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Chapter 16

Freshwater Policy

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Executive summary

Addressing drivers and pressures is the key to making effective freshwater policy. This can be achieved through regulatory command-and-control mechanisms, subsidies, supporting investments and enabling actors, but there is also value in process-based innovative approaches such as experimentation, learning and voluntary reporting. {16.2.1, 16.2.4}

Policy coherence and synergy are needed to address the water-food-energy-health-ecosystems nexus. Policy mixes are typically adopted to meet demands across multiple sectors and to manage implications outside the freshwater policy sphere. Intricate linkages among water quality and quantity, agriculture, human health, ecosystems and energy systems require that freshwater policy is developed with this nexus placed centre-stage. Achieving policy coherence and synergy are important benefits of this integrated thinking, as water policies influence policies in other sectors, especially agriculture and energy. {16.2.1, 16.2.2}

Much freshwater policy is highly context dependent, yet a variety of freshwater policy types and governance approaches can diffuse to fit diverse local contexts. Governance approaches and policy types are diverse. The design, implementation and evaluation of these policies require that institutional structures, economic resources and other enabling factors are in place. {16.1, 16.2.3, 16.2.5}

There is scope for freshwater policy to better consider co-benefits to ecosystems and human health. Changes to water quality and quantity through interventions such as infrastructure investment and natural hazards requires consideration of direct threats to human health but capitalizing on potential co-benefits is not yet widely practised. {16.1, 16.2.2, 16.3}

Policy effectiveness draws attention to the role of citizens, the private sector and non-governmental bodies, in particular through participatory processes. Implementing integrated water resources management (IWRM) is a participatory process, based upon intersectoral coordination and greater engagement of non-governmental actors. Collaborative efforts are required to involve the private sector and non-governmental organizations, or local governments and citizens**.** Stakeholder engagement is a long-term process and requires investment in supporting stakeholder relationships. Institutions should be designed to enable inputs into decision-making from these relationships rather than treating them on an ad hoc basis. Devolution of water governance requires supporting investments, capacity-building and sustained long-term efforts in raising awareness. Exchanging knowledge at the subnational level enables effective stakeholder involvement. {16.1, 16.2.1, 16.2.2, 16.2.5}

Evaluating policy effectiveness is enhanced by consistent and transparent reporting and systematic monitoring. For policy effectiveness, defining baseline conditions is needed prior to implementation for comparison and lesson learning. Standardization of sustainability reporting, development of national reporting mechanisms, and the use of knowledge hubs for scientific reporting have proven useful {Sections 16.2}. Reporting and monitoring helps tracking of Sustainable Development Goal (SDG) progress at both national and global levels and helps identify causal relations of specific policy interventions. {16.3.1, 16.3.2}

While policy approaches become further integrated and complex, there is an ongoing need to address basic environmental clean-up and the reversal of damaging legacies. Even in developed economies, regulation, technical fixes and investments are required to continually improve practices of water use and prevent water quality degradation {16.1}. Policies may need to be revised to change the direction of trends in water use. {16.6.1}

Environmental and freshwater policies can be effectively driven by the consideration of social issues, especially equity and health. Disparities within a country or between developed and developing countries can motivate national as well as global efforts for addressing access to water and sanitation services, underpinning the human right to water and sanitation. {16.2.3, 16.2.5}

Transformative potential can be seen in effective and innovative freshwater policies that benefit both people and planet. The environmental flows approach carries transformative potential, as it is a way of assessing quantitatively the water needs of the river as a living system, and of balancing these water requirements against the water requirements of various economic sectors. As more rivers are assessed in this way, environmental flows become a fundamental building block of river basin management and governance, leading to the integration of management of water and landscapes through the entire catchment. {16.2.1}

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16.1 Introduction

The Millennium Development Goals (MDGs) motivated countries to tackle issues relating to sustainable access to safe drinking water and basic sanitation. The Sustainable Development Goals (SDGs) now present an even more ambitious global framework within which the multidimensional concerns of availability, quality, use and governance of water can be addressed. Chapter 9 in Part A identifies a broad set of policies that have been used across the world to address specific aspects of targets defined in SDG 6. These include generic policy approaches such as market instruments, regulatory programmes, monitoring, capacity-building, as well as water specific interventions such as desalination and conjunctive use of surface and groundwater.

Policies highlighted in Section 9.9 demonstrate the increasing attention given to larger spatial scales, including considerations beyond the scale of the river basin, as exemplified in the case of virtual water trading, and the incorporation of multiple institutional scales not confined to the national level. Accordingly, this analysis of freshwater policy effectiveness begins by focusing on multiple water uses within policies and the multi-sectoral considerations of given policy approaches and highlights the strengths and weaknesses of policies addressing the nexus that connects water, food, energy, climate, ecosystems and health.

16.2 Key policies and governance approaches

There is traction in policy communities to address the water-food-energy nexus so that freshwater policy approaches can be sensitive to the ways in which the hydrological cycle, ecosystems, food and energy systems are connected. Efforts to meet this need are, however, relatively new and must tackle the challenge of engaging multiple spatial, temporal and governance scales. Consideration of equity aspects, so that injustices in procedure and outcomes are averted, plays an important part in the discussion of effectiveness of policies addressing this nexus. Through case studies and an analysis of indicators related to the SDGs, this chapter shows how the nexus concept matters in relation to policy effectiveness and cost-effectiveness. The case studies collectively demonstrate national and transboundary water policies from around the world that have had moderate successes and implementation challenges in dealing with the following:

- Empowerment of local water managers while maintaining consistent protections across countries and transboundary water basins;
- Design and operation of dams to minimize impacts on ecosystems while providing benefits to human health, agriculture and energy as well as considering environmental flows and the use of adaptive management;
- Reform of flood risk management policy in line with integrated water resources management (IWRM) with greater responsibilities given to local authorities;
- Provision of basic water services to poor communities in water-scarce regions; and
- Improvement of the consistency and transparency of sustainability reporting conducted by the private sector.

In addition, three policy-relevant indicators on access to water and sanitation and on water withdrawals are reviewed. These indicators represent another way in which global water policy can be assessed.

Collectively, the case studies and indicators demonstrate the mix of policy instruments and clusters that have evolved to manage nexus concerns in an integrated way, which represents a shift from decision-making by a singular governmental authority to governance through sets of rules, principles and procedures involving various stakeholders.

Policy approaches and case studies addressed in this chapter **(Table 16.1)** are linked to the policy typology of Chapter 10.

16.2.1 Regulatory frameworks for transboundary water quality management

Transboundary water bodies are shared by two or more States. The management of these shared rivers, lakes or aquifers relies on multilateral coordination and institutional development. International agreements between States are formal arrangements for transboundary water governance.

Table 16.1: Policy approaches and case studies

Governance approach	Policy instrument(s)	Case study
Command and control; enabling actors; supporting investments	Water quality goals coordinated through a binational transboundary agreement	North American Great Lakes Water Quality Agreement
Enabling actors; command and control	Environmental flow	Adaptive management of Glen Canyon Dam
Economic incentives; command and control	Collaborative institutional design	Disaster Risk Reduction Flood Risk Management, United Kingdom of Great Britain and Northern Ireland – 'Making Space for Water' and Flood Risk Management Policy
Command and control; economic incentives; supporting investments	Water pricing and free provision of basic water supply	Free basic water policy, South Africa
Promotion of innovation; enabling actors; convincing consumers, employers and stockholders	Standardization of sustainability reporting	Mining – sustainable water

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In particular for transboundary rivers, agreements have become more comprehensive and more numerous over time, reflecting an integrated approach to managing shared rivers and lakes (Giordano *et al.* 2014). By 2007, there were 250 freshwater treaties and 30 additional treaties are established every decade (Giordano *et al.* 2014), mostly focusing on water quality and the environment. However, obligations, responsibilities and enforcement mechanisms to address water quality have typically been left undefined (Giordano *et al.* 2014). Regulatory agreements have tended to exclude direct data- and information-exchange mechanisms (Gerlak, Lautze and Giordano 2011). These trends combined indicate that while water quality may be regarded as important, specific policy interventions have been hard to establish.

River basin organizations (RBOs) for transboundary water bodies can be vehicles of treaty implementation. In general, the main functions of RBOs are (i) data gathering, monitoring and regulation; (ii) river basin planning; and (iii) development of infrastructure and facilities (Global Water Partnership [GWP] 2017). Many RBOs are guided by IWRM principles that seek to achieve efficiency, equity and ecological sustainability, while also addressing water quality and quantity issues. Within the Drivers, Pressures, State, Impact, Response (DPSIR) framework (Section 1.6), this institutional approach is aimed at identifying pressures that cause water quality degradation, reasonable and equitable water use and ecosystem concerns.

The success of agreements and frameworks requires scrutiny as institutional development does not guarantee water quality improvement and prevent free-riding (Bernauer and Kuhn 2010), and effectiveness of cooperation can be questioned (Mirumachi 2015).

Case study: The North American Great Lakes Water Quality Agreement

In response to pollution of the Great Lakes Basin (Thornton *et al.* 1999), the United States of America and Canada, under the umbrella of the Boundary Waters Treaty (*Boundary Waters Treaty* 1909), signed the Great Lakes Water Quality Agreement in 1972 (*Great Lakes Water Quality Agreement* 2012).

With a population of more than 30 million people (United States Environmental Protection Agency [US EPA] 2017), the Great Lakes Basin receives substantial inputs of point source and non-point source pollution from a large range of industrial, agricultural, forestry and urban sources (Marvin, Painter and Rossmann 2004). Pollutants of particular concern in terms of impact on ecosystems and human health include biomagnifying metals such as mercury and persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated naphthalene (PCNs), organochlorine pesticides (OCPs), polybrominated diphenylethers (PBDEs) and perfluorinated chemicals (PFCs) (Helm *et al.* 2011). Another danger to the ecosystem comes from invasive species and harmful algal blooms and eutrophication (Smith *et al.* 2015).

The current agreement comprises annexes addressing a range of Great Lakes water quality issues, including areas of concern, lake-wide management, pollution control, ecosystem maintenance and climate change impacts. It encompasses a range of policy clusters involving federal, state and local institutions, facilitation of cooperative actions (both regulated and voluntary), with each country contributing actions from their domestic programmes, policies and resources.

The International Joint Commission (IJC) is a permanent, binational institution for dispute resolution. Under the Treaty from 1909, the IJC was given powers to apply governing principles for water use and the arbitrational power to resolve disputes (Krantzberg and De Boer 2008). Additionally, the federal governments of the two countries periodically request IJC to investigate specific boundary water issues (Findlay and Telford 2006; McLaughlin and Krantzberg 2012). Accordingly, the IJC conducts semi-annual meetings under the Boundary Waters Treaty, with the scope of these meetings covering a full range of boundary issues across the Canada-United States of America boundary (http://www.ijc.org/en_/meetings_minutes). Under the Great Lakes Water Quality Agreement, the IJC was given a reference unique to the Great Lakes – namely to provide advice and recommendations to government, and to report on progress in implementing the agreement. To this end, the Parties to the Great Lakes Water Quality Agreement (i.e. national governments) conduct semi-annual meetings specific to the implementation of the agreement (IJC 1980; IJC 1981; IJC 2001; IJC 2017).

Pursuant to the 1987 Protocol in the Great Lakes Water Quality Agreement, 43 'areas of concern' were identified. These areas were found to exhibit severely degraded water quality and ecosystem health (12 in Canada, 26 in the United States of America and 5 shared). The environmental degradation is primarily a legacy of the past, attributable to industrial activities, agriculture, urban and rural run-off, municipal wastewater effluents, land-use planning and practices on urban and rural lands, all contributing to degraded water quality, contaminated river and lake sediments, and severely impacted fish and wildlife populations and habitats. **Table 16.2** presents our evaluation of the effectiveness of the Great Lakes Water quality Agreement.

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Table 16.2: Evaluation of the effectiveness of the Great Lakes Water Quality Agreement

Criterion	Description	References
Success or failure	A total of seven areas of concern have been delisted (three in Canada; four in the United States of America). There are others considered areas of recovery, where actions have been completed and these areas are expected to be delisted soon.	(US EPA 2017)
Independence of evaluation	Progress is typically reported by the Parties and assessed by the International Joint Commission (IJC) on the basis of input from two major advisory boards (Great Lakes Water Quality Board and Science Advisory Board). The Water Quality Board provides policy advice and evaluation, and the Science Advisory Board provides scientific advice and evaluation. The IJC also publishes a triennial assessment report that reviews the progress of the Parties, summarizes public input on the Parties' progress report, and includes an assessment of the degree to which programmes are achieving the agreement's general and specific objectives.	United States National Research Council (1985); IJC (2017)
Key actors	The key actors are the governments of the United States of America and Canada, in collaboration with other jurisdictions that support implementation of the agreement. A key role of the IJC, in assisting the governments, is its assessment role.	IJC (2017)
Baseline	The Parties have adopted nine General Objectives under the agreement that outline high-level ecosystem objectives towards which they are working. The Parties have also established a suite of nine indicators of ecosystem health, supported by 44 sub-indicators, to assess the state of the Great Lakes, and whether or not progress is being made towards achieving the General Objectives.	IJC (2017)
Time frame	The agreement became effective with its adoption by both governments in 1972, with the most recent amendment in 2012. It has provided the binational framework for both countries to work towards the restoration and protection of the Great Lakes for over 45 years.	US EPA (2017)
Constraining factors	Although public scrutiny of the progress of the Parties provides a powerful oversight role (e.g. through binational public webinars on substantive issues), there have been calls for a more inclusive discourse and an increased role for citizen engagement, particularly during renegotiation periods of the agreement. A shift from an ad hoc problem-resolution mindset to a more imaginative and strategic thinking approach has also been advocated.	Krantzberg (2012)
Enabling factors	Canada and the United States of America have the capabilities to meet the substantial policy, institutional, technical, financial and personnel obligations inherent in carrying out the objectives of the agreement. They have an ongoing system of plans for remedial action in the areas of concern and target an adaptive system of experimentation and learning in pursuing remedial work in regard to addressing the General Objectives of the agreement.	Hall, O'Connor and Ranieri (2006)
Cost-effectiveness	Both countries depend on lake-derived ecosystem services that amount to US$7 billion annually in economic activity related to recreational and commercial fishing alone. The basin-wide approach resulted in doubling the habitat of fish species at a cost of US$70 million, whereas a less integrated approach of addressing only dams or only road crossings resulted in striking inefficiencies of 24 per cent and 88 per cent less habitat, respectively.	Southwick Associates (2008); Neeson *et al.* (2015)
Equity	The governance of the Great Lakes includes approximately 120 Native American, First Nation and Metis rights holders, as well as low-income and minority people, which provides opportunities for collective management. Traditional knowledge and input from the community of First Nations in Swan Lake Marsh, Canada, was used for a project on wetland restoration and to plan guided activities in the past few years.	Hildebrand, Pebbles and Fraser (2002); Jetoo (2017)
Co-benefits	The agreement, in enhancing the quality of the water, created wealth in several forms, including increased recreational and commercial fishing (see 'Cost-effectiveness'), as well as increased recreational use and tourism. The main beneficiaries were riparian inhabitants living around the lakes and their basins, water sports and fishing enthusiasts, tourists and visitors.	
Transboundary issues	Great Lakes water quality degradation, unless limited to restricted bays or similar settings, typically has transboundary implications; hence, the development of the agreement in the first place. The agreement fostered the creation of additional transboundary governance initiatives in the area, such as the Cities Initiative (see 'Possible improvements').	Jetoo (2017)
Possible improvements	In 2003, the Great Lakes and St. Lawrence Cities Initiative (the Cities Initiative) formalized a network of over 130 cities that participate in measures for Great Lakes restoration and protection. The Cities Initiative relies on government funding, associate fees and private foundation funding. Therefore, access to supranational funding would be an improvement. IJC may also pay more attention to indicators of progress, so that all those engaged in protecting and restoring the resource are up to date on the progress achieved.	Jetoo (2017)

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The degree to which the 43 originally identified 'areas of concern' (AOC) have been addressed over time can indicate policy progress (**Figure 16.1**). The removal of 7 of the original AOC indicates a degree of success, although the 36 remaining areas highlight the difficulty of such remedial actions. As biophysical change may take decades to achieve in an AOC, a more immediate measure of policy progress is the adoption and implementation of policies to protect the Great Lakes in the areas in which specific remediation measures are undertaken.

The governments of Canada and the United States of America report on progress achieved under the agreement every three years through the 'Progress Report of the Parties', as well as through other means. The enabling factors for cooperation include the appreciation of the vast range of ecosystem services provided by the Great Lakes to the two countries. Furthermore, the two countries share similar visions, expectations and reliance on the Great Lakes. Finally, compared to many other areas in the world, they have the capabilities to meet the substantial policy, institutional, technical, financial and personnel obligations inherent in carrying out the objectives of the agreement.

The costs of the extensive monitoring, analysis and remediation of Great Lakes water quality issues are substantial. For instance, the Great Lakes Restoration Initiative, launched in 2010 to accelerate efforts to protect and restore the Great Lakes, has provided funds for projects amounting to more than US$2.3 billion for the future functioning of the initiative (US EPA 2017). The efforts to enhance habitat for the fisheries include the removal of hundreds of small dams and culverts that partially or fully impede fish movement for spawning (Kemp and O'Hanley 2010). While economically a relatively minor activity, dam and culvert removal have an important impact on the aquatic life of the lakes and contribute to recreational value to the lake-side population. On the other hand, the removal of dams and culverts allows for spawning of some of the most aggressive invasive species in the lake, a side effect of the policy that requires a scientific assessment. The optimization models used by Neeson *et al.* (2015) indicate that the most cost-effective way of managing the Great Lakes restoration is when dams and road crossings are removed across the whole basin. The basin-wide approach results in doubling the habitat of fish species at a cost of US$70 million, whereas a less integrated approach of addressing only dams or only road

Figure 16.1: Map showing location and status of all United States of America and Canadian Great Lakes Areas of Concern

Source: Binational.net 2018.

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crossings results in striking inefficiencies of 24 per cent and 88 per cent less habitat, respectively. These results provide a cost-effectiveness argument for the ecosystem-wide approach taken by the IJC.

16.2.2 Adaptive management of environmental flows in the water and energy sectors

Concerns arising in response to degradation of river ecosystems due to diversion and impoundment of water have led to the widespread recognition of the importance of environmental flows (Poff *et al.* 1997; Arthington *et al*. 2006; World Bank 2018). They are defined as the "quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems" (International River Foundation 2007). As a 'master variable' for the sustainability of aquatic ecosystems, environmental flows can be incorporated into national-level legislation on water resources management as well as river basin planning (Poff *et al.* 1997; Speed *et al.* 2013). For example, the South African National Water Act (1998) requires water reserves to maintain river health as well as basic human needs. The environmental flow concept is particularly useful in considering the nexus between environmental development and human demands.

One way to influence and secure environmental flows is to adjust the timings and volumes of water released from dams in an adaptive manner. This approach attempts to influence the water and energy (i.e. hydropower) nexus, as well as the water-food nexus in cases where irrigation is required for agricultural production in water-scarce areas. Adaptive management utilizes experimental data derived from large-scale flow-release experiments designed to test hypotheses on physical and biological responses to streamflow in rivers, floodplains or estuaries (Konrad *et al*. 2011, p. 949). High flow release experiments are complex interventions and affect a range of factors beyond flow variability, and can result in more efficient attainment of a wide range of ecological, social and economic benefits (Olden *et al.* 2014, p. 179).

Adaptive management is considered to provide more flexibility than traditional management approaches because it has means available to account for and test uncertainties. Adaptive management focusing on environmental flows can simulate how the natural hydrological regime affects the sediment, water and habitat regimes downstream and can be modified over time as new information becomes available (Richter *et al*. 2006, p. 299). However, adaptive management is often constrained by complex institutional settings and lack of financing (Kingsford, Biggs and Pollard 2011; Allan and Watts 2017). In addition, environmental flow experiments have been constrained so far to large dams in the United States of America, Australia and South Africa, with little reporting from other regions such as South-East Asia, South America and parts of Europe where a significant number of dams exist or are being planned (Olden *et al*. 2014, p. 178). While adaptive management would enable procedural justice to be built into the process through instruments such as public participation, there are equity and ethical concerns because experiments differentiate groups within society (Huitema *et al*. 2009).

Large-scale flow experiments are not without contention and their success or failure is contested based on stakeholder perspectives (Olden *et al*. 2014, p. 177). The complexity and uncertainty of using flow experiments to inform adaptive management require a process for reflexive learning and incremental understanding (Sabatier *et al*. 2005). Active sharing of knowledge and collection of a diverse range of evidence regarding learning could further support the effectiveness of using environmental flows in adaptive management (Allan and Watts 2017). This feature of the policy approach addresses how responses can be influenced within the DPSIR framework (Section 1.6).

The following case study on the Colorado River below the Glen Canyon Dam in the United States of America highlights an example of a long-term commitment to experimentation and informed adaptive management used for the benefit of a spatially large area beyond the immediate dam catchment and for national conservation areas.

Case study: flow experiments and adaptive management of Glen Canyon Dam on the Colorado River, United States of America

Constructed in 1963, the Glen Canyon Dam impounds 300 kilometres of the Colorado River just upstream of Grand Canyon National Park, creating Lake Powell. The Colorado River carries a heavy sediment load that is integral to the habitat and ecology of the system. The dam had the effect of regulating river flow so that moderate flows are more frequent with less variance between high and low flows (Melis 2011, p. 8). Adaptive management was introduced as the negative impacts on aquatic and terrestrial species from the modified flow were observed; impacts such as riparian habitat loss and fish species endangerment (Collier, Web and Andrews 1997). Dam operating strategies began to take environmental flows into account with the Record of Decision of 1996 by the Secretary of the Interior setting up a flow experiment. The scheduled release of water from the dam aimed to artificially recreate conditions similar to pre-dam seasonal flows. The flow experiment addressed the water-energy nexus to "find an alternative dam operating plan that would permit recovery and long-term sustainability of downstream resources while limiting hydropower capability and flexibility only to the extent necessary to achieve recovery and long-term sustainability" (United States Department of the Interior [US DOI] 1996, p. G-11).

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Table 16.3: Evaluation of the effectiveness of adaptive management of the Glen Canyon Dam

Criterion	Description	References
Success or failure	The first experiment is considered to have been successful, paving the way for further experiments. The 2016 Record of Decision is a concrete example of an outcome that demonstrates the incremental nature of increased understanding of environmental flows.	US DOI (1996, p. G-11)
Independence of evaluation	The experiments and adaptive management approach have been evaluated by the United States Department of the Interior and United States Geological Survey, as well as extensively in peer-reviewed scientific literature.	Collier, Webb and Andrews (1997, p. 83); Webb *et al.* (1999); Meretsky, Patten and Stevens (2000); Hazel *et al.* (2006); US DOI (2008); Korman, Kaplinski and Melis (2010); Melis (2011); US DOI (2016)
Key actors	The Bureau of Reclamation and the National Park Services lead on setting out the adaptive management plan. These bodies engage with 15 stakeholder groups including other government agencies, river commissions, energy users and native tribes. The USGS Grand Canyon Monitoring and Research Centre plays a particularly important role in providing technical advice to government agencies and facilitates information exchange between these actors as well as civil society organizations.	US DOI (2016)
Baseline	The experiments were designed to mimic pre-dam conditions. Natural floods occur at a higher frequency and scale, during which the mean velocity of the river is estimated to be five times greater than base flows	Melis (2011, p. 7)
Time frame	Multiple experiments have occurred over the span of two decades and the *Glen Canyon Dam Long-term Experimental and Management Plan* (US DOI 2016) is designed to inform the next 20 years of dam operation.	US DOI (2016)
Constraining factors	An extensive list of laws, regulations and treaties constrains the alternatives for operation of Glen Canyon Dam and consideration must be given to a range of factors relating to the environment, cultural resources, tribal consultation, power marketing, and water allocation and delivery.	
Enabling factors	Multiple pieces of legislation work in tandem, in other words policy coherence, across different scales and sectors, has been ensured as the legislation has evolved.	e.g. United States Congress 1973; US DOI (1992); US DOI (2018)
Cost-effectiveness	The adaptive management decision of the Record of Decision 2016 used a comparison of seven options of dam operation and flow levels to assess costs and impacts. This enabled the finding that the net present value of adaptive management interventions compares favourably with the net present value of no action (status quo).	US DOI (2016)
Equity	Consultation with stakeholders in the form of public participation has sought to identify different ways that various stakeholders engage in processes. However, it has been pointed out that some native tribes have experienced challenges in expressing their cultural values, which do not fit the mould of scientific inquiry and assessments, highlighting some issues of capacity to engage in public participation processes, as well as the confrontation of scientific knowledge with traditional knowledge.	Austin and Drye (2011)
Co-benefits	The experiments have informed a set of co-benefits or 'resources goals' from the project site to downstream areas, ranging from cultural resources to recreational experience. Effects on human health from the experiments are not considered to be substantial (either as a benefit or harm), although it has been suggested that negative effects to health through degradation of water quality would be one criterion for terminating the experiments.	Valdez *et al.* (2000); Melis (2011); US DOI (2016)
Transboundary issues	The experiments are required to meet the allocation specified in the Water Treaty between the United States of America and Mexico, as well as in the Code of Federal Regulations Title XVIII-Grand Canyon Protection, Section 1801.	
Possible improvements	There are critiques that dispute-resolution mechanisms need to be further strengthened within the adaptive management approach.	Camacho, Susskind and Schenk (2010)

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The first high flow experiment was conducted in 1996. This was considered to be the first large-scale international flow experiment (Collier, Webb and Andrews 1997, p. 83; Meretsky, Wegner and Stevens 2000, p. 583). Further experiments were conducted in 2004 and 2008 (Melis 2011, p. 9) and additionally in 2012, 2013, 2016 and 2017. The first 16 years of high flow experiments have provided the basis for the high-flow experiment protocol (US DOI 2011) that provides for adaptive management of the Glen Canyon Dam. The effects of these experiments are analysed as part of the Environmental Impact Statement and adaptive management plans required under the National Environmental Policy Act. **Table 16.3** presents our evaluation of the effectiveness of adaptive management of the Glen Canyon Dam.

Through these experiments, scientific understanding and the policy approach for adaptive management have been incrementally modified to balance hydropower generation with ecological concerns (Gunderson 2015). The high flow release protocol has been successful in increasing the size of sand bars, with benefits to the endangered humpback chub, re-establishing of riparian vegetation and increasing recreation. The programme was successful in accomplishing these improvements within the bounds of existing agreements for water allocation and supply and integrating water management with hydroelectric demand.

Adaptive management was enabled through several policy elements. The mandate of the Bureau of Reclamation, an agency within the Department of Interior, is charged with balancing environmental and economic consideration when developing a dam (US DOI 2016). In addition, legislation such as the Endangered Species Act enables conservation of endangered species and the Grand Canyon Protection Act of 1992 recommends adaptive management (Meretsky, Wegner and Stevens 2000, p. 580). In addition, water supply to downstream states in the United States of America needs to be considered, not to mention in Mexico, as determined by the Water Treaty of 1944 between the two countries. Adaptive management therefore does not operate in an institutional void and multiple institutions cut across different scales, causing interdependence. Consequently, adaptive management requires comprehensive understanding of the set of institutions that can affect this policy approach.

The use of data as well as knowledge generation are also important where uncertainty is inherent in the flow experiments (Konrad *et al.* 2011, p. 955). In this regard, the United States Geological Survey (USGS) Grand Canyon Monitoring and Research Centre acts as a knowledge hub to facilitate experimentation and learning. Such uncertainty is both an enabling and constraining factor to making environmental flows and adaptive management approaches effective. Continuing experimentation and monitoring are vital in helping to modify strategies (Melis 2011, pp. 141-142).

16.2.3 A new approach to water-related disaster risk reduction

Disaster risk reduction is the "concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters" (United Nations Office for Disaster Reduction [UNISDR] 2017). Disaster risk reduction aims to reduce the severity of a disaster, considering that the occurrence of a natural hazard itself does not inevitably result in a disaster. Disaster risk reduction is therefore a preventative policy approach which includes objectives such as limiting exposure to hazards; reducing communities' vulnerability to property loss and damage, displacement, mortality and other negative outcomes of disasters. Benefits include: better managing and monitoring of land, environment and resources; and improving preparedness, for example through early warning systems and evacuation plans (UNISDR 2017). The key point of disaster risk reduction is that, through appropriate policy choices and implementing such preventative actions, countries and States can reduce the scale of environmental disasters. Disaster risk reduction frameworks have evolved to provide more effort to preventively limit the size of the disasters, consider the extended time frames (currently 2015-2030, aligned to other global frameworks), and to place the emphasis on implementation, rather than on final aims (Inter-Agency Regional Analysts Network [IARAN] 2016, p. 4).

The impacts of disasters are unique to each region and they impact disaster risk governance arrangements. Often this leads to high investments in infrastructure, often accompanied by strongly institutionalized arrangements (e.g. Poland, Netherlands, Singapore). Yet moderate (Belgium, France) or highly (United Kingdom of Great Britain and Northern Ireland) diversified strategies emerge from both the need and will to change, and from a mix of forces pushing for this change (Wiering *et al.* 2017, pp. 20-24).

Improvements in national disaster risk reduction efforts and individual preparedness often emerge after major disaster events such as the 2004 Indian Ocean tsunami (Hoffmann and Muttarak 2017, p. 32). Disaster risk reduction is gaining a higher profile on political agendas through developments such as the targets of the Sendai Framework of Action (UNISDR 2015). At the same time, a person-centred approach is being promoted through greater engagement of women, children and older people. There are stark differences on the level of disaster preparedness between the developed and developing world, and this raises serious equity concerns in terms of the capacity to deal with disasters, and the subsequent loss of lives in the developing world (Al-Nammari and Alzaghal 2015).

Policies may address disaster risk reduction by improving their effectiveness, that, for example, may affect availability of potable water, depending on local/regional vulnerability and levels of preparedness. In particular, floods and storms represent direct pressures on water quality, while droughts affect both water quantity and quality. Effective policies can also enhance disaster risk reduction responses by addressing threats to the availability of safely managed drinking water and the affected sewerage systems which can have impacts on human health.

Case study: Flood risk management policy in England and Wales (United Kingdom of Great Britain and Northern Ireland)
Floods cause great financial losses and health impacts in England and Wales; the floods of 2007 caused £3.2 billion damage (Penning-Rowsell 2015). As of 2014, the number of households on floodplain areas as designated by the Environment Agency (only England and Wales) "constitute 8.5 per cent of all properties, with one quarter of these at significant risk" (Penning-Rowsell and Pardoe 2015, p. 5). As a result, flood risk management policy has seen major shifts in the last 15 years. Most notably, there is an emphasis

Table 16.4: Evaluation of the effectiveness of the flood risk management policy in England

Criterion	Description	References
Success or failure	The United Kingdom Government has claimed that the flood risk management system has been effective and "has achieved notable successes including securing better protection for more than 500,000 properties since 2005". There are, however, concerns about the equity implications of the new cost-benefit analysis based allocation of funds and the remaining preference for structural methods of flood risk management	United Kingdom Parliament (2017)
Independence of evaluation	Sir Michael Pitt (2008) conducted an independent review following widespread flooding in summer 2007. The detailed assessment and recommendations of the review initiated a range of reforms in flood risk management as well as progress reports produced by DEFRA (2012). Chatterton *et al*. (2016) prepared an assessment of the costs and impacts of the 2013-2014 floods based on the categories of the 2007 assessment. The DEFRA report and the United Kingdom Government response in 2017 provide further material for assessing the policy.	Pitt (2008) ; DEFRA (2012); Chatterton *et al*. (2016)
Key actors	The stakeholders include the United Kingdom Department of Environment, Food and Rural Affairs (DEFRA), the Environment Agency, local authorities, water companies, flood wardens, National Flood Forum, consultants. The main policy reform to-date consisted in giving the local authorities greater responsibilities for flood risk management.	UK Government (2010); Laakso, Heiskanen and Matschoss (2016)
Baseline	Adjusted for inflation, the average damages from floods in the United Kingdom of Great Britain and Northern Ireland in the last 23 years are approximately £250 million per year (Penning-Rowsell 2015). Especially notable are the floods of the summer of 2007 with an estimated damage of £3.2 billion, which was a catalyst for the accelerated flood risk management reform.	Penning-Rowsell (2015)
Time frame	The Floods and Water Act (2010) is based on an earlier strategy, 'Making Space for Water', introduced in 2004 (DEFRA 2004) and a more recent government strategy 'Future Water' (DEFRA 2008), as well as the influential report from Sir Michael Pitt (DEFRA 2008).	DEFRA (2004); DEFRA (2008); Pitt (2008); UK Government (2010)
Constraining factors	The new policy framework has given local authorities the lead in preparing and responding to surface-water flooding without really equipping them with the necessary financial, human and technical capacity to deal with the new challenges. Local authorities across the country struggle with the high expectations for flood risk management as they remain underfunded and under-resourced.	Penning-Rowsell (2015)
Enabling factors	The record funds allocated to flood risk management for hard, soft and natural solutions amounted to £2.5 billion in the period 2015-2021.	Penning-Rowsell (2015)
Cost-effectiveness	The fact that the devastating floods of winter 2013/14 have caused economic damage that is within the average annual damage in the last two decades (ca. £250 million) may indicate that the flood risk management measures passed since 2007 have been effective (Thorne 2014).	Thorne (2014)
Equity	Some areas in the United Kingdom of Great Britain and Northern Ireland are more prone to flooding from surface water than others. The property insurance market is liberalized in the United Kingdom of Great Britain and Northern Ireland, which means that insurers may ask for higher premiums for houses located in areas under high risk of flooding. This puts some households at a disadvantage compared to others, raising concerns about the equity of flood risk management policy (Penning-Rowsell and Pardoe 2015; Begg, Walker and Kuhlicke 2015).	Begg, Walker and Kuhlicke. (2015); Penning-Rowsell and Pardoe (2015)
Co-benefits	Natural flood management, based on land-use planning and change, can help mitigate non-point pollution from agricultural land, and reduce soil erosion impacts on lake ecosystems (Dadson *et al.* 2017), illustrating how system scale management can address a complex nexus dynamic. The restoration of terrestrial and aquatic habitats would provide additional carbon storage services (Keesstra *et al.* 2018). Potential co-benefits may include retention of water upstream in ponds and aquifers that can supplement scarce water resources during droughts, as well as help mitigate the adverse ecological impacts of heat.	Dadson *et al.* (2017); Keesstra *et al*. (2018)
Transboundary issues	None	
Possible improvements	A future reform towards a stricter regulatory framework for sustainable drainage would be an improvement.	Begg, Walker and Kuhlicke (2015)

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on the 'softer' measures of flood prevention, nature-based solutions, and citizen preparedness, as outlined in the strategy 'Making Space for Water' (United Kingdom, Department for Environment, Food and Rural Affairs [DEFRA] 2004; Mukhtarov 2009) and included in the Flood and Water Management Act (United Kingdom Parliament 2010). This is as opposed to a heavier reliance on infrastructure (e.g. Wiering *et al.* 2017).

Another governance approach to flood risk management uses stakeholder collaboration at multiple levels and implements integrated water resources management (IWRM) through cross-sector coordination and greater engagement of citizens (Mukhtarov 2009). Local authorities now have a number of responsibilities in planning for and responding to surface water (e.g. flood waters) as a result of devolution of responsibilities from the United Kingdom Department of Environment, Food and Rural Affairs (DEFRA) and the Environment Agency as well as the outcomes of policy reviews (Pitt 2008) and the above-mentioned Flood and Water Management Act.

Policy has also encouraged that disaster risk reduction strategies consider biodiversity, human health and water quality benefits. The Pitt Review (Pitt 2007; Pitt 2008) called for sustainable drainage systems to be installed in new buildings and urban land-use change to reduce run-off and improve water retention. Currently, voluntary measures address sustainable drainage. **Table 16.4** presents our evaluation of the effectiveness of the flood risk management policy in England.

The United Kingdom of Great Britain and Northern Ireland case of flood risk management is a comprehensive reform of flood policy including the overhaul of surface-water management in England and Wales. Time will tell whether the new system is more effective than the previous one. However, major positive outcomes are already clear in terms of the large number of properties with better protection against flood risk, 500,000 since 2005 (United Kingdom Parliament 2017).

The continued success of the new flood risk management policy and its focus on surface-water management seems to depend on the ability of the national and regional governments to coordinate alleviation schemes and natural flood risk management with the local authorities. While more research into the outcomes of local management in flood risk strategies is necessary for a better understanding of its impacts, it seems reasonable to state that successful devolution of these responsibilities should be accompanied by increasing the budgets and coordinating powers of local authorities, together with a greater supporting role for the national bodies, such as the Environment Agency and DEFRA. While each local authority is responsible for leading in preparing for and responding to flooding, they require the necessary financial, human and technical capacity to deal with the new challenges. Local authorities across the country struggle with the high expectations for flood risk management as they remain underfunded (Begg, Walker and Kuhlicke 2015; Penning-Rowsell and Johnson 2015). Furthermore, the multiple actors and responsibilities involved in the policy create a further challenge for coordinated implementation (Begg, Walker and Kuhlicke 2015).

16.2.4 Economic incentives and subsidies for free basic water services

The right to water includes considerations of sufficiency, safety, acceptability, physical accessibility and affordability for personal and domestic uses (UN General Assembly Resolution A/RES/64/292, see United Nations, General Assembly [UNGA] 2010). A growing number of countries are now formally recognizing this human right following the 2010 UN General Assembly Resolution A/RES/64/292. The 2014 Global Analysis and Assessment of Sanitation and Drinking-Water reported that 70 out of 94 countries recognized the right to water (World Health Organization [WHO] 2014, p. 14).

Constitutions and legislation recognizing the right to water must be supported by policy instruments that target financing and budgeting. These instruments are important because financing and budgetary considerations are regarded as an obstacle to realizing the right to water and sanitation (de Albuquerque and Roaf 2012). States have often faced cost recovery and transaction cost issues (Obani and Gupta 2016, p. 679). Subsidies are part of water pricing efforts which provide economic incentives to realize the right to water. Subsidies are often used to support affordability of water and sanitation services, which include mechanisms such as income supplements, cross-subsidies, increasing block tariffs, universal price with rebate and free basic water (de Albuquerque and Roaf 2012, p. 54, 83).

The development of the MDGs enabled the human rights approach and treating water as an economic good to coexist, though there are tensions (Obani and Gupta 2014). Water pricing, if efficient, includes all of the economic costs required to provide water (Grafton 2017, pp. 30-31) and underscores that the right to water does not necessarily call for free water provision (United Nations Office of the United Nations High Commissioner for Human Rights [OHCHR] 2010, pp. 11-12). Moreover, the right to water needs to be considered within the wider context of multiple water uses, for example for food security, particularly at the household level. In general, the human right to water and sanitation does not consider how, for example, agricultural water requirements and virtual water transfer through trade could affect rich and poor users differently (Obani and Gupta 2016, p. 685). The right to water is thus defined by local contexts. The implication of rolling out this right indirectly illustrates the nexus of water and food security and the potential inequalities arising from differences in local contexts.

Within the DPSIR framework (Section 1.6), this policy approach is mostly aimed at guaranteeing a basic condition for safe and clean drinking water. Pricing and subsidies often operate within a broader governance context, including creating minimum requirements for water quality as well as establishing organizations as regulators (de Albuquerque and Roaf 2012). South Africa's free basic water policy is an early example of the constitutional recognition of the right to water, providing insight into over two decades of policy experience (**see Table 16.6**). It also exemplifies the need for economic instruments, such as increasing block tariffs, to be used in a way that considers local hydrological and socioeconomic contexts (von Hirschhausen *et al.* 2017).

Case study: Free Basic Water Policy, South Africa

The South African Government launched the Free Basic Water Policy (FBWP) in 2001. Its purpose was to address public health concerns of lack of access to safe water and sanitation, and to provide subsidized water services to the country's population. The policy targets the poor in particular, and allows for the provision of 6,000 litres (6 kilolitres) of safe water per household per month (Department of Water Affairs and Forestry [DWAF] 2002, p. 7). By extension, the policy aims to alleviate poverty through the provision of basic services (DWAF 2002, p. 1) in a country that had experienced historic inequalities within the population.

The FBWP requires that approaches to restrict water consumption ensure effective free provision of a basic level of water supply. Recognizing that municipalities are not homogeneous, the FBWP suggests that mixed service levels are offered according to the consumer's ability to pay. Services include hand pumps, communal taps, and regulated yard and roof tanks as well as house connections (DWAF 2002). In addition, several types of economic incentives have been put forward to meet the variety of consumers within a municipality (**see Table 16.5**). **Table 16.6** presents our evaluation of the effectiveness of economic incentives in the Free Basic Water Policy in South Africa.

The FBWP is an important first step to implementing the human right to water and brings together a set of legislation and policy instruments to consolidate the importance of this right. Municipalities are required to use a tariff system according to Section 74 of the Municipal Systems Act. This tariff system reflects the 'user pays' principle so that water consumption above a basic level is charged (DWAF 2003, p. 29). Metering is one way to measure or control the amount of water supplied without charge (DWAF 2002, p. 29). However, the figure of 6,000 litres/household/month has been controversial and it was recognized in 2007 by DWAF (2007, p. 5) that the amount of 25 litres per person per day might not be enough for many households and needs to be incrementally increased.

The economics of implementation are not negligible because there is high regional as well as socioeconomic variation across the country, with implications for equity. For rural water supply, the cost recovery is very low (WSP 2011). Urban water supply has achieved 96 per cent coverage, but maintaining assets has received low priority, risking deterioration in the future (WSP 2011) and with possible impacts on cost-effectiveness.

Efficient cost recovery by water service authorities (i.e. municipalities) also comes with issues of equity. Problems with cost recovery impinge on the levels of service provision. The free basic minimum has become the maximum amount for households in places like Durban (Loftus 2006). Cost recovery is necessary to provide benefits to extend coverage and address geographical unevenness of burden so that FBWP is not exclusive to those that already have infrastructure and thus benefit from the subsidy easily (Balfour *et al.* 2005, p. 16).

Table 16.5: Three options for free basic water supply

	Option 1 **Rising block tariffs**	**Option 2** **Targeted credits**	**Option 3** **Service-level targeting**
Description	Rising block tariff is applied to all residential consumers, with the first block typically set from 0 to 6 kilolitres with a zero tariff. No fixed monthly charge applicable to those using below poverty relief consumption limit.	Each consumer who is selected for poverty relief gets a credit on their water account which would typically be sufficient to cover the charge for the poverty relief amount (often 6 kilolitres per month) free.	Those service levels which provide a restricted flow, (below the poverty relief consumption level) are provided at no charge. Those with higher service levels pay the normal tariffs, except for poor consumers who historically have high service levels.
Targeting method	No targeting (first 6 kilolitres free to all households). However, targeted fixed monthly charge may be necessary for holiday areas.	Requires a system for identifying those who require poverty relief. Typically, this is based on a benchmark poverty indicator (household income or household expenditure).	Targeting takes place through selection of service level by the consumer (or authority in some cases).
Applicability	Mainly larger urban municipalities. Not suited to situations where there is a high proportion of holiday homes unless it is supplemented with a targeted fixed monthly charge.	Can be used in large municipalities but more typical for middle to small sized, largely urban municipalities. Requires a billing system to be in place for all consumers.	Best suited to municipalities which are largely rural in character.

Source: DWAF (2002, p. 27-29).

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Table 16.6: Evaluation of the effectiveness of economic incentives through the Free Basic Water Policy in South Africa

Criterion	Description	References
Success or failure	The Department of Water Affairs and Forestry (DWAF) reported that there was a good track record of implementation particularly in urban areas during the first 22 months of implementing the provision of free basic water. In 2007, DWAF further reported that over 75 per cent of the population was provided with free basic water and the majority of those (69 per cent) were poor households. However, this success is uneven between urban and rural areas as provision of water supply in remote, rural locations has continued to lag behind. Moreover, it has been reported that drinking water provision decreased by 8 per cent from 2012 to 2014.	DWAF (2002); Muller (2008, p. 79); Water and Sanitation Program [WSP] (2011a, p. 2); Department of Water and Sanitation [DWS] (2014, p. 7)
Independence of evaluation	The Free Basic Water Policy (FBWP) has been evaluated internally through review by DWAF, the Water Research Commission and other related government agencies, and extensively in the peer-reviewed scientific and grey literature.	DWAF (2002); Mehta and Ntshona (2004); Balfour *et al*. (2005); Loftus (2006); DWAF (2007); Loftus (2007); Muller (2008); von Schnitzler (2008); Dugard (2008); WSP (2011a); Naidoo *et al.* (2012); DWS (2014); Statistics South Africa (2016)
Key actors	DWAF (now the Department of Water and Sanitation [DWS]) is the ministry responsible for overseeing the FBWP. Central government has the role of regulator in this decentralized process. Municipalities, water boards and private service providers are involved in local implementation.	WSP (2011a)
Baseline	There was no recognition of a right to water prior to policy implementation. When FBWP was introduced in 2001, it was reported that out of 44.8 million people, "5 million (11 per cent) had no access to safe water supply and a further 6.5 million (15%) did not have a defined basic service level" (DWAF 2003, p. 1).	DWAF (2003, p. 1)
Time frame	The policy developed out of a wider political process of post-apartheid democratization after 1994. In addition, the FBWP has also been implemented and monitored during the period 2000-2015 to achieve the MDG Target 7C.	
Constraining factors	Physical constraints of water availability in a dry region challenge the provision of water supply. The policy has not defined a 'poor' household, despite it targeting such water users.	Muller (2008); Naidoo *et al.* (2012)
Enabling factors	This policy enacts Section 27 of the Constitution, which states the right to water and is governed by the 1997 Water Services Act and the 1998 National Water Act. In addition, regulatory frameworks such as the 2003 Strategic Framework for Water Services guide the implementation of FBWP and are complemented by national standards on service levels such as DWS (2017). A mix of economic instruments is supported by the policy to help address provision in a situation where water has been bound up in social inequalities from apartheid. This policy is also part of an effort towards decentralization, and thus can be seen as part of a broader governance shift.	Muller (2008); DWS (2017)
Cost-effectiveness	The average per capita water supply investment in South Africa is relatively high (urban water supply US$385 per capita; rural water supply US$278 per capita). The uneven nature of cost-effectiveness is exemplified by the fact that across municipalities, the viability of cross-subsidization depends on a number of factors, including the level of wealth of consumers, and type and ratio of users.	DWAF (2007); WSP (2011)
Equity	According to one study, the disease burden attributable to unsafe drinking water and sanitation in South Africa in 2000 was estimated at 13,434 deaths, among which children were disproportionately highly represented (Lewin *et al.* 2007). The policy is a first step towards addressing these health implications. However, the use of prepaid water meters for cost recovery of water services has brought about a problem where consumption in excess of the free basic minimum becomes costly for some. The use of households as a unit of provision gives little attention to those in informal settlements and backyard dwellings.	Bond and Dugard (2008); McDonald (2008)
Co-benefits	The FBWP was set up to have co-benefits in public health, welfare and gender equity. Mehta and Ntshona (2004, p. 19) reported some evidence in this regard. However, published results and data on this aspect are not available in the public domain.	DWAF (2002); Mehta and Ntshona 2004, p. 19
Trans-boundary issues	While South Africa has several transboundary river basins and aquifers, the policy pertains to national aims and implementation, which do not seem to have direct or explicit implications for the exercise of the human right to water in other riparian states.	
Possible improvements	Since the introduction of FBWP, the Free Basic Sanitation Policy was established in 2009. Co-benefits of the latter's implementation to FBWP could be analysed in detail in the future. Cost-effectiveness could incorporate health costs and deal with the efficacy of the Free Basic Sanitation Policy. Policy coherence could be further enhanced by integrative approaches involving better institutional interplay. A more specific focus on the needs of informal settlements would improve equity.	

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16.2.5 Voluntary sustainability reporting on water in the mining sector

Mining requires significant amounts of water and presents considerable short- and long-term risks to water resources (Spitz and Trudinger 2008) (see also Section 9.5.5). The potential impacts on existing users and values of water resources are a common concern for local communities faced with both large- and small-scale mining projects. Such concerns stem from experiences of mines that have caused (or continue to cause) pollution or other impacts on water resources (e.g. reductions in stream flows, declines in groundwater levels, river diversions, undesirable changes in quality). Governments, companies and communities have recognized the fundamental need for the mining industry to manage water resource-related risks effectively (e.g. Norgate and Lovel 2006; Rankin 2011).

The main protocol for sustainability reporting is the Global Reporting Initiative (GRI), which began in 1997 as a coalition of government, community and corporate stakeholders, and aimed to make sustainability reporting as commonplace and important as corporate reporting. The current GRI standard includes a wide range of indicators across social, economic, environmental and local-community health aspects, and was designed to be used not only by the mining sector, but by any company or organization. It addresses equity issues through providing guidance on reporting on management approaches affecting vulnerable groups, the means by which local stakeholders are identified and engaged with, and the means by which companies address risks to and impacts on local communities. Since the Johannesburg Earth Summit in 2002, the global mining industry, through the International Council of Mining and Metals, now requires their corporate members to publish annual sustainability reports.

Case study: Australian mining industry's Water Accounting Framework

Early research into the water data reported by mines found that data in sustainability reporting could be changed from year to year without explanation, that different mines interpreted terms such as 'consumed water' or 'recycled water' inconsistently, and that water quality issues were poorly addressed (Mudd 2008; Northey *et al.* 2016). This led the Minerals Council of Australia (MCA) to develop the Water Accounting Framework (MCA 2012), which allows a mine's water balance to be quantified and the specific Global Reporting Initiative indicators to be reported through sustainability reports. The Water Accounting Framework was a major step forward in providing a consistent reporting approach to water management for mines. The 49-member companies of the MCA represent 85 per cent of Australia's mining activity and more than 90 per cent of mineral exports (MCA 2017a).

Growing interest in corporate responsibility has been a strong enabling factor for sustainability reporting, with pressures from investors and shareholders in mining companies as well as local communities affected by mining. The main constraining factor for water risks in mining is the technical capacity of an individual company and its mines. For example, a mine may not be equipped with the necessary monitoring, technical (especially water-balance modelling) expertise and reporting systems to ensure accurate and timely sustainability reporting. Efficient management of water use and associated costs requires monitoring in any case, meaning that it is beneficial for a mine to invest in such systems to help it reduce operational costs, ensure transparency and improve its reputation, as well as minimizing water-resource-related risks. In terms of cost-effectiveness, the value gained from conducting good sustainability reporting compared to taking no action can be significant, from positive investor sentiment, a social licence to operate from a local community, reduction in operating costs from water efficiencies or recognition from regulators of successful environmental management – as noted by the MCA in its business case for the Water Accounting Framework (see MCA 2017b). **Table 16.7** below presents our evaluation of the effectiveness of the Australian mining industry's Water Accounting Framework.

The growing number of companies having adopted sustainability reporting is a sign of a successful policy initiative and approach. The fact that the MCA and now the International Council of Mining and Metals have mandated water reporting by their members also demonstrates success. However, four major weaknesses in the Water Accounting Framework and International Council of Mining and Metals protocols are:

i. the issue of water quality of the water sources used in mining;
ii. the links between detailed monitoring of potentially affected water resources, especially water quality and flows, and Global Reporting Initiative metrics;
iii. links between regulatory requirements for water resources and sustainability reporting; and
iv. improving the catchment and climate context of water data so that mining's use of water and risks to water resources can be more readily interpreted and understood.

Furthermore, there are very few formal evaluations of water data and information published in sustainability reports, except for a limited number of academic studies. With the Global Reporting Initiative moving to a standards framework rather than a guideline structure, independent auditing and assurance are now more prominent, as well as being important for responsible investors, regulators and interested community stakeholders.

The effectiveness of the policy in terms of the impact of mining operations on water resources generally has not yet been rigorously evaluated. However, the large proportion of Australian mining companies publishing sustainability reports incorporating the Water Accounting Framework suggests that the approach is useful as a management tool.

16.3 Indicators (link to SDGs and MEAs)

The following indicators on access to drinking water, sanitation and water withdrawal further examine the variety of policies used in managing freshwater resources, contributing to improving human health through various pathways. These indicators were selected for being policy sensitive and for being widely recognized for their importance under the current SDG targets and established multilateral environmental agreements. For the purposes of this chapter, the indicators are analysed in order to present policies influencing global

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Table 16.7: Evaluation of the effectiveness of the Australian mining industry's Water Accounting Framework

Criterion	Description	Reference(s)
Success or failure	The growing number of companies that have now adopted sustainability reporting in Australia, as well as the fact that both the Minerals Council of Australia (MCA) and International Council of Mining and Metals (ICMM) have mandated water reporting, signals successful diffusion of the policy approach.	Mudd (2008); Northey, Haque and Mudd (2013)
Independence of evaluation	With the Global Reporting Initiative (GRI) moving to a standards framework rather than a guideline structure, external assurance auditing is being increasingly conducted, although the extent of such auditing is variable. Very few formal evaluations of water data reporting have been done.	Mudd (2008); Northey *et al.* (2016)
Key actors	Individual mining companies, their membership associations, local communities, interested stakeholders (e.g. environmental groups), government regulators, financial stakeholders.	Franks *et al*. (2014)
Baseline	There was no formal baseline. A tacit baseline could be the lack of water reporting prior to the mid-1990s.	Mudd (2008)
Time frame	The process of sustainability reporting and the data it contains have evolved over the past 20 years. From 2016, the GRI has been a formal standard rather than a guideline.	Mudd (2008); Northey, Haque and Mudd (2013); Northey *et al*. (2016)
Constraining factors	Companies and mines are constrained by their technical capacity to monitor and record water-related processes and impacts.	Mudd (2008); Northey, Haque and Mudd (2013); Northey *et al*. (2016)
Enabling factors	The growing interest in demonstrating corporate responsibility, with pressures from investors and shareholders in mining companies as well as communities affected by mining.	Mudd (2008); Franks *et al*. (2014); MCA (2017a)
Cost-effectiveness	It is logical for companies to engage in self-reporting to avoid project-delaying conflicts, expensive litigation and brand damage. Also, good sustainability reporting may lend companies a social licence to operate from local communities.	Mudd (2008); Franks *et al*. (2014);
Equity	Although sustainability reporting may result in win-win situations for mining companies, communities and government in Australia, it is unclear how sustainability reporting might impact on equity in other parts of the world.	Franks *et al*. (2014)
Co-benefits	Sustainability reporting results in data availability to researchers, enabling quantification of the life cycle costs of specific metals and minerals, innovation that may benefit the sustainability of processes, and evaluation of impacts of new mining technologies on water resources.	MCA (2017a)
Transboundary issues	The global uptake of standardized sustainability reporting may foster improved transnational management of mining water-related issues.	International Council of Mining and Metals (ICMM) (2017)
Possible improvements	Detailed study of water-resource-related sustainability reporting by companies should be conducted to assess its extent, quality and effectiveness. There are major weaknesses in the Water Accounting Framework and ICMM protocols. Online databases of pooled water-resource data would foster usability of water data and improve transparency.	Mudd (2008); Northey, Haque and Mudd (2013); Northey *et al*. (2016)

trends in drinking water and sanitation and water withdrawal. There is a considerable diversity of policies and our analysis underscores the importance of policy mixes in further achieving global targets such as the SDGs and facilitating implementation at the local level.

16.3.1 Indicator 1: Proportion of population using safely managed drinking water services

SDG indicator 6.1.1 is defined as the proportion of the population worldwide using safely managed drinking water services, in support of public health. 'Safely managed' refers to water from an improved water source located on premises, available when needed and free of faecal and priority chemical contamination (WHO and the United Nations Children's Fund [UNICEF] 2017), wherein 'improved water source' (the MDG indicator) includes rainwater, water that is piped, made available from taps, standpipes, boreholes, wells or springs, or is packaged or delivered. 'Drinking water services' refers to the accessibility, availability and quality of the main source used by households for drinking, cooking, personal hygiene and other domestic uses (WHO and UNICEF 2017). Priority chemical contaminants vary by country, but arsenic and fluoride are assigned as priority contaminants globally due to their potential impacts on human health.

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Scope and measurement
From 2000 to 2015, the World Health Organization and United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme for Water Supply and Sanitation (JMP) used a binary classification of improved/unimproved sources of drinking water as an indicator for monitoring and evaluation purposes. In order to monitor SDG target 6.1, the JMP further developed this indicator to facilitate further differentiation between service levels and assessment of safe management of supplies (WHO and UNICEF 2017). Corresponding updates were made to the JMP drinking water service ladders with 'safely managed' occupying a new rung positioned at the top **(Table 16.8)**.

According to the JMP, 2.6 billion people worldwide gained access to an improved source of drinking water in the period between 1990 and 2015 (UNICEF and WHO 2015) **(Figure 16.2).** This brought the proportion of the global population using piped water supplies on premises to approximately 75 per cent.

Policy relevance
This indicator is a modification of the MDG indicator 7.8 (proportion of population using an improved drinking water source) and directly relates to SDG target 6.1, which aims to achieve universal and equitable access to safe and affordable drinking water for all by 2030. This indicator also relates to long-standing global policy efforts addressing water and human health, including multilateral environmental agreements such as the 1999 Protocol on Water and Health.

Table 16.8: The JMP Service Ladder for drinking water

Service level	Definition
Safely managed	Drinking water from an improved water source which is located on premises, available when needed and free of faecal and priority chemical contamination
Basic	Drinking water from an improved water source provided collection time is not more than 30 minutes for a roundtrip including queuing
Limited	Drinking water from an improved source where collection time exceeds over 30 minutes for a roundtrip to collect water including queuing
Unimproved	Drinking water from an unprotected dug well or unprotected spring
No service	Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

Source: Adapted from WHO and UNICEF (2017).

Causal relations
The gradual shift towards water governance can be broadly attributed to changes in the provision of safe drinking water services. The initial intervention involves installing physical infrastructure for safe water supply. For example, efforts that upgrade water services to piped supplies typically reduce microbial contamination of both source and household-stored water quality (Shields *et al.* 2015). While technical solutions are still seen in the sanitation sector (WSP 2011b), there is increasing use of participatory approaches to complement them (see also Section 16.2.2). In India, for example, the national water policy aiming to provide safe water adopts a socio-technological approach (Khurana and Sen 2008).

Target setting at the national level also appears to encourage an increase in the size of populations with access to safe drinking water. In a recent assessment of water access in 97 countries, approximately half had established or were working towards universal access as a target between 1980 and 2013 (Luh *et al.* 2017). The MDG on safe drinking water halved the proportion of people requiring access by 2012, three years before the MDG deadline. This early success has been followed up with national targets motivated by the ambitious global goals of the SDGs: countries with the appropriate capacity can be expected to meet ambitious targets, leading to greater coverage than is found in countries lacking such ambitious targets (Luh *et al.* 2017).

Other influencing factors
Universal access may be hampered not only by hydrological factors such as rainfall, which may contribute to water scarcity, and water-related hazards such as microbial contamination, but also by economic factors. In rapidly developing countries such as India, pollution and overexploitation of water are linked to industrialization and agricultural expansion, which in turn influence water quality (Khurana and Sen 2008). The pace of population growth also challenges drinking water and sanitation coverage, especially in sub-Saharan Africa and Oceania (UNICEF and WHO 2015).

A lack of awareness or understanding of water quality problems may hinder safety of drinking water services in both developed and developing countries. In Bangladesh, while tube wells have increased, water quality testing is not commonly practised (Fischer 2017). This contributes to poor understanding of the health risks posed by both microbial and non-microbial contaminants. This can have serious consequences in terms of public health. For example, measures taken in the 1970s to reduce the health impacts of microbial disease from surface-water use resulted in the widespread installation of tube wells, themselves a source of water with high levels of inorganic arsenic (Flanagan, Johnston and Zheng 2012). Populations using these sources for drinking water have experienced severe health consequences ranging from skin lesions to cancer and cognitive effects (Abdul *et al.* 2015), resulting in stigmatization and other serious social impacts (Kabir *et al.* 2015).

Possible alternative indicators
A useful alternative indicator to understand the population benefiting from safely managed drinking water services might focus on disparities between rural and urban populations combined with wealth quintiles. The JMP has been able to track coverage between 1995 and 2012 (UNICEF and WHO 2015) but could benefit from comprehensive data and rigorous reporting.

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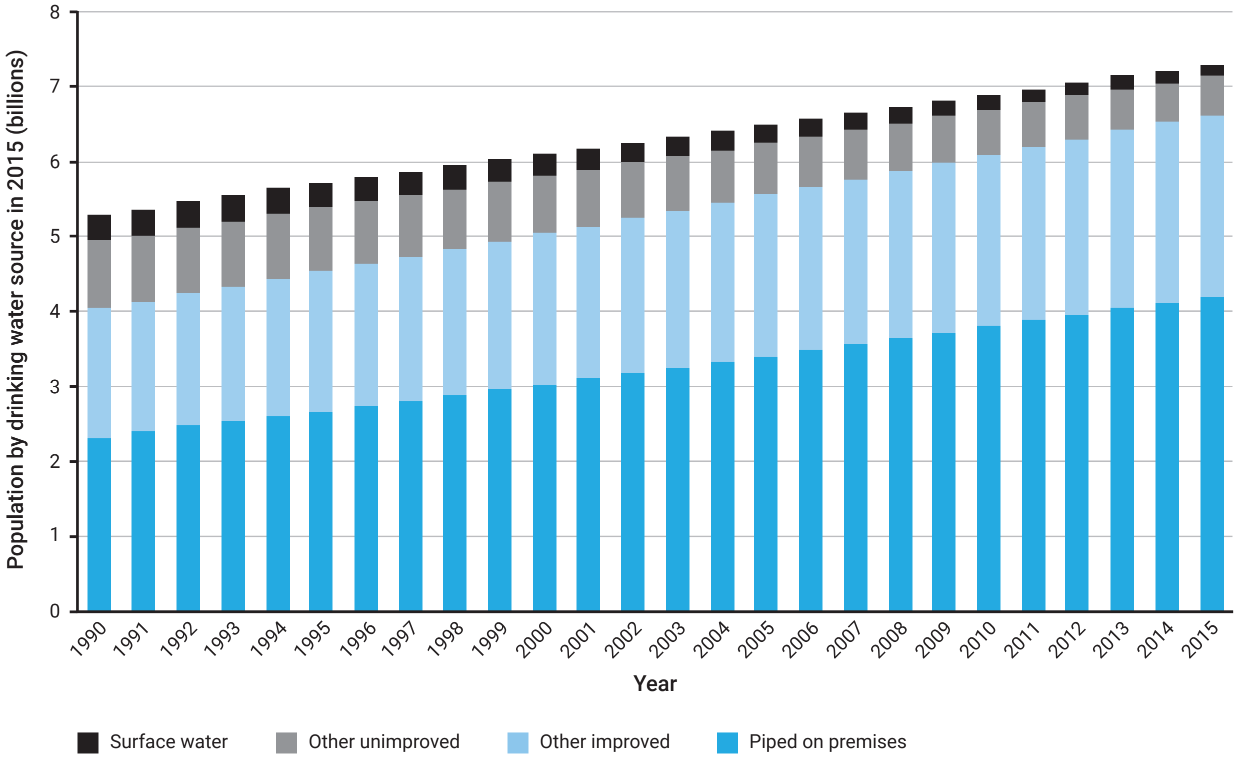
Graphical representation

Figure 16.2: Change in global population by drinking water source, 1990-2015 (billions)



Source: Adapted from WHO and UNICEF (2017).

16.3.2 Indicator 2: Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water

SDG indicator 6.2.1 refers to the proportion of the population using safely managed sanitation services, including a hand-washing facility with soap and water, wherein 'safely managed' is defined as "an improved sanitation facility which is not shared with other households and where: excreta is safely disposed of *in situ*, or excreta is transported and treated off-site" (WHO 2017, p. 1).

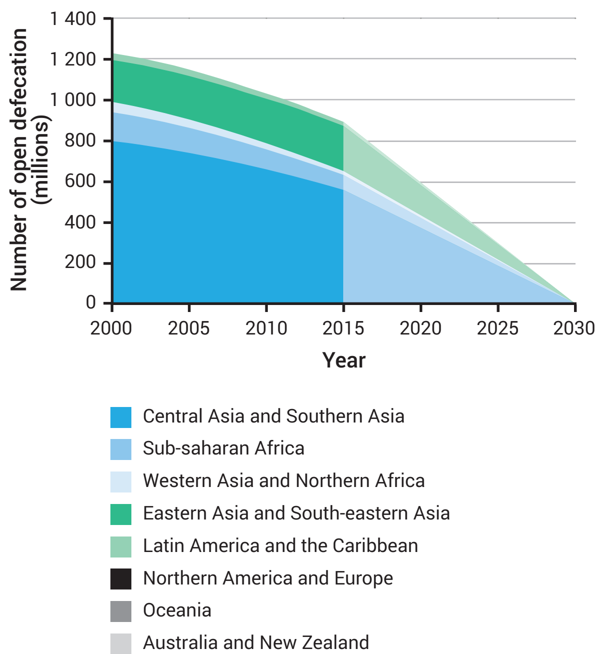
Scope and measurement

The levels of sanitation services vary from safely managed, through basic, limited and unimproved, to no service according to the JMP. These levels focus on whether excreta is separated and disposed of safely, avoiding human contact. In addition, the levels depend on whether sanitation facilities are shared or private (WHO 2017).

Graphical representation

There has been great progress made in decreasing the number of people without access to safe sanitation services. As **Figure 16.3** shows, between 2000 and 2015 the number of people practising open defecation declined from 1,229 million to 892 million, which is an average reduction of 22 million people per year. Furthermore, all regions have made progress in decreasing this indicator apart from sub-Saharan Africa and Oceania.

Figure 16.3: Regional trends in proportion of national population practising open defecation, 2000-2015



Source: WHO and UNICEF (2017).

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Another notable trend is the rate of change in various countries in the world. While 14 countries have shown progress sufficient to be on track for universal basic sanitation by 2030, the majority either need to accelerate progress or to reverse a negative trend of increasing number of people with no access to safe sanitation **(Figure 16.4)**.

Policy relevance

The proportion of the population using safely managed sanitation services directly relates to the SDG target 6.2: "by 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations" (United Nations 2018). SDG indicator 6.2.1 increases recognition of these relationships and furthers ongoing global efforts to address water and sanitation, including the MDGs preceding this SDG target, as well as the Plan of Implementation of the World Summit on Sustainable Development.

Causal relations

Improved water supply and sanitation are the most fundamental indicators related to water, sanitation and hygiene (WASH) interventions. Policy interventions have aimed to provide and maintain infrastructure such as wells, water transport and distribution networks, and water-treatment facilities (Hunt 2011). Water quality interventions and hygiene promotion such as handwashing have also been effective in prevention of disease (Peletz *et al.* 2013).

Community-led total sanitation (CLTS) has been actively taken up in many parts of the world to improve the number of people using improved sanitation services. CLTS is the main policy used to tackle open defecation in rural areas in developing countries (Bateman and Engel 2017). The uptake has been rapid with 60 countries implementing CLTS since 2000 (Crocker *et al.* 2017). CLTS is a participatory and bottom-up approach that incorporates awareness-raising at the community level.

One reason for the spread of CLTS is its perceived low cost, even given the relative scarcity of studies examining its true costs (Crocker *et al.* 2017).

Other influencing factors

As with access to safe drinking water services, sanitation is a focus of global ambitions as reflected in the SDGs. However, rather than attempting to assess WASH and preventative health interventions at the global level, it is more effective to decentralize policy so as to better understand those factors that serve to enable WASH in local contexts (Whittington *et al.* 2012).

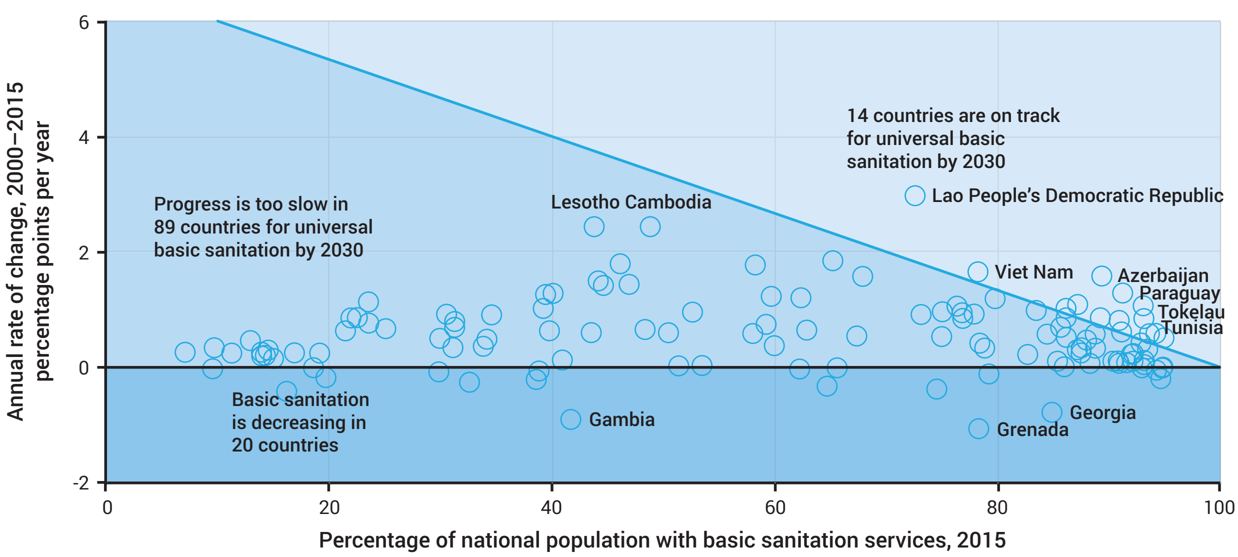
Possible alternative indicators

The concomitant rise in pit-latrine sanitation and groundwater use has led to increasing concerns about the potential impact of resulting contamination of drinking water on health. In order to measure the robustness of sanitation service hygienically separating excreta from human contact, consideration may be required to not simply measure the sanitation service provision but also any secondary or knock-on effects. Indicators based on integrated data to identify and mitigate risk could be useful and it has been suggested that water supply and pit-latrine mapping is effective, as well as the monitoring of key groundwater contamination indicators (Back *et al.* 2018).

16.3.3 Indicator 3: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

SDG indicator 6.4.2 refers to level of water stress (freshwater withdrawal as a proportion of available freshwater resources). Water withdrawal can be defined as the amount of freshwater resources removed from rivers or aquifers for agricultural, industrial and domestic uses (Food and Agriculture Organization of the United Nations [FAO] 2016). Agricultural water use makes up the majority of global water withdrawal, underscoring a major dimension of the water-food nexus

Figure 16.4: Progress towards universal basic sanitation services (2000-2015) among countries where at least 5 per cent of the population did not have basic services in 2015



Source: WHO and UNICEF (2017).

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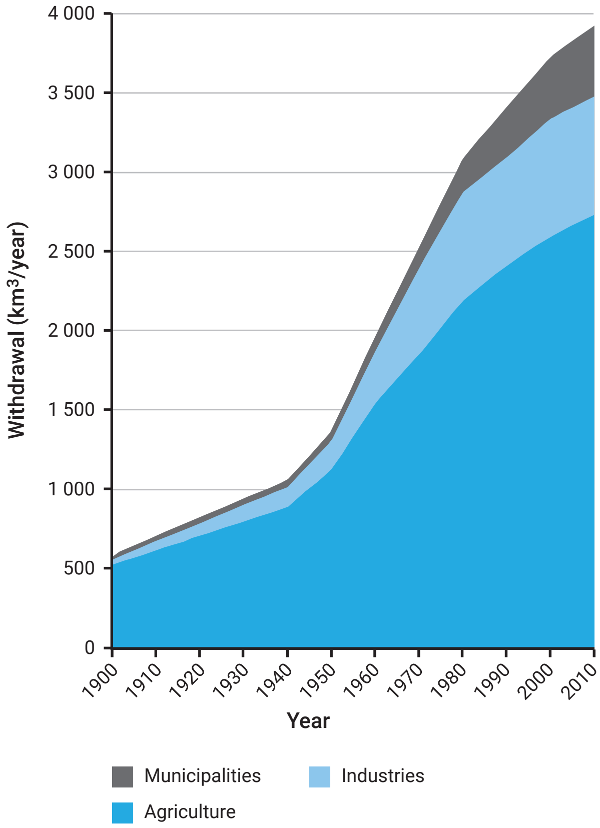
(see Sections 4.4.3 and 9.8.2) with consequences for livelihoods, nutrition, public health and well-being. Agricultural water withdrawal is used for irrigation, livestock and aquaculture (FAO 2016). In particular, irrigation makes up the majority of total water withdrawal (67 per cent) (United Nations World Water Assessment Programme [WWAP] 2016).

Scope and measurement
Water withdrawal trends indicate how human use of fresh water has changed over time. At the global level, over the last century water withdrawal has increased **(Figure 16.5)**. The changes to blue water withdrawal suggest how irrigation has increased over time. The ratio of agricultural water withdrawal to total water withdrawal within a country varies across the globe with factors such as climate and priority given to agricultural activity **(Figure 16.6)**. The development of dams has contributed to anthropogenic water use and evaporation from storage of water in lakes or reservoirs. However, this type of water withdrawal is not currently reflected in the indicator discussed in this section (FAO 2016).

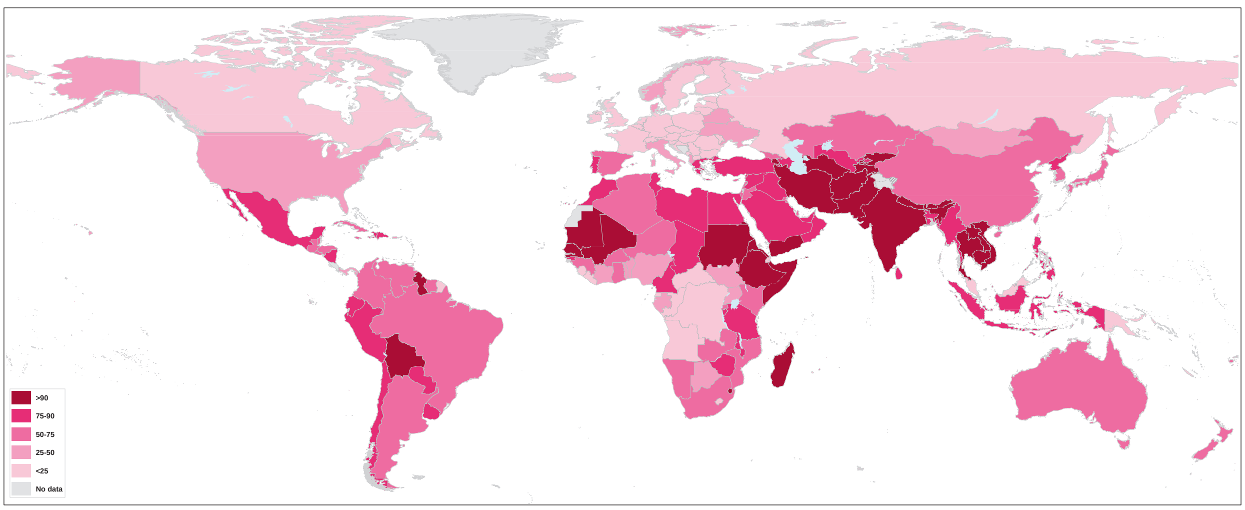
Graphical representation

Figure 16.5: Trends in global water withdrawal by sector between 1900 and 2010 (km³ per year)



Source: Adapted from FAO (2016).

Figure 16.6: Proportion of total water withdrawn for agriculture



Source: Adapted from FAO (2015).

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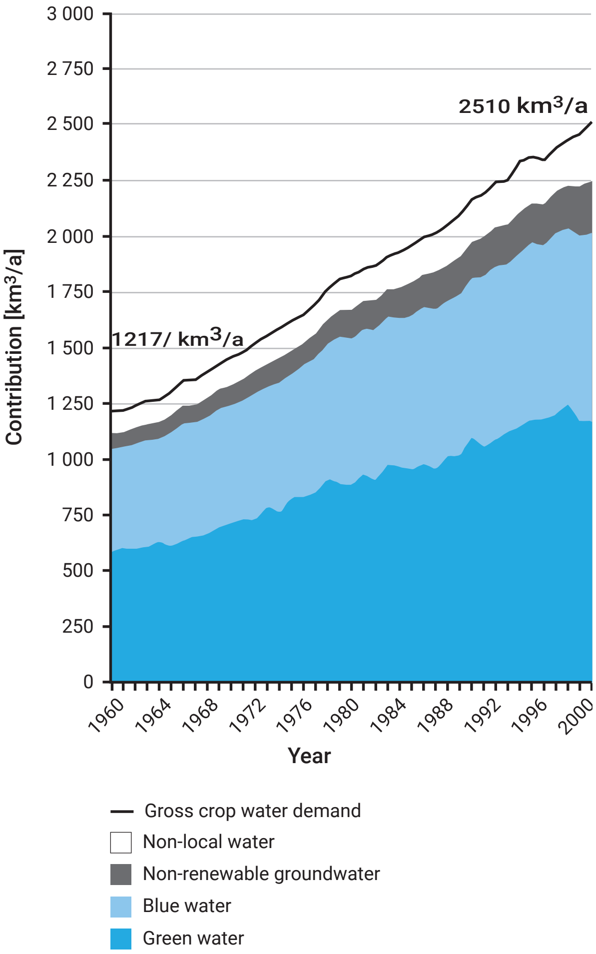
Figure 16.7: Changes in global gross crop water demand over time



Source: Wada, van Beek and Bierkens (2012, p. 14)

Policy relevance

This indicator is directly relevant to SDG target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of fresh water to address water scarcity and substantially reduce the number of people suffering from water scarcity. Concerns over water quantity have been repeatedly raised in global policies and numerous multinational environmental agreements such as the 1977 Mar del Plata Action Plan, 1992 Dublin Statement of Water and Sustainable Development, the 1997 Convention on the Law of the Non-navigational Uses of International Watercourses (United Nations Watercourses Convention), the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention), and the International Law Commission's 2008 Draft Articles on the Law of Transboundary Aquifers. In addition, this indicator also draws attention to the balance between water for agriculture and water for industrial, household and ecosystem needs, which is addressed specifically in SDG target 6.5 advocating integrated water resources management (IWRM).

Causal relations

Subsidies are a major contributor to the expansion of irrigation agriculture. Full cost recovery rarely happens in developed countries. In developing countries, water user associations have been set up to decrease use of subsidies and charge for water use. However, such charges are not sufficient to meet full cost recovery (Toan 2016). Consequently, the price of irrigation undermines supply cost and disregards impacts on the environment. It has been suggested that the 'polluter pays' principle should be included in the price of irrigation (Howarth 2009).

While large-scale public investment in irrigation has been made in the past, it is unlikely for investments at such scale to be made in future. Instead, participatory irrigation management and irrigation management transfer are providing investment at the local scale and proving very popular (Turral *et al.* 2010).

Groundwater is increasingly used for agricultural purposes **(Figure 16.7)**. In particular, private groundwater wells and abstraction have become the main method for irrigation in India and are used widely in other developing countries such as China, Pakistan and Thailand (Turral *et al.* 2010). Here, the water-energy nexus is evident as cheaper pumping technology and easier energy access has enabled extraction, often at the individual level (Shah 2014). However, groundwater governance, especially for transboundary aquifers, has yet to be well established (Albrecht *et al*. 2017). There are also reported cases where efforts to improve irrigation efficiency have not contributed to the reduction of groundwater use, but rather the opposite (Pfeiffer and Lin 2014).

Other influencing factors

Molden *et al.* (2010) suggest supply management focusing on allocation has had a bigger impact on water efficiency than pricing to influence the behaviour of farmers. However, in large river systems, supply management through dams can lead to increased irrigation activity whereby dam-impacted catchments have 25 times more economic activity per unit of water compared with non-impacted catchments (Nilsson *et al.* 2005).

Possible alternative indicators

Vörösmarty *et al*. (2010) examined the ways human water security and biodiversity threats intersect globally. An indicator of these composite factors shows effects not only water withdrawals but also downstream and on ecosystems, beyond meeting water needs for agricultural output. Alternative indicators could provide insight into water scarcity at the subnational level. Considering that water scarcity is experienced at local level, alternative indicators could cover the spatial variation of water scarcity within countries. There are some emerging concepts and methodologies, for example the World Resources Institute Aqueduct water risk mapping makes detailed data accessible to a range of users including investors and companies (https://www.wri.org/our-work/project/aqueduct).

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16.4 Discussion and conclusions

Various policy approaches show that water quantity and quality have serious implications for human and ecosystem health, and that these interactions are driven by changes in multiple sectors. Governance is increasingly opened up to non-State actors, such as the private sector and civil society. Decision-making thus needs to consider the full range of sectors and actors so that drivers and pressures (see Chapters 2 and 9) are addressed in an integrated fashion, considering economic, social and environmental issues. Achieving policy coherence and synergy are important features of the nexus interactions between fresh water and other sectors. Policy interventions should be designed to exceed purely technical fixes. This does not diminish the importance of provision of infrastructure such as wells, latrines and dams, but such provision should be considered within the complexity of a policy mix and with coherence in mind. In several case studies, public participation and stakeholder engagement have been implemented. However, the distribution of burdens and benefits of policies could be improved to address issues of equity and environmental justice.

The governance approaches and policy types examined in this chapter were not assessed in terms of evaluating non-monetary values. Where economic evaluations were conducted, trade-offs were mainly captured in monetary terms, and typically failed to assess impacts on human health or ecosystems. Negative impacts of policies on health have typically focused on natural hazards or infectious disease, and little has been done to capitalize on the potential co-benefits on human health (Grellier *et al.* 2017) or ecosystems.

Effective policies may be sought through active involvement of stakeholders. However, devolution of water governance does not necessarily result in better stakeholder engagement, as illustrated in the disaster risk reduction policy in England and Wales (Section 16.2.3); capacity-building and long term efforts of awareness-raising and knowledge use are also required to enable effective stakeholder involvement.

Monitoring thresholds and baseline conditions are a key component in the implementation of policy as well as for ensuring its overall effectiveness. Baseline conditions should be defined at implementation and subsequently monitored, causal relationships should be hypothesized and tested, and counterfactual thinking used to avoid misattribution of policy effectiveness due to confounding factors (Ferraro 2009). This is particularly true of access to safe drinking water and sanitation.

The selection of case studies in this chapter was guided by a number of requirements, in particular that case studies are described in depth in peer-reviewed literature, and as such the cases were drawn chiefly from developed economies. Developed economies are often equipped with resources and structures that allow for experimentation and innovation; accordingly, lessons learned from developed world case studies are not intended to be applied globally. On the contrary, a cautious approach should be taken with problems considered on a case-by-case basis, when embedded in their own specific context (Ingram 2013; Mukhtarov *et al.* 2015).

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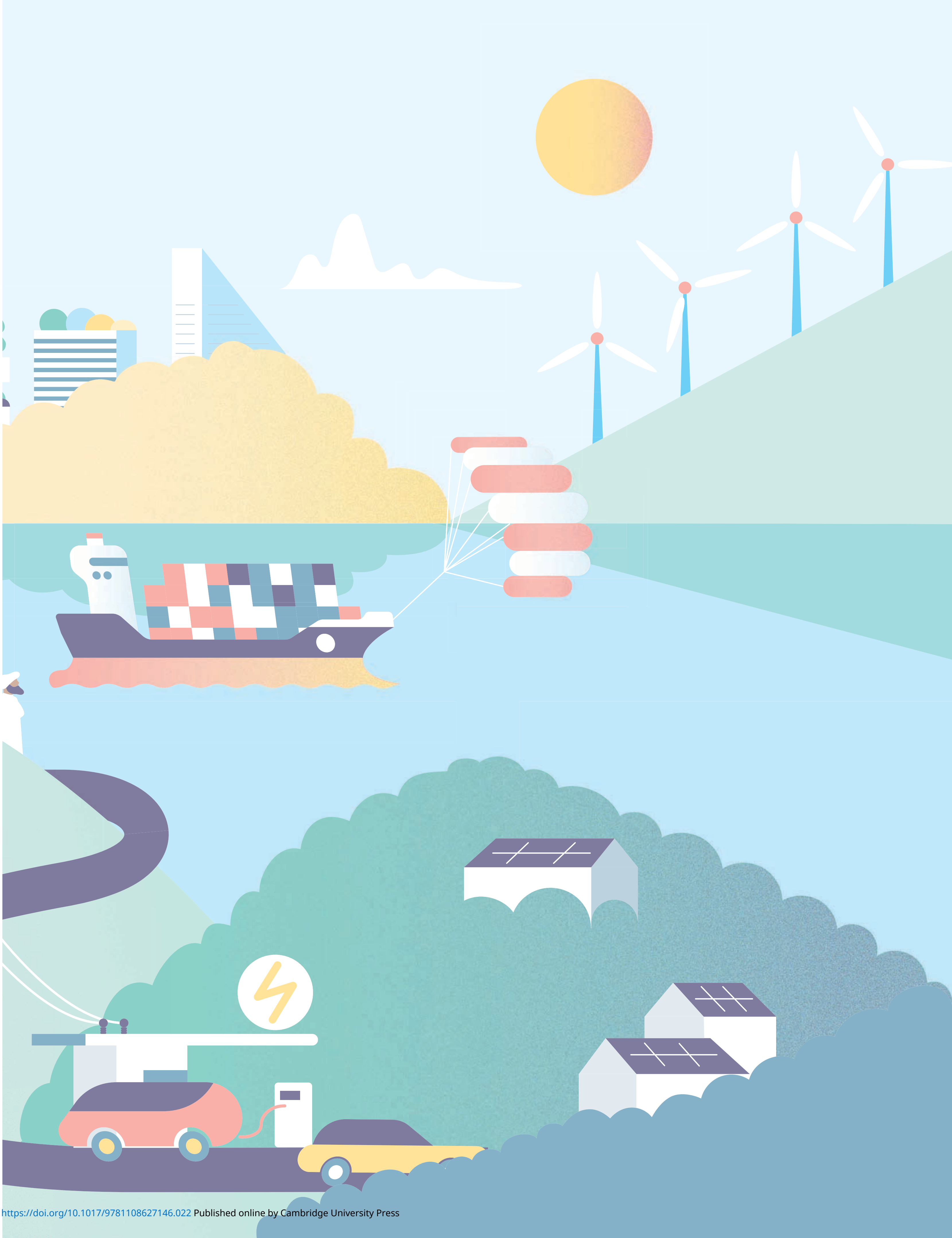

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