Ronald Solutions Inc. (Ronald Bernard)

While I support the trail in general, I'm concerned about potential parking overflow into nearby neighborhoods. Please consider adding designated parking areas and monitoring plans in the EIS to avoid burdening local residents with increased congestion.

UN WATER

Policy Brief

Water Quality

Cover photo: UNEP

It is easy to throw anything into the river, but difficult to take it out again.

Kashmiri proverb

Introduction

Clean, safe and adequate freshwater is vital to the survival of all living organisms and the smooth functioning of ecosystems, communities and economies. Declining water quality has become a global issue of concern as human populations grow, industrial and agricultural activities expand, and climate change threatens to cause major alterations to the hydrological cycle. Water quality issues are complex and diverse, and are deserving of urgent global attention and action. This policy brief is a collaborative output of UN-Water members and partners directed at practitioners, policymakers and decision-makers in water resource management and other relevant sectors. The policy brief outlines the challenges and trends, drivers and impacts related to water quality. It also presents four strategies that form the basis of policy solutions. It concludes by detailing a series of specific recommendations by which these solutions can be achieved.

Water Quality Challenges and Impacts

Both natural processes and human activities influence the quality of surface waters and groundwater. Water naturally contains dissolved substances, non-dissolved particulate matter and living organisms; indeed, such materials and organisms are necessary components of good-quality water, as they help maintain vital biogeochemical cycles. There are few exceptions where naturally occurring substances trigger water quality challenges detrimental to human health. For example, in Bangladesh, where nearly 90 per cent of the population uses groundwater as its primary source of freshwater, up to 77 million people have been at risk of exposure to arsenic in recent decades (*1, 2*).

But domestic use, agricultural production, mining, industrial production, power generation, forestry practices and other factors can alter the chemical, biological and physical characteristics of water in ways that can threaten ecosystem integrity and human health. The major sources of water pollution are from human settlements and industrial and agricultural activities. Negative factors related to these activities include unhygienic disposal and inadequate treatment of human and livestock wastes, deficient management and treatment of industrial residues, inappropriate agricultural practices and unsafe solid waste discharge. For example, over 80 per cent of sewage in developing countries is discharged untreated directly into water bodies (*3*). Industry is responsible for dumping an estimated 300–400 million tonnes of heavy metals, solvents, toxic sludge and other waste into waters each year (*4*). Nitrate from agriculture is the most common chemical contaminant in the world's groundwater aquifers (*5, 6*). In the United States of America, manure and fertilizer run-off from agriculture is the single greatest source of water pollution, with croplands alone accounting for nearly 40 per cent of the nitrogen pollution and 30 per cent of the phosphorus pollution (*7, 8, 9*). In addition, pesticide use has increased, with recent growth rates estimated at 4 to 5.4 per cent in some regions (*10, 11*).

In almost all countries with major land salinization, water salinization is an accompanying problem. Major problems have been reported in Argentina, China, India, Sudan and many countries in Central Asia, where more than 16 million hectares of irrigated land are salinized (*12, 13*). Intrusion of saline seawater in aquifers is another important cause of salinization of water resources in coastal areas, particularly where groundwater extraction is excessive.

Pollution and contamination from such sources manifests itself in the form of increased acidity and higher concentrations of nutrients, sediments, salts, trace metals, chemicals and other toxins, as well as harmful pathogenic organisms that may thrive in warmer waters (*14*). Nutrient enrichment has become one of the most widespread water quality problems, severely degrading freshwater and coastal ecosystems (*15*). In addition, a growing number of new contaminants are being detected in the world's waterways. These include contaminants that contain endocrine-disrupting compounds, such as pharmaceutical products, steroids and hormones, industrial additives and agents, as well as gasoline additives. These contaminants present a new challenge to water quality management as data on their ecotoxicology and associated risks are lacking (*16*). In addition, their synergistic interactions with existing contaminants and pollutants may result in complex concoctions that are difficult to treat and whose impacts are as yet unclear.

Ecosystems are damaged by degraded water quality, among other factors. According to the Millennium Ecosystem Assessment (*17, 18, 19*), the biodiversity of freshwater ecosystems has been degraded more than any other ecosystem, including tropical rainforests. In the United States, for example, nearly 40 per cent of freshwater fish species and 40 per cent of amphibians are threatened with extinction. In Europe, more than 40 per cent of freshwater fish species are in imminent danger of extinction. And in South Africa, nearly two thirds of freshwater species are considered threatened or endangered. Most polluted freshwater ends up in the oceans, causing serious damage to many coastal areas and fisheries, thereby constituting a major challenge to ocean and coastal resource management.

While aquatic environments have often in the past been regarded as mere sources of water supply and waste disposal, to be consumed or contaminated without regard for the resultant impacts, there is growing appreciation of the vital goods and services they provide, which are critical for livelihoods in many parts of the world. The degradation of ecosystems through polluted water affects humans directly as fisheries and biodiversity are destroyed, threatening food production and other benefits to humankind.

People most affected are those who live near contaminated waterways and those who have no alternative access to safe water or to improved sanitation. In 2008, 2.6 billion people, or 42 per cent of the world's population, still lacked access to improved sanitation (*20*). Chemicals and toxins affect humans directly or bioaccumulate in fish and other organisms consumed by humans, causing developmental and neurological damage. Every year 1.8 million people die from diarrhoeal disease attributable to unsafe water or poor sanitation and hygiene (*21*). More than 1.5 million of these are children under five, who are more at risk from diarrhoea than from malaria, human immunodeficiency virus (HIV) or even all types of fatal injuries combined (*22*). Other stark statistics include the facts that in 2009 over 50 countries still reported cholera to the World Health Organization (WHO), and approximately 200 million people around the world are infected with schistosomiasis, a debilitating, water-borne parasitic disease (*23*). There are no reliable estimates of the total burden of ill-health resulting from water contaminated by domestic, industrial and agricultural discharges. Many of these impacts are long term and attributing them to a specific cause is difficult.

Sanitation and drinking-water investments have high rates of return in costs avoided, lives saved, reduced disease and health-care expense, more healthy workdays, improved education and increased productivity. Through the Millennium Development Goals, the international community has committed to halving the proportion of people without sustainable access to safe water and basic sanitation by 2015 as a key element of eliminating poverty and improving the lives of billions of people worldwide. Access to clean, safe water for human consumption was declared a human right by the United Nations General Assembly in July 2010 – and water quality is central to the realization of that right (*24*).

Poor water quality has a direct impact on water quantity in a number of ways. Polluted water that cannot be used for drinking, bathing, industry or agriculture effectively reduces the amount of useable water within a given area. Notwithstanding, the use of low-quality water (for example saline or brackish waters) may have important and direct impacts on productive water use, such as irrigated agriculture, with important effects on land degradation, crop production and, consequently, on rural income and food security. Around 700 million people in 43 countries suffer today from water scarcity, a situation whereby there are insufficient water resources to satisfy long-term average requirements (*25*, *26*, *27*).[1] By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two thirds of the world's population could be living under water-stressed conditions. With the existing climate change scenario, almost half the world's population will be living in areas of high water stress by 2030, including between 75 million and 250 million people in Africa (*28*).

Water quality deserves increased attention alongside water quantity in water resource management. However, given the complexity and magnitude of the challenges outlined above, an effective response to water quality challenges will involve concerted action by all stakeholders, including the public and private sectors and civil society.

1 Hydrologists typically assess water deficiency by looking at the population–water equation. One index, first proposed by Falkenmark and Lindh (1976), defines water stress as occurring when annual water supplies drop below 1,700 cubic metres per person in a given area. When annual water supplies drop below 1,000 cubic metres per person the population faces water scarcity, and below 500 cubic metres per person, absolute scarcity (25).

Strategies to Combat Water Quality Problems

There are four fundamental strategies to combat water quality problems that can form the basis of policy solutions for improving water quality (*29*):

- Prevention of pollution;
- Treatment of polluted water;
- Safe use of wastewater;
- Restoration and protection of ecosystems.

Prevention of Pollution

Pollution prevention strategies focus on the reduction or elimination of waste at the source. Prevention is widely regarded as the cheapest, easiest and most effective way to protect water quality. Furthermore, not only are there environmental benefits to preventing or reducing pollution, there may also be tremendous financial benefits, as generation of waste, especially from industrial and agricultural processes, is a demonstration of inefficient use of materials and resources (*30*).

In industry, solutions include reformulating products so that they produce less pollution and require fewer resources (including water) during their manufacture. In agriculture, reducing the use of toxic materials for pest control, nutrient application and overall water usage can reduce pollution. Examples of implementation of Good Agricultural Practices[2] include crop rotation, cover cropping, conservation agriculture, improved irrigation management and integrated pest management techniques (*31, 32*). In human settlements, the most obvious solutions include increasing improved sanitation coverage, considerations of settlement design (such as the types of materials used for construction), the location of industry and the handling of storm water, as well as reducing wastewater production (*33*).

Treatment of Polluted Water

In cases where contaminants result from domestic, industrial or agricultural activities, wastewater must be treated before discharging. Treatment strategies for contaminated water range along a continuum from high-technology, energy-intensive approaches to low-technology, low-energy, biologically and ecologically focused approaches. Where good water distribution and treatment systems are already in place, constant effort is needed to maintain and expand their effective operation. Nevertheless, many wastewater treatment facilities are not working due to deficient human, technical and financial resources for operation and maintenance. Poorly maintained or operated systems can lead to degradation of even high-quality water before it reaches its point of use.

The appropriate treatment options depend on the circumstances and intended afteruse. For example, to supply drinking-water for larger settlements, modern multiple-stage water treatment plants are typically required. At the community level solutions may include solar stills, and smaller-scale filtration or disinfection plants. At the household level options include boiling, solar pasteurization, simple water filter, solar water disinfection and chlorine treatment. While several of the options mentioned may also be appropriate for treatment of water for industrial use, agricultural source water can, in some cases, be of much lower quality, especially where harmful contaminants that can accrue in soil and crops are absent.

Safe Use of Wastewater

Wastewater is usually disposed of into water bodies, ideally following treatment to render it environmentally safe (see previous section). However, it can be safely used, sometimes even untreated, in circumstances where

2 Good Agricultural Practices are "practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products" (32).

impacts on human health and the environment are well understood and all possible action is taken to eliminate risks (*34, 35*). If well regulated, safe use of wastewater, for example in agriculture, can reduce the pressure exerted by human activities on existing freshwater resources and augment water supply in water-scarce and semi-arid zones and in rapidly growing peri-urban settings (*36*).

Furthermore, wastewater can be a source of nutrients and, when properly managed, is potentially valuable for certain agricultural uses, reducing the need for expensive chemical fertilizers (*37*). Additionally, agriculture may act as a form of biological treatment, removing nutrients from water that, otherwise, may pollute watercourses.

In peri-urban and rural areas, treated human wastewater can be a viable source of water for reuse. Ecological sanitation, for example, is a low-cost method of dealing with human waste promoted by many development agencies. It involves the separation of urine and faecal matter – sterile urine may be applied directly to plants, while faecal matter is composted until it is safe for land application. This approach has been implemented in several countries and regions, including China, India, Burkina Faso, Kenya, Niger, Sweden and parts of Eastern Europe (*38*). By recycling water and using dry pre-stored human wastes, jobs are created for local populations as well as market opportunities for provision of indigenous fertilizers and soil conditioners for agriculture.

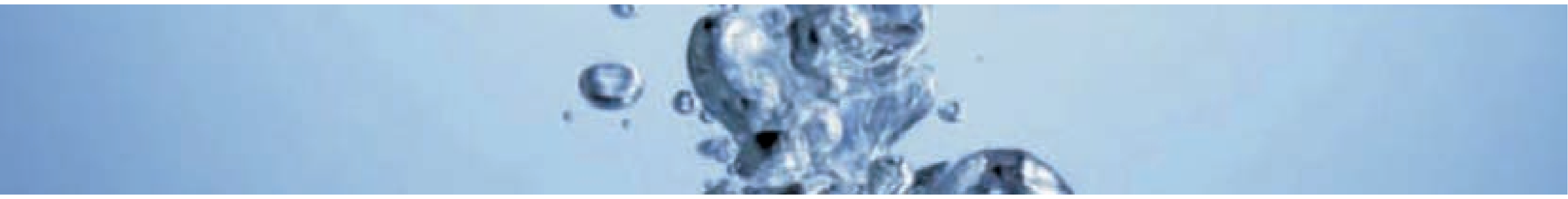
Some industries, such as the food and processing industry, utilize large volumes of water, and often also discharge considerable quantities of wastewater. In such instances, safe reuse of wastewater, as a component of cleaner production application, can improve water and energy efficiency and generate environmental benefits. For example, industry can reuse wastewater from certain processes in other applications that do not require high-quality water, or apply appropriate technologies to process wastewater for procedures requiring water of higher quality. Examples can be derived from Namibia and Singapore, where freshwater resources for both industrial and human consumption are supplemented with treated wastewater (*39, 40*).

Restoration and Protection of Ecosystems

Healthy ecosystems provide water quality benefits in the form of water purification, often at far lower cost than subsequent engineered efforts to clean contaminated water (*41*). When water systems, including watersheds, are adversely impacted by poor water quality, strategies to remediate pollution and restore systemic health and functions are important (*42*). Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (*43*). Strategies for freshwater restoration can be as straightforward as removing upstream dams and the restoration of rivers and wetlands. One of the well-established approaches that can be used to deal with pollution from both point and non-point sources is ecohydrology (*44*).

An ecohydrological approach is based on the understanding of the interrelationships between the ecological processes and the water cycle in a given catchment, and supports the role of ecosystem processes in water quality improvement. Linking this approach with social and economic capacities in a region by involving all users through a watershed management council is a foundation for system solutions that incorporate environmental and social elements. Ecohydrology can address water-related threats, such as reducing flood risk by increasing the retention capacity of the landscape, or by creating wetlands that prevent pollutants from entering waterways. Examples of ecohydrological approaches can be found worldwide, including in Iraq, Japan and Poland (*45*).

Given the costs and difficulty associated with restoration of degraded groundwater systems, and the frequent time lag between the discharge of contaminants and their impacts on groundwater reserves, prevention is the most cost effective and often the only feasible means to protect such systems. Groundwater systems do not have efficient self-cleaning capacities, hence polluted groundwater is difficult and expensive to treat in situ (*46*). Because groundwater conditions cannot be readily observed, it is critical to focus on appropriate monitoring of groundwater supply and quality (*47*).



Policy Interventions to Achieve Solutions

Addressing water quality problems requires actions at various levels (see Annex A for a summary of possible interventions categorized by scale – international, national, watershed and community/household). Key policy interventions include (*48*):

- Better understanding of water quality and its impacts through improved monitoring, data collection and analysis, and scenario building;
- More effective communication, education and advocacy;
- Improved financial and economic approaches;
- Improved legal and institutional arrangements;
- Improved technology and infrastructure.

Improving Understanding of Water Quality

Ongoing monitoring and good data are the cornerstones of effective efforts to improve water quality. Water and sanitation managers, governments and communities need to know what pollutants are in the water, how they entered the waterway or aquifer, and what are effective approaches for improving water quality. Addressing water quality challenges will mean tracing water contaminants to their source, and defining prevention and treatment plans. Once a prevention or treatment plan is implemented, ongoing monitoring of water quality is needed to ascertain whether the remediation efforts have been successful. Monitoring technology also needs to be improved, made economically affordable and deployed so that water quality can be measured in real time, and the number and types of indicators should be expanded to monitor new pollutants and associated challenges.

Capacity needs to be built, including on the application of low-cost technologies to reveal possible faecal contamination in drinking-water, such as the hydrogen sulphide paper strip test, a community-based tool for water quality monitoring that has been used in the Pacific Islands (*49*), or new technologies such as the use of satellite imaging to monitor inland and coastal water quality (*50*).

Currently, many governments are making a policy shift in their drinking-water quality standards and norms. Rather than water quality testing at a single point, globally agreed (but in many settings hard to attain) standards and guidelines of values, integrated risk assessment and incremental risk management are increasingly being applied to the assurance of water quality. In other words, new policies promote a system that considers the entire chain of events from catchment to tap, identifies critical risk points, assesses those risks and manages them in a way that cumulatively leads to the desired risk reduction level. This approach was promoted in the third edition of the *WHO Guidelines for Drinking-Water Quality* (*51*) and is now operationalized through water safety plans (*52*). The guidelines have also been applied to the safe use of wastewater in agriculture and aquaculture and for ensuring safe recreational waters, and provide a model for water quality management in general. National and international policies should be adjusted to take on board this approach.

To improve water quality monitoring and data collection attention needs to be given to:

- Developing international data protocols, standard data formats and data-sharing arrangements;
- Developing standards and a recommended schedule for monitoring;
- Strengthening regional, national and local capacity to collect, manage and analyse water quality information, particularly in developing and emerging economies;
- Establishing, maintaining and expanding monitoring networks in transboundary basins;
- Ensuring that monitoring networks are able to take into account new circumstances and needs, such as climate change;
- Improving monitoring technology, including real-time in situ monitoring, expanding the number and types of indicators monitored, and reducing cost and improving reliability of sampling tools and data analysis;
- Linking water quality and water quantity monitoring for comprehensive understanding and management of water resources.

Improving Communication, Education and Advocacy

Among the most effective tools for solving water quality problems are communication, education and advocacy on the importance of clean water and the availability of effective solutions. Demonstrating the importance of water quality to households, farmers, business owners, industry managers, the media and policymakers can have a significant impact in winning key improvements. Buy-in from various stakeholders will lead to more effective efforts to put in place the financial and legal tools and capacity needed to improve water quality.

Changing behaviour, convincing policymakers and exciting media interest require greater attention to the numerous ways in which water quality intersects with human needs and values. Communities can be engaged through education and awareness-building efforts to promote better water quality behaviour and exert pressure on policymakers to develop and implement appropriate water quality regulations, enforce them and allocate sufficient resources (*53*).

Capacity-building, training and technical assistance for practitioners on the implementation of good practices may also have important positive impacts. In the case of agriculture, the farmer field school[3] approach has been proven to be highly effective (*54*).

To improve communication, education and advocacy, attention needs to be given to:

- Increasing global and local culturally sensitive education and awareness-building campaigns;
- Educating individuals and the community about the links between behaviour and water quality impacts;
- Training practitioners and providing technical assistance for the effective implementation of best practices to prevent and manage water pollution;
- Developing water management capacity through formal education programmes that focus on training future water and sanitation experts;
- Building the capacity of local governments to make improvements in wastewater management and drinking-water treatment;
- Engaging in advocacy to demonstrate to local and national governments the social, environmental and economic benefits of improved water quality, thereby building political will to engage in relevant programmes and projects;
- Connecting information on water quality with local education, social marketing and awareness-building campaigns to trigger behaviour change.

Improving Financial and Economic Approaches

Financial and economic solutions require (a) improved tools for understanding the true costs of poor water quality and valuing ecosystem and environmental water purification services; and (b) increased access to financing for wastewater infrastructure, operation and maintenance, and management (*55*).

Improvements in the economic tools used to assess the true costs of poor water quality and the benefits of water quality improvements or clean-up efforts are needed. In order to ensure that society appropriately values the services that water quality and ecosystems provide, more comprehensive socially, ecologically and economically grounded cost-benefit analyses for water quality need to be developed. In addition, refinement of the environmental economics within economic appraisal tools is needed (*56*). For instance, significant improvements in the tools for the economic appraisal of water reuse projects are being achieved by including methods for cost-benefit, cost-effectiveness, and financial feasibility analysis (*57, 58*).

Many water quality problems are the result of inadequate access to financing to develop water treatment or pollution prevention programmes, or arise from inappropriate pricing or subsidy policies (*59*). As a result, many of the solutions to water quality problems require national and international financing for water and wastewater treatment infrastructure. Other solutions can rely on local financing and economic approaches. Policies are needed to support more effective water-pricing systems that permit sufficient cost recovery, ensure adequate investments and support sustainable long-term operation and maintenance.

Efforts to address and reduce pollution will require polluters to pay the costs of their contamination, rather than passing those costs along to the environment, the general public and future generations. Such “polluter

3 The farmer field school approach is based on the concepts and principles of people-centred learning, and was developed as an alternative to the conventional top-down test and verification extension approach (FAO).

pays" efforts offer several key benefits. Notably, it is often less expensive to control pollution at the source than it is to remediate it downstream or restore damaged and degraded ecosystems. Methods to require polluters to internalize such costs include regulations, standards, enforcement, public pressure and, in some cases, targeted subsidies (*60*).

Appropriate water and wastewater pricing can also help provide incentives for water efficiency improvements, which can reduce the quantity of water that is being contaminated by pollutants. Inappropriate subsidies for water infrastructure and services that do not improve or protect water quality should be avoided (*61*). Cost recovery sufficient to ensure investment, operation and maintenance of water systems that protect water quality and service delivery should come from an equitable combination of tariffs, taxes and transfers.

To improve financial and economic approaches attention needs to be given to:

- Undertaking more analyses of the benefits and costs of water quality;
- Promoting application of polluter pays and beneficiary pays principles, ensuring reinvestment in water quality improvements;
- Developing consumer and investor campaigns to encourage all users to reduce water pollution;
- Expanding financing for proven, cost-effective water and wastewater treatment infrastructure (engineered and natural), at multiple scales;
- Considering the use of innovative economic instruments such as payments for ecosystem services, as appropriate;
- Avoiding inappropriate subsidies for water infrastructure and services;
- Implementing user fees within sustainable cost recovery policies that recover full capital, operation and maintenance costs and incentivize water use efficiency.

Improving Legal and Institutional Arrangements

New and improved legal and institutional frameworks are needed from the international level down to the watershed and community level to protect water quality. As a first step, laws on water quality should be adopted and adequately enforced. Model pollution prevention policies should be disseminated more widely at all levels, and guidelines developed for ecosystem water quality, as they are for drinking-water quality. At the national scale, new institutions and regulatory actions are needed to take an integrated approach to water that prioritizes pollution prevention and sets enforceable water quality standards. Planning at the watershed scale needs to involve multisectoral platforms comprising different sectors, such as water, environment, trade, agriculture, energy and planning, in order to identify major sources of pollution and appropriate interventions, especially when watersheds are shared by two or more political entities. Many countries have already begun to create management institutions at the watershed scale and such efforts need to be further encouraged (*62*).

For effective legal and institutional arrangements, attention should be given to:

- Promoting model pollution prevention policies;
- Developing international guidelines on water quality for ecosystems and guidelines to characterize in-stream water quality and identify priority areas for remediation;
- Formulating national policies on ensuring water quality standards for ecosystems;
- Establishing and enforcing national and joint basin water quality standards that protect human and ecosystem health;
- Creating watershed-based planning units and river basin management approaches that integrate information, identify sources of pollution and focus on reducing those sources;
- Improving the management, monitoring and performance of water distribution and wastewater collection networks.

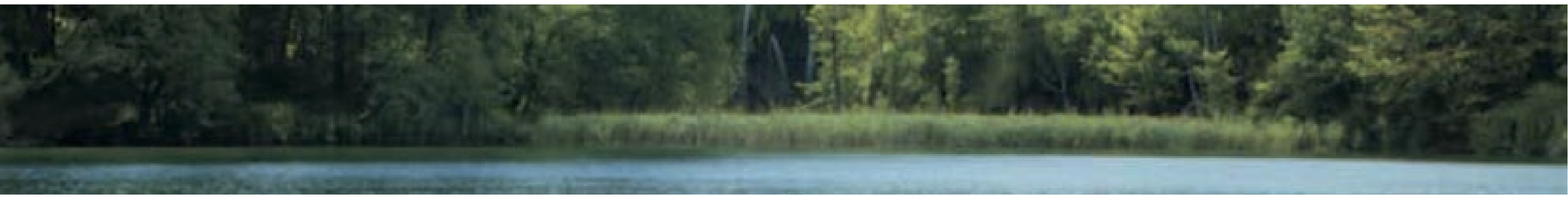
Improving Technology and Infrastructure

Water infrastructure, including irrigation systems and dams, brings undoubted benefits, but can adversely affect water quality by disrupting the natural hydrological processes of water systems and their associated ecosystems (*63*). Effective technologies and approaches are available to improve water quality. These technologies include nature-based as well as engineered infrastructure – nature has the capacity to improve water quality through natural purification and detoxification processes, hence the importance of maintaining the health and integrity of ecosystems, including via restoration. Appropriate technologies can be used to treat wastewater if funding is available to communities to develop and operate the requisite infrastructure. In many instances it is necessary to build capacity to develop and implement such technologies. Also, there is a need to develop new technologies for improving water use efficiency and treating wastewater polluted with new contaminants.

Cleaner production also offers a paradigm shift towards sustainable production and service for organizations and products (*64*) by promoting the proactive deployment of strategies that reduce or even eliminate at the source the production of any nuisance, pollution or waste, and help to save raw materials, natural resources and energy. In industry, for example, packaging that reduces food waste can be an important tool to reduce the total environmental impact of production (*65*). The utilization of best available technologies in agriculture, such as through the reduction or even elimination of fertilizer and pesticide use through adoption of Good Agricultural Practices, can be an effective pollution prevention strategy. Simple approaches may include a proper schedule for manure disposal into fields to avoid overfertilization or losses in nutrition components and contamination of soil and water with manure residues. In addition, reformulation of products with ingredients that are less toxic and more biodegradable can offer new market opportunities for chemical producers while increasing their profits.

To improve technology and infrastructure, attention needs to be given to:

- Connecting communities, governments and businesses to effective water quality technologies and approaches;
- Developing new technologies when needed to meet the particular environmental or resource conditions in a particular location;
- Providing financing to implement needed technologies and infrastructure projects;
- Providing technical and logistical support to help communities and governments implement technology and infrastructure projects to improve water quality;
- Planning treatment in relation to intended reuse of water (domestic, agriculture, industry) for efficient management of water quality;
- Promoting cleaner production in industries and agriculture for increased efficiency of water and other materials, preventing and reducing water pollution at the source.



Moving Forward: Clean Water for Today and Tomorrow

The decisions made in the next decade will determine the path we take in addressing the global water quality challenge. Inaction today will lay open the possibility of some disturbing scenarios: many waterways will be no more than open running sewers, particularly threatening the well-being of developing country cities; people will no longer be able to use local water resources for recreation or to support livelihoods; more people will die from preventable water-related diseases; and industries and farms will have to increase their expenditure on sourcing and treating water to ensure a supply that is clean enough to use (*66*), with serious consequences for global food security.

Taking bold steps internationally, nationally and locally to protect water quality could mean a very different future. Watercourses can again become the centrepieces of cities and villages, the cultural and social gathering places, and residents will once more turn towards the rivers and streams that gave them life. Pollution prevention efforts will enable farms, industries and cities to reduce their costs, operate more economically and counteract health risks. And, in places throughout the world, the joy of swimming in local rivers and lakes and fishing for recreation and sustenance will thrive again. Instead of spending more money and energy on water treatment, utilities and communities will be able to focus on meeting other basic human needs (*67*).

This vision can be realized if decision-makers embrace it and provide leadership to all other stakeholders at local, national and international levels. An example is provided by the fifth World Water Forum, Istanbul, Turkey, June 2009, where the ministers and heads of delegation agreed to "strengthen the prevention of pollution from all sectors in surface and groundwater, appropriately applying the polluter pays principle, while further developing and implementing wastewater collection, treatment and reuse" (*68*).

Clean water is life. We already have the know-how and skills to protect our water quality. What is now needed is the will. Human life and prosperity rest on our setting the policy framework today for the actions of tomorrow, so that we are the stewards, not the polluters, of our precious water resources.

Annex A: Summary of Possible Interventions by Scale

	Education & capacity-building	Policy/law/governance	Financial/economic	Technology/ infrastructure	Data/monitoring
International	Develop water management capacity through formal education programmes that focus on training future water and sanitation experts, decision-makers, planners and the public Conduct awareness-building campaigns for the general public and policymakers	Require policies that take integrated approaches to water management Regulate drinking-water quality and quantity Focus on pollution prevention Establish enforceable water quality standards that protect human and ecosystem health Change building codes and planning processes to consider non-structural water treatment options (e.g. low-impact development, source water protection) Promote comprehensive approach to water-related legislation across different areas of law (waste management, chemical safety, etc.) Promote access to information, public participation and access to justice in environmental matters	Establish polluter pays and beneficiary pays principles Avoid inappropriate subsidies for water infrastructure and services Provide appropriate market incentives for efficient use and allocation, while protecting the interests of the poor and those without access to markets	Promote best practices and support capacity-building initiatives for the deployment and implementation of sustainable infrastructure and technologies Support the research and development of adapted technologies, considering the national context for scaling up	Monitor key water quality and ecosystem indicators to track effectiveness of legal and other measures Evaluate water quality in concert with ecosystems in order to identify minimum ecosystem water needs Build national capacity to collect, manage and analyse water quality information Evaluate the links between water quality and water quantity Fund and publish research that addresses the time series statistics needed to establish baselines, seasonality and trends Improve monitoring technology, such as measuring water quality in real time and expanding the number and types of indicators that are monitored Promote low-cost, rapid and reliable field sampling tools and technologies
National	Develop water management capacity through formal education programmes that focus on training future water and sanitation experts, decision-makers, planners and the public Conduct awareness-building campaigns for the general public and policymakers	Require policies that take integrated approaches to water management Regulate drinking-water quality and quantity Focus on pollution prevention Establish enforceable water quality standards that protect human and ecosystem health Change building codes and planning processes to consider non-structural water treatment options (e.g. low-impact development, source water protection) Promote comprehensive approach to water-related legislation across different areas of law (waste management, chemical safety, etc.) Promote access to information, public participation and access to justice in environmental matters	Establish polluter pays and beneficiary pays principles Avoid inappropriate subsidies for water infrastructure and services Provide appropriate market incentives for efficient use and allocation, while protecting the interests of the poor and those without access to markets	Promote best practices and support capacity-building initiatives for the deployment and implementation of sustainable infrastructure and technologies Support the research and development of adapted technologies, considering the national context for scaling up	Monitor key water quality and ecosystem indicators to track effectiveness of legal and other measures Evaluate water quality in concert with ecosystems in order to identify minimum ecosystem water needs Build national capacity to collect, manage and analyse water quality information Evaluate the links between water quality and water quantity Fund and publish research that addresses the time series statistics needed to establish baselines, seasonality and trends Improve monitoring technology, such as measuring water quality in real time and expanding the number and types of indicators that are monitored Promote low-cost, rapid and reliable field sampling tools and technologies

	Education & capacity-building	Policy/law/governance	Financial/economic	Technology/ infrastructure	Data/monitoring
Watershed	Strategic level for raising awareness on the impacts of individuals on water quality Develop training campaigns for practitioners and provide technical assistance for the effective implementation of best practices to address water pollution	Create watershed-based planning units that integrate information, identify sources of pollution and focus on reducing those source inputs Develop water quality goals and corresponding parameters for each water body, including establishing minimal flow requirements for dilution Promote access to information, public participation and access to justice in environmental matters	Apply effective pricing systems that permit sufficient cost recovery to support capital, operation and maintenance costs, informed by sustainable development principles Incentivize water use efficiency Ensure that applied solutions provide ecosystem services for local societies	Invest in infrastructure and appropriate technologies to remediate pollution and restore watershed functions	Build regional capacity to collect, manage and analyse water quality information
Household/ community	Connect individual and community behaviour to water quality impacts, and build capacity to make improvements in sanitation / wastewater and drinking-water treatment	Amend city and community codes to allow innovative storm water treatment options Promote access to information, public participation and access to justice in environmental matters	Encourage investments	Consider decentralized treatment technologies	Carry out and analyse household/ community surveys, possibly in conjunction with participatory processes

Source: adapted from: United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions.* UNEP, Nairobi, 2010.

References

1. Smith, A.H., E.O. Lingas, and M. Rahman. "Contamination of Drinking-Water by Arsenic in Bangladesh: A Public Health Emergency." *Bulletin of the World Health Organization*, 2000, 78(9).
2. Van Halem, D., S.A. Bakker, G.L. Amy, and J.C. Van Dijk. "Arsenic in Drinking Water: Not Just a Problem for Bangladesh." *Drinking Water Engineering and Science Discussions*, 2009, 2:51–64.
3. World Health Organization and United Nations Children's Fund Joint Monitoring Programme (JMP) for Water Supply and Sanitation. *Progress on Drinking-Water and Sanitation: Special Focus on Sanitation*. UNICEF, New York, and WHO, Geneva, 2008 (http://www.who.int/water_sanitation_health/monitoring/jmp2008/en/index.html).
4. United Nations World Water Assessment Programme. *Water and Industry* (http://www.unesco.org/water/wwap/facts_figures/water_industry.shtml).
5. Morris, B.L, A.R.L. Lawrence, P.J.C. Chilton, B. Adams, R.C. Calow, and B.A. Klinck. *Groundwater and Its Susceptibility to Degradation: A Global Assessment of the Problem and Options for Management*. Early Warning and Assessment Report Series, RS 03-3. United Nations Environment Programme, Nairobi, Kenya, 2003.
6. Mahvi, A.H., J. Nouri, A.A. Babaaei, and R. Nabizadh. "Agricultural Activities Impact on Groundwater Nitrate Pollution." *International Journal of Environmental Science and Technology*, 2005, 2(1):41–47.
7. Revenga, C., and G. Mock. "Dirty Water: Pollution Problems Persist." In: *Pilot Analysis of Global Ecosystems: Freshwater Systems*, 2000 (http://earthtrends.wri.org/text/water-resources/feature-16.html).
8. Faeth, P. *Fertile Ground: Nutrient Trading's Potential to Cost-Effectively Improve Water Quality*. World Resources Institute, Washington, DC, 2000.
9. Food and Agriculture Organization of the United Nations (FAO). *Prospects for the Environment: Agriculture and the Environment*. FAO Corporate Document Repository (http://www.fao.org/docrep/004/y3557e/y3557e11.htm).
10. United Nations World Water Assessment Programme. *Water and Industry* (http://www.unesco.org/water/wwap/facts_figures/water_industry.shtml).
11. Food and Agriculture Organization of the United Nations (FAO). *FAOSTAT* (http://faostat.fao.org/).
12. Food and Agriculture Organization of the United Nations (FAO). *AQUASTAT* (http://www.fao.org/nr/water/aquastat/main/index.stm).
13. Ghassemi, F., A.J. Jakeman, and H.A. Nix. *Salinisation of Land and Water Resources: Human Causes, Extent, Management and Case Studies*. Center for Resource and Environmental Studies, Australian National University, Canberra, Australia, 1995.
14. United Nations World Water Assessment Programme. *The United Nations World Water Development Report 3: Water in a Changing World*. UNESCO, Paris, and Earthscan, London, 2009 (http://webworld.unesco.org/water/wwap/wwdr/wwdr3/).
15. United Nations World Water Assessment Programme. *The United Nations World Water Development Report 3: Water in a Changing World*. UNESCO, Paris, and Earthscan, London, 2009 (http://webworld.unesco.org/water/wwap/wwdr/wwdr3/).
16. EUGRIS Portal for Soil and Water Management in Europe. *Emerging Pollutants* (http://www.eugris.info/FurtherDescription.asp?Ca=2&Cy=0&T=Emerging%20Pollutants&e=95).
17. Millennium Ecosystem Assessment (R. Hassan, R. Scholes, and N. Ash, eds). *Ecosystems and Human Well-Being: Current State and Trends*. Findings of the Condition and Trends Working Group (Millennium Ecosystem Assessment Series). Island Press, Washington, DC, 2005.
18. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Wetlands and Water – Synthesis*. World Resources Institute, Washington, DC, 2005 (http://www.millenniumassessment.org/documents/document.358.aspx.pdf).
19. Millennium Ecosystem Assessment. *Living beyond Our Means: Natural Assets and Human Well-Being*. Statement of the MA Board, 2005 (http://www.millenniumassessment.org/en/BoardStatement.aspx).
20. World Health Organization and United Nations Children's Fund Joint Monitoring Programme (JMP) for Water Supply and Sanitation. *Progress on Sanitation and Drinking Water: 2010 Update*. World Health Organization, Geneva, 2010 (http://www.wssinfo.org/fileadmin/user_upload/resources/1278061137-JMP_report_2010_en.pdf).

21. World Health Organization (WHO). *Water, Sanitation and Hygiene Links to Health: Facts and Figures, Updated November 2004*. WHO, Geneva, 2004 (http://www.who.int/water_sanitation_health/publications/facts2004/en/).
22. World Health Organization (WHO). *World Health Statistics 2010*. WHO, Geneva, 2010 (http://www.who.int/whosis/whostat/2010/en/index.html).
23. World Health Organization (WHO). *World Health Statistics 2010*. WHO, Geneva, 2010 (http://www.who.int/whosis/whostat/2010/en/index.html).
24. United Nations. "General Assembly Declares Access to Clean Water and Sanitation is a Human Right." *UN News Centre*, 28 July 2010 (http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=sanitation&Cr1).
25. Falkenmark, M., and G. Lindh. *Water for a Starving World*. Westview Press, Boulder, Colorado, 1976.
26. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2001. Working Group II: Impacts, Adaptation and Vulnerability*. IPCC Third Assessment Report, 2001 (http://www.grida.no/publications/other/ipcc%5Ftar/?src=/climate/ipcc_tar/wg2/180.htm).
27. European Commission: Environment. *Water Scarcity and Droughts in the European Union* (http://ec.europa.eu/environment/water/quantity/about.htm).
28. United Nations. *International Decade for Action: Water for Life, 2005–2015. Water Scarcity*. (http://www.un.org/waterforlifedecade/scarcity.html).
29. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 36 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
30. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 36–37 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
31. Food and Agriculture Organization of the United Nations (FAO). *Control of Water Pollution by Agriculture*. FAO, Rome, 1996.
32. Food and Agriculture Organization of the United Nations (FAO). *Development of a Framework for Good Agricultural Practices*. Committee on Agriculture, seventeenth session, Rome, 31 March–4 April 2003 (http://www.fao.org/docrep/meeting/006/y8704e.htm).
33. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 37–39 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
34. World Health Organization, Food and Agriculture Organization of the United Nations, United Nations Environment Programme (WHO/FAO/UNEP). *Guidelines for the Safe Use of Wastewater, Excreta and Grey Water. Volume II: Wastewater Use in Agriculture*. World Health Organization, Geneva, 2006.
35. Food and Agriculture Organization of the United Nations (FAO). *The Wealth of Waste: The Economics of Wastewater Use in Agriculture*. FAO Water Report 35. FAO, Rome, 2010.
36. Choukr-Allah, R. *Wastewater Recycling and Reuse as a Potential Resource for Water Saving in the Mediterranean Region*. Agadir, Morocco, 2004 (http://ressources.ciheam.org/om/pdf/a66/00800305.pdf).
37. Scott, C.A., N.I. Faruqui, and L. Rachid-Sally, eds. *Wastewater Use in Irrigated Agriculture: Coordinating the Livelihood and Environmental Realities*. CAB International, Wallingford, United Kingdom, 2004 (http://www.idrc.ca/openebooks/112-4/).
38. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 44–45 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
39. Menge, J. *Treatment of Wastewater for Re-use in the Drinking Water System of Windhoek*. City of Windhoek, Namibia (http://www.wastewater.co.za/).
40. Public Utilities Board (PUB). *NEWater: Overview*. Government of Singapore, PUB (http://www.pub.gov.sg/NEWater/Pages/default.aspx).
41. Costanza, R., R. d'Arge, R. de Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. "The Value of the World's Ecosystem Services and Natural Capital." *Nature*, 1997, 387:253–260 (http://www.uvm.edu/giee/publications/Nature_Paper.pdf).
42. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality*

Solutions. UNEP, Nairobi, 2010, page 75 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).

43. Society for Ecological Restoration International Science & Policy Working Group. *The SER International Primer on Ecological Restoration*. Society for Ecological Restoration International, Tucson, 2004 (http://www.ser.org/pdf/primer3.pdf).
44. Wagner, I., and M. Zalewski. "Ecohydrology as a Basis for the Sustainable City Strategic Planning: Focus on Lodz, Poland." *Reviews in Environmental Science and Biotechnology*, 2009, 8(3):209–217 (http://www.springerlink.com/content/d903712655j56003/fulltext.pdf).
45. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 47 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
46. Nyer, E.K., ed. *Groundwater Treatment Technology, Third Edition*. John Wiley & Sons, 2009, page 1.
47. Morris, B.L., A.R. Lawrence, P.J. Chilton, B. Adams, R.C. Calow, and B.A. Klinck. *Groundwater and Its Susceptibility to Degradation: A Global Assessment of the Problem and Options for Management*. Early Warning and Assessment Report Series, RS 03-3. United Nations Environment Programme, Nairobi, Kenya, 2003.
48. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 8 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
49. Mosley, L., and D. Sharp. *The Hydrogen Sulphide (H2S) Paper Strip Test: A Simple Test for Monitoring Drinking Water Quality in the Pacific Islands*. South Pacific Applied Geoscience Commission (SOPAC), Suva, Fiji, 2005.
50. Bukata, R.P. *Satellite Monitoring of Inland and Coastal Water Quality: Retrospection, Introspection and Future Directions*. Taylor and Francis, London, 2005.
51. World Health Organization (WHO). *WHO Guidelines for Drinking-Water Quality*. WHO, Geneva, 2008 (http://www.who.int/water_sanitation_health/dwq/guidelines/en/).
52. Davison, A., G. Howard, M. Stevens, P. Callan, L. Fewtrell, D. Deere, and J. Bartram. *Water Safety Plans: Managing Drinking-Water Quality from Catchment to Consumer*. Geneva, World Health Organization, 2005 (http://www.who.int/water_sanitation_health/dwq/wsp0506/en/index.html).
53. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 51–52 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
54. Food and Agriculture Organization of the United Nations (FAO). *Land Resources: Farmer Field School* (http://www.fao.org/nr/land/sustainable-land-management/farmer-field-school/en/).
55. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 33, 67 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
56. Food and Agriculture Organization of the United Nations (FAO). *The Wealth of Waste: The Economics of Wastewater Use in Agriculture*. FAO Water Report 35. FAO, Rome, 2010.
57. Food and Agriculture Organization of the United Nations (FAO). *The Wealth of Waste: The Economics of Wastewater Use in Agriculture*. FAO Water Report 35. FAO, Rome, 2010.
58. European Commission. *Water Reuse System Management Manual*. AQUAREC Project, 2006.
59. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 9 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
60. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 68–69 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
61. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 75 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).
62. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, pages 74–75 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).

63. World Commission on Dams (WCD). *Dams and Development: A New Framework for Decision-Making*. Earthscan, London, 2000.

64. Hall, J., and S. Crowther. "Biotechnology: The Ultimate Cleaner Production Technology for Agriculture." *Journal of Cleaner Production*, 1998, 6:313–322.

65. Williams, H., and F. Wikströma. "Environmental Impact of Packaging and Food Losses in a Life Cycle Perspective: A Comparative Analysis of Five Food Items." *Journal of Cleaner Production*, 2011, 19:43–48.

66. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 77 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).

67. United Nations Environment Programme (UNEP). *Clearing the Waters: A Focus on Water Quality Solutions*. UNEP, Nairobi, 2010, page 77 (http://www.unep.org/publications/contents/pub_details_search.asp?ID=4123).

68. *Fifth World Water Forum Ministerial Process: Istanbul Ministerial Statement*. Fifth World Water Forum, Istanbul, Turkey, 16–22 March 2009. Ministry of Foreign Affairs of Turkey and World Water Council, 2009.

UN-Water Members and Partners

Members

United Nations Secretariat
United Nations Department of Economic and Social Affairs (UNDESA)
United Nations International Strategy for Disaster Reduction (UNISDR)

Programmes and funds
United Nations Children's Fund (UNICEF)
United Nations Conference on Trade and Development (UNCTAD)
United Nations Development Programme (UNDP)
United Nations Environment Programme (UNEP)
United Nations High Commissioner for Refugees (UNHCR)
United Nations Human Settlements Programme (UN-HABITAT)

Regional commissions
United Nations Economic Commission for Europe (UNECE)
United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP)
United Nations Economic Commission for Latin America and the Caribbean (UNECLAC)
United Nations Economic and Social Commission for Western Asia (UNESCWA)
United Nations Economic Commission for Africa (UNECA)

Specialized agencies
Food and Agriculture Organization of the United Nations (FAO)
International Fund for Agricultural Development (IFAD)
International Labour Organization (ILO)
United Nations Educational, Scientific and Cultural Organization (UNESCO)
United Nations Industrial Development Organization (UNIDO)
World Bank Group (WB)
World Health Organization (WHO)
World Meteorological Organization (WMO)
World Tourism Organization (UNWTO)

United Nations related organizations
International Atomic Energy Agency (IAEA)

Conventions
Secretariat of the United Nations Convention on Biological Diversity (UNCBD)
Secretariat of the United Nations Convention to Combat Desertification (UNCCD)
Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC)

Other entities
United Nations University
United Nations Institute for Training and Research (UNITAR)

Partners with special status

United Nations Global Compact
United Nations Office for Outer Space Affairs (UNOOSA)
United Nations Secretary-General's Advisory Board on Water and Sanitation (UNSGAB)
Water Supply and Sanitation Collaborative Council (WSSCC)

Partners

AquaFed
Gender and Water Alliance (GWA)
Global Water Partnership (GWP)
International Association for Water Law (AIDA)
International Association of Hydrogeologists (IAH)
International Association of Hydrological Sciences (IAHS)
International Commission on Irrigation and Drainage (ICID)
International Hydropower Association (IHA)
International Water Association (IWA)
International Water Management Institute (IWMI)
International Water Resources Association (IWRA)
Public Services International (PSI)
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
Stakeholder Forum for a Sustainable Future
Stockholm International Water Institute (SIWI)
WaterAid
Women for Water Partnership (WfWP)
World Business Council on Sustainable Development (WBCSD)
World Conservation Union (IUCN)
World Water Council (WWC)
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