



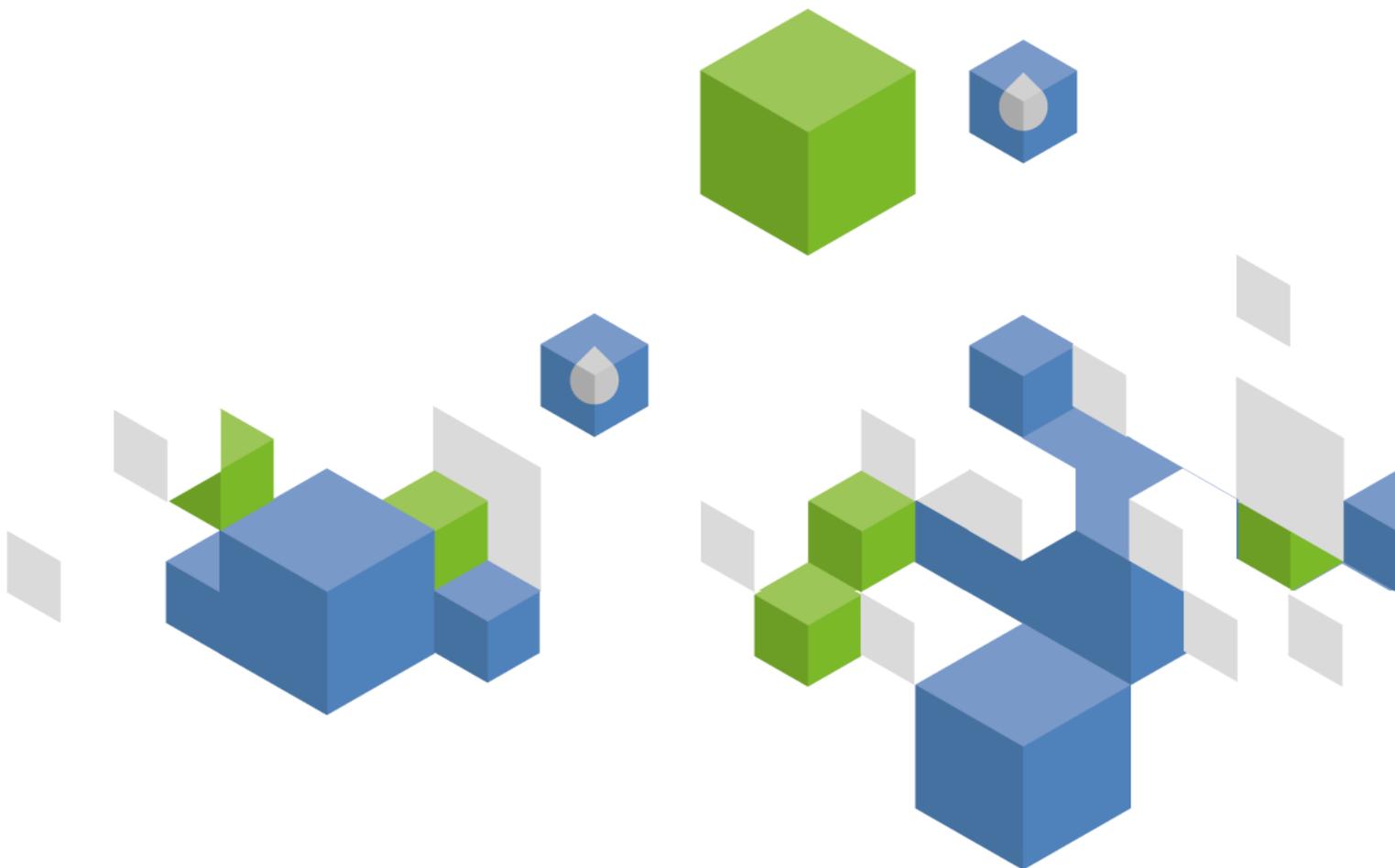
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# Country profile – Maldives

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# Maldives

## GEOGRAPHY, CLIMATE AND POPULATION

### Geography

The Maldives are composed of 1 190 low-lying islands, spreading along a north-south axis over a distance of some 1 000 km, about 600 km southwest of Sri Lanka in the Indian Ocean, of which 198 are inhabited.

The total land area of the Maldives is 300 km<sup>2</sup> (Table 1). The islands form 26 natural atolls, which for administration purposes are grouped into 19 atolls (atholhu, singular and plural): Alifu, Baa, Dhaalu, Faafu, Gaafu Alifu, Gaafu Dhaalu, Gnaviyani, Haa Alifu, Haa Dhaalu, Kaafu, Laamu, Lhaviyani, Meemu, Noonu, Raa, Seenu, Shaviyani, Thaa, Vaavu; and the capital city: Male (Maale). Most of the islands are very small, few have a land area of more than 1 km<sup>2</sup>, with elevations of not more than 2 m above sea level. All the main islands lie around the rim of the atolls, the lagoons are shallow, containing sandbars and cays with deep passages between the atolls.

TABLE 1  
Basic statistics and population

Physical areas			
Area of the country	2009	30 000	ha
Cultivated area (arable land and area under permanent crops)	2009	7 000	ha
• as % of the total area of the country	2009	23	%
• arable land (annual crops + temp fallow + temp meadows)	2009	4 000	ha
• area under permanent crops	2009	3 000	ha
Population			
Total population	2009	312 000	inhabitants
• of which rural	2009	61	%
Population density	2009	1 040	inhabitants/km <sup>2</sup>
Economically active population	2009	146 000	inhabitants
• as % of total population	2009	47	%
• female	2009	42	%
• male	2009	58	%
Population economically active in agriculture	2009	23 000	inhabitants
• as % of total economically active population	2009	16	%
• female	2009	39	%
• male	2009	61	%
Economy and development			
Gross Domestic Product (GDP) (current US\$)	2009	1 473	million US\$/yr
• value added in agriculture (% of GDP)	2009	5	%
• GDP per capita	2009	4 721	US\$/yr
Human Development Index (highest = 1)	2010	0.602	
Access to improved drinking water sources			
Total population	2008	91	%
Urban population	2008	99	%
Rural population	2008	86	%

In 2009 the total cultivated area was an estimated 7 000 ha, of which 3 000 ha were under permanent crops such as coconut and arecanut. Annual crops such as maize, sorghum, cassava, onion and chilies were grown on the other 4 000 ha.

FIGURE 1  
Map of Maldives



MALDIVES

FAO - AQUASTAT, 2011

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## Climate

The islands have a tropical climate with two monsoons, the:

- southwest monsoon from May to September; and
- northeast monsoon from November to March.

There are many thunderstorms during the months of April and October, which is in between the two monsoons. Precipitation is uniformly distributed throughout the year, except for a dry period of about 90 days from January to March. The long-term mean annual rainfall is 1 972 mm.

The daily temperature varies little throughout the year. The annual mean temperature is 28°C, ranging from 26.2 to 30.6°C.

## Population

The total population in 2009 was 312 000 inhabitants, of which around 61 percent lived in rural areas (Table 1). The annual average growth rate during the period 1999-2009 was an estimated 1.5 percent. The population is concentrated on Male Island, while many of the other islands remain sparsely populated. Only 198 islands out of 1 190 are inhabited. Considering all islands together, in 2009 the average population density was 1 040 inhabitants/km<sup>2</sup>, but it is much higher if taking only those islands where the majority of the people live.

Access to improved drinking water sources in 2008 reached 91 percent (99 and 86 percent for the urban and rural population respectively) and 98 percent of the population had access to improved sanitation (100 and 96 percent for urban and rural populations respectively). Following the 2004 tsunami, 79 islands had no safe drinking water and 15 percent of the water systems were destroyed or contaminated.

## ECONOMY, AGRICULTURE AND FOOD SECURITY

The total population economically active in agriculture was around 23 000 inhabitants (2009), amounting to 16 percent of the economically active population. Of the total population economically active in agriculture 39 percent were women. In 2009, the gross domestic product (GDP) was US\$ 1 473 million of which agriculture accounted for 5 percent.

Maldivians rely on natural rainfall for agriculture. The main crops are maize, sweet potatoes, millet, almonds, sugarcane, pineapples, taro, cassava, and a number of tropical fruits and vegetables. Fruits, such as sweet bananas, papaya, mangoes, limes, star-apples and guavas are grown within the compounds of each family's property together with a few vegetables.

The Maldives depend on imports for most food requirements and income that is generated by the two main activities, fisheries and tourism, is used to meet import requirements (Shabau, 2008). Fish is the main export product, followed by that coir and copra that are produced from the coconut palms. Recently, attempts have been made to encourage people to return to farming rather than depending on imported goods such as rice, which is the staple food, and wheat. Uninhabited islands, especially those next to the inhabited, are often leased to individuals, or villages, who become responsible for the maintenance of the island's vegetation, coconut trees and imeber. Coconut production is the dominant agricultural activity and a large variety of local timber is grown for domestic use. Watermelons are grown mainly on Thoddoo Island in the Alifu atoll. Some villagers keep goats and chickens although space is limited (Lamberti, 2007).

The impact of the tsunami in December 2004 was felt across the country, rather than in certain parts or regions. About 100 000 people, or one-third of the population, were severely affected. While loss of life, fortunately, was low, damage on many islands was great, especially hitting tourism on which the

economy depends heavily. Of the 198 inhabited islands, 53 suffered severe damage and 10 percent of the islands were destroyed. Schools, clinics and pharmacies were destroyed on some 50 islands. According to the National Disaster Management Centre 64 schools, 30 health centres, and 60 island administrative facilities needed to be reconstructed or rehabilitated. In total, more than 5 000 buildings were damaged (ADB, 2006).

## WATER RESOURCES

There are no permanent rivers or streams on any of the islands, but small brackish ponds or freshwater lakes known as kulhis are found on some islands. Rainwater is collected on a small scale and used for drinking.

The Maldives finds it extremely difficult to obtain suitable drinkable water. Groundwater is found in freshwater lenses underlying the atolls and floating on top of the saline water, but heavy abstraction for municipal use has depleted them, especially in the capital city of Male, causing saltwater intrusion. Groundwater is recharged by rainfall but becomes contaminated while percolating through the soil, which is generally polluted with organic and human waste.

A rough estimate of the groundwater resources, based on an assumed 0.1 m/year recharge throughout the country (300 km<sup>2</sup>), is 0.03 km<sup>3</sup>/year, may be the Maldives' only renewable water resource. This is hardly exploitable because of seawater intrusion and pollution (Table 2).

TABLE 2  
Water resources

Renewable freshwater resources			
Precipitation (long-term average)	-	1 972	mm/yr
	-	590	million m <sup>3</sup> /yr
Internal renewable water resources (long-term average)	-	30	million m <sup>3</sup> /yr
Total actual renewable water resources	-	30	million m <sup>3</sup> /yr
Dependency ratio	-	0	%
Total actual renewable water resources per inhabitant	2009	96	m <sup>3</sup> /yr
Total dam capacity	-	-	million m <sup>3</sup>

Where the quality of water has been degraded (by high salinity and/or polluted water), and where there is insufficient space available for rainwater collection and storage, desalination has become the only alternative means of providing a safe water supply. This is the case in the capital Male and in what was the most densely populated island Kandholhudhoo in Raa Atoll. The size of this latter island is only 0.044 km<sup>2</sup>, meaning roughly 210 m by 210 m. It was home to over 3 000 people, but it was one of the islands most affected by the tsunami and all inhabitants were left homeless and had to evacuate.

The first desalination plant in Male was installed in 1988 with a capacity of 200 m<sup>3</sup>/day. In line with increases in population and water consumption, the capacity has been increased steadily and is now 5 800 m<sup>3</sup>/day. The quantity of desalinated water used in Male has increased from 323 300 m<sup>3</sup> in 1996 to 1 206 900 m<sup>3</sup> in 2001, equal to about 900 and 3 300 m<sup>3</sup>/day respectively (Ibrahim et al., 2002). The desalination plant in Kandholhudhoo, constructed in 1999, has a production capacity of 50 m<sup>3</sup>/day (18 262 m<sup>3</sup>/year), and is a reverse osmosis plant.

When the population of Kandholhudhoo was served by desalinated water in May 1999, about 28 percent of the population of the Maldives had access to desalinated water and over 20 percent of the population almost entirely depended on desalinated water, besides the tourists on the resort islands. Desalination plants have been used in the Maldives' tourist resorts since the late 1970s. Currently each resort island has its own desalination plant, which is usually operated and maintained by a technician appointed for that purpose.

A large international company signed a US\$ 42 million water purchase agreement in 2010 with Southern Utilities Limited to provide potable water to the Southern Province of the Maldives, which includes the

Seenu and Gnaviyani atolls. The current population of around 26 000 is projected to increase to around 37 000 over the life of the contract. The company will construct six seawater reverse osmosis desalination plants with a total production of 3 000 m<sup>3</sup>/day and will design and construct the distribution system to enable storage and delivery of potable water to over 4 500 households. After the commissioning period, it will operate and maintain the desalination plants for 20 years. In addition, it will design and construct four new sewage treatment plants as well as a new sewer collection system to transport wastewater from households to the new treatment plants and it will operate and maintain the sewage treatment system for the same 20 year period (IRC, 2010).

## WATER USE

No recent figures are available on water withdrawal in the Maldives. It is, therefore, estimated that in 2008 the total municipal water withdrawal was 5.6 million m<sup>3</sup> against 3.3 million m<sup>3</sup> in 1987 (Table 2 and Figure 2). The industrial withdrawal was around 0.3 million m<sup>3</sup> against 0.1 million m<sup>3</sup> in 1987. No information is available on water withdrawal for irrigation. If, however, there is irrigation it will mostly rely on collected rainwater. This gives a total water withdrawal of 5.9 million m<sup>3</sup>, of which 1.225 million m<sup>3</sup> is provided by desalinated water. The above amounts do not include water used by tourists. An estimated 500 000 tourists visit the Maldives per year and all tourist resorts have their own desalination plants. In addition, many people collect and store rainwater for their use, which is not included in the above amounts.

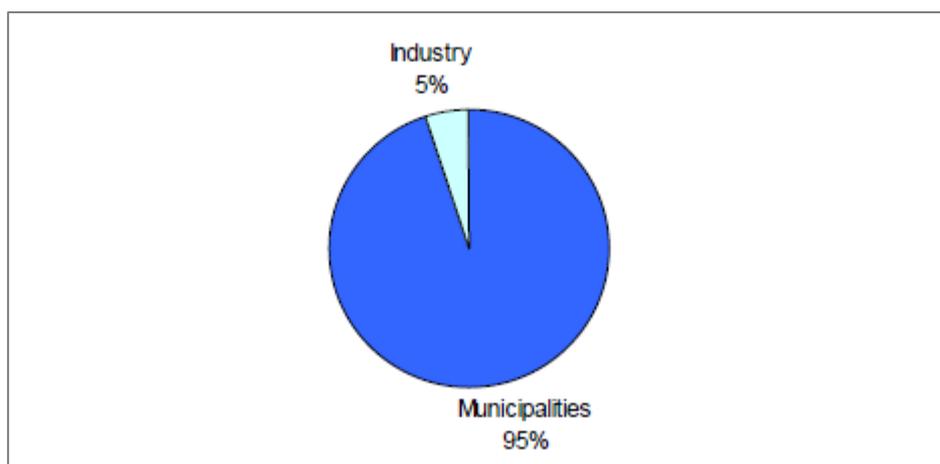
TABLE 3  
Water use

Water withdrawal			
Total water withdrawal	2008	5.9	million m <sup>3</sup> /yr
- irrigation + livestock	2008	-	million m <sup>3</sup> /yr
- municipalities	2008	5.6	million m <sup>3</sup> /yr
- industry	2008	0.3	million m <sup>3</sup> /yr
• per inhabitant	2008	19	m <sup>3</sup> /yr
Surface water and groundwater withdrawal	2008	4.675	million m <sup>3</sup> /yr
• as % of total actual renewable water resources	2008	15.6	%
Non-conventional sources of water			
Produced wastewater		-	million m <sup>3</sup> /yr
Treated wastewater		-	million m <sup>3</sup> /yr
Reused treated wastewater		-	million m <sup>3</sup> /yr
Desalinated water produced	2001	1.225	million m <sup>3</sup> /yr
Reused agricultural drainage water		-	million m <sup>3</sup> /yr

Rainwater is tapped from roofs and collected and stored in various types of tanks. All the islands have individual household as well as community tanks. The situation is different on the island Male, which is the capital and where everyone has access to desalinated water distributed through a piped network. In Male it is common for people to use desalinated water for drinking and cooking, bathing and other domestic purposes because the groundwater is highly contaminated. Groundwater is mainly used to flush toilets. Those who can, however, often prefer to collect rainwater for drinking to save money. Those who cannot afford to have house connections can collect limited quantities of water for free from tap bays located in 15 places around the island (Ibrahim et al., 2002).

As in Male, many islands are now facing groundwater problems caused by human activities such as over-abstraction and sewage pollution. The island of Kandholhudhoo, the most densely populated island before the tsunami, had experienced problems similar to Male. A freshwater lens polluted by poor sanitation facilities and depleted by over-extraction, coupled with insufficient space to collect enough rainwater for the island's population, has left little alternative but desalination.

FIGURE 2  
**Water withdrawal by sector**  
 Total 0.0059 km<sup>3</sup> in 2008



In the tourist resorts, the desalinated water produced is generally used for cooking and bathing only, as guests are encouraged to buy bottled water for drinking. Rainwater is sometimes collected for staff to drink, and groundwater is sometimes used for irrigation of tiny areas, though neither resource is used to its full extent. On a few resorts treated wastewater is used for irrigation of food crops and some landscaping, but no data are available, though the amount must be very small (Ibrahim et al., 2002).

## IRRIGATION AND DRAINAGE

### Evolution of irrigation development

No information is available on irrigation areas. There is usually no irrigation because crops are rainfed, but some irrigated areas may exist around tourist resorts for some crops, such as vegetables and for landscaping.

Currently, some agricultural activities in the Maldives may rely on sunken wells and manual watering for crop irrigation. That procedure, while labour intensive, ensures sustainable use of water as a small plot of land, or a number of plots close together, may be adequately served by one or two wells (Zuhair, undated). On some islands, such as Thoddoo Island in the Alifu Atoll, mechanized irrigation systems are used. Pumps are used to draw water from a number of sunken wells through large hoses. Water is applied over the entire soil surface, but most of it will not reach the roots and will be lost through evaporation, making it a crude and wasteful form of irrigation. Localized irrigation aimed directly at the roots would be more feasible. Some new methods are being tested by the Ministry of Fisheries and Agriculture.

## WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

### Institutions

The most important institutions concerned with water management are:

- Environmental Protection Agency (EPA): In 2009, the President of the Maldives abolished the Maldives Water and Sanitation Authority (MWSA), established in 1973, and the Environment Research Centre and transferred all activities to the newly established EPA. Following this change, the EPA was linked to the Ministry of Housing, Transport and Environment. It operates as a regulatory authority administered under a governing board (WASH, 2009).
- Male Water and Sewerage Company (MWSC): This was established in 1995 and is responsible for the operation and management of water supply and sewerage services in Male.

- Ministry of Housing, Transport and Environment.

Ministry of Fisheries and Agriculture (MOFA): Has the overall mandate for the sustainable management and development of the nation's fisheries, agriculture and marine resources.

### Water management

The development of sustainable water supplies should rely on a combination of developing groundwater resources and rainwater harvesting. Desalination is considered an expensive alternative in the Maldives, but one that is necessary on some islands. Desalination is widely used in the 87 tourist resorts. These are islands set aside solely for tourists, and each island has its own small desalination plant. It is an affordable option, because the islands are generating substantial revenue from the tourists.

Groundwater resources management requires improved land-use planning, assessment of groundwater conditions before development, and the designation of groundwater protection zones. The need for groundwater quality protection through improved sewage treatment and disposal of wastewater is recognized. Trials are to begin on use of gravel bed hydroponics (GBH) or constructed wetlands for sewage treatment to protect the groundwater from pollution. The kulhis (freshwater ponds) could be developed as a water resource, though studies have yet to be undertaken to explore this feasibility (Ibrahim et al., 2002).

Training is required for the following (Ibrahim et al., 2002):

- water quality monitoring and groundwater assessment, processing and interpretation of data and selection and use of equipment;
- developing geographical information systems (GIS) and groundwater modelling techniques, hydrology, hydrogeology and surveying;
- water balance studies to assess groundwater recharge and sustainable yield using climate and other data;
- design of appropriate groundwater pumping systems including infiltration galleries; and
- appropriate methods and techniques for determining marine water quality.

The government's policy is to ensure that all inhabited islands have water supplies that meet basic requirements. Except for Male, current investment on the islands is for rainwater collection to develop a consistent supply of safe water for drinking and cooking. The Government's objective, according to the Health Master Plan 1996–2005, is to provide access to 10 litres/person per day of safe water for drinking and cooking for the entire population and, on islands where groundwater is not potable, to provide 40 litres/person per day.

In 2006, MWSA presented the five-year activity plan, with the following activities: water resources assessment and monitoring, water supply and sanitation guidance and regulation development, and water and wastewater quality compliance monitoring (MWSA, 2006).

### Finances

The cost of water varies, depending on whether it is used for domestically or commercially. The domestic tariff is stepped to provide a minimum quantity of water per day at an affordable rate. Table 4 gives the details of water tariffs in Male (Ibrahim et al., 2002). Male's desalinated water is expensive. The average household spends between US\$ 40–60 per month on water, while earning something like US\$ 668 dollars per month, so people can spend about 6–9 percent of their income on their water bill (MPND/UNDP, 1998). Wastewater charges are also included in the water charge. The advantage of the present arrangement is that the public has the choice of using groundwater, rainwater or desalinated water according to the customer's needs and their income. The application of charges has made the public aware and willing to conserve and use water judiciously (Ibrahim et al., 2002).

TABLE 4  
Water tariffs in Male (2002)

Consumer group	Thresholds for fixing rates	Price to consumer, per m <sup>3</sup>
Domestic household	Up to 90 litres/day	MRf 25.32, equivalent to US\$1.99 (band A)
	90–270 litres/day	MRf 75.95, equivalent to US\$5.96 (band B)
	270 litres/day and above	MRf 101.26, equivalent to US\$7.94 (band C)
Institutions	Metered flat rate	MRf 75.95, equivalent to US\$5.96
Commercial	Metered flat rate	MRf 101.26, equivalent to US\$7.94

The associated costs of desalinated plants on resort islands are covered by revenue accrued by the resorts, of which they are a relatively small percentage.

The total cost of purchase, transport and installation of the desalination plant in Kandholhudhoo was US\$ 102 000 and the cost per m<sup>3</sup> of water around US\$ 7.84. This tariff covers the cost of operation and routine maintenance, but does not provide any additional funds to cover the cost of replacing the filter membranes or other spare parts, which can be expensive and difficult to obtain. The government met the capital cost of the plant and no attempt is being made to recover this cost through the tariff being collected. The responsibility for operation and maintenance of the plant on Kandholhudhoo is held by the Island Office, equivalent to a local government office.

### Policies and legislation

The following policies for the sustainable development of water resources were set out in the context of the Health Master Plan 1996–2005 and the Second National Environmental Action Plan 1999:

- To increase collection and storage of rainwater at household level. This will include the sizing of rainwater tanks at the household level to have sufficient capacity to store rainwater to last the whole year through.
- To improve community collection and storage by increasing the storage capacity, renovating existing tanks, increasing catchment areas and conducting information, education and communication (IEC) activities to ensure rainwater is collected safely. This will include the building of underground rainwater tanks during construction of community buildings, and will encourage directing rainwater into household wells where rainwater tanks are not available.
- To pilot new schemes such as community groundwater systems (infiltration galleries) in areas of low salinity with a low risk of pollution, as a means of supplementing rainwater supplies where necessary.
- In order to protect groundwater resources from becoming saline, to discourage the use of electric pumps.

### ENVIRONMENT AND HEALTH

During the 1970s, the quantity of water drawn from Male's aquifer increased tremendously together with the amount of sewage disposed into the ground made it more susceptible to groundwater pollution. Water-borne diseases such as diarrhoea, cholera, shigella and typhoid started spreading because of the poor sanitary conditions. In response to this problem, a special office was established in 1973, the Maldives Water and Sanitation Authority (MWSA). A study carried out by MWSA in Male revealed about 1.3 million litres of water were being used from the aquifer daily, the thickness of the freshwater lens had reduced to about 12 m and there was rapid deterioration of groundwater quality. This was because of a larger population and poor sanitary conditions.

Outbreaks of cholera in 1978 and shigella in 1982 claimed many lives. As a result, the Male Water Supply and Sewerage project was conceived (Ibrahim et al., 2002). Detailed surveys were carried out in 1980/1981. Subsequently, with assistance from West German Aid, the Saudi Fund for Development and the European Commission, the Government implemented the Male Water Supply and Sewerage Project in 1985. Under the project, the following work was carried out in Male between 1985 and 1988:

- eight boreholes were drilled to investigate the aquifer and for subsequent monitoring;
- large steel tanks were installed for storage of rainwater, with a total capacity of 9 900 m<sup>3</sup>;
- water from these tanks was pumped into a holding tank (600 m<sup>3</sup>) and later distributed from a water tower (95 m<sup>3</sup>) by gravity and distributed at 30 tap bays free of charge during selected hours;
- 1 154 household tanks were built, with a total capacity of 4 157 m<sup>3</sup>;
- new wells were sunk in mosques and disinfected well water was fed to tap bays located at these locations, and distributed to the public free of charge throughout the day; and
- a sewerage scheme was built for the whole island of Male. Sewage flows by gravity to sumps located in nine areas and is pumped from pumping stations into the deep sea without treatment through six outfalls located at four different places (Ibrahim et al., 2002).

In the 1990s, the population of Male continued to grow and increasing pressure was placed upon the island's freshwater lens. Though the new sewerage scheme, using septic tanks and soakaways, helped to alleviate the pollution of the lens, it contributed to another problem. The increased volume of groundwater being used to flush toilets was no longer returning to the aquifer but was being discharged into the sea. As a result, the salinity of the aquifer increased sharply, limiting its usefulness as a resource. Because the available roof catchment area and the space available for rainwater storage was too limited to provide for Male's increasing population, desalination became one of the few options available for providing sufficient safe water to Male.

In 1988 the first desalination plant was installed, a reverse osmosis plant with a capacity of 200 m<sup>3</sup>/day. Since then, more plants have been installed to satisfy demand, currently 5 000 m<sup>3</sup> of desalinated water can be produced per day. In 1995 a joint venture company, Male Water and Sewerage Company (MWSC) was formed and the responsibility was transferred for the operation and management of water supply and sewerage services in Male. The Maldives Water and Sanitation Authority became responsible for regulating this company, though it retains responsibility for providing services to the other inhabited islands (Ibrahim et al., 2002).

Outside the capital, the major source of groundwater pollution is poor household sanitation. Fortunately, there are relatively few heavy industries and intensive agriculture is practiced on only a couple of islands. The majority of households have septic tanks and soakaways. The tanks are often poorly built or have suffered from hydrogen sulphide corrosion and are prone to leakage. As a result, tanks are often full or nearly full of sludge and have very short retention times. Soakaways are usually deep pits, not shallow trenches. Rather than use the unsaturated soil above the water table to remove at least some of the pollutants from the septic tank effluent, they effectively create a shortcut for septic tank effluent to reach the groundwater below. These factors combine to cause the contamination of groundwater resources by septic tank effluent (Ibrahim et al., 2002).

When the December 2004 tsunami hit the Maldives, waves swept over many islands, affecting nearly one-third of the country's inhabitants. The saltwater from the tsunami completely flooded the sewage systems, contaminating groundwater with raw sewage and creating unsanitary conditions and increasing the risk of disease. The powerful waves also destroyed much of the infrastructure by overflowing sewage catch-pits, bursting pipes and filling the air with a foul stench. The islands' residents rely on groundwater as their main source of water for domestic activities such as cooking, cleaning and washing (ARC, 2006). An Asian Development Bank (ADB) grant for environmental management focuses predominantly on environmental health and awareness. It designed a strategy for reconstructing the water and sanitation sector following the tsunami and improving the country's environmental assessment capability. It also tests innovative environmental public awareness programmes and promotes community management of sanitation and solid waste systems (ADB, 2006).

## PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

The Maldives, ranks fifth amongst the countries with the highest population density, the most important preoccupation remains water availability and accessibility. Ways are sought continuously to improve availability by desalinating water, treating wastewater, collecting and storing rainwater and responsibly using and conserving the little groundwater available.

Following the tsunami, it was estimated that the Maldives would need about US\$ 304 million to effectively implement a recovery and reconstruction strategy, according to the joint needs assessment Tsunami: Impact and Recovery carried out by the ADB, the United Nations system, and the World Bank (ADB, 2006).

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