acknowledges customary water rights and practices. The Namibian Act, as well as the 1998 Water Code in Côte d'Ivoire, require a thorough consideration of customary rights in evaluating, assigning and licensing water rights.

Some legislation on groundwater integrates customary and written water law by recognizing, formalizing and compensating violations of customary rights. The rationale for this approach is that without sanction and compensation, modern groundwater development may destroy or impair traditional and indigenous water user rights (Solanes, 1999). Thus, for example, Papua New Guinea's Water Resources Act compensates customary rights if groundwater development affects them.

Some jurisdictions define and legalize customary laws through a registration scheme. In this way, unwritten rights are essentially transformed into written rights. For example, after enacting its 1984 Water Code, Cape Verde required that customary water rights be claimed and proven in front of the National Water Council within six months, after which the customary rights would be regulated according to the Water Code. Namibia's 2004 Water Act recognizes and protects customary rights and practices by imposing terms and conditions in the administration of water abstraction licences. The 1992 French Water Act requires registration of customary riparian rights in order to better regulate them in the future.

However, in some contexts mandating registration may have negative impacts on the poor – particularly women and indigenous peoples – who may not be able to successfully navigate complex formal administrative processes, reach government offices in urban centres, communicate in the official language of the state, complete the forms necessary to claim and formalize their water rights or even be aware that such measures are necessary. To protect against inequity, states implementing mandatory registration schemes should establish effective notification procedures to ensure public awareness, and should adopt simple registration procedures and mechanisms.

Another approach to securing traditional water rights is to assign powers to the traditional management authorities. In Malawi, traditional water authorities participate in planning and implementing water development projects. The 1983 Burkina Faso Water Code and 1993 Niger Water Code also formalize local authorities' participation in these activities. The United States Environmental Protection Agency has involved Native American tribes in implementing water management policies, whilst the Namibian Act, mentioned above, allows the Traditional Council (representing chiefs and traditional communities in general) to join the Water Advisory Council.

4.2. Integrating market-based regulations

Traditional water legislation has often favoured command and control mechanisms that require strong, centralized government oversight and enforcement. Although this type of mechanism has been effective in certain situations (such as in combating pollution or over-abstraction), it can also prove inefficient and overly bureaucratic in some settings. Accordingly, states are increasingly turning to the market as another means of regulating water resources and pollution. Market-based regulation strategies may include imposing taxes, creating financial incentives or establishing permit-trading schemes. Market-based mechanisms allow water users the flexibility and financial incentive to decide for themselves the least expensive means of complying with the regulatory requirements.

When governments give water users the freedom to pursue their own solutions through market-based regulations, corporations and other water users are given the incentive to innovate and thereby arrive at more economical and effective water use and pollution controls. Under market-based regulatory mechanisms, water users and polluters have more financial incentive to conserve resources or to use them more efficiently than if they were required to take a mandated action or install a specific technology to combat pollution (Stewart, 1992). Water conservation if employed in this fashion improves the company's or household's bottom line, saving money and improving profits.

It is important to recognize that even where there is greater reliance on market-based instruments, governments do not abdicate their authority entirely. Market-based instruments simply provide an efficient means for parties to meet their regulatory requirements; they do not remove them. Moreover, market-based instruments are not well-suited for all situations; command and control mechanisms may be more effective in certain situations and contexts. Indeed, many water resource management problems are best addressed by a combination of command and control limits and market-based flexibility. For example, the United States reduced lead in gasoline by first limiting the lead content of gasoline and then allowing refiners to trade the allowed lead content of their gasoline with lead content "credits". The federal Environmental Protection Agency gradually decreased the allowable content by promulgating more stringent standards and reducing the number of credits circulating in the market.

4.3. Transforming government institutions

The structure of government institutions plays a central role in how state authority, responsibility and accountability are allocated across various agencies or ministries Thus, enacting a comprehensive legal framework for integrated water management will often call for institutional and administrative reform (FAO, 1995c). A complete revamping of the water sector may well require staffing changes and changes in the responsibilities of ministries, agencies and councils, although in practice such changes are often neither politically nor financially feasible. In such situations, ensuring coordination among the relevant institutions and agencies must often suffice (see Box 3.2).

Box 3.2 - Fostering Cooperation under Albanian Water Law

Albania's Law on Water Resources (No. 8093, 21 March 1996) institutionalizes a high degree of cooperation between the National Water Council (NWC) and other public entities. Under the Law, the NWC is entitled to get information, data, reviews or technical and advisory support from other ministries, committees, agencies and public structures to enable it to prepare the National Water Strategy and National Water Resources Plan. The NWC is required to prepare, in cooperation with other concerned agencies, projects and programmes to prevent or remediate harmful impacts on water resources. These may address irrigation plans and crop cultivation practices, drainage, protection of river banks and reforestation, amongst others.

Albania's legislation has allowed for particularly close cooperation between NWC and the Ministry of Health and Environmental Protection. The Law provides that the NWC *must* collaborate with health and environmental protection institutions in areas posing a danger to human life and health. In accordance with the mandated procedure, the NWC first declares an area harmful to the public interest and then deals with the affected land and water. Furthermore, the NWC and the Minister of Health and Environmental Protection share responsibility for prescribing requirements for different kinds of discharges and for setting quality standards for water for human consumption.

Box 3.3 - Catchment Water Management Boards in Australia

The State of South Australia Water Resources Act (No. 27, 1997) establishes catchment water management boards. The Act provides that one member must be a woman; one must be an active member of a community within the board's catchment area; one or more must have expertise in the management, development or use of water or other natural resources; one must have expertise in the conservation of ecosystems; one must represent local government or administration within the board's area, and all others must have expertise in public or business administration, regional economic development or any other area that the Minister finds relevant.

Under the Act, the boards prepare and implement catchment water management plans, advise the Minister and the catchment area's constituent councils on water resource management and promote public awareness of the importance of proper management and sustainable use of the water resources of the catchment area. The boards have the power to stop, reduce the flow of, hold, divert or otherwise control water in a watercourse; deepen, widen or alter watercourses or lakes; construct embankments, wells, channels, roads, buildings or other works; excavate land to create a lake or for any other purpose; install pipes, machinery or other equipment; drill boreholes; inspect or survey land and fix posts, stakes or markers; dig to determine the nature of soil and remove samples; and acquire land by contract with a land owner on approval of the Minister.

Boards do not issue water allocation licences within their catchments, although water plans can empower them to grant water permits. Generally, allocation is carried out at ministerial level, with the Minister evaluating, issuing and amending licences in accordance with the relevant water allocation plan.

Many countries are moving away from centralized water administrations towards more local water management structures at the catchment, river basin or aquifer level. If local capacity is sufficient, many water resources management activities are more effective when administered at the local level. However, certain activities such as information collection and monitoring may be more efficiently managed by the central government, since local authorities may not always have the requisite knowledge or access to information for informed decisions and may be subject to more political pressure than a central or national authority. Whatever the case, decisions affecting local water authorities must consider the local conditions (De Koning, 1987).

Within each nation, political, institutional and geographic factors will determine the appropriate level for decision-making. The technical capacity and expertise of regional government administrators and technicians will also affect decentralization decisions. For example, water authorities in New Zealand and Australia (known as catchment management authorities, see Box 3.3) have been restructured to exercise jurisdiction over particular watersheds. There the institutional scale is aligned with the hydrological scale.

4.4. Incorporating planning

Comprehensive water legislation should provide a framework for water resource planning, the principal aim of which is to predict the impact and needs of humans and the environment in relation to water resources. Water resource planning also aims to direct the development of water resources to meet human and environmental needs and to address potential harmful effects on the water resource, the surrounding ecosystem and dependent populations. Water planning is also used to mitigate any harmful effects that may be caused by water resources, for example through flooding, waterlogging or soil erosion. Insofar as possible, water management plans should aim toward the efficient and rational distribution of water to meet present and future water demands through the sustainable development of water resources. France introduced and regulated a complex water resources planning system in its 1992 Water Act (see Box 3.4).

Within Australia, the State of New South Wales' Water Management Act of 2000 mandates the formation of statutory water resources management plans for designated "water management areas". These plans, which are in effect for 10 years at a time, are to be formed by local committees and cover water resources allocation and sharing; environmental protection; drainage; and flood plain management. In the State of Victoria, amendments (2001) to the 1989 Water Act provide for "streamflow management plans" – prepared in respect of surface water resources under stress – to limit total water abstractions. South Australia's catchment-level "water allocation planning", introduced by the 1997 Water Resources Act, fixes volumes of water that can be taken from a catchment area for use.

Box 3.4 - Planning Provisions in French Legislation

France's elaborate water resources planning system is based on General Water Plans (*Schémas directeurs d'aménagement et de gestion des eaux*, or SDAGE), covering one or more basins, and on Detailed Water Plans (*Schémas d'aménagement et de gestion des eaux*, or SAGE), covering one or more sub-basins or specific aquifers. These instruments reserve good-quality groundwater so as to satisfy the drinking water needs of the population and apportion the available groundwater to the competing user groups by quotas.

One distinctive feature of the French water planning system is the direct participation of civil society in the formulation and adoption of the plans. If the government grants a water abstraction concession or permit that is at variance with the determinations of a SAGE or SDAGE, that concession or permit can be challenged in the courts and quashed. This ability to challenge conflicting government concessions is actively used in practice: in one instance, the state granted a permit for the extraction of groundwater for industrial use from an aquifer that the Seine-Normandie SDAGE had reserved for drinking water use. The permit was quashed by the court and withdrawn (FAO, 2003).

As described above, water policies should provide the flexibility to respond to developments in water resources assessment and technological and socio-economic change. In this regard, the new Netherlands Water Act (expected 2009) mandates that water management plans be reviewed every six years. Moreover, the preparation and periodic review of river basin management plans is a mandatory requirement for member states of the European Union (EU) under the EU Water Framework Directive of 2000.

4.5. Integrating environmental and ecosystem concerns

As described above, a comprehensive legal framework for water must adequately take into account the environment and ecosystems. Focusing on development to the exclusion of environmental concerns can lead to unsustainable water uses, water pollution and damaged ecosystems, as well as negatively affect the ecosystem services they provide and on which communities depend. Water laws should therefore require that water resource management administrators keep environmental considerations in view. For example, water laws may mandate that before making any change in water allocation and management, government must carry out an environmental impact assessment (EIA). EIAs formally evaluate projects (especially but not only government-funded ones), assess whether they may cause any harm to the environment and finally, recommend ways to prevent or mitigate this damage. Most countries have legislation requiring these assessments where a particular activity may have a significant effect on the environment.

Many other countries mandate the use of a health impact assessment (HIA), which evaluates how a proposed policy, programme or project may affect the health of people. At a minimum, legislation could require that an EIA and a HIA be conducted for major projects such as the construction of a dam. The details of when an EIA and HIA are required and the procedures for conducting them should be clearly specified in the legislation.

Those countries that employ EIAs should consider broadening the assessment process to ensure that water resource concerns are specifically accounted for and adequately addressed. This can be achieved by tailoring the EIA to the relevant scale, i.e. the river basin or aquifer. Both the water resources and the ecosystem should be assessed for potential impacts. The EIA process should also consider the cultural and social values of water for the local communities, particularly for indigenous peoples (see FAO, 2003). EIAs may include measures to mitigate any harmful effects on local people and ecosystems, such as alternative sites for projects and compensation for any harm done.

The United States implemented its impact assessment process in 1969, when it passed the National Environmental Policy Act (NEPA). NEPA requires all federal agencies to prepare impact statements for major federal actions significantly affecting the environment. The assessment process established by NEPA has two prongs: an initial environmental assessment and, if warranted, a more comprehensive environmental impact statement (EIS). The EIS must detail the environmental impacts of the planned federal action and outline any available, less harmful alternatives.

4.6. Integrating health and development

Public health and development are inextricably linked to an adequate and safe water supply and to the level of water quality and sanitation. Public health issues must be integrated into every level of water management decisions, beginning at the strategy formulation stage and continuing through to project planning, design and implementation (FAO, 1995c). Water policies and planning often neglect these issues, focusing only on water as it relates to agriculture, transport and energy. Health specialists tend to look at water quality only as it relates to drinking and recreation. Such divisions have created gaps in policy and legislation, as well as missed opportunities for more effective management of water resources.

Health and development concerns may be integrated in several ways. One strategy is to require close institutional cooperation between the water resources administration and the public health authority. In addition, health professionals should be included on any water strategy resources team during the policy review phase. In many cases, the ministry of environment, water resources or agriculture, without consultation, sets up a working group, develops draft legislation in isolation and then circulates the draft to other ministries (including the ministry of health) for comments. Similarly, health experts often develop health legislation on their own. Full participation of all ministries, relevant agencies and other stakeholders is required for legislation to reach all sectors. To the extent possible, water legislation should formally institute such cross-sectoral cooperation.

Impact assessments are one important tool for integrating health concerns into water policy. As described above, before development projects can be undertaken, environmental legislation often requires EIAs, HIAs or both. Health-specific impact assessments may either be part of an EIA or may be implemented separately. In either case the goal is to ensure that health issues related to the environment and water resources management are neither marginalized nor ignored.

Integration of health concerns is also essential with regard to water services provision, particularly where water supply is managed privately. Governments must protect consumers by mandating oversight of water service provision, balancing the profit motivations and expectations of the water businesses against the legitimate interests and expectations of consumers. In England, for example, where privatization of the water sector began in the late 1980s, water companies had the power to disconnect supply if consumers did not pay their water bills and also had the ability to limit supply as a means of enforcing payment. In response to mounting concern over the health implications of water disconnections, England's 1999 Water Industry Act removed the power of water companies to disconnect or reduce water supply for non-payment, and strengthened consumers' rights with respect to standards of service provision. Consumers' rights to water services provision can also be enforced through court decisions. For example, the High Court of South Africa (2001) and the Appellate Court of Brazil's Paraná State (2002) upheld – on constitutional, human rights and statutory consumers' rights grounds – the demands of petitioners to have water service provided, although they were in default with respect to water charges.

4.7. Involving water users

Another legislative step toward improving water management is to establish a role for a water users' associations (WUA). WUAs – also known as irrigation associations, user associations or water user organizations – are ordinarily non-governmental organizations that farmers and other water users form to manage an irrigation system at the local or regional level. These users pool their resources, financial and otherwise, to operate and maintain the irrigation systems.

WUAs are created to benefit users. They can ensure that water is equitably distributed amongst all users (regardless of their location or the size of their property); the water supply is reliable; access to water is more responsive to users' needs; disputes are quickly resolved; canals and the system in general are well maintained; and there are fewer free riders and less water theft (IWMI, 2003).

Unfortunately, such benefits are not always realized. This may be due to poorly designed organizational structures, for example, where WUAs are managed from the top down instead of the bottom up. This means that local users who know the resource and community needs best may have little or no say in the organization, structure or development of the association. They may therefore come to feel little ownership of the WUA and avoid fee payments (IWMI, 2003). Furthermore, without adequate government guidance or the consultation of all stakeholders, influential users of the WUA may take over the decisions and the management of the irrigation system for their own benefit (Fayesse, 2004). Influential users may draw more water than they are entitled to, often because the agreements and organizational rules are ambiguous on ownership rights (Fayesse, 2004). Finally, if the benefits of being a member of a WUA are not understood to be linked with the costs, then users may become free riders rather than participate in the funding and management of the system (Freeman, 1989).

Many countries have formally recognized or informally set up WUAs. WUAs are generally created as separate legal entities that self-fund and have autonomy. If a country has already developed a system of WUAs, then legislation may be required only to recognize local management systems or improve their operation to ensure equity in distribution and participation (for example, to readjust from top-down to bottom-up management). Or, if water resources are still managed by a centralized government and the government intends to devolve to a local, user-based management system, it will be necessary to enact laws that transfer management to the WUAs.

Unless there is a longstanding traditional system of community water management in place, WUAs require a strong legislative framework. Many countries include these provisions within one comprehensive water law. Other countries, especially those without a long history of such associations, create a separate legislative provision dealing with the creation and management of WUAs. Chile, Kazakhstan and South Africa, for example, include provisions for WUAs within their respective national water laws. Kyrgyzstan and Morocco, by comparison, have separate laws dealing with water user associations.

It is critical that political and administrative authorities legally recognize WUAs once they are created (Freeman, 1989). WUAs should operate as legal persons that may enter into contracts, hold bank accounts, employ staff and defend themselves in legal proceedings (Hodgson, 2007). Legislation should also ensure that WUAs maintain non-profit status, so that neither the organization nor its members are personally enriched from their water management activities. This helps prevent conflicts of interest. Legislation might also provide for an equitable membership requirement to ensure that the full range of stakeholders' views are heard. For example, associations may be mandated to include women, members from traditionally disadvantaged groups such as indigenous peoples and both large-scale and small-scale farmers.

Legislation should also address which agency will have regulatory oversight over WUAs. Although any state actor may play that role, the water resources management authority generally provides oversight and support (Hodgson, 2007). However, excessive oversight, especially by a central government, may diminish participants' role and management powers and intrude upon WUA decision-making practices (Hodgson, 2007). Governments must therefore balance WUAs' self-governance and self-determination rights against water user rights and good water resources management. They must decide on the appropriate supervisory relationship and how accountable the WUAs will be to both the state and water users. Germany, for example, limits the central government's role to auditing and to carrying out a residual, legal, supervisory function. The central government may only challenge a WUA's decision if it is actually illegal.

On the other hand, the oversight bodies must stand behind WUAs when they exert control over free riders, and be willing to uphold the decisions of dispute resolution bodies. Without clear and unambiguous acknowledgement of the association's authority, free riders will exploit the system, and the WUA will have difficulty exerting control over them and over other members that do not cooperate (Freeman, 1989).

It is difficult for a WUA to be effective unless it has both responsibility for management *and* authority to exercise that responsibility. Thus, legislation should contain a clear guarantee that the government will transfer responsibility and authority to manage and control water to the WUA, and ensure that the WUA is fully prepared to take on that management. Capacity building efforts may be required.

V. CONCLUSION

Review of the national legal framework for water is laborious, but it is absolutely essential to ensure good governance and effective implementation of water policies. All aspects of the existing legal framework should be assessed to determine which provisions need to change. When national water policy and law are revised, it is particularly important to bridge the traditional divide between laws on water resources abstraction and water pollution on the one hand, and laws on drinking water and water services on the other. The review and revision of national water law and policy should take an integrated approach that involves the broadest spectrum of water uses and stakeholders in order to ensure that national water resources are comprehensively protected. Similarly, since the various water laws and regulations will often be under the jurisdiction of different authorities or agencies, any new administrative scheme must ensure effective coordination.

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4

INTERNATIONAL WATER LAW[*]

Contents

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Efforts to improve the policy and legal framework for water resources management must go beyond the national sphere. In part, this is because water bodies do not observe national borders. Globally, 263 river basins cross international boundaries, with one-third of these crossing the borders of more than two countries and 19 basins crossing five countries or more. The Danube, for example, flows adjacent to or through 18 countries (UNESCO, 2003). And because water is transient, actions taken in one country can affect the quantity and quality of water in others. The erection of a dam on the main stem or tributary of an international watercourse may affect water levels, fisheries, recreation and other uses both upstream and downstream of the dam. Similarly, pollution-causing activities on a watercourse in an upstream country will have effects on countries and users downstream.

With water bodies and catchment areas crossing national boundaries and with activities in one country having far-reaching impacts on water resources in others, coordinated and multinational actions are the best way to manage shared water resources. At the same time, ensuring access to sufficient quantities of usable water has become an imperative for the international community. International cooperation and collaboration offer the best chance to properly balance human and environmental needs whilst ensuring sustainable development, use and protection of water resources especially in the face of climate change.

Shared water plainly calls for both shared strategies and shared solutions. Nations must work in concert to find lasting regional solutions. This requires countries to exchange information and knowledge, as well as establish joint water management plans, surveillance, early warning systems, contingency plans and institutional arrangements with their neighbours.

This chapter introduces a range of international approaches to the complex challenges of water resources management. It describes binding and non-binding sources of international water law, including water-related treaties, conventions and agreements, general principles of international law and guidelines formulated by international organizations. Finally, the chapter discusses emerging principles in international water law.

I. BINDING INTERNATIONAL LAW

Like national law, international law expresses government priorities, sets up structures, embodies commitments and identifies acts and omissions that policy-makers wish to reduce or prohibit. International law is mutually agreed upon by two or more sovereign states. It consists of the rules that govern their relationships and is only binding on countries that ratify the agreements (Janis, 2003). Box 4.1 lists some of the principal international agreements elaborated to address water resource challenges.

As outlined briefly in the previous chapter, international law is generally accepted to emanate from four sources, which are recognized in Article 38 of the Statute of the International Court of Justice, the United Nations' principal judicial body. The four sources are: (1) international treaties, conventions and agreements; (2) international customary law; (3) general principles of international law; and (4) judicial decisions. Each of these is now discussed in more detail.

1.1. International water-related treaties, conventions and agreements

International agreements can be described by a variety of names, such as treaties, conventions, inter-state agreements, binding decisions of international and regional bodies and declarations (Caponera and Nanni, 2007; Shaw, 2008). Regardless of the denomination, international agreements establish rules and conditions that are expressly recognized by the nations that voluntarily enter into them. They become law through the mutual consent of these nations: upon signing, states legally bind themselves to observe agreements made between them (ICJ, 1945; Shaw, 2008). To ensure compliance, parties to a treaty may mandate that any breach of treaty obligations will have consequences. Some treaties impose fines or institute dispute settlement proceedings against states that violate them.

International conventions may be general or particular. General conventions (multilateral agreements) codify a given sector's rules of conduct (Caponera and Nanni, 2007) and can be sub-divided into universal (global) and regional agreements. Particular conventions, by comparison, regulate specific aspects of international law and may be either multilateral or bilateral. Once a state agrees to a convention and signs or registers it, the convention must usually be ratified by the state's legislature.

Box 4.1 - Major International Water Instruments

Agreement	Year Enacted	Description
International		
United Nations Convention on the Law of Non-Navigable Uses of International Watercourses	1997	Spells out rights and obligations for all transboundary water; only offers general guidance; vague on groundwater and surface water systems; not yet legally binding.
Helsinki Rules on the Uses of International Watercourses	1966	Does same for transboundary rivers, lakes and underground aquifers; non-binding but widely respected.
Regional		
European Union (EU) Groundwater Directive	2006	Implements the provisions of the EU Water Framework Directive on the prevention and control of groundwater pollution; sets criteria to assess groundwater chemical status and to identify pollution trends; regulates input of pollutants into aquifers; and fights deterioration of all groundwater bodies.
European Union Water Framework Directive	2000	Covers all EU member states' surface and groundwater resources, both domestic and transboundary; states must adapt national legislation to the directive's requirements.
United Nations Economic Commission for Europe (UNECE) Protocol on Water and Health	1999	Requires member states to establish national/local targets for drinking water quality, discharge quality, water supply performance and wastewater treatment to reduce water-related disease outbreaks.
Protocol on Shared Watercourses in the Southern African Development Community Region	1995	Requires member states to enact legislation that provides for water abstraction licensing and wastewater disposal permitting.
UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes	1992	Requires member states to pass legislation regulating point source wastewater disposal and to adopt water quality objectives and criteria consistent with the parameters of the convention.

The type of treaty or convention determines both how it will become effective and the responsibilities that it will impose upon the signatories. Some treaties are "self-executing", meaning that when a country ratifies a treaty it automatically puts the treaty and all of its obligations into action. These self-executing treaties can apply immediately and be judicially enforced (Kiss and Shelton, 2004).

Other treaties are not self-executing, which means that they require a signatory country to make changes to its domestic law to enable it to fulfil the treaty's obligations. Such treaties might require states, for example, to pass new laws or amend existing ones in order to forbid, monitor or regulate certain activities, to establish licensing schemes or to create and appoint organs with specific tasks. In practice, treaties often have some elements that are self-executing and others that are not. That is, even treaties that are not self-executing may contain self-executing clauses that can be implemented immediately, whilst even treaties generally described as self-executing may contain provisions requiring additional domestic legislation or regulations. It is thus advisable to examine each treaty provision individually rather than describing the treaty as a whole.

Although domestic legislation and international treaties are governed by separate rules and systems, they affect and influence one another. A host of domestic legal obligations may arise from treaty enforcement, compliance and implementing mechanisms. This is especially true in nations with a legal system that automatically gives international agreements priority over domestic legislation. It is also true in cases where parties to a treaty agree between themselves that a treaty supersedes national law. In such instances, national legislation must be altered or set aside if it conflicts with the treaty's provisions.

International water-related treaties, conventions and agreements are the prime source of legally binding rights and obligations between and amongst states. The next section examines various types of water-related agreements which are entered into to address different water management problems.

1.1.1. Framework agreements

By signing framework agreements, states commit themselves to specific principles and establish a process for future joint action on a specific issue. Framework agreements are aptly named, for they create the framework for future actions that can take into account subsequent information and technical developments. According to agreed principles, subsidiary agreements or new institutional structures can be developed over time to address emerging issues (Berlin Recommendations, 1998). This flexibility explains why framework agreements are seen by many commentators and international donor organizations as the best way to achieve integrated management, equitable distribution and sustainable development.

Some framework agreements set out a series of substantive and procedural rules that govern the apportionment of water flows, the establishment of joint basin development plans, the launch of water development projects, the determination of equitable utilization or a combination of the above. These agreements generally provide for permanent, multi-state, institutional arrangements to administer the treaty's complex obligations.

A particularly important framework agreement is the European Convention on the Protection and Use of Transboundary Watercourses and International Lakes (the "Helsinki Convention"), which was initiated by the United Nations Economic Commission for Europe (UNECE). The convention was signed by 25 European countries and entered into force in October 1996. Under the convention, state parties must take specific measures to prevent, control and reduce pollution, to ensure ecologically sound and rational water management and to ensure the conservation and, where necessary, restoration of ecosystems (art. 2). It also commits signatory states to cooperate in developing harmonized policies and programmes in fields such as research, development and the exchange of information (art. 2(6) *et seq.*).

State parties are required to set emission limits for discharges of hazardous substances from point sources based on the best available technology. They must also apply biological treatment or equivalent processes to municipal wastewater, issue authorizations for wastewater discharges, monitor compliance, adopt water quality criteria and define water quality objectives (art. 3). Countries must develop and implement best environmental practices to reduce the emission of nutrients and hazardous substances from diffuse sources, in particular from agriculture (art. 3(1)). Moreover, states must employ environmental impact assessment procedures and the ecosystem approach to prevent any adverse impact on transboundary waters.

The Helsinki Convention requires countries to collect and monitor a wide range of data on water resources. For example, parties must monitor emission sources to obtain information on the concentration of pollutants in effluents and carry out pollution-load assessments. Countries must compile information related to instream features such as water quantity and quality; aquatic and riparian flora and fauna; sediment; and extreme conditions in waters caused by accidents, floods, drought or ice cover.

Framework conventions often create a secretariat or working party to administer the treaty and carry out the day-to-day activities. Thus, for example, a Working Party on Water Problems (WPWP) and several task forces were established to implement the Helsinki Convention. One of the convention's most important task forces addresses monitoring and assessment of transboundary waters. Under Article 11 of the Convention, states must establish and implement coordinated programmes to monitor and assess transboundary water conditions. Such programmes aim to ensure that changes in transboundary water conditions caused by human activity do not adversely affect human health and safety, plant and animal health and life and soil and air quality.

In March 2000, the WPWP and contracting states developed and formally adopted *Guidelines on Monitoring and Assessment of Transboundary Groundwaters* and *Guidelines on Monitoring and Assessment of Transboundary Rivers* intended to harmonize monitoring and assessment systems. The guidelines call for coordinated implementation of water policies based on sound institutional arrangements that facilitate cooperation between nations. The guidelines also stress the importance of nations integrating a comprehensive understanding of the dynamics of the groundwater flow system and the geology and hydrology of the transboundary area into all national and transboundary water resources management decisions. The guidelines are strategic rather than technical, and specifically state that they are not legally binding.

Institutional agreements are a sub-category of framework agreements that establish an international forum or institution to oversee a shared water body. For example, an agreement made in 1994 by Angola, Botswana and Namibia provides for a Permanent Okavango River Basin Water Commission (OKACOM), whose advisory mandate spans the entire spectrum of water development and management functions in the basin. OKACOM's functions include assessment of water supply and demand; water planning; water pollution prevention; drought mitigation; and others. To further the agreement's objectives, OKACOM must formulate environmentally sustainable development and integrated management plans for the entire Okavango River Basin. Similarly, in 1994, Kenya, Tanzania and Uganda agreed to establish the Lake Victoria Fisheries Organization (LVFO) to promote cooperation and coordination on all matters related to the conservation and management of the lake's fisheries resources. LVFO is an independent intergovernmental organization with its own operating budget that the member states fund in equal parts.

1.1.2. Subsidiary agreements

As noted, framework agreements often generate supplementary agreements or protocols that expand or elaborate on certain issues or concerns in the main agreement. One important example is the Protocol on Water and Health, which covers the prevention, control and reduction of water-related diseases in Europe. It builds and elaborates on the 1992 United Nations Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992 UN Convention). The protocol, which was brokered by the World Health Organization (WHO), marks the first major international initiative at the intersection of water and health. Noting a "serious burden of water-related diseases and problems in water management, water supply and sanitation" in the European Region, 35 countries signed the protocol at the Third Ministerial Conference on Environment and Health held in London in 1999. Twenty-one countries have ratified the protocol since then.

Both the 1992 UN Convention and the Protocol cover transboundary waters, which are defined in the protocol as surface water and groundwater that mark, cross or are located on the boundary between or amongst two or more member states of the UNECE or of the WHO Regional Committee for Europe (WHO/EURO). The protocol's basic objective is to "promote at all appropriate levels, nationally as well as in transboundary and international contexts, the protection of human health and well-being, both individual and collective, within the framework of sustainable development, through improving water management, including the protection of water ecosystems, and through preventing, controlling, and reducing water-related disease" (art. 1).

The protocol also specifies the measures that state parties must take in order to achieve these objectives, including ensuring protection of drinking water sources, providing a standard of adequate sanitation that sufficiently protects human health and the environment and establishing effective systems to monitor situations likely to result in outbreaks or incidents of water-related disease (art. 4(2)). In addition, to meet the objectives of the protocol, parties must aim to provide universal access to drinking water and sanitation, as well as establish and publish local targets for the standards and levels of performance needed to protect against water-related disease. Furthermore, the protocol calls for the establishment of water management plans, surveillance programmes and early warning systems to respond to outbreaks and incidents of water-related disease (art. 13(b)). In effect, the Protocol provides a "floor": states are free to implement more stringent measures over and above those outlined in the protocol but need not do so to be in compliance.

The Protocol mandates that before implementing any water management measures, states shall thoroughly assess the likely consequences and effects and take note of the possible benefits, disadvantages and costs for human health, water resources and sustainable development (art. 4(4)). Furthermore, parties have the duty to ensure that water management activities within their state jurisdiction are guided by principles such as precaution (see Section 3.1 of this chapter), polluter pays (see Section 3.2) and equitable access to water, and that the activities in question do not damage the environment in other states or jurisdictions (art. 5). To ensure successful implementation, the protocol emphasizes international cooperation and action, exchange of information and knowledge about water management problems and risks and the enhancement of public awareness (art. 11–13).

1.1.3. Water apportionment agreements

Water apportionment agreements allocate and assign transboundary river flows. State parties enter into such an agreement to formally allot each nation's respective "share" of the transboundary river flow. Each country may then use and develop its share as it sees fit, according to domestic priorities and plans. Classic examples of this type of international water agreement are the 1944 Treaty apportioning the Rio Grande flows between Mexico and the United States, the 1959 Nile Waters Agreement apportioning the regulated flow of the Nile between Egypt and Sudan and the 1960 Indus Waters Treaty apportioning the flow of the Indus and many of its tributaries between India and Pakistan.

A 1994 agreement between China and Mongolia on the protection and use of their shared watercourses is a more recent example. Under this agreement, the countries pledged to cooperatively survey, investigate and monitor the quality and flows of several transboundary waters and to develop and use the waters according to the principles of fairness and equity. The two countries also agreed to adopt measures to prevent and mitigate harm to waters and ecosystems from floods, ice runs and industrial accidents; to establish annual consumption quotas for the abstraction and use of transboundary waters; and to ensure that the established quotas are not exceeded.

1.1.4. Joint development agreements

Under joint development agreements, countries establish their respective rights and duties and agree to jointly develop a shared watercourse's water potential. Successful examples of this type of agreement include the 1964 Columbia River Treaty between Canada and the United States to develop the river's power potential, as well as the series of agreements entered into in the 1970s by Mali, Mauritania and Senegal – later joined by Guinea – to jointly develop the hydropower, navigation and irrigation potential of the Senegal River.

More recently, in 1996 India and Nepal agreed to develop the water and power potential of the Mahakali (Sharda) River. The joint development agreement signed by the two countries fixes Nepal's water and power entitlements, establishes India's obligations for water and power releases, determines how expenses will be shared and sets up an arbitration procedure. In addition, the parties pledged never to "use or obstruct or divert the waters of [the river] adversely affecting its natural flow and level" except by agreement (art. 7). The Treaty also sets forth minimum flow requirements and the details of benefit and cost sharing (art. 1–4).

1.1.5. Technical agreements

Technical agreements are limited agreements that focus on narrowly defined technical issues, such as pollution, transportation or a specific development plan. In the area of pollution prevention, Canada and the United States signed a Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes in 1997. The strategy encapsulates a variety of actions and programmes to prevent pollution and to eliminate toxic substances. It privileges incentive-based actions to phase out the use, generation or release of priority substances (Level I substances) in a cost-effective manner within the most expedient time. For other less critical substances (Level II substances), the strategy encourages the parties to take pollution prevention measures or to conform to national laws and policies.

1.2. Enforcement of international legal instruments

Treaties, conventions and other international agreements are more than statements of intended future conduct: they create legally enforceable obligations (Janis, 2003). It is a basic rule of international law that states must observe and carry out in good faith the obligations set out in the treaties that they have agreed to be bound by (Kiss and Shelton, 2004). However, there is no existing international machinery to monitor compliance by states or to ensure that they fulfil their obligations. In most cases, it is not the threat of actual sanctions but, rather, the mutual benefits of adherence to conventions and international agreements (and the moral obligations to do so) that prevent states from breaching treaty provisions.

In certain circumstances, however, a special supervisory international organ may be created to monitor state activities. A treaty may set up a system whereby states are obliged to periodically report to a designated supervisory organ regarding implementation progress. For example, Article 16 of the African Convention on the Conservation of Nature and Natural Resources designated the Organization of African Unity as the organ to which states must report (Kiss and Shelton, 2004).

Although it is still unusual to come across supervisory organs that "override state jurisdiction" (Kiss and Shelton, 2004), it is increasingly more common (especially in the environmental and trade contexts) to see multilateral or bilateral agreements that create their own enforcement mechanisms which states, through ratification of the agreement, agree to abide by. Such mechanisms can include compulsory arbitration or recourse to a dispute settlement body established by the treaty. For example, Article 10 and Protocol II of the International Convention for the Prevention of Pollution from Ships provides for binding arbitration. Compulsory referral of disputes to the International Court of Justice (ICJ) is another way to enforce international obligations, although the ICJ only has jurisdiction to hear a case where the parties had previously agreed to refer to that court all disputes on a particular subject.

II. OTHER SOURCES OF INTERNATIONAL LAW

2.1. Customary law

International customary law is another source of international law, according to Article 38 of the Statute of the ICJ. As noted in Chapter 3, customary law derives from a group's repeated acts or practices, which the group recognizes as legally binding (Caponera and Nanni, 2007), and generally creates an expectation that a practice will be observed in the future (Janis, 2003). A customary practice will only become a general rule of international law if a large number of states consider it to be binding on them, and if the international community does not protest the practice's extension to international relations (Greig, 1976). It may be difficult to prove the existence of conformity in state conduct and to discern when the conduct is no longer simply "discretionary habitual practice" but authoritative and internationally valid (Bishop, 1962). On the other hand, customary practices do not bind those states that have consistently objected to them (Sands, 1994).

An abundance of customary law informs international water law. As a result of growing international acknowledgement of the need to cooperatively use and protect international rivers and water bodies, several attempts have been made to regulate international watercourses and to codify the existing customary principles on the topic (Lazerwitz, 1993). The last 35 years have seen a number of global, regional and bilateral initiatives in international water law. Some of these are described below.

2.1.1. Helsinki Rules

The work of the non-governmental International Law Association (ILA) codifying customary transboundary watercourse law was the most important of the early initiatives. In 1954, the ILA's first committee (the Committee on the Uses of the Waters of International Rivers) began a study of the legal aspects of water uses in international drainage basins. The study culminated in the so-called Helsinki Rules on the Uses of the Waters of International Rivers, adopted in 1966. For the first time, these rules incorporated the principle of equitable utilization, which holds that each state within an international drainage basin has the right to a reasonable and equitable share of the beneficial use of the basin waters.

The Helsinki Rules have subsequently been enlarged and amplified by additional sets of rules prepared by ensuing committees of the ILA over a period of 30 years and consolidated as a whole in the "Campione Consolidation". Because the ILA is a private organization, neither the Helsinki Rules nor the supplemental rules have received formal recognition, nor do they legally bind states. Nonetheless, they have proven valuable to international law, constituting an authoritative restatement of customary international law on the non-navigational uses of international rivers, lakes and groundwater.

In 2000, the ILA revisited the Helsinki Rules, taking note of the Campione Consolidation, and in 2004 adopted a set of new rules known as the Berlin Rules on Water Resources Law. These rules attempt to incorporate the experience of the nearly four decades since the Helsinki Rules were adopted. In particular, the new rules take into account developments in international environmental law and international humanitarian law, as well as the framework treaty adopted by the United Nations General Assembly (UNGA): the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (1997), discussed in the next section.

2.1.2. UN Conventions

The International Law Commission (ILC) is the United Nations (UN) body responsible for the progressive development and codification of international law. In 1970, the UNGA directed the ILC to "take up the study of the law of the non-navigational uses of international watercourses with a view to its progressive development and codification" (UNGA Resolution, 1970). This task of trying to codify international customary law was not a simple one, given the different interests and practices of the member states. The ILC studied the topic for over 20 years, and in 1994 provisionally adopted "Draft Articles on the Law of the Non-Navigational Uses of International Watercourses". It then recommended that the UNGA elaborate on these articles through a convention or an international conference of national representatives. The UNGA subsequently met as a Working Group of the Whole in the 6th Legal Committee. All UN member states and member states of the UN specialized agencies were welcome to participate and negotiate.

The UNGA adopted the UN Convention on 21 May 1997 with limited changes. A large majority of states (103) voted in favour, indicating broad agreement in the international community on the law of non-navigational uses of international watercourses. The 1997 UN Convention is at present the most significant restatement of customary international water law. The Convention applies to "uses of international watercourses and of their waters for purposes other than navigation and to measures of protection, preservation and management related to the uses of those watercourses and their waters" (art. 1). The convention is the only global international agreement covering the management and use of transboundary waters, and gives force to many general principles of water law (outlined below). It will come into force upon the ratification of 35 member states of the United Nations; as of 2009, 17 states had ratified the convention.

The UN Convention provides a framework that states can build upon and implement bilaterally and multilaterally for the use and development of transboundary watercourses. It has also proven useful in the negotiation and interpretation of other watercourse agreements that *are* binding upon states. In the event that the convention does not enter into force, its provisions would likely continue to serve as recommendations to states.

More recently, the efforts of the ILC have focused on codification of international law regarding shared groundwater resources. On 11 December 2008, the UNGA endorsed the second reading of a draft agreement on transboundary aquifers prepared with the assistance of the International Hydrological Programme at the United Nations Educational, Scientific and Cultural Organization (UNESCO). The resolution states that the proposed text is to be considered a basis for the future elaboration of a convention on transboundary groundwater. In the meantime, it recommends that states make bilateral and regional arrangements to manage transboundary aquifers, in accordance with the principles and provisions of the draft agreement annexed to the resolution (UNGA Resolution 63/124).

The five main principles set out in the draft text are the sovereignty of aquifer states, equitable and reasonable utilization, the obligation not to cause significant harm, the obligation to cooperate with neighbouring states and the regular exchange of data and information. The principles are largely the same as those established by the 1997 UN Convention. The draft also addresses water management, ecosystem protection, recharge and discharge zones and pollution control. The proposed agreement includes aquifer management planning and monitoring of aquifer systems as essential management tools, along with the assessment of the potential impact of planned activities on shared groundwater resources. Emergency procedures are set out to ensure communication and joint action between parties in case of an "imminent threat of causing serious harm" to water bodies in any affected state.

2.2. General principles of international law

The third source of international law consists of general principles of law. General principles are seen as certain "basic legal notions of justice and equity" (Greig, 1976) and are expressed in most if not all nations' domestic legislation. This source of law was inserted into Article 38 of the Statute of the ICJ to close any gaps in areas of international law due to the absence of an existing treaty or customary law (Shaw, 2008). Six general principles related to water resources management are outlined below, including (1) equitable and reasonable utilization; (2) no significant harm; (3) general obligation to cooperate and duty to exchange data; (4) protection and preservation of ecosystems and integrated management; (5) dispute settlement; and (6) exchange of information and prior notification on planned measures. Box 4.2 reviews an ICJ case which explicitly referred to several general principles of law.

2.2.1. Equitable and reasonable utilization

Equitable and reasonable utilization is one of the most basic principles of international water law. According to it, all states bordering an international watercourse – or states through whose territory segments of a river flow – have an equal right to use that watercourse. This principle is encapsulated in the UN Convention with the following language:

> Watercourse states shall in their respective territories utilise an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be developed by watercourse States with a view to attaining optimal and sustainable utilisation thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse (art. 5).

Box 4.2 - General Principles of Law Cited by the ICJ

The Gabcikovo-Nagymaros dispute between Hungary and Slovakia was the first water-related case to be heard by the ICJ for over five decades. The case concerned a 1977 Treaty in which Hungary and the former Czechoslovakia had agreed to build two dams on the Danube River, which would then be jointly operated. Alleging that the project would lead to significant environmental harm, Hungary suspended work on the project in 1989. In 1992, it attempted to terminate the 1977 Treaty after Czechoslovakia proceeded unilaterally to build on its own territory a single dam that required a diversion of 80 percent of the Danube's waters. Challenging Czechoslovakia's actions, Hungary relied on a number of international environmental law principles that had emerged since the finalization of the 1977 treaty.

The case gave the ICJ an opportunity to examine general principles of international environmental law relevant to transboundary watercourses. In its analysis, the ICJ stated that:

> [T]he environment is not an abstraction but represents the living space, the quality of life and the very health of human beings, including generations unborn. The existence of the general obligation of States to ensure the activities within their jurisdiction and control, and to respect the environment of other States or of areas beyond national control is now part of the corpus of international law relating to the environment.

Moreover, in its holding, the ICJ specifically referred to the principle of equitable and reasonable utilization, stating: "by unilaterally assuming control of a shared resource the former Czechoslovakia deprived Hungary of its right to an equitable and reasonable share of the natural resources of the Danube". The ICJ also mentioned the obligation to cooperate, noting that in the management of international watercourses, cooperation between riparian states is crucial

This principle emerged from the Helsinki Rules and is generally rooted in the theory of limited territorial sovereignty, which posits that no state has an exclusive right to use an international river, lake or aquifer. Rather, each riparian state has the right only to reasonable use of the international water resource (Lipper, 1967). According to the International Law Association, the principle of equitable utilization developed into an international customary law rule that forbids states to cause substantial injury to other states' territories (Lazerwitz, 1993).

The question of what constitutes "equitable and reasonable" utilization is generally decided through negotiation and according to the particular set of facts. To facilitate negotiation, the UN Convention sets out the relevant factors to be considered when making equitable utilization determinations, including geographical and hydrological factors; social and economic needs; the effects on populations that depend on the watercourse; conservation and economy of the use of water resources; existing and potential uses; and the availability of alternatives (art. 6). These factors do not have a fixed weight: the UN Convention states that "the weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors" (art. 6.3).

One weakness is that the weighting system allows each country to claim that its preferred factor is paramount in the evaluation of what is equitable and reasonable. As one commentator has noted, the effect of not stipulating a hierarchical order is that "the settlement of conflicting aims is likely to be informed more by power politics and other factors than the factors prescribed in [the convention]" (Elmusa, 1998). This commentator recommends giving priority to socio-economic and environmental needs, as this would create an opportunity for "a change in water allocations that reflect the changing circumstances" as well as an opportunity to encourage "more efficient uses" (Elmusa, 1998).

2.2.2. No significant harm

A second general principle of international water law concerns the obligation of watercourse states not to cause significant harm to the territory of other states. The rule is usually favoured by downstream states, as it affords their existing water uses a degree of protection against the actions of upstream states. This general principle of doing "no significant harm" is embodied in the UN Convention as follows:

> Watercourse states shall, in utilising an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse states (art. 7).

The no significant harm principle provides that states must exercise due diligence to avoid significant harm when using an international watercourse. However, if significant harm results, the harm is not necessarily unlawful: it is unlawful only if it results from negligent or wilful conduct. Stated otherwise, the "no harm" obligation is one of intention, not of result. The second half of Article 7 sets out the consequences of lawful harm, which include payment to compensate for the harm suffered.

The principles of "equitable and reasonable use" and "no significant harm" are often viewed to be the "twin cornerstones" of the UN Convention (Lazerwitz, 1993). Article 7 seeks to avoid significant harm to the extent possible whilst achieving an equitable result in the specifics of each case. Thus, "equitable utilization" may accommodate a degree of significant harm. How much and what kind of harm would qualify as "equitable and reasonable" is debatable and may be negotiated between or among concerned states. Presumably, serious harm to human health and safety would constitute a breach of the principles of the convention.

2.2.3. General obligation to cooperate and duty to exchange data

The UN Convention includes the general principle of international cooperation, which requires watercourse states to cooperate in order to optimally use and adequately protect international watercourses. This collaboration is founded on sovereign equality, territorial integrity, mutual benefit and good faith. To facilitate cooperation, watercourse states may establish joint mechanisms or commissions (art. 8).

Similarly, the convention mandates that states must regularly exchange readily available data and information on the conditions of the watercourse, including data on water quality, hydrology, ecology, meteorology and related forecasts. States must also try to collect and process data to facilitate the use of the watercourse by other watercourse states (art. 9). States may request compensation for supplying other watercourse states with the information solicited (art. 9).

2.2.4. Protection and preservation of ecosystems, and integrated management

The UN Convention also incorporates the general environmental principle of preventive action, which obligates states to prevent damage to the environment or otherwise reduce, limit or control activities that may cause harm. The convention requires watercourse states to "protect and preserve the ecosystems of international watercourses" and to harmonize their pollution policies to "prevent, reduce and control pollution of international watercourses" (Sands, 1994).

However, as with the "significant harm" principle, the UN Convention does not ban pollution. Rather, it establishes that states have a "due diligence" obligation to control, abate and prevent pollution that may cause significant harm. Even if significant harm does result from a polluting activity, if the polluting state argued convincingly that it had exercised due diligence, the behaviour and effects would likely be excused. The ILC had been inclined to regard such polluting activities as inequitable and unreasonable *per se*, whilst the UN Convention reflects a more nuanced balance between economic development and protection of human health and the environment.

2.2.5. Exchange of information and prior notification of planned measures

States have a specific duty to cooperate and exchange data when they plan measures that may affect or threaten any existing uses on a shared watercourse. This procedural principle was first recognized by the ILA in the Helsinki Rules (art. XXIX), and is elaborated upon in the UN Convention (art. 11). It includes a detailed procedure for prior notification. The obligation to notify other watercourse states in advance of any planned measures applies with respect to those measures that "may have a significant effect upon other watercourse states" (art. 12). Available technical information and data must accompany notifications.

Following notification, states may study and evaluate the planned measures for a six-month period, which may be extended for an additional six months if the planned measures are particularly troublesome (art. 13). During the six- or twelve-month period the notifying state may not implement or permit implementation of the planned measures without the notified state's consent. If the notified state concludes that the planned measures are inconsistent with the principle of equitable and reasonable utilization or the principle of no significant harm, the UN Convention provides for a period of consultation and negotiation (art. 17). It urges states to try to find an "equitable resolution" to the situation through good faith negotiations that reasonably respect the other state's rights and legitimate interests. These negotiations can delay the measures' implementation by an additional six months.

A special provision deals with urgent implementation of planned measures, where the measures are "of the utmost urgency in order to protect public health, public safety or other equally important interests" (art. 19). In such cases, the state planning the measures may proceed if it complies with the principles of equitable and reasonable utilization and no significant harm. However, the state must make a formal declaration of its plans in order to alert other watercourse states to the measures and their urgency and must provide relevant data and information. Other states may require consultation and negotiation after receiving the special notification (McCaffrey and Rosenstock, 1996). Some commentators have cited the inclusion of this obligation in the UN Convention as proof that the "international community as a whole emphatically rejects the notion that a state has unfettered discretion to do as it alone wishes with the portion of an international watercourse within its territory" (McCaffrey and Rosenstock, 1996).

2.2.6. Dispute settlement

Peaceful dispute settlement has been recognized by both the Helsinki Rules and the UN Convention as a general principle of international law. The Helsinki Rules state that "states are under an obligation to settle international disputes as to their legal rights or other interests by peaceful means" (art. XXVII.1), whilst the UN Convention goes further by providing a detailed dispute settlement procedure (art. 33). The UN Convention compels states to settle disputes through negotiation or conciliation or by agreeing to submit the dispute to arbitration or the ICJ. As noted earlier, the ICJ only has jurisdiction to hear a case if the parties have previously agreed to refer the dispute to it.

More controversially, the UN Convention provides that when the parties cannot settle their dispute through these means, or have not settled their dispute, the dispute can be submitted to a "Fact-finding Commission" (art. 33). The Commission must adopt a report by a majority vote and submit it to the parties, setting forth its findings, the reasons for its findings and such recommendations as it deems appropriate to resolve the dispute equitably. The parties then have to consider this report "in good faith". Although there is no real enforcement mechanism, certain states have voiced concerns that this compulsory fact-finding mechanism is an infringement on their sovereignty.[1]

2.3. Judicial decisions and scholarly opinion

The final source of international law is judicial decisions, which include judgments and advisory opinions of international courts, awards rendered by arbitral tribunals and decisions by national tribunals (Caponera and Nanni, 2007). The ICJ's judgments and various arbitral tribunal and national court decisions have contributed to and helped codify international water law, even though they are only binding on the parties to the case and lack the force of precedent.

Many general principles of international law have their roots in international and national case law. For example, case law brought about the recognition that states have limited rather than absolute territorial sovereignty over waters within their boundaries. This judicially created principle, established by the ICJ and developed by the decisions of other arbitral tribunals and national courts, underpins the essential principle of equitable utilization.

Under the theory of absolute sovereignty (also known as the Harmon Doctrine, after an opinion by Justice Harmon in a United States Supreme Court case from 1895), an upper riparian state may freely use and dispose of the water that flows through its territory. Later judicial decisions shifted toward a concept of limited territorial sovereignty, according to which upper riparian states may use the river waters so long as they avoid harming lower riparian states. This principle was expressed in the 1941 Trail Smelter Arbitration (TSA) case between the United States and Canada, where an arbitral tribunal found that Canada should have prevented a smelter on its territory from emitting poisonous fumes that caused harm in the United States.

Although the TSA case concerned transboundary pollution, it has been applied by analogy to water uses by upper riparian states that injure lower riparian nations.[2] In 1957, the Lake Lanoux case, which resolved a dispute between France and Spain about hydroelectric developments, further refined

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[1] See for example the comments of China in the UNGA discussions prior to the vote on the UN Convention. UNGA Press Release GA/9248 (available at www.africanwater.org).

[2] The case is also used in support of the no significant harm rule (see Section 2.2.2 of this chapter).

the principle. It held that current international practice not only requires states to safeguard neighbours' riparian rights, but also to take account of "all interests, of whatsoever nature, which are liable to be affected by the works undertaken, even if they do not correspond to a right" (quoted in Lipper, 1967).

Finally, national courts have also helped develop international water law. For example, Kansas v. Colorado (United States) and Württenburg and Prussia v. Baden (Germany) aided the development of the principle of limited sovereignty and helped establish it as international law (Lipper, 1967). The former case supported the principle that two states have equal rights to water, whilst the latter resolved a dispute between two German states over the upper riparian state's water diversions, and ruled that the principle of equitable utilization mandated that "the interests of the States in question must be weighed in an equitable manner against one another". The German court held that one must consider not only the absolute injury caused to the neighbouring state, but also the relative weights of the advantage gained by one and the injury caused to the other (Wouters, 1997).

Scholarly writings include contributions by academics and scientific associations, as well as studies undertaken by lawyers on legal questions. These writings clarify the nature, history and practice of the rules of international law (Shaw, 2008). International legal scholarship may aid national parliaments in the preparation of legislation and may influence national and international court judgments. Apart from functioning as evidence of state practice, academic writings often highlight the defects in existing systems, influence states to adopt new practices and encourage debate about the values and aims of international law (Greig, 1976).

2.4. Non-binding instruments

The corpus of international law consists of non-binding instruments in addition to the treaties, conventions and other more formal agreements just reviewed. In the area of health and environment in relation to water, four non-binding instruments and mechanisms are of particular note and are reviewed in the next sections.

2.4.1. Millennium Development Goals (MDGs)

In 2000, 189 countries signed the Millennium Declaration, which outlined eight goals designed to improve the lives of the world's poorest people by 2015. These non-binding Millennium Development Goals (MDGs) are intended to provide a framework to aid development efforts, to provide countries with a common set of objectives to address poverty and to judge any progress that countries have made. The eight goals are:

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.

The MDGs reflect the international community's desire to see an end to the worst aspects of poverty and hunger. The last goal, calling for a "global partnership for development", acknowledges the role developed nations must play – and the actions they must take – to help developing nations reduce poverty and improve the quality of life for their people.

Accompanying these 8 goals are 18 targets to achieve the goals. Target 3 of Goal 7 seeks to halve the proportion of people without access to safe drinking water and sanitation, since the lack of one or both of these can exacerbate poverty and hunger. Water-borne diseases prevent adults from working and thus raising themselves out of poverty or feeding their families. In addition, as noted in Chapter 1, lack of access to safe drinking water often means that women and girls spend hours each day gathering water, which can prevent them from finishing school or pursuing livelihood activities.

2.4.2. Stockholm Framework

In 1999, following an expert meeting in Stockholm, WHO published a document entitled "Water Quality – Guidelines, Standards and Health: Assessment of Risk and Risk Management for Water-related Infectious Disease". Now known as the Stockholm Framework, the document sought to address the perceived lack of consistency in health guidelines concerning water and risk management.

The purpose of the Stockholm Framework is to devise health-based guidelines and standards for hazards in water and sanitation. The document is intended to capture a "harmonised approach to the development of guidelines for water-related exposures to microbiological hazards" (Fewtrell and Bartram, 2001). Although it is mainly concerned with microbiological hazards, the Stockholm Framework may also be used to address chemical hazards. The framework calls for assessing health risks before setting health targets. It defines basic control approaches and outlines how to evaluate the impact of these approaches on public health status. The framework encourages a flexible approach, suggesting that countries adapt guidelines appropriate to their own social, cultural, economic and environmental circumstances. The framework now forms the backbone of various WHO guidelines, including the guidelines for drinking-water quality and for wastewater reuse.

2.4.2.1. WHO guidelines for drinking water quality

The WHO Guidelines for Drinking-Water Quality are based on the Stockholm Framework and provide a structure for countries to evaluate and improve their drinking water and sanitation standards. The guidelines outline certain control measures intended to help prevent microbial and chemical hazards from harming public health, and prescribe various management plans.

The guidelines define "safe water" and set benchmarks for how water suppliers should provide it. The guidelines also contain health-based targets that are based on a "tolerable risk" standard, which each country is to decide according to country conditions, current water quality and the willingness and ability of people to pay for their water services. The guidelines are discussed further in Chapter 7.

2.4.2.2. WHO guidelines for wastewater reuse

Wastewater reuse offers the potential to increase irrigation efficiency and improve nutrition and livelihoods but it poses health hazards, specifically from pathogens and chemicals. The concentrations of pathogens or chemicals vary according to "the number and type of industries that discharge waste" and whether (or the degree to which) those industries treat the waste they are discharging (WHO, 2006). The WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater were revised in 2006.

Like the guidelines for drinking water quality, the guidelines on wastewater reuse have a health component and an implementation component (WHO, 2006). The health component defines the "level of health protection expressed as a health-based target for each hazard" and identifies "health protection measures that can achieve specified health-based targets" (WHO, 2006). The implementation component establishes the monitoring and system assessment procedures; defines supervisory and institutional responsibilities; calls for system documentation; and requires confirmation by independent surveillance (WHO, 2006). The goal is to ensure that effective systems and standards are in place to protect humans against exposure to intolerable risks of disease and other hazards related to the use of wastewater. The guidelines are discussed in more detail in Chapter 8.

III. EMERGING PRINCIPLES OF INTERNATIONAL WATER LAW

A number of emerging principles and concepts are shaping water resources management policy and practice and, more generally, the field of international environmental law. Although not yet customary rules or general principles of law, some of these principles affect state regulation of the use, development and management of transboundary waters. Each of these evolving areas of international water law is examined in the next sections.

3.1. Precaution

The World Charter for Nature (adopted by the UNGA in 1982) was the first international endorsement of the precautionary principle, which holds that the lack of a scientific consensus should not prevent a state from adopting preventive measures where an intended action or policy might cause severe or irreversible harm to persons or the environment. The precautionary principle was implemented in an international treaty as early as the Montreal Protocol on Substances That Deplete the Ozone Layer (1989) and appears in other international treaties and declarations. It is reflected in Principle 15 of the Rio Declaration on Environment and Development (Rio Declaration), signed at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992.

As stated in the Rio Declaration, precaution requires that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (Rio, 1992). In effect, the precautionary approach shifts the burden of proving innocuity on the one intending to take action rather than on those potentially harmed. The principle acknowledges the fallibility of human understanding and recognizes the scientific uncertainty inherent in environmental protection. In practice, states have differed on how much scientific uncertainty is acceptable.

3.2. Polluter pays

Under the polluter pays principle, any person or entity responsible for polluting the natural environment must bear the costs associated with remedying the harm. This principle has not been strongly endorsed by a broad cross-section of the international community (Sands, 1994) but it has received strong support in most OECD countries and in the European Community. This principle was also expressed in compromise language in the Rio Declaration as follows: "National authorities shall endeavour to promote the internationalisation of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the costs of pollution, with due regard to the public interests and without distorting international trade and investment" (Principle 16).

The polluter pays principle contemplates that the costs "associated with" pollution should be borne by those responsible for it. It is worth noting that these associated costs can include not only the costs of developing and implementing prevention, control and reduction measures, but also the cost of cleaning up impaired water resources and paying compensation for the loss, damage or harm that the pollution has caused. Although the polluter pays principle is well known and commonly embraced, applying it in full can be challenging because of the economic impact on polluting entities, and for this reason implementation tends to vary across states according to political will and regulatory frameworks.

3.3. Common but differentiated responsibility

The principle of common but differentiated responsibility holds that the special needs of developing countries must be taken into account in the development, application and interpretation of international law. That is, due to their "differing capacities" (Vig and Axelrod, 1999), rich and poor nations should not be treated the same: rather, richer nations have an affirmative obligation to assist poorer nations and must bear the greater share of the costs of remedial action. This principle is expressed in the Rio Declaration (Principle 7) as follows:

> States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, states have common but differentiated responsibilities. The developed countries acknowledge the responsibility they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and the technologies and financial resources they command (Rio, 1992).

As applied to international waters, the principle might imply that developed countries should take on greater responsibilities with regard to the conservation, protection and restoration of the earth's water resources or of water resources shared with developing countries.

3.4. Sustainable development

Sustainable development is generally defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The term appears in the Rio Declaration, which states that to achieve sustainable development, environmental protection must be an integral component of development (Rio, 1992). The Rio Declaration enumerates various "strategic imperatives" of sustainable development, including, amongst others, meeting essential needs for jobs, food, energy, water and sanitation; ensuring a sustainable population level; and protecting and enhancing the resource base. The principle of sustainable development has been generally accepted in international discourse, partly due to growing concerns over environmental degradation, species endangerment, climate change and other pressing issues.

IV. CONCLUSION

One commentator has posited that water scarcity "need not necessarily result in heated conflict ... [but] can instead become the catalyst for increased co-operation" (Turton, 1999). The hope is that as countries begin to understand the pending dangers of water depletion, they will increasingly work together in pursuit of lasting solutions that benefit them all. The numerous agreements, conventions and protocols described in this chapter that cover shared waters and water management illustrate the experiences and willingness of states to cooperate in relation to water matters. In this respect, international law has been, and will continue to be, instrumental in defusing much of the potential for conflict over water.

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5

WATER RESOURCE QUANTITY: ALLOCATION AND MANAGEMENT [*]

Contents

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[*] This chapter was prepared by Bruce Aylward, Christie Popp and Stefano Burchi.

With an overview of the water cycle (Chapter 2) and national and international regulatory frameworks as backdrop (Chapters 3 and 4), this and succeeding chapters turn to the specific challenges of water management. This chapter examines the challenges of managing water quantity. Despite centuries of water resource development, water is still often not available for human uses in the right quantity at the right time and place. Water is therefore often "scarce" relative to the demands placed on it for human use and consumption. Similarly, as humans have altered the landscape and the hydrologic regime to meet their needs, this has meant that water is no longer available in the quantities and at the time and place required by species and ecosystems, which also provide valuable services to humankind. This is the essence of the challenge of sustainable water allocation and management.

This chapter begins by examining the water quantity function of watershed hydrology, groundwater and surface water. The chapter next turns to the rich complexity of the challenge humans face as they take on the task of managing water for human and ecosystem uses. This challenge can be broken down into several components: first, effective management is undercut by a lack of understanding, which is due to the technical complexity of the issues, a lack of good scientific information and the persistence of popular misconceptions about causes and effects in relation to water quantity. Second, there is a tension between the desire to manage water as a private good and the growing recognition that leaving the allocation and management of water to the market can have adverse effects on the social and environmental values of water. Accordingly, the chapter proposes a new conceptual classification of water-related goods and services in an effort to explain the public and private incentives operating on the various actors that provide or produce these goods and services. Third, the chapter describes institutional and governance challenges that function as yet one more barrier to effective water management. Finally, the chapter reviews legal and regulatory approaches – past and present – to managing water quantity.

I. THE PHYSICAL AND TECHNICAL CHALLENGE

1.1. Hydrology and water quantity

As described in Chapter 2, effective water resource management needs to take into account the hydrologic processes of watersheds, groundwater and surface water and how these processes inter-relate and interact. The following section highlights the types of hydrologic functions and how these functions, and quantities of water, are altered by human activities.

1.1.1. Precipitation and watershed hydrology

Broadly speaking, upland areas in a watershed, whether in a natural or altered state, possess certain characteristics that determine how and at what rate the landscape and its associated vegetation transfer precipitation into groundwater or surface water. The specific characteristics of the watershed will also affect the quality of the waters, but this chapter focuses on the quantity effects.

Human activities that disturb or alter vegetation and soils can take many forms, and each type of activity will alter the hydrologic response from the watershed. The changes that occur vary depending on site conditions such as climate, topography, soils and vegetation. The main hydrologic responses include changes in:

- annual water yield, or in the total volume of water produced by the watershed on an annual basis;
- seasonal flows, particularly baseflow during the driest part of the year;
- groundwater recharge; and
- stormflow response or flood flows during major precipitation[1] events.

Each of these is described in more detail below.

Water yield. Ecosystems do not create water. They do, however, affect the amount and timing of water as it moves through the landscape (Brauman *et al.*, 2007). When human activities reduce vegetation (primarily through the removal of forests), the rate of evapotranspiration is usually also reduced, thus increasing the annual water yield from the watershed. This is the case in both temperate and tropical regions (Bosch and Hewlett, 1982; Bruijnzeel, 2004). In foggy or cloudy climates, however, vegetation can provide an intercepting surface that fosters precipitation of water droplets. One study of coastal redwood forests in California found that 34 percent of stored water had originated as fog, whereas fog contributed only half that amount in treeless sites (Brauman *et al.*, 2007).

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[1] Precipitation itself is another hydrologic response, reflecting a feedback loop between watershed management and climate.

There exists a popular perception that forest areas produce more water than non-forest areas. This may be due to the fact that forests tend to grow where there is more precipitation. But precipitation causes forests, not the other way around. Moreover, an area maintained in natural forest may produce less water than if it were cleared, but the water that is consumed by the forest is consumed for a dual purpose: growing biomass, wood and trees, and providing habitat for species. Moreover, unless care is taken in removing the forest and subsequently managing the land, the water that is produced will likely be of lower quality and therefore of less value than that produced with the forest, due to higher rates of infiltration and natural filtering of runoff by forest vegetation. For the purposes of water quantity management, it is important to recognize that reforestation of previously deforested watersheds may well not increase water supplies downstream.

Seasonal flow and groundwater recharge. Human alterations of natural vegetation have a less clear-cut impact on seasonal flows, particularly on dry season baseflow.[2] Baseflow is of particular importance to water quantity management during the dry season, i.e. when at its lowest levels.

Although lower levels of evapotranspiration following vegetation removal can cause dry period baseflow to rise, this response may be reduced or even reversed if soils are so compacted by the subsequent land use that infiltration of precipitation is significantly curtailed (i.e. a reduction in the "sponge" effect ascribed to forests and other natural vegetation). Nevertheless, much experimental work has shown that the evapotranspiration effect overwhelms the infiltration effect. If infiltration rates are normally quite high, then severe compaction is necessary to reduce infiltration capacity to the threshold level where infiltration during normal precipitation events is affected.

Questions remain on whether experimental conditions sufficiently reflect typical real world conditions. Still, it is clear that the hydrological impact of land use changes depends not just on the impacts of the initial intervention but the impacts of the subsequent form of land use, as well as the type of management regime undertaken (Bruijnzeel, 2004). In other words, effective land management may well produce higher downstream baseflow after the conversion of natural vegetation to other uses, whilst poor management may

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[2] Baseflow is the streamflow component derived from the discharge of groundwater, not that derived from overland flow during a rainfall event. As baseflow reflects water routed through the groundwater system, this discussion also applies to impacts of watershed management on groundwater recharge.

have the reverse effect. As one review article has concluded, "When groundwater storage is important, ecosystems that promote infiltration can be instrumental in improving supply ... . Ecosystems such as upland forests and riparian buffers promote the transfer of surface water to groundwater by infiltration, which reduces flood peaks whilst increasing base flow, generally increasing the predictability of water availability" (Brauman *et al.,* 2007; Smakhtin, 2001). At the same time, studies in two Australian catchments found that shrub and grass ecosystems were more effective at ensuring summer time baseflows than tree-dominated ecosystems (Brauman *et al.*, 2007).

In sum, given the important variables of climate, soil, vegetation and land use patterns, it is difficult to make a general statement about the direction or magnitude of the effect on dry season baseflow of disturbing (or restoring) watersheds.

Flood flows. The relationship between vegetation, particularly forests, and flood flows may run counter to common perceptions. Science suggests that the effects of removal of vegetation on flood flows dissipates with distance downstream, and the threat from deforestation comes largely where the geomorphology is conducive to flash flooding, such as narrow canyons. In 2005, FAO and the International Center for Forestry Research (CIFOR) produced a policy brief reporting that the link between deforestation and flooding is uncertain (FAO and CIFOR, 2005).

Interestingly, one reason for the confusion over floods and forests relates to the institutional politics of governmental budget allocations in the twentieth century, for example as in the United States, where the Forest Service battled the Army Corps of Engineers to be the agency responsible for flood control (Calder and Aylward, 2006). As the century progressed, settlement of flood plain areas increased as did deforestation. As floods continued to ravage flood plain areas, deforestation and flooding were conflated, leading deforestation to become an immediate and convenient scapegoat, particularly in the media, for each new disaster (FAO and CIFOR, 2005).

For all of these reasons, it is difficult to be proscriptive regarding best practices for watershed management *vis-à-vis* water quantity. Upstream areas have many different productive and consumptive values for society and it is unlikely that land owners or governments will agree to manage them solely on the basis of downstream hydrological impacts. Furthermore, the common perceptions of the direction and magnitude of these impacts are not linked to scientific understanding, making such manipulations even more problematic (Aylward, 2004). Some efforts to develop payment or incentive systems to encourage land owners to manage their lands are based in part on expected downstream water quantity benefits from improved watershed management. As outlined above, depending on the specific characteristics of the watershed, these assumptions may be unwarranted. A further concern, discussed below, is whether these schemes may suffer from the regulatory difficulty of ensuring that those that bear the costs can appropriate the expected water quantity benefits.

1.1.2. Groundwater

Groundwater consists of what goes in the ground (recharge) and what comes out (discharge), and it has both stock and flow components. In a natural steady state where groundwater stocks do not vary, the amount of recharge can be assumed to be equal to the rate of discharge. Groundwater quantity becomes a concern when humans or ecosystems rely on it and so alter its functioning. Reliance on or demand for groundwater comes at two junctures: extraction of groundwater (by humans) and natural discharge (for use by humans and ecosystems).

Groundwater has a renewable component – annual recharge and discharge – and an exhaustible component – fossil groundwater stocks. As noted above, human activities in upland areas that affect evapotranspiration can also lead to changes in groundwater recharge, thus ultimately affecting stocks and discharge of groundwater. If rates of extraction and net changes in evapotranspiration exceed natural recharge rates, then impacts will be felt on both stocks and discharge, which means that mining of the resource is occurring. If relatively minor rates of extraction are occurring then the impacts on discharge will likely be minor, as well.

A further complicating factor is that changes in recharge can be due not only to changes in land use and evapotranspiration, but also to changes in surface water bodies and conveyance. Large reservoirs and the diversion of large amounts of water into unlined canals can lead to significant increases in groundwater recharge. As new groundwater wells are drilled or as new diversions of surface water downstream from the point of discharge are developed, there will likely be increased competition for the existing flux of water through the system. If unchecked, this also will eventually lead to mining of the resource, despite the increased recharge.

Furthermore, as new human uses (of discharge or extraction) are developed, the amount of discharge available to surface waters for the maintenance of downstream freshwater ecosystems is diminished. Thus, management of groundwater, including its "upstream" linkages to watershed management (land use and evaporation) and its downstream linkage to surface water, will be critical to good water management. This can prove difficult, since groundwater development is "hidden" and therefore its impacts may not be immediately and fully appreciated.

1.1.3. Surface water

Surface water is appropriated for human use in a number of ways, largely through the diversion and removal of water from surface water bodies and the damming of rivers to generate stored water. In this manner, water is shifted from its natural time and place so that it will become available when and where humans need it for irrigation, municipal and industrial use, hydropower and transportation. In the case of flood control, dams are also used to hold back water during peak flow periods, and that water is then available for use in non-peak periods or during the dry season.

The consequences of this reorganization of the natural hydrologic regime can be extensive, with a cascading series of physical, chemical, biological and ecological impacts on the riverine and surrounding environment and on human populations nearby. The construction and siting of these facilities can also lead to massive dislocation and resettlement of populations, whether voluntary or involuntary. The competition for surface water and the resulting impacts and tradeoffs are better known than those surrounding watershed management and groundwater management, but even so, society as a whole has been slow to recognize and confront these challenges.

1.2. Technical challenges in managing water quantity

Given the nature of the water cycle, true integrated water resource management will require an understanding of watershed hydrology, surface water hydrology and groundwater hydrology, as well as knowledge of how these systems interact. The ideal tool for informed management would therefore be a suite of physical models permitting the analysis of these systems and their interactions and taking into account variables of human behaviour. Unfortunately, few examples of such comprehensive analysis exist. Furthermore, it is rare to see technical information integrated across the physical systems. At present, the current state of knowledge permits only partial or step-wise exploration.

Quantitative efforts to assess the relationships between land use and land cover and impacts on evapotranspiration, surface runoff and groundwater recharge include paired watershed experimentation, statistical analysis of time series data and physical process models, to name a few. As suggested earlier, however, it is not unusual that in a given watershed there will be neither site-specific analysis nor a model available. There is a significant challenge therefore in making relatively precise predictions, as these will rely on a diagnostic tool that is data-intensive and requires an understanding of local conditions.

Modelling of surface water is perhaps the most straightforward endeavour in physical terms, given gravity and the conservation of mass (as water is neither created nor destroyed; it just flows downstream or evaporates). Modelling how human behaviour interacts with the surface water system is more difficult. Quantitative models should also account for storage and diversions. This would include predicting the operations of highly engineered systems with multiple dams in parallel or in series (which is amenable to sophisticated programming approaches), as well as analysing the behaviour of large numbers of irrigators, either on a few diversions or many. Although not insurmountable, this task may be difficult as it requires large amounts of historical data if the behavioural parameters and trends are to be well identified.

Modelling of both watershed hydrology and surface water is, however, incomplete without an accounting of subsurface interactions. Although numerical models exist that combine information on geological parameters with information on hydrology, they are necessarily imprecise given the assumptions involved and given the need to rely only on observation of inflows, outflows and levels of groundwater storage in order to assess model effectiveness. The seeming “black box” nature of the groundwater system (due to the ability only to observe what goes in and what comes out) can make it difficult for non-specialists to understand or have faith in such models. Moreover, such models can be expensive to develop and are unlikely to be available.

A further complication is that aquifers and watersheds do not necessarily sit on top of one other. As discussed in Chapter 2, an important question in integrated water resource management is the unit of analysis and management. A watershed of a certain spatial size may sit astride one or more aquifers with different geologies, or it may share an aquifer with other watersheds. This may pose difficult problems for modellers, since water inputs to a basin may not equal outputs due to the difficulty of documenting inter-basin transfers that occur deep underground.

Another issue is that although water resources serve a wide range of human and ecosystem needs, the functions that are included in assessments and models tend to be those of the dominant user group. For example, in the United States, the Bureau of Reclamation's surface water distribution model is designed to accommodate irrigation water rights through storage nodes and points of diversion, but it does not have an explicit routine for accommodating instream water rights. In the absence of comprehensive science, data and models, it becomes that much more difficult to develop governance processes that lead to equitable and efficient water resource management.

1.3. Human and ecosystem uses of water quantity

In this book, freshwater is water of various forms that occurs in nature, including precipitation, surface water and groundwater. This may be called "ecosystem water", i.e. the water that is made available naturally by the water cycle and freshwater ecosystems. In its natural state, ecosystem water provides many goods and services to humans and the environment – the "ecosystem services" described in detail in Chapter 2.

Once ecosystem water has been regulated, diverted, pumped or stored by humans, it is transformed into a product that can be delivered to meet human needs. Examples include irrigation water and piped and treated water for municipal and industrial uses. Human ingenuity and effort add value to the raw ecosystem water; therefore, this type of water may be called "value-added water".

This value-added water can itself be transformed into a number of products and services ("water-related services") that humans use in household or productive activities. For example, hydropower facilities store water in order to generate electric power: power or energy is the water-related service. Flood control dams regulate flows to protect property and lives, providing another water-related service that safeguards downstream communities.

Human and ecosystem uses of water may therefore be classified according to whether they are ecosystem services, value-added water or water-related services. This classification reflects the degree of human investment required to generate useful services from precipitation, groundwater and surface water. Each use of water may also be categorized as having economic value in direct consumption by individuals, in production of goods and services of value to the household or in productive activities that generate goods and services for sale outside the home. Finally, each use may be classified by the extent to which it results in the full evapotranspiration of the water, i.e. whether it is a consumptive or non-consumptive use.

1.4. Water scarcity and tradeoffs amongst uses

Water scarcity is the fundamental physical problem in water quantity management. As demands are placed on ecosystem water, value-added water or water-related services, the combination of uses eventually leads to a shortfall in the availability of water or water-related services at the time of demand. Since water exists in the form of both stocks and flows, a deficit in water availability may be countered by drawing down stocks. Mining of groundwater reserves is one example. Storing water in reservoirs for later use during a dry period is another response to scarcity.

Scarcity leads to tradeoffs between different categories of use and between uses within categories. A tradeoff exists when there is not enough water to satisfy all demands and hence, a choice must be made as to how to allocate the available water across competing demands. A few examples from around the world are presented below.

United States of America
In the Western United States of America, historical reclamation of semi-arid and arid areas for the purposes of irrigated agriculture led to the dewatering of creeks, streams and rivers in the summer and the depletion of winter flows due to water storage in the headwaters. Where agriculture developed largely in valley bottoms in close proximity to the stream, water was effectively used and reused. It was diverted and applied to land, and the non-consumptive portion returned via the ground to the stream – and then the process repeated again at the next farmer's point of diversion downstream.

Such a pattern of abstraction often impaired the stream's capability to support fish and maintain ecosystem health. After the passage of many environmental laws and regulations since 1970, this tradeoff between (value-added) irrigation water and ecosystem water has led to conflict and litigation over increasingly scarce water resources. In the last couple of decades, efforts at collaborative management of these resources have led to innovative approaches to achieving the voluntary reallocation of water from traditional out-of-stream uses to newly recognized instream uses that support ecological function. Many small non-profit groups, including “water trusts” and “river conservancies”, have been formed to help society revisit the tradeoffs made in the past (Neuman, 2004).

In the 1980s and 1990s, declining profitability of farming along with renewed population pressure on small towns and rural areas led to the development of formerly agricultural valleys into homes and resorts. With long-established farmers holding rights to most if not all of the surface water and with developers needing high-quality water for domestic purposes, many such developments have turned to groundwater for water supply. However, the connectivity between surface and groundwater means that these developments are merely intercepting the non-consumptive portion of applied water or natural recharge, which was previously diverted by farmers downstream.

State water codes penned a century ago often fail to account for this hydraulic connectivity and the ensuing tradeoff between water uses (Glennon, 2002). Efforts to update water legislation are vital to making these tradeoffs explicit. In Montana, partnerships between conservation and agricultural interests emerged to take these arguments to the state supreme court, ultimately leading to new legislation recognizing the importance of conjunctive management of surface water and groundwater (Trout Unlimited, 2007).

Costa Rica

Another example comes from Central America. Costa Rica is a middle-income country which has little in the way of fossil fuel reserves, but which is amply endowed with high levels of rainfall and short, steep watersheds along the Central American isthmus. In recent decades, the parastatal (quasi-governmental) agency responsible for energy, as well as private business interests, have turned to financially attractive small hydropower projects. These are often located in the numerous canyons that line the centre of the country. The facilities are typically run-of-river installations in that they do not require large dams or storage. Instead, they take water from the stream or river and run it through pipes to a powerhouse located at a considerable elevation drop from the point of diversion.

Many of these sites are located in canyons that are also valued by local communities for their recreation and tourism value, since the same conditions that make for attractive small hydropower projects can also be of great ecological, scenic or recreational value for activities such as rafting. Local communities have raised concerns about being excluded from the selection and implementation of government power projects. New regulations requiring environmental impact assessments have provided one avenue for communities to participate in the design of such projects and the related decision-making.

India

In the Indian subcontinent, the seasonal nature of surface water supplies has led to the development of large storage systems to provide water for extensive irrigation schemes, although the more marginal classes of society are not necessarily the beneficiaries of the value-added water provided by such projects. This is because these projects often result in the involuntary resettlement of large numbers of people (WCD, 2000). In addition, for some groups, water that was available for domestic use is now impounded and sent down canals for irrigation.

South Africa

Under South Africa's previous government, large upland forests which formerly had only sparse native vegetation were planted with alien species. This increased evapotranspiration and reduced streamflow downstream. The new government revamped the national water law to guarantee water for ecosystems and to provide access to water for the bulk of the population, and sought to restore and protect flows in a number of ways. A new initiative called the Working for Water Programme was created in which unemployed workers were contracted to remove alien invasive species across the country. A streamflow reduction tax was also instituted, which would apply to plantation forests that have higher-than-natural evapotranspiration rates (see Chapter 9). Taking on a much larger responsibility for providing water to people and ecosystems, the government has recognized the tradeoff between land use and streamflow, and has implemented projects and policies to counteract past land use choices.

Changes in the pattern and extent of human demand for ecosystem water, value-added water and water-related services have caused greater water scarcity and prompted calls for explicit tradeoffs between different uses. Conflict can arise as water users gain or lose in the struggle over water quantity. The next section looks more closely at the nature and origins of these tradeoffs and the ensuing conflicts, before turning to potential legal and regulatory solutions.

II. THE SOCIAL AND ECONOMIC CHALLENGE

As stated earlier, the technical difficulties inherent in managing water quantity arise in the first instance from the physical complexity and interconnectedness of the water cycle and the resulting lack of adequate scientific information. But the key challenge in water management is increasingly recognized as more of a social than a physical problem. As explained in Chapter 3, the water crisis is increasingly understood as a crisis of governance rather than simply one of physical supply and demand. Water may be physically available, but the problem is how society organizes itself to make water available when and where it is needed.

In this section the root cause of this problem is analysed based on ideas from political economy: the concept of public goods and the problem of collective action. The discussion then reviews many possible solutions to this fundamental problem.

2.1. Fundamental cause of water management problems

The fundamental problem faced in water management is one of incentives. Incentives refer to more than just financial rewards and penalties: they are "the positive and negative changes in outcomes that individuals perceive as likely to result from particular actions taken within a set of rules in a particular physical and social context" (Ostrom, *et al.*, 1993). These incentives may be economic, social or moral. Regardless of the nature of the incentives faced by individuals (or groups), when taken as a whole the incentives available in a given situation affect the individuals' evaluation of the costs and benefits of alternative courses of action, and correspondingly affect human decisions and behaviour.

In the case of water resources, the incentives that have governed human behaviour with respect to the management of water resources have often not been consistent with balancing the different needs for these resources. This has resulted in economically inefficient, socially inequitable and environmentally unsustainable outcomes. The present chapter draws on the concepts of political economy to diagnose the fundamental cause of water management problems. The concepts of public goods and market failure are explained and then applied to ecosystem water, value-added water and water-related services.

2.1.1. Public good characteristics: exclusion and rivalry

The economic concepts of exclusion and rivalry define public goods ("good" here is shorthand for goods and services (Cornes and Sandler, 1986; Randall, 1983)). Exclusion refers to whether, once a good is provided, it is easy or difficult (i.e. costly) to exclude or limit consumption by other potential users or beneficiaries. Exclusion can be achieved through means of physical barriers and control (e.g. the application of technology) or through legal tools (e.g. a legal system of property rights). Goods can therefore be classed as excludable (high degree of exclusion) or non-excludable.

The second characteristic that distinguishes public from private goods is rivalry: the degree to which the use of a unit of a good by one individual reduces, or does not reduce, the potential for others to use that same unit. For instance, consumption of a piece of chocolate by one individual prevents it from being consumed by others. On the other hand, it is possible for many people to simultaneously access and consume a television show without affecting others watching the same show. Many natural resources and ecosystem services are conditionally rival in that at low levels of use they are non-rival but they become rival as congestion occurs (i.e. as more people use them).

The combination of these two attributes, exclusion and rivalry, proves to be a powerful method for understanding the incentives that different actors may have for the provision or production of different goods (Randall, 1983). Private goods are subject to exclusion, making them easy to confine or control. Those that want to consume them are excluded from consumption unless they pay the price the producers set. The consumption of these goods by consumers is also rival. Once the consumer has purchased the good, it is no longer available to other consumers. Because of this, if a demand exists, the producers have incentives to satisfy it, given that they can expect to cover production costs and even make a profit. A free market environment is generally considered to be the most efficient way for these goods to be produced, allocated and consumed – provided that an institution (typically government) provides a stable framework underpinning the transactions.

By contrast, public goods do not lend themselves easily to exclusion, and they are non-rival. Once they are produced, everyone has access to them (although perhaps within certain geographic or political limits). Even those that do not contribute equally to the costs of production are able to consume them (and free ride). Because of free riding, producers have little incentive to produce, since their costs may not be covered. Hence, the provision of public goods requires collective action and is typically considered to be the province of government.

There are two other categories of goods beyond the purely private and the purely public. Common pool resources refer to those goods that are non-excludable and rival, such as a fishery or the open range. Like public goods, open-access common pool resources do not lend themselves easily to exclusion, but their consumption is separable. As long as total demand does not exceed the productive capacity of the resource, individual users can consume the goods without impeding consumption by others. When demand exceeds availability, congestion occurs and users operating on an exclusively voluntary basis have a strong incentive to continue appropriating the goods as fast as possible. Those that abstain from consumption simply yield benefits to those that continue consuming. And in the absence of a defined system of property or usage rights, all users are at liberty to consume the resource. Economists typically presume that this leads to an inefficient level of production since the resource is harvested unsustainably and the well-known "Tragedy of the Commons" ensues (see Box 5.1).

Box 5.1 - The Tragedy of the Commons

The "Tragedy of the Commons" seeks to explain what happens when access to a common pool resource is unfettered or unregulated. Each person with control over a portion of a common resource and no regulation or other incentive to keep his or her use in check will try to "maximize" his or her profit even if that profit is to the detriment of other users and the sustainability of the resource itself. This maximization causes other users to lose profits unless they, too, increase their use of the resource. Eventually, the common pool resource will be depleted, to the detriment of all.

Source: Hardin, 1968.

The last category consists of club (or toll) goods and services, which are non-rival in consumption but afford the possibility of exclusion. In this case, the ability to deny access to non-members may serve to limit the numbers of people seeking to share in the consumption. This may limit degradation of the good and allow some to enjoy its benefits. However, the benefits are ultimately non-rival (since demand increases relative to supply) and thus there remains the threat of congestion, for example if the number of members increases. In Figure 5.1, these two characteristics and the different classifications that emerge from their juxtaposition are presented.

Figure 5.1 - Public Goods: Exclusion and Rivalry

	Rivalry	
Exclusion	*Non-rival goods (low)*	*Rival goods (high)*
Non-excludable goods (low)	Public goods National defence Light houses Biodiversity	Common pool resources Rangeland resources Fisheries
Excludable goods (high)	Club (or toll) goods Private toll roads Golf clubs	Private goods Livestock Crops

In the analysis that follows, these concepts of rivalry and exclusion are applied to water resources to determine whether ecosystem water, value-added water and water-related services may best be regarded as public goods, private goods, common pool resources or club goods. Once their character is identified, the discussion turns to the institutional structure best suited to manage each type of good.

2.1.2. Exclusion and water

Speaking purely from the perspective of economics, bottled water is excludable, as an individual consumer can easily keep the water solely for his or her own consumption. Electricity generated by a hydropower plant is also excludable, since in order to enjoy the power a user must subscribe to the grid. Similarly, municipal and industrial water supply and irrigation deliveries are also excludable, since pipes, canals, laterals, ditches and headgates are all designed to physically exclude non-participants in the system from access to water. Patrollers keep an eye on canals and laterals, as do land owners on their ditches, in order to prevent water theft. But there are degrees even here. Each of these goods can somehow be poached or stolen – with bottled water the easiest, followed by water piped underground, power on a grid and water in a ditch, in that order.

Waterways that have been re-engineered for transportation purposes, through channels, locks, canals and associated infrastructure, provide the opportunity to exclude potential consumers, particularly where lock systems are in place to raise and lower ships and boats from one waterway to the next. Flood control, on the other hand, is the one water-related service that is non-excludable. Once flood control structures are in place, they provide flood control benefits to everyone in downstream flood plain areas. The dam or levee owner has no way to physically exclude businesses and residences from locating in the area and enjoying the benefits of flood control.

The ecosystem water coursing through rivers, wetlands and lakes is a different story. In a state of nature, with no institutional protection or regulation, this surface water and the various services it provides are available to all comers. As surface water is always moving downhill, it is very difficult for a single user to prevent others from finding it. Likewise, it is difficult to exclude consumers from the recreational and fishing opportunities afforded through the creation of public reservoirs and other artificial surface water bodies.

With groundwater, its physical isolation provides an important barrier to human use. By controlling access to surface lands, one consumer may attempt to physically exclude others. However, aquifers are typically large compared to land holdings, making this a difficult proposition. Furthermore, current drilling technology allows wells to be drilled at angles to the surface. It is thus difficult for one consumer to exclude others whose land also covers the groundwater or is located nearby.

Precipitation falling on land is subject to physical appropriation and therefore exclusion. But this is possible only at a very small scale, for example where rainwater is harvested from impermeable surfaces such as roofs of buildings. Similarly, when a farmer alters land use and vegetation to grow crops, other consumers downstream are subject to any change in streamflow that occurs as a result of changes in evapotranspiration and soil compaction on the farmer's property. Obviously, precipitation and consequent runoff and recharge from a property become part of surface and groundwater. There is only limited ability for a land manager to capture precipitation and change evapotranspiration rates (thereby excluding downstream uses), and thus this type of ecosystem water must generally be regarded as non-excludable.

It is important to note that as the good in question goes from ecosystem water to a value-added service (like irrigation) to a water-related service (such as energy), water tends to move from non-excludable to excludable. This is precisely because as human effort and resources are expended to store, divert and pump water, humans are able to exert more physical and institutional control over the water. Building dams makes water excludable because the stored water behind a dam is now under the physical control of the dam operator. Also, any increase in the height of water through impoundments gives the dam operator a certain amount of control over the potential energy of the water stored (for purposes of power production). Diverting water into a ditch or a pipe also increases options for excluding others from access to water. Thus, the degree of excludability varies directly with the investment in transforming water into useful products (like irrigation water, treated water or electricity) that can be transported to places of end use.

In economic terms, the ability to exclude others creates the possibility for the agent to appropriate the reward associated with the expenditure of effort and, as a result, provides an economic incentive to improve the accessibility of the resource to target populations. In other words, the ability to exclude strengthens the incentives for the agent to invest in improving the resource.

2.1.3. Rivalry and water

In the case of water resources, rivalry can be difficult to assess, depending as it does on a number of characteristics of the resource, the level of use and whether one views the resource from the perspective of an upstream or a downstream user. The first characteristic has to do with whether a number of users jointly consume the good (is the good "collective") or whether the good is available in discrete units ("separable"). Ecosystem water is typically a collective good – i.e. one that many different users may enjoy or use at once. For example, groundwater is a body of water from which many individuals may draw at any one time. Similarly, recreation on a river is collective, since quite a number of users may enjoy the resource simultaneously without impairing the consumption of others. By contrast, bottled water is made available to consumers in discrete, separable units. At first glance, then, many water uses appear to be non-rival in nature.

Water is of course a multifunctional resource, which in practical terms means that the use of the quantity and quality of water by one user begins to impinge on the water's use by others. Goods subject to the problem of degradation or loss of function as use increases are referred to as "congestible" in the sense that as more users attempt to consume them the impacts of congestion are felt and there is a higher degree of rivalry. In the case of water resources this is the same as saying that the quantity or quality aspects of water become scarce relative to demand. In order to analyse the possibility of congestion it is first useful to define the quality and quantity of water that is "consumed" when water is used.

Almost all uses of water involve some physical manipulation of water whether through damming, diversion, abstraction or storage. In addition, many uses will alter the energy content, the chemical quality, the biological quality or other attributes of the water. For example, run-of-river hydropower diverts water from the stream and avails itself of water's potential energy. Transport is one use that has little to no impact on water quantity but simply uses the water's kinetic energy. However, as the level of use increases, the use of one function of water may conflict with (or subtract from the satisfaction of) another use.

Once a hydropower project sends water down a pipe towards a turbine, the potential energy of that water is fully consumed and is not available to other users. Nor is the water diverted from the river available to sustain ecosystem function. Therefore, a run-of-river hydropower project is potentially congestible in that the use of water for the hydropower purpose will be rival with other energy and ecosystem uses. This is of course true only in the reach where the water is diverted and run through a pipe. Once the water is returned to the stream, hydropower (in this case as a non-consumptive use) is non-rival with other uses downstream.

This suggests that rivalry for water resources can be examined from both an upstream (at the site of the use) and downstream perspective (Aylward *et al.*, 1998). Whether a given use is rival or not with other downstream uses – and more to the point whether it is congestible with regard to these uses – will depend on the extent to which the use of water is consumptive or non-consumptive. Most uses result in some portion of the water being consumed physically, i.e. evaporated back into the atmosphere. The remaining non-consumptive portion of the water returns to the hydrologic system and is available, for example as groundwater or groundwater discharge, further down-gradient (assuming that there is no significant change in water quality).

Consumptive uses of water are therefore congestible goods from a downstream perspective in the sense that as they become scarce, adding additional uses upstream will subtract from the availability of water downstream. Irrigation, municipal and industrial uses will all typically be consumptive and therefore have attributes of congestible goods. Hydropower, recreation and transportation uses have a claim to be largely non-consumptive (absent storage) and therefore have non-rival attributes from the downstream perspective. This is because the diversion or use of water for power or transport does not reduce the potential use of this same water for downstream consumptive users.

Combining these characteristics into a single analysis is difficult but suggests that a number of the more passive ecosystem water uses will be non-rival in nature whereas many of the consumptive human uses of water (involving diversion, storage and pumping) are congestible. Once scarce relative to demand, the consumptive use of water by an upstream user is therefore likely to affect the water and services available to other users at the site or downstream, and exhibit rivalry. Meanwhile, the delivery of value-added and water-related services such as irrigation water and hydropower are generally non-rival when delivery is well planned and managed, i.e. where the majority of users use such systems without having an impact on other users. Of course, when poorly managed, these uses can become rival. Finally, the end use of value-added and water-related services such as bottled water, on-farm irrigation water, water from the tap and electricity in the home will of necessity be rival as the good is partially or fully consumed.

2.2. Economic nature of water

Water is often classified as a common pool resource, as are many other natural resources that in a state of nature are available to all but exhibit congestion at higher levels of demand and use (Ostrom and Ostrom, 1972; Dinar *et al.*, 1997). However, as illustrated above, the classification of water will depend on the type of water and on the use being discussed, as well as on the particular context. For example, irrigation water (a value-added good) is identified as a common pool resource in a doctoral dissertation examining rivalry and exclusivity along distribution systems in Nepal (Lam, 1994), whereas a later World Bank study treats irrigation water largely as a club good (although with variations depending on differences in rivalry and exclusivity at the levels of the main canal, the distribution system and the turnout to the farm) (Dosi and Easter, 2003).

Figure 5.2 - Exclusion and Rivalry

	Rivalry	
Exclusion	Non-rival (low rivalry)	Rival (high rivalry)
Non-excludable (low)	Public goods **Ecosystem water** • Surface water o Boating o Cultural o Domestic o Recreation o Transport o Ecosystem support **Water-related services** • Flood control	Common pool resources **Ecosystem water** • Precipitation* o Direct capture o Land use • Surface water* o Fishing o Diversion and storage of water for irrigation, M&I and hydropower • Groundwater extraction*
Excludable (high)	Club goods **Value-added water** • Irrigation water delivery • M&I water delivery **Water-related services** • Hydroelectric power • Transport	Private goods **Value-added water** • Bottled water • On-farm irrigation water • M&I water at the tap **Water-related services** • Electric power at end use

*Goods that are congestible, so that at high levels of use relative to supply they would become rival and therefore common pool goods.

The classification of water that emerges from the above discussion is therefore necessarily imperfect and incomplete. Nonetheless, Figure 5.2

attempts to combine the analysis of rivalry and exclusion with the identification of the various uses (ecosystem water, value-added water and water-related services) as public, private, common pool or club. The emphasis here is on the analysis of these goods and services in a state of nature – that is, absent regulation. Later in the chapter the arrangements and regulations that have emerged to manage water resources for human uses are described.

Public goods. The use of naturally occurring surface water for recreation, transport and cultural purposes is largely non-rival. Many individuals may simultaneously enjoy the scenery at Niagara Falls, for example. Similarly, water's role in providing support to ecosystems and their ecological functions such as habitat for spawning and raising fish are generally available for enjoyment by all consumers. Value-added water for use in recreation and the water-related service of flood control are also non-rival. Consumption (enjoyment) of flood control by one downstream property owner does not affect the enjoyment of this service by his or her neighbours. Since it is also difficult to exclude users from the recreational uses of ecosystem water, these would also be prime examples of public goods. Of course, at specific times and at specific locations, these goods may be subject to congestion, in which case they would be rival and non-excludable and therefore classified as common pool resources.

Common pool resources. A number of ecosystem and value-added water uses are very susceptible to congestion, meaning that they will often be rival goods. For example, fishing as a use of surface waterways – whether natural or man-made – can easily become a lose-lose proposition as additional fishers enter the fishery. Domestic uses of springs or small creeks may also become rival as more people use them or as sanitation issues lead to water quality problems. Again, the problem with regulating the use of these goods comes from the lack of exclusion, or open access, combined with their rival nature. Absent any intervention, the resource will be degraded as existing and new users overuse it.

The act of diverting surface water or pumping groundwater for irrigation and for municipal and industrial (M&I) purposes has similar characteristics. At low levels of use, the diversion of units of water from a river may not affect other collective uses of the water such as recreation, fishing and ecosystem support. However, as levels of abstraction increase the river is dewatered, and the other uses provided by the river are affected. Furthermore, the abstractive uses are consumptive and therefore detract from the availability of water for downstream users. In this sense, the use of water for irrigation and M&I purposes has the potential to be rival as usage increases. At the water source there is little or no possibility for one user to exclude another and hence the ecosystem water withdrawn for these value-added services must be regarded as a common pool resource.

Widespread access to electric power means that the potential to abstract groundwater through pumping is practically limitless in many cases. It can be argued that due to technological change associated with development of pumping capabilities and availability of electric power, the extraction of groundwater has gone from being excludable and non-rival (i.e. a club good) to non-excludable and rival (a common pool resource). Because mining of groundwater stocks (or surface water bodies) is feasible in technical and economic terms, groundwater use is therefore increasingly a rival use. Thus, the mining of aquifers, such as the Ogallala in the United States, and of surface water bodies such as the Amu Darya and the Syr Darya (which supplied the Aral Sea in Central Asia), are examples of rival uses, since present consumption reduced later consumption opportunities. As noted earlier, it is difficult to limit access to these stocks of water, so they are also non-excludable, making them common pool resources.

Similarly, the storage and release of water for irrigation, M&I or hydropower uses alters the hydrologic regulation of the river and therefore is rival with respect to uses that depend on the natural timing of surface water discharge. As with diversions, for dams there is generally no ability to exclude others.

These examples suggest that the extraction, storage, pumping and use of ecosystem water for these purposes are typically rival with respect to other human and ecosystem uses of water. This highlights the tradeoffs between augmenting the water services provided to humans and maintenance of ecosystem service benefits.

Club goods. The delivery of irrigation and M&I water and the provision of hydroelectric power through large distribution systems are non-rival. The incentive problem faced in these cases is that the cost of excluding others by building canals and delivery systems is significant relative to the benefits any one user might derive, and so collective action is therefore required in order to actually realize the benefits. Well-planned and managed irrigation or M&I delivery systems resolve this issue by sharing the costs of exclusion in an orderly fashion across large numbers of users. In this way it is possible to exclude non-participants along the distribution system from access to the resource. Therefore, these distribution systems are non-rival and excludable and may be classified as club goods.

Private goods. Electric power – as the end product of hydropower generation and distribution – along with M&I water from the tap and on-farm irrigation water are separable and rival goods. Once the consumer receives the power or water, he or she can exclude other consumers from using it. In this respect, these end uses of value-added water and water-related services are similar to the case of bottled water, and all of these uses may be considered private goods. Should an end user so wish, he or she could take the power or water, repackage it and sell it to others in market transactions.

2.3. Institutional arrangements for water management

The preceding analysis shows that just a few of the end uses – but the dominant human end uses – of water are private goods. But this does not mean that the other uses are all public goods. A large number of the uses examined are not "pure" public goods (i.e. non-rival and non-excludable). Instead, they have only one or the other of the public good characteristics.

Economists have long held that an efficient allocation of resources is achieved by the market – but of course, this is only when the goods being allocated are private goods. The prevalence of public good characteristics associated with the many uses of water and its derivative services means that water itself ought not to be considered and managed as a private good, i.e. left entirely to the free market. This implies that society must therefore decide how to manage water, in all its forms and services, in a way that considers all the economic, social and environmental costs and benefits. The challenge is for society to settle upon an institutional structure that achieves effective allocations of water among the many competing demands.

There is not necessarily one answer to which institutional arrangement is appropriate for which type of good. Different goods and services associated with water are public or private to varying degrees, and these goods and services are also inter-dependent (Ostrom and Ostrom, 1972). In addition, a given use's classification is not fixed, as a range of factors affect the excludability and rivalry of every good, as seen above. Similarly, since classifications will vary over time and space, an institutional arrangement that succeeds in providing or producing the good in one site in an efficient manner may not do so in another.

Water services that are classed as club goods (such as power, irrigation and M&I) have often been regarded as natural monopolies since the capital investment in infrastructure required to build a distribution network on a sufficient scale may preclude competition. Moreover, if provided by the private sector, enough revenues must be generated to repay the investment. The allocation problem is therefore to provide an incentive for the financing and construction of such systems, part of which may involve guaranteeing to the private provider exclusive service areas (and therefore profits) in advance. For these reasons, large irrigation schemes have often been managed by centralized agencies, bypassing private provision entirely. For example, in the Western United States early efforts to promote the formation of private irrigation companies (under the Carey Act of 1894) failed, and the federal government stepped in and took on the task of building large irrigation schemes (through the Reclamation Act of 1902).

Once the system is in place, the issues change. In well-managed systems where potential users are easily excluded (unless they pay), there is the threat of monopoly power since the system operator exerts control. To counter this problem, many countries have chosen to require centralized provision of water through public utilities or parastatal organizations. Other countries have chosen a polycentric arrangement whereby private companies provide the network and services, but they do so under the regulatory authority of a public utility commission that sets rates and limits profits.

In poorly managed systems where exclusion is not enforceable, illicit taking of water may occur, reducing the consumption of water by legitimate members of the scheme. Alternatively, users may shirk their responsibility to pay. This can lead to problems of repayment of capital investment as well as inability to pay for maintenance costs. Thus, irrigation sector reform in many countries now promotes self-governance by water user groups.

In developed countries, the increasing demand for M&I water, a decline in agriculture, new interest in river restoration and the exhaustion of water supply sources are changing priorities and spurring innovation in institutional arrangements. In developing countries, unmet and growing needs for M&I water, along with poor cost recovery by municipal suppliers and irrigation schemes, have led donors and governments to rethink centralized provision and experiment with other arrangements. Three of the major trends in institutional set-ups – decentralization, privatization and polycentric arrangements – are reviewed in the next section.

2.3.1. Decentralization

The local nature of many water problems has led to increased efforts to decentralize power and authority over water management from national governments to regional or local actors. Efforts to establish river basin organizations, watershed councils, catchment management agencies or groundwater management districts are evidence of this trend. As central government's role in allocating water has waned, centralized agencies have focused more on planning, monitoring and oversight.

The theory of decentralization originates from the so-called subsidiarity principle, which holds that government works most effectively when decisions are made at the lowest level that has the authority to decide (IUCN, 2003). The term "decentralization" is generic, and represents a variety of institutional arrangements. Traditionally, decentralization denoted a transfer of power or authority (fiscal or legislative) to sub-national governments (Ostrom *et al.*, 1993), but other power transfers are now recognized as forms of decentralization. Political decentralization, for example, occurs when the central government transfers decision-making power to locally (or regionally) elected representatives (WRI, 2003), whereas administrative decentralization means that the central government agencies or ministries transfer some of their functions to their regional or local branch offices. Other forms of decentralization consist of a sharing of power between the government and local users or between the government and local non-governmental organizations.

Decentralization, in any of these forms, can offer several advantages over centralized management. Because local authorities or groups have better contact with the resource and the actors that influence it, they may more efficiently apply policy and strategy goals to the water resource under their control. For example, local water users associations can internalize the costs and benefits of irrigation system management and reshape such systems to the real needs of users, rather than the needs perceived by central governments thousands of miles away.

However, decentralization can be wrought with the same problems as centralized management, such as lack of accountability (Ostrom *et al.*, 1993), which can arise in particular where power is devolved to unelected groups or institutions (as these groups may be loyal only to their members) (WRI, 2003). In order for decentralization to work best, the centralized government must transfer significant powers to an elected institution that represents all local interests and that is accountable, through elections or other democratic processes, to the local people. And of course, as with all forms of government, "[f]iscal and regulatory incentives must be in place to promote sustainable management of [the resource] over the long term" (WRI, 2003).

2.3.2. Privatization

Privatization is not an institutional arrangement in and of itself, reflecting rather a transition from a system with centralized, public provision of services to an arrangement in which the private sector plays a larger role. Whereas decentralization shifts power to local authorities with responsibility for local communities, privatization involves the private sector in the operation and management of water utilities (Dosi and Easter, 2003). In practice, privatization has often meant transferring water infrastructure to multinational corporations and leaving the ownership of water with the state.

Governments may choose to privatize municipal systems for many reasons, including reducing operating costs, avoiding future infrastructure expenses or achieving higher levels of efficiency (WRI, 2003; Dosi and Easter, 2003). In many countries, long periods of undercharging municipal customers and failing to increase charges to keep pace with inflation have left public service providers short of funds to maintain aging (and leaky) systems. Cost recovery, or lack of cost recovery, is the main problem. With no prospect of paying off new investments, municipalities are often unable to finance new infrastructure or services through loans or bonds. Experience suggests that an unspoken motive of governments privatizing water management is to pass on to the private sector the politically unattractive task of implementing or improving cost recovery.

If cost recovery is not the objective, then privatization is often undertaken because current management is perceived to be inefficient. However, the argument that private companies are more efficient is contested. Recent work from the United States suggests that there is little difference in efficiency between public and private management of municipal systems (Wolff and Hallstein, 2005). In developing economies as well, years of encouraging private management have had mixed results in terms of increasing the efficiency of municipal service provision (UNDP and IFAD, 2006).

Since the private sector must have the potential to profit before it will engage in an activity, this means that it must either increase water prices or improve cost recovery to pay for expected improvements. To some extent, then, public anger over price hikes by recently privatized utilities in Manila, La Paz and other cities is misguided. In certain respects, public discontent represents more a failure of governance than a failure of privatization. If government is unable or unwilling to subsidize water users through the provision of public funding, then the private operator that is brought in to improve efficiency has no alternative but to raise prices. Clearly, however, passing this task on to multinationals without adequately preparing the public is a recipe for political turmoil.

Although there are potential benefits to private water management, there are also risks. Because private companies are beholden to their shareholders and are expected to make a profit, they may not necessarily be accountable to water users and also may not reinvest profits into improving infrastructure (Hildering, 2004). For the same reasons, there are concerns that private water managers will not adequately provide services to the poor and under-served. Potential solutions are to increase government oversight or to require government to maintain infrastructure and provide service to all customers.

2.3.3. Polycentric arrangements

Polycentric arrangements are another option for governments considering various institutional structures for water management (Ostrom *et al.*, 1993). Polycentric arrangements give simultaneous and concurring powers and responsibility to national and local authorities: each geographical area has a government with the authority to make and enforce its own rules. In such a system, "[a]ll public authorities have official standing, and no individual group serves as the final, all-purpose authority that stands above the law" (Ostrom *et al.*, 1993).

The power and responsibilities that the different levels of government possess depend on the country and the type of power that is transferred, for instance general powers of government versus specific powers given for one purpose such as maintaining an irrigation canal. Any disputes between the levels of government are settled in courts or other fora for alternative dispute resolution (Ostrom *et al.*, 1993).

Given the multi-faceted and inter-dependent nature of water resources, a flexible polycentric arrangement seems a logical outcome. This evolution reflects a shift from a dependence on centralized management of water to one that better captures the explicit call in the Dublin Principles to recognize water as an economic good. Seen in that light, devolving authority to relevant watershed bodies or user groups and increasing public participation in decision-making regarding water resources both grant water producers and consumers greater freedom to act in their economic interests. As already discussed, however, conceiving of water as an economic good (i.e. a scarce resource with value) should not be conflated with managing water using purely market arrangements. Water has too many public good aspects for this to succeed.

The remainder of this chapter considers the legal and regulatory approaches to allocating and managing water, considered in light of the challenges discussed above. This section does not address regulatory issues related to specific water-related services, such as drinking water, irrigation or ecosystem water, as these are explored in Chapters 7, 8 and 9.

III. ALLOCATING AND MANAGING WATER

The next sections examine legal and regulatory issues related to water quantity – specifically the ownership, use and management of water (see Box 5.2) – using national examples to illustrate the various options available to policy-makers. Where feasible, the discussion is organized around surface water, groundwater and watershed hydrology.

3.1. Ownership of water

Given the public good characteristics of ecosystem water, it is not surprising that the historical mode of regulating the ownership and use of water was for the government to retain an ownership interest and allow uses through licences, permits or use rights. Roman Law included the concept of common waters (common to all and thus no one could own them), public waters (belonging to public institutions) and private waters (associated with the land). Islamic Law does not permit private ownership of water, nor does Chinese Law. The evolution of these traditions solidified the concept of state or public ownership of water in most countries around the world.

Box 5.2 - Key Questions for Assessing Allocation and Management in Water Laws

Ownership of water. Does the state own water or can private entities own it? Does ownership vary for different types of water?

Use rights for water. If the state owns water or retains control over its allocation, how do public or private entities obtain state permission to use water? Which water uses require formal permission and which can simply be exercised?

Allocation of water rights. How is water shared in times of shortage? Are there rules for prioritizing the allocation of water to different uses?

Duration and transferability of use rights. What is the duration of the permission to use water? Does the permission depend on continued use of the water? Are use rights transferable between users?

Conditions on use rights, and fees. What conditions are placed on the use of the water? Are there state fees and charges associated with the use of the water?

Although it is often stated that water belongs to the public or to "all", and this may be a powerful emotional concept, the counter-argument is that "what belongs to all belongs to no one." In fact, the Roman concept of common waters that no one could own raises the question of how to manage the waters if there is no relevant authority. In practice, the concept of common water is generally understood to give government the role of managing water on behalf of the public, as well as the concomitant role of deciding who may use water and for what purpose.

The state's legal role in protecting public goods such as water may be expressed in different ways and in different texts, such as a constitution or statute. In Indonesia, for example, the constitution places water and other natural resources under the state's control, and the Ugandan Constitution states that the government must protect water resources on behalf of the people and manage the resources in a sustainable way. Under South Africa's

National Water Act of 1998, the government holds water resources as a public trustee, whereas in Japan, rivers are public property and no one may have a private right over them. Although water is not mentioned in Kyrgyzstan's Constitution, the 2005 Water Code does specify that all water resources are the property of the Kyrgyz Republic.

In the United States, water is treated as a public resource. Private rights to the use of water may be established, but these are always incomplete and subject to the public's common need (Getches, 1997). The federal government and the states share jurisdiction over water resources, with the federal government generally regulating water quality and the states allocating quantity. In the State of Oregon, for example, the legislature declared in 1909 that all "waters of the state" belong to the public, with "waters of the state" defined to mean "any surface or ground waters located within or without this state and over which this state has sole or concurrent jurisdiction" (Oregon Revised Statutes (emphasis added)).

National constitutions and laws often treat different types of water (i.e. precipitation, surface water and groundwater) differently. Interestingly, Roman Law recognized rainfall and other waters associated with land (i.e. groundwater and minor waters) as private property. Civil law, which arose from the Napoleonic Code and applies in most of Europe and its former colonies, likewise distinguishes between water that falls and runs or pools on a property versus water that flows freely on the surface: only the former is amenable to private ownership. In Chile (where most water is national property), springs, non-navigable minor lakes, lagoons and swamps lying wholly within one's property are private. Indonesia also recognizes the rights of land owners over water flowing to and from their land.

In parts of the United States, water that is on the surface of land from rain, snow or floods is called "diffused surface waters" and is the property of the land owner. In the State of Texas, for example, this water is not subject to state control, and Texas courts have affirmed that until diffused water enters a natural waterway it is the property of the land owner (Kaiser, 2005).

Although modifying vegetation and land to appropriate rainwater will alter the timing and availability of water downstream, these are generally left unregulated by the state if water is the property of the land owner. However, the state does retain oversight to determine whether certain planned uses will affect other users. In the State of Oregon, for example, land owners planning to irrigate with surface water or groundwater must obtain a permit to do so. Transfers in these use rights likewise engender state review to determine if other users will be adversely affected. At the same time, changes in land use or farming practices on rain-fed lands are not generally regulated, even though the change in land use will affect groundwater recharge and surface water runoff.

Unlike surface water, groundwater was considered private property under Roman Law. Civil law systems likewise recognize that water underneath a property belongs to the land owner, as do certain common law jurisdictions, including some states in the United States. Many states typically regulate groundwater separately from surface water, although some states have no groundwater rules at all (Getches, 1997). In 1904, the Supreme Court of the State of Texas adopted what has become known as the "rule of capture", which simply states that land owners may extract as much water as they want from under their property. De facto ownership is thus exercised by extraction, allowing surface occupants to pump as much as they can. The lateral movement of groundwater from below one property to another is simply ignored (Kaiser, 2005).

In earlier times groundwater may have been regarded as a club good (i.e. non-rival and excludable), but modern pumping technology and the spread of electric power have greatly lowered the degree of exclusion that may be exercised whilst increasing the availability of groundwater for extraction. At the same time, the scale of use implies that one user's use increasingly affects others' uses; hence, in some locales, groundwater is increasingly a rival good. As a result, groundwater may now be regarded as a common pool resource with a need for common property management approaches. This is an example of how changing technology may alter the economic nature of a good, thereby calling for review of the legal framework if water is to be managed sustainably. Groundwater in this case needs to be actively managed, rather than allowing a "Tragedy of the Commons" to occur (see Box 5.1).

3.2. Use of water

A key characteristic of any system for regulating water quantity and its use is whether and which sorts of uses require some form of government permission. Under Roman Law the use of public waters (those that were navigable) required authorization from the state. Similarly, the right to use waters from streams adjacent to riparian lands required state authorization.

In the Eastern United States, increasing growth and pressure on water resources led many states to adopt statutory permit systems by the middle of the last century (Getches, 1997). These permit systems were necessary in part for evolving non-riparian uses, such as for municipal supply. Typical uses exempt from permitting include domestic uses, farm ponds and, in some cases, irrigation. The State of Indiana, for example, does not require permits for riparian water uses limited to domestic, stock or agricultural water needs so long as withdrawals do not exceed 100 000 gallons per day.

In the Western United States, many states follow either the "prior appropriation" doctrine or a combination of the prior appropriation doctrine and the riparian rights doctrine. The prior appropriation doctrine originated from the customary practices of miners who resolved disputes over water based on who had first established a claim. All prior appropriation states have permit systems established by statute except for the State of Colorado, which adjudicates permits through special water courts in each water district. In most Western states, the permit system typically requires filing, public notice and review, followed by issuance of the permit. The permit is not a "perfected" right (i.e. the user cannot begin relying on it) until the user has demonstrated his or her intent to apply the water to a beneficial use. This is principally satisfied by constructing the infrastructure necessary to apply the water to the intended use, such as irrigation, mining or industry.

In Indonesia, uses are separated into beneficial and commercial ones. For the former, a licence is required for all beneficial uses that: (a) change a water source's conditions, (b) are intended for small-scale farming outside of the irrigation systems or (c) serve people with high-volume water needs. All other normal household and local irrigation uses do not require a licence (Law No. 7, art. 8(2)). On the other hand, all commercial uses of water require a government licence.

In Uganda, land owners or occupiers who want to use water or construct any works on land must obtain a permit from the government, both for surface water and groundwater (Water Statute, art. 18). There are exemptions for water for domestic uses including drinking, cooking and washing. Also exempted are watering of livestock (not to exceed 30 animals), fire fighting and water for subsistence agriculture, a subsistence fish pond or a subsistence garden (secs. 2 and 7(a)). For groundwater, a permit is required to drill any borehole.

Chile grants some water use rights without permits, and these are linked to land ownership. For example, rainwater that falls on a land owner's property may be used so long as it does not form a natural watercourse (Water Code, art. 10). As mentioned above, the water in minor lakes, lagoons and swamps may also be used by the land owner without a licence (art. 20). Finally, a land owner may dig a well on his or her property for domestic needs, even if that well harms the well of another, unless the harm is disproportionate to the benefits (art. 56).

In Krygyzstan, the water code requires permits for some water uses but not all. For example, domestic and personal uses, such as drinking and stock watering, do not require permits if the water is obtained from surface water sources and the construction of permanent waterworks is not required (art. 22(1)). Additionally, recreational uses, water for fire fighting and irrigation water supplied by a water users' association do not require a permit (art. 22(1)). Groundwater uses do not require a permit if extracted for domestic needs (art. 22(2)). Other uses, including dams, do require a permit.

Under South Africa's water law, domestic uses of water, including gardening, animal watering, fire fighting and recreation do not require a permit (sec. 4), whilst other uses do. Land owners and occupiers have the right to use the water on their land for domestic purposes. Other use rights, however, are not linked to land ownership. For example, an individual may obtain a licence to enter onto another's land to exercise certain use rights (Schedules 1(1) and 2). Groundwater is covered within the same scheme. An applicant may receive a licence to use groundwater that is under another person's property, but only if the land owner consents (sec. 24).

Japan's legislative framework classifies rivers as those that are particularly important for land conservation or the national economy (Class A – as designated by the Minister of Construction) and those that have an important public interest (Class B – as designated by the Governor of the Prefecture) (River Law, arts. 4(1), 5(1)). There are also rivers that are chosen by city, town or village leaders and regulated as Class B rivers (art. 100). Any person wanting to abstract water from a river must obtain permission from the Minister of Construction for a Class A river, or from the Governor of the Prefecture or the town or village leader for a Class B river (see arts. 9, 10, and 23).

From the preceding review of national laws covering water use, it can be seen that large users, including municipal, commercial and irrigation users, typically require permits. Household and stock water uses, on the other hand, tend to be free from permit requirements. This may derive from either a rights-based concept (as in South Africa) or from the perspective that rural household uses are not significant enough to regulate. Interestingly, as populations grow and development proceeds, water resources are becoming more fully exploited and the small uses that were previously considered "insignificant" and exempt from regulation may become more problematic for water managers.

3.3. Distribution and priority of use

The availability of water may be highly variable throughout the year, from one year to the next and from a wet cycle of years through a drought cycle. How legal and regulatory systems provide for allocation of such a variable resource is therefore of great importance both to managing water resources and to avoiding conflict.

The prior appropriation system used in most of the Western United States takes the "first in time, first in right" approach to allocating water for all current users. In these states, priority dates are established for each and every water right or permit. When water shortages occur, senior rights holders, i.e. those that appropriated water first, have the first priority for the available water, even if after their use no water remains for those who hold junior, inferior rights. In the State of Colorado, however, water users are prohibited in the summer from using water in excess of what is actually necessary for their irrigation or domestic uses (Colorado Revised Statutes). If the state government later takes water for other uses, depending on the circumstances it may need to pay compensation for "taking" the private water rights.

In Japan, permission to use river water is only granted if the Minister of Construction finds that new uses will not interfere with existing ones. There are exceptions, however, if a new project will provide a public benefit greater than that afforded by an older one. In such a case, the Minister may permit the new use after consulting with the heads of other interested administrative agencies (arts. 35(1) and 40). In Japan, then, existing use priorities are acknowledged but not to the exclusion of valuable new uses. This is not dissimilar to the case of Chile, described above, where a well dug on a land owner's property to get water for domestic needs is allowed even if it harms another's well. Here the potential benefits from new uses are not ignored, but they are balanced against the costs they impose on others.

Drought provides the extreme case of shortage and the inevitability of cutbacks for at least some water users. In the case of unusual drought in Japan, the authorities may intervene to ensure that permittees cooperate with one another to agree on water use. In drought periods, the oldest use does not necessarily receive priority: rather, there is an expectation that users will agree on the best use of water. If they cannot agree, the river administrator may require mediation or arbitration, particularly if an unmediated situation could harm the public interest (art. 53). With the river administrator's permission, a water user may permit other water users in greater difficulty from the drought to use his or her water allocation for the duration of the drought. The Industrial Water Law also gives the government certain authority in times of water need. For example, the governor may restrict groundwater abstraction when groundwater may be depleted (art. 14). The Japanese system provides a process for allocating water to higher-value uses, but this is left to the water users to decide.

Indiana, an Eastern riparian state of the United States, limits water withdrawals in the case of groundwater or surface water emergencies, which are defined in the state's water code. When the Department of Natural Resources (DNR) determines that water withdrawals have significantly lowered the normal levels of a lake or aquifer, and the lowering was caused by a "significant water withdrawal facility" (i.e. a facility that withdraws more than 100 000 gallons of water per day), then the DNR may restrict the amount of water that the facility withdraws. In this way, smaller facilities are preferred. Users that withdraw smaller amounts of water are typically land owners who use groundwater or riparian water for domestic supplies, whereas the significant water withdrawal facilities are large irrigators or industry. According to the state water code, "The use of water for domestic purposes has priority and is superior to all other uses" (Indiana Code).

Another approach to prioritization comes from customary law irrigation systems, known as *subak*, in Bali, Indonesia. There, *subak* members have a right to receive water from the water source in a fixed share that is determined by their contribution to the construction of the irrigation system: this has no relationship to the size of their plot of land. It is worth noting that this system pertains more to the water-related service of irrigation water delivery than permission to use the source itself, since without the irrigation system the water could not be diverted. This system is therefore analogous to methods for balancing investment and return on large irrigation projects. The larger the investment a user makes in the system, the larger the right to the product of the investment, i.e. irrigation water.

The legislation in Chile defines several categories of water use rights. Consumptive rights entitle the owner to use the amount of water that is necessary for a given activity, whereas non-consumptive use rights require the owner to return the unused portion of water. Contingent use rights provide rights to any water surplus left over after the permanent right holders have satisfied their needs. Rights are further divided into continuous and discontinuous rights: the former can be exercised without interruption, whilst the latter can only be enjoyed at certain times. These categories are designed to assist in the management of variability in water supply.

The Krygyz Water Code provides a detailed ordering of water use priorities, namely: (1) drinking water; (2) irrigation and stock watering; (3) hydropower generation; (4) industrial activities (e.g. mining); (5) fishing and fish farming; (6) sport and recreation; and (7) any other purposes (art. 24). The legislation also permits the government to limit or restrict water use in times of drought or water shortages (art. 74).

In its 1998 Water Act, South Africa established a clear priority for basic human needs and ecosystem uses of water. These two uses are superior to all others, including those recognized under the prior 1956 Water Act. Apart from these two uses and international obligations, no set priorities are defined for normal, licensed uses of water.

Thus, a number of approaches exist to prioritize which potential users may access water and for which specific uses. An explicit, centralized approach may prioritize use rights based on perceptions of their societal necessity or worth (e.g. Krygyzstan and South Africa). In a locational approach, such as in the case of traditional riparian rights, those with land adjacent to the river have access, or higher priority access, than those farther away. Moreover, in times of shortage, the closer to the source the users are, the more chances they have to obtain water. Some jurisdictions may combine a centralized approach and a locational approach, designating priorities for non-riparian uses. A third possibility is to establish priority based on established versus new uses. One variant of this last approach is the prior appropriation doctrine, which fully differentiates among all permitted uses based on their date of establishment. It is important to note that the United States is the only country that uses prior appropriation.

It can be difficult for a riparian system to accommodate the many competing uses, many of which will be non-riparian. The weakness of prior appropriation systems is that there is no clear relationship between the longevity of use and social, economic or environmental value. Centralized allocation systems may therefore seem the best option, except that laws and regulations most often only define categories of use in general terms, with the actual priority of allocation left to the executive branch to decide. Accordingly, there exists a very real possibility of rent-seeking behaviour, where government officials with the power to determine allocations are susceptible to influence (and bribes) from water users. This may result in a less than optimal allocation of water from a social, economic or environmental perspective. A second difficulty is that such a system is based on the assumption that government – even in the absence of rent-seeking behaviour – can pick the "best" use of available water.

An alternative is to let market forces determine the "best" result through water trading. In Australia, for example, the National Water Initiative (NWI), passed by the national and state governments in 2004, encouraged water trading to promote a more profitable use of water. Some United States states that follow the prior appropriation doctrine also have trading schemes. In these systems, some users have secure allocations (senior users) and some users have interruptible supply depending on hydrological conditions (junior users). If a junior user or a prospective user has a more valuable use, then he or she may apply to use water assigned to a senior user. The senior user then reduces or retires his or her use of water, but obtains compensation for the water transferred. This allows both parties to improve their situation through the trade of the permission to use water, resulting in a more financially efficient allocation of water.

The drawback of such a purely market approach is that disadvantaged social groups may not have participated, and the interests of the environment may not have been taken into account. Water may have moved to the activities with the highest market return but these may not be the activities with the highest value to society as a whole. For this reason, further regulation or restrictions on the market may be necessary. One solution is to prioritize categories of uses and then allow trade within, but not between, categories or across certain categories. For example, domestic supplies could have first priority; minimum ecosystem needs might be the second-tier category; and industrial, commercial, agricultural and additional ecosystem needs would come last.

Another possible solution is not to make explicit *a priori* prioritizations but rather to follow the Japanese approach where the government compels the users to make the hard choices of how to prioritize the use of available water in times of shortage. This approach may succeed where central power is strong and there is a tradition of communal management of resources. Where this is not the case, the approach taken in the State of Indiana may have merit, where, upon request from water users, the water commission will mediate disputes.

3.4. Details of use rights

The details of use rights have important economic effects. These will include the duration of the permit, the ability to transfer a permit from one user to another and the requirement to forfeit the permit in certain circumstances.

The expected duration of the permit has an important effect on incentives for investment. All other things being equal, a short duration will discourage investment, whilst a long duration will encourage it. Also relevant will be the degree of certainty that the permit and its validity will not be abrogated by the issuing agency.

Transferability of permits allows trade in water when the original permitted use becomes economically unproductive. One system of transferability is called a cap and trade system, whereby the government establishes a withdrawal limit for a group of users but then allocates allowances for each user. The individual users may then trade their allowances amongst themselves, so long as the overall withdrawals remain within the authorized limit. Such a system may be more efficient than one in which unused permits are simply forfeited through non-use, especially where new rights were simply doled out without regard to their productive role in society. (See Chapter 9.)

A third condition of the use permit that will have economic consequences is the threat of forfeiture for unused permits and the ability to transfer a permit to another user. If there is no compulsion to use the water, then there is not as much urgency to do so. This means that over time the number of outstanding permits will increase, since water is not being used and new permits are being issued. Potentially, this may cause confusion and problems once the water source becomes legally over-allocated. For example, if market conditions change for the better, and agricultural permits are put back into use, then this may lead to conflict over water or harm to low priority uses.

Many combinations of these three components of a water quantity regulation regime (duration, transferability, forfeiture) are possible. From an economic standpoint, permits that are valid in perpetuity, transferable and subject to forfeiture for non-use appear to ensure the most productive use of water in market terms. However, as discussed further in Chapter 9, this relies on the willingness of users whose use is on the downturn to trade their water to higher value uses. Also, it relies on new uses having the market power and financial resources to acquire water rights. It is not clear that environmental and social uses, such as ecosystem services or drinking water, will be in such a position. Without some sort of centralized oversight to ensure that water moves both to where it is needed and where it is socially productive, issuing water permits in perpetuity may be problematic, locking in private gain at the expense of the public benefit. Conversely, granting only short-duration permits is unlikely to promote investment in the efficient use of water.

A variety of approaches have been tried in countries granting use permits. In Kyrgyzstan, applicants for water permits generally receive them for 15 years, with two exceptions: where the applicant requests a shorter duration or where the permit is for gravel or mineral extractions, for which the duration is 5 years. Long-term investment works, such as dams, may receive a special use permit that is valid for up to 50 years. Permits for irrigation in Kyrgyzstan are transferable, although the new permit holder must register the transfer within two months or the permit becomes invalid. On the other hand, the legislation permits the government to limit or restrict water use in times of drought or water shortage.

In South Africa, all water licences are subject to a term of duration, for which the absolute limit is 40 years. All licences are subject to review at regular intervals, although the intervals cannot be more than 5 years. During the period of validity the amount of water specified on the licence may be reduced if the water use is not implemented fully (or at all). Only licences for irrigation may be transferred, and only temporarily. Licences may also be partially or fully surrendered in certain circumstances.

In Uganda, the transferability of the permits is only allowed when the land to which the permit applies is sold or transferred. The permits are thus attached to the land – a concept known as appurtenance. Anyone who buys or takes over property as to which there is a permit granted may continue to use water in accordance with the permit conditions for three months, after which he or she must apply for a new permit. The conditions attached to the new permit may not be more stringent than the previous ones.

Under the riparian doctrine in the Eastern United States, water rights are also regarded as transferred with the land to which they are appurtenant (Getches, 1997). A failure to use water does not usually result in forfeiture of rights. By contrast, under the prior appropriation doctrine in the Western United States, a failure to use water for a "beneficial use" can lead to forfeiture. The arid nature of the West prescribed the necessity of a system structured on the principle of "use it or lose it".

Depending on the particular permits and the definition of beneficial use, in some prior appropriation systems water rights are transferable, subject to the assurance that the transfer does not cause harm to existing uses of water. This concept of "harm" even protects junior users. For example, if a junior water right holder located downstream from an irrigator with a senior water right relies on return flow from the upstream irrigation use, the senior user may not be allowed to transfer the senior water right to a new diversion point downstream of the junior user. If the senior user were permitted to do so, in dry periods the junior user would lose access to water to which he or she was previously legally entitled to divert, and would therefore suffer harm.

In Chile, water use permits become the property of the right holder upon their registration. Owners of these rights may subsequently use or dispose of the right; the rights are transferable.

In Japan, neither the River Law nor the Industrial Water Law specifies the duration of the permission to use water, although the former law does permit the cancellation, alteration or suspension of the permission (or the imposition of new conditions in certain circumstances). Additionally, as mentioned above, when a new project affords a greater public benefit than an old one, the older project may lose permission for its activities, although the new permittee must compensate the old permittee for the loss suffered.

3.5. Conditions, fees and charges

As part of the permitting system, states may impose conditions when they grant use permits, and may levy fees and charges on the use. In South Africa, for example, water abstraction licences are not unconditionally granted. The government may impose conditions such as requiring a management plan and certain management practices, or specifying the amount of water permitted or the method of abstraction. Conditions placed on permits in the U.S. State of Oregon consist of "advisories" that list limitations on the use of water based on applicable laws and operational constraints (Bastach, 1998). For example, in basins where surface water and groundwater linkages may require future regulation of water use, permittees are given permits conditioned on the possibility of future regulation or mitigation requirements. It is also now standard in Oregon for permits to require all new groundwater permittees to meter and report their use.

In Japan, the Minister of Construction may attach certain conditions when granting permission to use river water, but these must be reasonable and necessary. The Industrial Water Law also permits the imposition of certain conditions on the abstraction of groundwater: the conditions must be the least restrictive means of promoting conservation of groundwater resources in the relevant area and, as under the River Law, must not impose unreasonable obligations.

With respect to charges, daily and small-scale uses do not have to pay under Indonesian law. Other users may be subject to fees (established through regulation) based on the economic capacity of the user and the volume of water used. In Kyrgyzstan, water charges may be levied based on the government's actual expenses for research, protection and administrative activities related to water. Water users in South Africa are subject to water use charges to recover the direct and indirect costs of water management, allocation and development activities. In Uganda, fees may be charged for both administrative costs and resource use. Water charges may be collected in Japan, the amount of which is fixed by government ordinance, although there is no provision for water charges on groundwater extraction.

IV. CONCLUSIONS

The preceding survey of legal doctrines and country experiences points to a wide variety of approaches to managing water quantity. With a few notable exceptions, water is generally managed by the state on behalf of the public. Rights to use water are granted to public and private users by the state, with domestic and small-scale uses typically exempted.

Water is replete with public good characteristics. This argues against a pure market arrangement for the allocation of water resources and in favour of a system in which central government, water users' associations and local actors decide how water is to be allocated. The distinction made in this chapter between ecosystem water, value-added water and water-related services provides a framework for understanding that the public goods problem is most pressing for unimproved ecosystem water. As human involvement and investment in water infrastructure occurs, water takes on private good characteristics and there are increasing opportunities to manage water with market tools.

The problem of over-allocation and shortage is also addressed in a variety of ways, with some systems failing to address the question, some having extremely detailed priority systems and some relying on case-by-case negotiations to resolve allocations in times of shortage. Similarly, the duration of a permit varies from a limited span to a right in perpetuity. In some countries and states the permission to use water is transferable and in others not. Where transferability is permitted, many conditions may apply. Amongst these are the requirement to pay for water use, which the government assesses as reimbursement for various expenditures incurred in water management and administration. In the United States, the loss of permission to use water due to non-use was not contemplated in riparian systems, but in arid areas with defined priority systems the concept of forfeiture has become commonplace.

The allocation and management of water resources entails tradeoffs amongst different social, economic and environmental objectives to ensure that water is available not only where it is needed but also when it is needed by those that have the right to use it. These tradeoffs are made more difficult by scientific uncertainties over how the water cycle works in a given watershed. Even with a clear set of objectives and perfect information, the fundamental problem of optimizing allocations of water quantity would remain because of competing values and conflicting demands for a scarce resource.

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