Chapter 15

SUSTAINABLE WATER MANAGEMENT

15.1 Introduction

At the beginning of the 21st century, many people face formidable challenges to meet increasing demand for water. However, there are significant pressures that make it difficult to meet these demands including inefficient agriculture, expanding urban areas, water pollution, and international conflict. The situation has led many in the international development community to point to a 'global water crisis'. Since the 1960s widespread acute water shortages have attracted increasing attention. For example, 1981–90 was declared the International Drinking Water Supply and Sanitation Decade. Following this, in 1992 the Earth Summit in Rio de Janeiro set goals for sustainable development, including guaranteeing every individual access to clean water and sanitation. Significant progress has been made since then, but an enormous challenge remains. Sound management of water resources and access to water services are now regarded as key components of sustainable development. Therefore, Sustainable water management (SuWM) becomes the challenging issue in the global concern. The definition that has evolved indicates that: a water supply system is sustainable when it

- provides an efficient and reliable service at a level which is desired;
- can be financed or co-financed by the users with limited but feasible external support and technical assistance;
- is being used in an efficient and effective way, without negatively affecting the environment.

15.2 Elements of SuWM

SuWM has three key elements. They are: management, finance and governance. They are aimed at proper coordination and planning in order to ensure that water is available at the right time and in the right place, and simultaneously economic, ecological and social sustainability are achieved. In other words, SuWM requires re-examination of 'the roles played by the state and other public and private actors' in water financing and governance. Therefore, the user community, which is part of the total governance, will ensure the proper management of technology that can confer by the finance either managing by the user community themselves or from the local government/institutional environment. Therefore, the combination of these three crucial dimensions of the elements will make a water supply system sustainable (Figure 15.1).

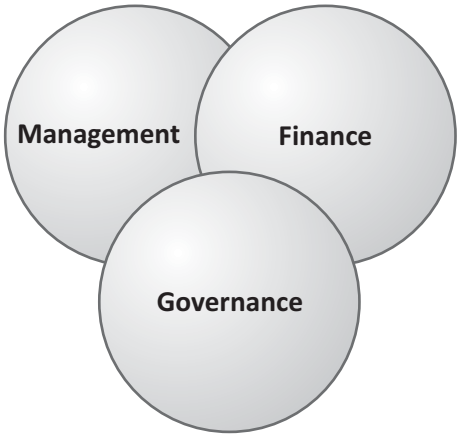

Figure 15.1: Elements of SuWM

15.3 Principles of Suwm

The extensive literature on water management shows ten fundamental principles for SuWM. These principles, objectives and underlying assumptions are summarized in Table 15.1. The key feature of SuWM is the synergy of state, market and community. The combination of demand-driven and supply-driven water management is to address the past mistake of relying on one side or the other. In addition, the SuWM principles are aimed at meeting five dimensions of sustainability.

- Cost recovery, water pricing and clearly defined property rights are intended to achieve economic sustainability and efficiency.
- Pulling in the private sector and the involvement of community help to sustain financial sustainability and viability.
- Technical sustainability is achieved by appropriate technology and good monitoring systems to reduce the chances of infrastructure breakdown.
- Increasing the sense of water ownership and including marginal groups in water-use committees are an attempt to address social sustainability, equity and access. While strengthening the rule of law and regulations promotes good governance, decentralisation gives autonomy to local governments to deal with geographically specific needs.
- Environmental sustainability is expected to be achieved when water is used more efficiently and waste is minimised. Despite the recognition of multiple dimensions of sustainability, environmental concern is not

Table 15.1: Ten SuWM principles and objectives

Key principles	Assumptions and objectives
(a) 'User pays' principle	• Water as economic goods • Economic sustainability (achieve efficiency by empowering water users) • Water as public goods • Ecological sustainability (creating less waste to reduce negative externalities)
(b) Appropriate technology	• Supply-side management (to guarantee adequate/constant supply of water) • More environmentally friendly devices (ecological sustainability)
(c) Establish clear boundary	• Clearly defined property rights (economic and ecological sustainability)
(d) Key stakeholders' involvement in decision-making processes in formal institutions (e.g. water-user committees)	• Respecting indigenous knowledge (they know best!) • Negotiating appropriate water-related rules and roles to increase legitimacy • Including marginal voices (social equity)
(e) Clear sets of rules and roles	• Providing high incentives to reduce free-riding behaviour • Negotiating access to water
(f) Monitoring	• Technical sustainability • Creating incentive for water efficiency • Social equity
(g) Sanctions	• Creating incentives by punishing non-compliance
(h) Conflict resolution mechanisms (e.g. arbitration body)	• Resolving conflicts by negotiation and regulations
(I) Community participation in collective choices	• Acknowledging indigenous knowledge • Enhancing project sustainability by a high sense of ownership • Providing alternative cash and manpower support
(j) Decentralisation (autonomy at local level) and rules governing nested relationships with central government	• Recognising power dimensions • Acknowledging local conditions • Reducing bureaucracy

Source: After (Jean, Abdulrahman et al. 2003)

placed high in the SuWM principles in developing countries. This is because environmental sustainability, concerning inter-generational obligations, is not regarded as the first priority while the present generation is currently suffering from drought and poverty.

15.4 The Role of Institutions in Shaping Water Behaviour

The SuWM model highlights the role of institutions in shaping the individual's water-use behavior, distribution and access. As mentioned before, institutionalists argue that the failure of water resources management lies in inadequate institutions in water efficiency. Institutions, therefore, need to be designed to alter the incentive structure by increasing the opportunity cost of free-riding and formulating mutual expectations of cooperative behavior.

Institutions are generally regarded as 'rules of the game' which determine what behavior is appropriate (North, 1990). There are three forms of institutions: judiciary, bureaucratic and socially embedded. Judiciary institutions comprise the law and regulations which determine who has access to water and how much. Clear sets of rights and responsibilities are laid down, so that water users know what is expected of them. Sanctions, such as threatening to cut water supply, are used to deter free-riding behavior and to ensure water efficiency. Bureaucratic institutions are water-use organisations and committees that make decisions about rules, access and distribution. In contrast, socially embedded institutions are social values and norms which govern and shape water-use behavior. These three forms of institutions, however, are not mutually exclusive.

The institutional arrangements are not 'once-and-for-all' in nature, but are consistently reviewed for ongoing rearrangement to ensure efficiency and sustainability. The ultimate aim of the arrangements is to form contractual relations between the community and individuals to secure a self-enforcing form of ownership and responsibility for their community resources (Lockridge 2004). This approach moves away from mere provision of water facilities to long-term resource management.

Water partnership and building trust between central and local governments, between private and public sectors, and between individuals, experts and government officials, become crucial in creating the contractual relationships. These partnerships are essential as 'a framework for dialogue through which all stakeholders can reach agreement that is acceptable to all members. Through

their representatives on these committees, local people are able to articulate what they want and how they want it done (Figueres, 2003) .

Generating social capital, in the form of close networks and a high level of trust, increases the ability of individuals to engage in collective action.

15.5 Appropriate Technology in SuWM

It has become fashionable to talk of the need for appropriate technology in the design of water supplies in developing countries to establish SuWM. Appropriate technology is the technology which fits the circumstances and is thus appropriate. Technology must be appropriate in terms of coat in order that it can he afforded; it must be appropriate in performance so that it does the job required; and it must be appropriately simple so that he operated and maintained.

Unfortunately, there are many cases of inappropriate technology and most of these arise from the unquestioning export of technologies From Europe and North America to the developing countries. Some engineers trained in Europe and America, or trained with a syllabus borrowed from those areas, have come In believe that the water supply practice developed in the affluent countries can and should be applied everywhere. This is incorrect. Good engineering involves the sensitive application of basic principles to a particular problem so that a solution is derived which is genuinely appropriate to the local context.

Engineering should not involve the rigid application of certain standard designs. The excitement and the challenge of the profession comes largely 1mm the degree of flexibility and ingenuity required to produce appropriate solutions for novel problems. Thus the use of appropriate technology is good engineering and sound common sense.

15.6 Operation and Maintenance

However, the construction of new water supplies does not necessarily solve the problem, without the capability to operate and maintain the water supplies which have been built. Many countries have found that construction is relatively easy compared to the task of keeping a large waterworks running continuously, or of servicing hundreds of small village supplies scattered about the countryside. Besides, it is usually easier to obtain development finance for the construction of

new supplies than funding for the recurrent expenditure of a maintenance programme. Frequently, not enough money is available to cover operating costs and to carry out running repairs, let alone to carry out necessary preventive maintenance. Operation and maintenance require a long-term commitment of money, staff, and institutions and can be a major drain on the resources of a developing Country. Even where the money is available, there is frequently a shortage of technicians and a lack of viable institutions able to carry out the job.

Water supplies for the larger cities often use sophisticated equipment for which spare pails — and skilled workers to install them - are not easily available. They require chemicals such as chlorine for their operation, which may become difficult or impossible to impost. Poor pipe-laying, frequent illegal connections and soil erosion in the dusty streets of these cities may cause frequent damage to distribution mains, and the public taps are rapidly worn out or broken by heavy use, or even stolen for re-sale. Water rates are extremely difficult to collect horn more than a fraction of subscribers, and what can be collected is usually inadequate to cover the full costs of operation and maintenance.

Urban supplies may provide water of doubtful quality, and for only a few hours of the day but only occasionally do they break down completely. In rural areas, however, problems of operation and maintenance have resulted in very high breakdown rates. In a typical developing country, over a quarter of the rural community water supplies may be out of action, with no adequate organization able to repair and operate them. Some countries rely upon community involvement to maintain supplies, but this method has often failed. Broken-down supplies represent an enormous wastage of investment and, in many countries, the most economical way of bringing good water to more people is to repair the broken supplies rather than build mote new ones. Operation and maintenance is the most deficient area in most water supply programmes. It is very difficult and requires mare efforts, not less, than construction if success is to be achieved.

15.7 Benefits

The technology used must be appropriate to the various costs and improved water supplies. Engineers are accustomed to designing with cost in mind, but as far as water supplies are concerned it is not so common to evaluate benefits or to define exactly what objectives it is hoped to reach. This is largely because in die developed countries a high level of provision of water services come to be

regarded as essential, and to be embodied in codes of practice and legislation. The available resources are generally adequate to provide this level of service, so that it has not been necessary to consider carefully whether the major objective is concerned with health, or convenience, or something else.

However, for the majority of the world's population in the poor villages and urban slums of the tropics, there is no possibility with the available resources of having the same high level of water provision enjoyed by the people of Europe and North America. And so decisions about the level of service and the type of technology are not pie-ordained but are important aspects of the design. The types of water supply improvement with the most benefits, at a given limited cost, should be determined so that the anticipated cost-effectiveness of alternatives can be compared.

Bold and sometimes wildly exaggerated claims have been made fur the benefits of water supplies. The major ones occur in three fields: production, health, and the saving of time and energy in the water-collection journey.

Production

It is here that the most unrealistic claims arc made. The development of a new water-using industry or agricultural practice may often appear to be dependent on a water supply, but in practice this is not usually a sufficient condition for such development and in many cases not evens a necessary one. For example, many industries prefer to build their own water supplies rather than use the public ones.

The water requirements of domestic use and of large-scale irrigation are difficult to meet in a combined system. Domestic water supplies require relatively small amounts of good quality water, and to supply it in quantities suitable for irrigation would be wasteful in most cases. When domestic water supplies arc used for cattle- watering, careful planning is required to avoid overgrazing around water points.

Health

In urban water supplies, water quality is clearly important. Traditional water sources in cities are more liable to faecal pollution, and liable to infect more people, than in rural areas. Many great water-borne epidemics have been caused to defective urban water supplies. However it seems that most endemic cases of faecal-oral disease are not water-borne but water washed. Insofar as they axe water-home, improvements in water quality will reduce their incidence.

Time and energy savings, and their money value

These are the most immediate and easily measured benefits, and most appreciated by the population. The magnitude of the time savings depends on conditions prevailing before installing the new water supply. In rural areas it is typical for women to spend about an hour day collecting water, and in some communities four or five hours a day are required (Figure 15.2). In some urban areas, the time spent collecting water is due not so much to distance as to the long queues which form at water points. It is not usually practicable to predict how the time saved will be spent, but it represents a significant improvement in people's standard of living, and can be regarded as a benefit in itself.

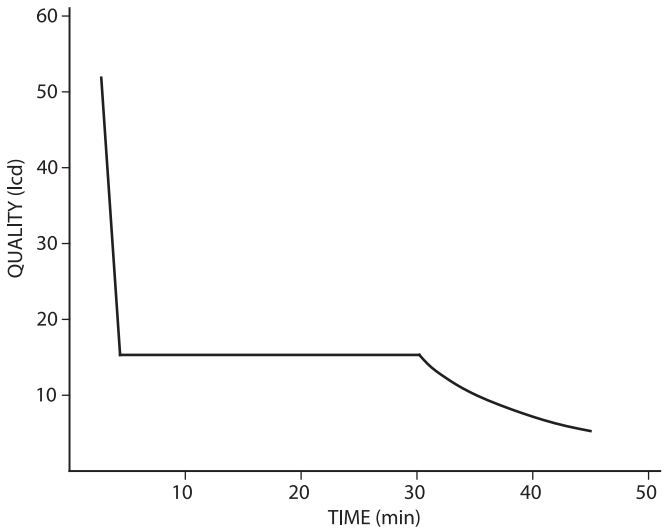

Figure 15.2: domestic water consumption (lpcd) to the time required for water collection shows a plateau for times less than 30min. (Cormos, Bandyopadhyay et al. 2007)

Reductions in the cost of water to the poor are an important, but often neglected benefit of urban water supply schemes. It has been estimated that 20-30% of the urban population of the developing world, mainly the poorest, buys water from vendors, who sell it from tanker trucks or buckets hung from their shoulders. Typically, these households spend one fifth of their income in this way, though the poorest pay a larger proportion. In fact, the amount they pay to informal water vendors in many cities is greater than the total revenue of the formal water agency—although ills often the agency's water which is being re-sold' Water vending can also found in some rural communities.

The fact that poor housewives are prepared to pay for water delivered to their door, rather than collects it themselves, shows that they put a money value on their time. For appraisal of the benefits a reasonable valuation of this time is the local unskilled wage rate (ChunhilL A. de Feminui, Roche et al. 1987). Since this is not far the poor they place on their time, it can also be used to estimate their willingness to pay fir their services.

15.8 Management Options and Public/private Partnerships

The current trend is to develop management options tailored to local needs and capacity, with an equation between local authorities, private sector and communities. These options are described in various recent publications, and in many countries experience is being built.

Many water supply programmes around the world are based on private-public partnerships, which range from government agencies that use private contractors for construction through to government agencies which act in regulatory roles with all services being provided, usually on a contract basis, by private groups. Responsibilities for investment and operations can be transferred to private firms under a concession or BOT (build-operate-transfer) arrangement without transferring the ownership of the assets from the government agency. Health education and community organization are only recently being seen as a task of a water service provider or a contractual service to be provided by NGOs. However health and consumer education/ mobilization are client-oriented services that can result in greater community commitment and satisfaction. Furthermore, few government agencies are able to develop successfully the detailed work required for community organization and mobilization. The NGO sector can play a major role in this (Al-Senafy, Al-Fahad et al. 2003).

Interestingly these management options are being tested in many small towns, but could prove very valuable for meeting the challenges of big agglomerations where water producing-utilities are required to enter into partnership with different private and semi-private smaller service providers. A summary of these options is given in Table15.2.

Table 15.2: Characteristics of private/public management options

Management options	Main characteristics
Public management	
Municipal management	Management by a municipal department, with direct control by the municipal administration
Supra-municipal management	Management by a supra-municipal department created under an agreement between a group of municipalities
Parastatal	This parastatal utility is usually named board, corporation or authority, and is established by a special act. The governing boards are usually composed of senior public officials. Being subject to public law, the autonomy is often very restricted.
Public-Private partnerships	
Management contract	The municipality is responsible for investments and operation, but contracts the management out to a private party, against a fixed fee, or a percentage of the collections
Lease contract	The municipality is responsible for the investments, but the operation and maintenance of the system is contracted out for a fixed period of up to 10 years to a private party. The private party collects the tariffs and transmits part of this to the municipality
BOOT (Build-Own-Operate-Transfer). Other, similar options: BOT (Build-Operate-Transfer); BOO (Build-Own-Operate); reverse BOOT.	BOOT: under a contractual agreement, a private firm is responsible for the financing, construction, management, operation and maintenance of a part of the system, and will transfer the assets to the municipality at the end of the contract, which is usually 20 to 30 years.
Concession	Under a contractual agreement between a private party and the Municipality, the private party will take full responsibility for investing and operating a complete system. The private party can be a commercial firm, an association of users or otherwise.
Public Water PLC	The system is managed by a private company under the prevailing private company law. The shares of the private company are exclusively owned by (local) government
Joint Venture	A private company is established for the expansion and operation of the system, The shares are divided between public and private owners. Usually, private owners bring in investment funds and management capacity, and the public owners the assets and the staff.

Private management	A Private party owns and operates the system, within the confines
Direct Private management	of a regulatory framework set by government. The private party can be a commercial firm, an association of users or otherwise

BOX 15.1

How are small community water supplies defined?

Small community water supplies are defined by the challenges faced in their administration and management.

Typical challenges include:

- Often under-trained operators;
- Remoteness and isolation;
- Harder to leverage financial and political support;
- Larger percentage of the population is vulnerable;
- Larger geographical spread; and
- Larger per unit cost of materials and construction.

These supplies include those serving rural villages and towns, individual households, vacation homes and trailer parks. Water supplies serving transient populations and those in periurban areas (the communities surrounding major towns and cities) are often organized in the same way and are beyond the reach of municipal services. These can also be considered small community water supplies.

BOX 15.2

Urban slum water supply, dhaka; intituted by dushtha shashtya kendra

Dushtha Shasthya Kendra (DSK) is an NGO based in Dhaka whose goals include building strong and functional community organisations. As part of its projects funded by WaterAid, the World Bank and the UNDP, DSK has developed a series of 'waterpoints' in several Dhaka slums – legal connections to the city supply arranged and financially guaranteed by DSK on the slum dwellers' behalf. The waterpoints consist of a water storage reservoir from which water is pumped using a simple suction handpump. The reservoir is topped with a concrete slab, which serves as a place for the users to bathe and wash clothes. Users can also collect water to take back to their homes. Some

waterpoints also have a latrine on them for public use. The waterpoints cost £500-1000, which is loaned to the community as credit and eventually repaid out of the profit the site, generates from sale of water and user charges for the latrines. Ownership of the facilities (which are built on city land) is, thus, transferred to local community groups who operate them as a business. Procuring permission to build these sites from both legal and unofficial authority figures, and then ensuring the sites stay in the communities' hands, is a difficult process, requiring a great deal of negotiating, politicking, and compromising. There are many people who do not want to see the waterpoints in place. Through its many years of experience, DSK has learned that there is no standard solution to overcoming opposition from these parties, although there are a number of options at their disposal.

When DSK decides to build a waterpoint, they first meet with local inhabitants to explain the plan and decide on a specific location. Usually, most slum dwellers are very keen on the idea, whilst others are adamantly against it – they have illegal connections to city pipes from which they already sell water at a price twice that which the waterpoints charge. During one of the first projects, DSK's problems began with the local mustan, or strongman. The community feared him a great deal and were, at first, reluctant to back anything that he would object to. After speaking to DSK however, they realised that the waterpoint would benefit them enormously and helped select a site. Suitable land is extremely difficult to find in Dhaka's slums, and the only available space was very close to one of the mustan's illegal connections. Of course, he wanted none of this, until the community bought his co-operation with the proposal that he could head the site management committee. DSK eventually got permission from the city corporation (DCC) and the water authority (DWASA) to build.

However, once the mustan realised how the site would be run and that he would not personally profit at all, he changed his mind. Under community pressure to keep his word, he did not overtly offer any resistance, instead sending his lackeys to harass the workers and insist they were digging on private land. Although they had permission from the city to build there, DSK had to persuade community leaders to stand up to the thugs and make them back down. Work resumed, but a few days later the workers were once again told to cease construction, this time by trade union leaders from a local fabric factory that apparently had the site in mind for an office. DSK decided to review the site selection and, once again, consulted the community. One slum

dweller offered the use of his land, provided that a reservoir was built on top of which he could place his residence. The community approved of the idea and construction on the new site began. However, authority figures from another local fabric factory told the workers, yet again, to stop. When they refused, the factory had the police arrest the workers, even though there was no legal premise. Realising this, the police let the workers go but, assuming that DSK had contracted out the work to a smaller group, demanded bribe money. In fact, DSK was doing the work itself and so directly confronted the police, who backed off, having no desire to clash with the city authorities. Eventually the site was finished and the community began operating the facility (without the mustan at the helm). Soon after it opened, an 'informer' who represented the police came and demanded US$25 a month for protection. DSK met with him and, having learned that throwing their weight around could work, told him to stop. This apparently succeeded, since six months have passed with no further harassment. DSK has faced a variety of similar problems at their other sites also. In several cases, factory owners have hindered construction on uninhabited land near their factories ideal for a waterpoint. Usually, this is because they have unofficially claimed the land as their own and fenced it off as a barrier against the slum. DSK tries to maintain civil relationships with the owners, who have political ties, but sometimes have to resort to playing their own political power game with city officials and, even in some cases, cutting illegal fences to access public land. Working with DWASA and the DCC has also proved trying; it took DSK a long time to establishgood relationships. DWASA is fighting corruption within its employees; even so, there were frequent demands for money. DSK and its funding agencies have a policy of not paying bribes, so as a result, applications would get redirected and delayed, in some cases taking a year to process as opposed to a day if palms were greased. Through persistence and a successful (but hardfought) appeal to the morality of water authority workers, DSK is no longer approached for bribes, and frequently enjoys DWASA's support on legal issues. Another problem is preventing operational sites from falling into the hands of mustans. The community groups are designed to prevent this, but it is easy for a local strongman to get himself "elected" as head of the committee. The first site that DSK put in place was seized in such a manner: the mustans told DSK to leave them alone and never return, that they would manage the site themselves. This was unacceptable since the entire idea was to have a community-run, legal connection to the city pipes. The mustans bribed the meter readers to list the meter as broken and, thus, charge a vastly reduced water bill. In addition, DSK

was unable to recover the cost of construction. At the time, the organisation was quite small and unsure of how to resolve the issue. They have since gained a good reputation with the city authorities and have returned to the site, demanding that the construction costs be repaid or the connection will be shut off. This appears to have worked – the mustans have agreed to repay the construction costs, although removing them from the committee is harder, since they are the "elected" representatives of the slum dwellers.

Therefore, these examples demonstrate how, with the right balance of diplomacy and political force, it is possible for an NGO to navigate its way through the red tape and power struggles that hinder project implementation. This is a skill frequently unique to smaller, locally-based NGOs who have the experience and cultural know-how to overcome such difficulties. Working with these NGOs is crucial for larger organisations that are developing projects in such environments. Lessons learned The committees can be weak and easily controlled by the mustans. So now, DSK selects members of the committee from participants in their credit program. They discuss clearly who will own and operate what and place emphasis on participation by women. DSK now implements a two-committee system. The first committee, which manages the regular affairs of the site, is made up of only women. The second, smaller committee (five members) is an advisory committee of only men, who help the management committee to deal with problems such as strong-arming by mustans and 'informers.' Now that DSK is bigger, they have enough employees to monitor the sites regularly, something they were unable to do before. Mustans no longer have the opportunity to steal sites from under DSK's nose. Having the backing of DWASA and the DCC is of enormous help; they are regarded as organisations that no one wishes to cross. DSK's work also benefits DWASA because the connections are legal and the bills get paid – a most unusual occurrence in Dhaka. The city workers generally have a good opinion of DSK and tend to co-operate. Furthermore, DWASA's meter-reading branch is due to be privatised soon, which should drastically reduce corruption and encourage the establishment of legal connections.

15.9 Conclusion

From the above discussion, it is evident that sustainability of water supply management recognises the following features:

- Present and future generations

- The value of water supply
- Shared responsibilities
- Renewable but not limitless water supply stewardship
- Reasonable use and acceptable impacts
- Maintenance of integrity of societal an ecological systems
- Adaptability and flexibility to deal with uncertainties and risks

Moreover, the non-sustainable management of water supply management includes:

- Inadequate consideration of future generations
- Undue recognition of the value and limits of water
- Singular decision making
- Unreasonable use, unacceptable impacts, and high costs
- Imbalance between meeting societal and ecosystem needs
- Inability to deal with droughts, climate change etc.

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Appendix

List of Abbreviations

AIRPs	Arsenic and Iron Removal Plants
APSU	Arsenic Policy Support Unit
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
BAMWSP	Bangladesh Arsenic Mitigation Water Supply Project
BGS	British Geological Society
BNBC	Bangladesh National Building Code
CIDA	Canadian International Development Agency
CSSE	Canadian Society of Safety Engineering
DALYs	Disability Adjusted Life Years
DFID	Department of International Development
DOE	Department of Environment
DPHE	Department of Public Health Engineering
DWASA	Dhaka Water Supply and Sewerage Authority
EPA	Environmental Protection Agency
ETVAM	environmental technology verification for arsenic mitigation
FWPCA	Federation Water Pollution Control Administration
GOB	Government of Bangladesh
HCEs	Health Care Establishments
HCW	Health Care Waste
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature

IWA	International Water Association
MDG	Millennium Development Goal
MICS	Multiple Indicator Cluster Survey
SADC	Southern African Development Community
UFW	Unaccounted for Water
UNDP	United Nations Development Programme
UNICEF	United Nation Children's Fund
USEP	A Environmental Protection Agency
USEPA	United States Environmental Protection Agency
WASH	Water, Sanitation and Hygiene
WDM	Water Demand Management
WEHAB	Water Environment Health Agriculture Biodiversity
WHO	World Health Organization
WSS	Water Supply and Sanitation
WSSD	World Summit on Sustainable Development