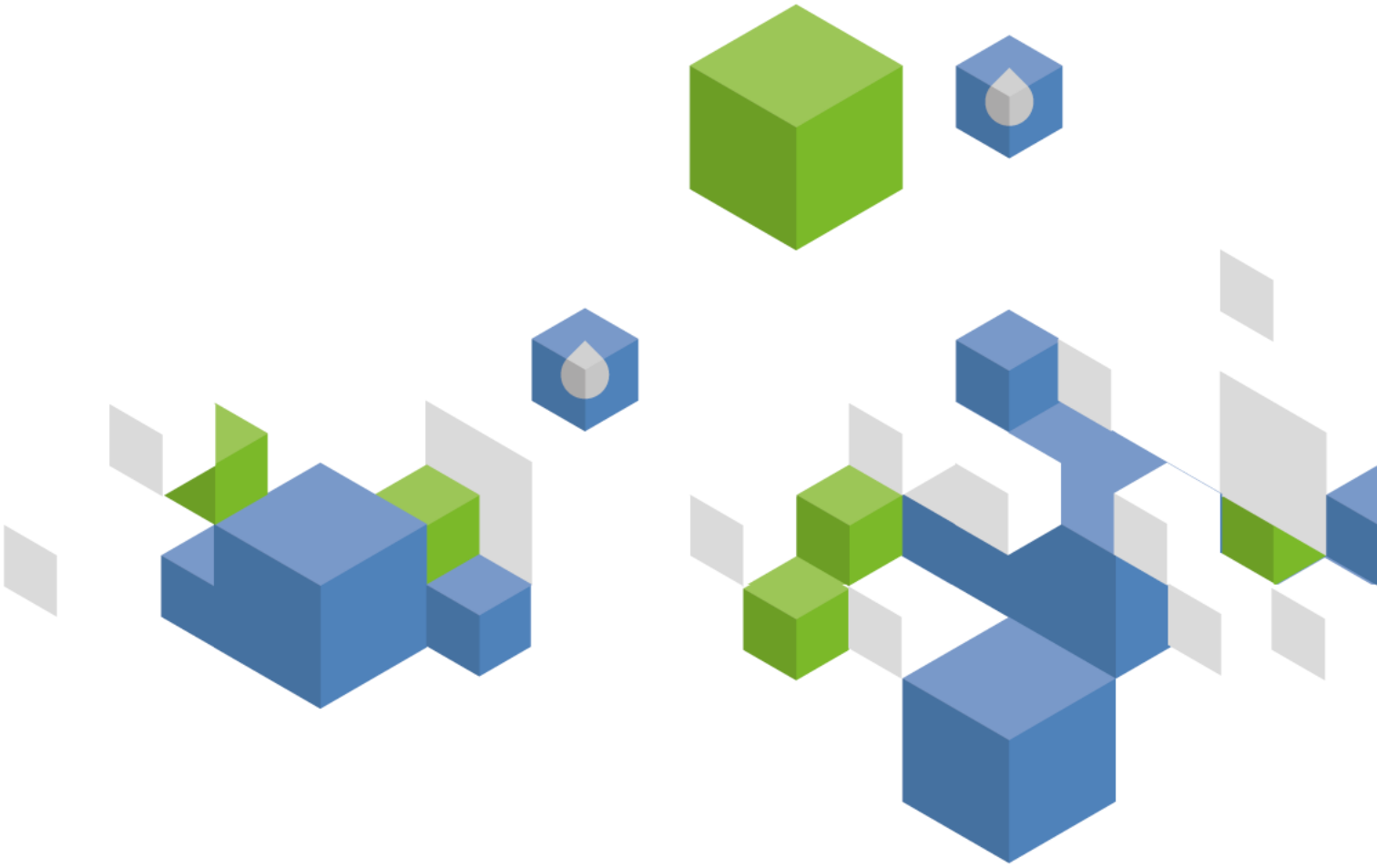
Food and Agriculture Organization of the United Nations

FAO AQUASTAT Reports

Country profile – Yemen

Version 2008



Recommended citation: FAO. 2008. AQUASTAT Country Profile – Yemen.
Food and Agriculture Organization of the United Nations (FAO). Rome, Italy

Yemen

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Yemen, with a total area of 527 970 km^2, is located on the south-western edge of the Arabian Peninsula. Apart from the mainland it includes many islands, the largest of which are Socotra in the Arabian Sea and Kamaran in the Red Sea. The country is bordered by Saudi Arabia to the north, Oman to the east, the Arabian Sea and the Gulf of Aden to the south, and the Red Sea to the west. The present Republic of Yemen was created in 1990 as a result of the unification of the former Yemen Arab Republic (YAR) and the People's Democratic Republic of Yemen (PDRY). The country is divided into 21 administrative governorates, including the three newly created governorates Amran and Al-Daleh, created in 2000, and Raimah, created in 2004.

The cultivable land is estimated at about 3.62 million ha, which is 7 percent of the total area. In 2004 the total cultivated area was 1.19 million ha, compared with 1.05 million ha in 1994, of which 81 percent consisted of temporary crops and 19 percent of permanent crops (Table 1). The main crops were cereals, covering about 686 000 ha (58 percent of the total cultivated area), and qat, covering 122 844 ha (10 percent). Farm size, including both rainfed and irrigated agriculture, is generally very small: 62 percent of farms have less than 2 ha, while only 4 percent cover more than 10 ha.

TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2005	52 797 000	ha
Cultivated area (arable land and area under permanent crops)	2004	1 188 888	ha
• as % of the total area of the country	2004	2.3	%
• arable land (annual crops + temp. fallow + temp. meadows)	2004	956 855	ha
• area under permanent crops	2004	232 033	ha
Population			
Total population	2005	20 975 000	inhabitants
• of which rural	2005	73.7	%
Population density	2005	39.7	inhabitants/km^2
Economically active population	2005	6 820 000	inhabitants
• as % of total population	2005	32.5	%
• female	2005	28.5	%
• male	2005	71.5	%
Population economically active in agriculture	2005	3 091 000	inhabitants
• as % of total economically active population	2005	45.3	%
• female	2005	44.2	%
• male	2005	55.8	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2007	22 520	million US$/yr
• value added in agriculture (% of GDP)	2000	10	%
• GDP per capita	2005	796	US$/yr
Human Development Index (highest = 1)	2005	0.508	
Access to improved drinking water sources			
Total population	2006	66	%
Urban population	2006	68	%
Rural population	2006	65	%

FIGURE 1
Map of Yemen

YEMEN

FAO - AQUASTAT, 2008

Geographically, the country can be divided into three physiographic regions: the western, the eastern and the southern escarpment. Cultivated areas are mostly silty, with a high degree of heterogeneity, both laterally and vertically. Lower wadi reaches are extensively affected by blown sand, which tends to form dunes. The wadi soils are alluvial deposits, mostly consisting of fine sands and silts, which may reach several metres in depth. Agricultural soils have a high pH of about 7.8 to 8.0, very little organic matter and are nearly always deficient in nitrogen and phosphorus. Most of the land areas in the highlands are steep, rugged and badly eroded as a consequence of overgrazing and removal of woody vegetation. Agriculture is restricted to hillside terraces and riparian farms on the sides of the wadis, which range in size from a few metres to more than 100 metres, depending on the geologic and geomorphic features of the wadis. Soils captured by terraces show profiles of varying depths and morphology.

Climate

The climate is semi-arid to arid. Rainy seasons occur during the spring and the summer. Rainfall depends on two main mechanisms: the Red Sea Convergence Zone (RSCZ) and the monsoonal Inter-Tropical Convergence Zone (ITCZ). The RSCZ is active from March to May. Its influence is most noticeable at the higher altitudes in the western parts of the country. The ITCZ reaches Yemen in July-September, moving north and then south again so that its influence lasts longer in the south. Rainstorms observed during the winter months of December and January are attributed to the influence of the Mediterranean Sea.

The country can be divided into fourteen agro-climatic zones, which can be grouped into five regions:

- The Coastal Plains: the plains are located in the west and southwest and are flat to slightly sloping, with maximum elevations of only a few hundred meters above sea level. Temperatures vary from 27°C to 42°C and rainfall is low to very low (< 200 mm/year). Nevertheless, the plains contain important agricultural zones due to the numerous wadis that drain the adjoining mountainous and hilly hinterland.
- The Yemen Mountain Massif: this massif constitutes a high zone of very irregular and dissected topography, with elevations ranging from a few hundred meters to 3 760 m above sea level. The climate varies from hot at lower elevations to cool at the highest altitudes. The western and southern slopes are the steepest and enjoy moderate to rather high rainfall, on average 300–500 mm/year, but in some places even more than 1 000 mm/year. The eastern slopes show a comparatively smoother topography and average rainfall decreases rapidly from west to east.
- The Eastern Plateau: this region covers the eastern half of the country. Elevations decrease from 1 800 to 1 200 m at the major watershed lines to 900 m on the northern desert border and to sea level on the coast. The climate in general is hot and dry, with average annual rainfall below 100 mm, except in the higher parts. Nevertheless, floods following rare rainfall may be devastating.
- The Desert: between the Yemen Mountain Massif and the Eastern Plateau lies the Ramlat as Sabatayn, a sand desert. Rainfall and vegetation are nearly absent, except along its margins where rivers bring water from adjacent mountain and upland zones. The Rub Al Khali Desert in the north extends far into Saudi Arabia and is approximately 500 000 km^2 in area.
- The Islands: the most important island is Socotra, where more exuberant flora and fauna can be found than in any other region in Yemen.

Population

Total population is almost 21 million (2005), of which 74 percent is rural (Table 1). The average annual demographic growth rate is estimated at 3.2 percent during the period 2000-2005. The average population density is about 40 inhabitants/km^2, but the population density is quite different from one governorate to another. About 43 percent of the population lives in four governorates: Ta'iiz with 2.4 million, Hodiedah with 2.2 million, Ibb with 2.1 million and the capital city Sana'a with 1.8 million

inhabitants. This is closely related to the physical environment. By far the largest part of the population lives in the Yemen Mountain area in the western part of the country, where rainfall is still significant, although not high in many locations. The hostile environment of the desert and eastern upland areas is reflected in low population density.

In 2006, 46 percent of the population had access to improved sanitation (88 and 30 percent in urban and rural areas respectively) and 66 percent had access to improved water sources (68 and 65 percent in urban and rural areas respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2007, the national Gross Domestic Product (GDP) of Yemen was US$ 22.5 billion. The total economically active population was 6.8 million (32.5 percent of the total population), of which 71.5 percent male and 28.5 percent female.

The agriculture sector plays an important role in the economy of the country. Although its contribution to GDP is only about 10 percent (2000), the sector employs more than 45 percent of the total economically active population (50.4 percent in 2000) and provides livelihood to more than two-thirds of the population. The discrepancy between the contribution of agriculture to GDP and the percentage of those employed in this sector reflects seasonal employment, underemployment and the low productivity of workers and factors of production, thus resulting in low incomes and poor standards of living for workers in agriculture. Women are involved in nearly all agricultural activities, providing 44 percent of the population economically active in this sector, but cultural traditions keep them at a lower status and prevent them from gaining control over important household resources.

According to the Agriculture Census, the total cereal area showed a negative trend between 1998 and 2004, with total cereal production decreasing by 0.6 percent per year. The average domestic cereal production in 2000–2004 covered only 21 percent of the domestic demand, estimated at 2.73 million tons. The cost of imported cereal has increased from US$ 195.2 million in 2000 to US$ 315 million in 2004. When aggregating main food imports, cereals (2.3 million tons), sugar (468 000 tons), vegetables and fruit (77 000 tons), livestock and milk products (164 000 tons), the food import bill reaches US$ 744 million. Food exports total around US$ 236 million and are dominated by fish products with 76 percent of food export value (US$ 181 million), coffee (US$ 14.4 million), banana (US$ 8 million), onion (US$ 7.6 million) and other fruits (US$ 4.3 million).

WATER RESOURCES

Annual rain volume all over the country varies between 67 and 93 km^3. Precipitation falls more on the western highlands, southwest highlands and the upper plateaus. It then gradually becomes lower towards the east. The ratio between the rainfall and potential evaporation reaches around 0.03–0.25 in the Rub Al Khali Desert.

The country can be subdivided into four major drainage basins, grouping numerous smaller wadis:

- the Red Sea Basin
- the Gulf of Aden Basin
- the Arabian Sea Basin
- the Rub Al Khali Interior Basin

The floods of the wadis are generally characterized by abruptly rising peaks that rapidly recede. Between the irregular floods the wadis are either dry or carry only minor base flows. Surface water resources have been estimated at 2 km^3/year, but this quantity corresponds to the runoff from major rivers and does not include the runoff produced within the smaller catchments. Renewable groundwater resources have been estimated at l.5 km^3/year of which a large part, estimated at 1.4 km^3/year, probably comes

from infiltration in the river beds. Total internal renewable water resources are thus estimated at around 2.1 km^3/year (Table 2).

TABLE 2
Water resources

Renewable freshwater resources			
Precipitation (long-term average)	-	167	mm/yr
	-	88.17	10^9 m^3/yr
Internal renewable water resources (long-term average)	-	2.1	10^9 m^3/yr
Total actual renewable water resources	-	2.1	10^9 m^3/yr
Dependency ratio	-	0	%
Total actual renewable water resources per inhabitant	2005	100	m^3/yr
Total dam capacity	2006	462.5	10^6 m^3

Surface runoff to the sea measured in some major wadis is estimated at 270 million m^3/year and groundwater outflow to the sea at 280 million m^3/year. There might be some groundwater flowing into Saudi Arabia but no data are available. The existence of surface drainage crossing into Saudi Arabia suggests that some sharing of surface flows could be possible, but details are not known.

The volume of groundwater reaches around 10 km^3, of which 1 km^3 in the Al-Masila Basin, 2.5 km^3 in the Tihama Basin and the remaining distributed over the other regions.

Yemen has a long history of dam construction and the ancient civilization was founded upon the great dam of Ma'areb, the destruction of which marked the end of its existence. After the revolution, the government carried out the reconstruction of the Ma'areb Dam financed by the United Arab Emirates. The new dam has a capacity of 400 million m^3. The remaining dams have a total capacity of 62.5 million m^3, giving a total dam capacity of 462.5 million m^3.

There are over a thousand hydraulic structures falling into three different categories:

1. Dams: 347 storage dams have been constructed in the upper lands to store rainfall water for irrigation and for domestic use, and to recharge sub-aquifers. There are three types: large dams with a capacity above 500 000 m^3, medium dams with a variable capacity from 200 000 to 500 000 m^3 (71 dams of this type have been constructed) and small dams with a capacity of less than 200 000 m^3.
2. Spate water diversion structures: 33 of these structures have been constructed in the main wadis for spate water regulation and diversion.
3. Small water harvesting structures: this category includes cisterns, pits and reservoirs with a storage capacity ranging from 500 m^3 to 50 000 m^3.

Thirteen wastewater treatment plants (WWTP) are in operation. They are concentrated in the capitals of the governorates and in some secondary cities. However, while the cities are growing fast, the capacity of the plants has not increased. For example, in Sana'a the WWTP was designed to treat 25 000 m^3/day of wastewater, but now it receives more than 50 000 m^3/day. Similarly, in Ibb city the WWTP was designed to receive 5 000 m^3/day, but now it receives more than 10 000 m^3/day. These examples reflect the insufficient treatment leading to the production of bad quality water that is not suitable for irrigation. The Ministry of Agriculture and Irrigation considers this water to be harmful and it should be appropriately treated in a way that prevents environmental pollution. In 2000, the total volume of produced wastewater was 74 million m^3 and the treated wastewater was 46 million m^3 in 1999, while the amount of treated wastewater used in agriculture was only 6 million m^3/year in 2000.

In 2002, the total installed gross desalination capacity (design capacity) was 76 596 m^3/day or 28 million m^3/year (Wangnick Consulting, 2002). The production of desalinated water reached 25.1 million m^3 in 2006, an increase of 151 percent compared with 1989, contributing to the water supply of Aden city.

WATER USE

Between 1990 and 2000 total water withdrawal increased from 2.9 km^3/year to 3.4 km^3/year. In 2000, 90 percent of water withdrawal was used for agricultural purposes, 8 percent for municipal use and 2 percent for industrial use (Table 3 and Figure 2). Most of the water withdrawn was groundwater (from wells and springs) (Figure 3), resulting in groundwater depletion as withdrawal exceeded the annual groundwater recharge. The rate of decline of the groundwater levels is alarmingly high in many zones, especially in the highlands, where a decline of 2 to 6 m/year is commonly observed. In coastal zones overexploitation of groundwater leads to salt water intrusion. The decline in groundwater tables has also significantly reduced spring-fed irrigation.

TABLE 3
Water use

Water withdrawal			
Total water withdrawal	2000	3 400	10^6 m^3/yr
- irrigation + livestock	2000	3 060	10^6 m^3/yr
- municipalities	2000	272	10^6 m^3/yr
- industry	2000	68	10^6 m^3/yr
• per inhabitant	2000	187	m^3/yr
Surface water and groundwater withdrawal	2000	3 390	10^6 m^3/yr
• as % of total actual renewable water resources	2000	161	%
Non-conventional sources of water			
Produced wastewater	2000	74	10^6 m^3/yr
Treated wastewater	1999	46	10^6 m^3/yr
Reused treated wastewater	2000	6	10^6 m^3/yr
Desalinated water produced	2006	25.1	10^6 m^3/yr
Reused agricultural drainage water		-	10^6 m^3/yr

FIGURE 2
Water withdrawal by sector
Total 3.400 km^3 in 2000

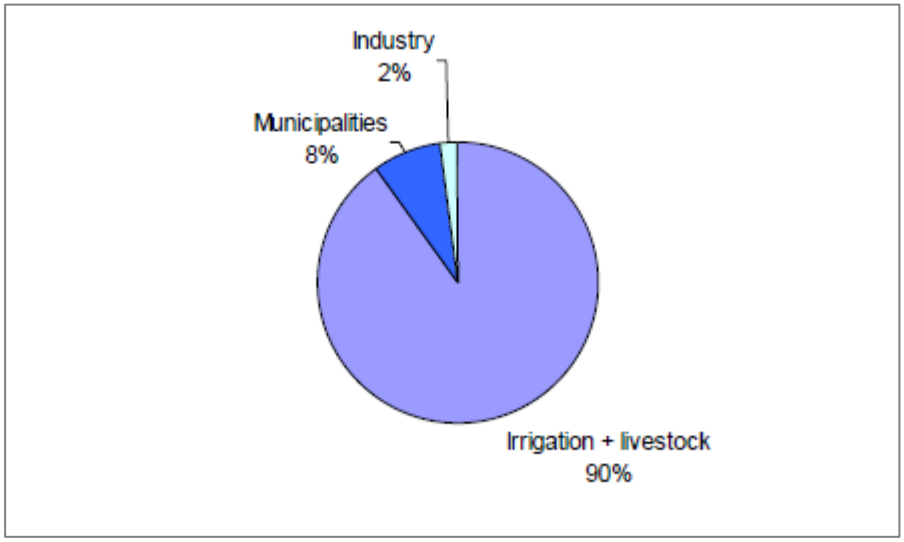
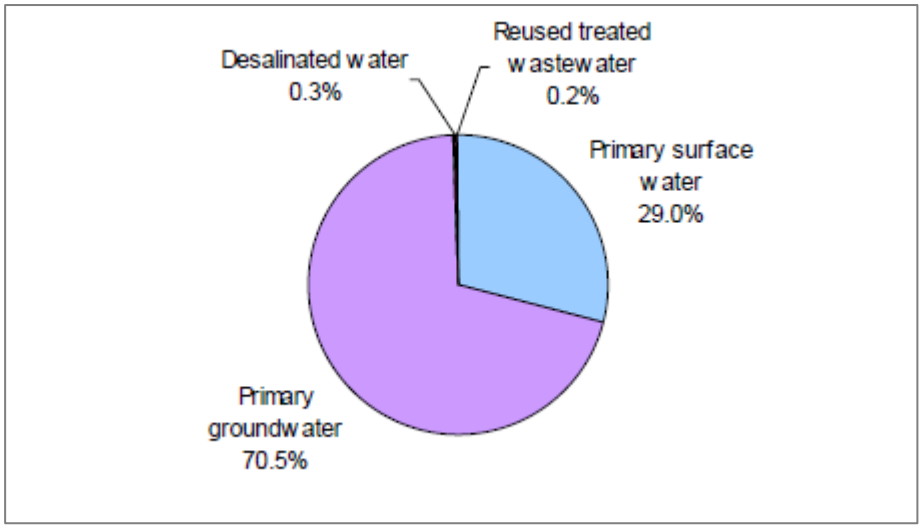


FIGURE 3
Water withdrawal by source
Total 3.400 km^3 in 2000



Many farmers are pumping groundwater from wells using diesel or electric pumps. The yield of wells is between 5 and 50 l/sec. It is estimated that there are 52 000 to 55 000 active wells in Yemen. The volume of the water that is pumped every year from these wells is about 1.5 km^3. About 800 water well drilling rigs are in use that are owned by individuals or companies which generally do not have any permits despite government legislation limiting the drilling of wells. Recently, the National Water Resources Authority started a programme of registrations & licensing for the water well drilling companies; the records show that in May 2005 only 70 rigs were licensed and only 1 000 wells were registered and licensed (Al-Asbahi, 2005).

Two types of treated wastewater reuse in agriculture exist (Al-Asbahi, 2001):

- controlled irrigation, which is practiced in government projects by the Ministry of Agriculture and Irrigation to build the green belts, mainly in the coastal plain cities (Aden, Al Hudaydah), and for sand dune fixation or desertification control in the affected areas of coastal plains;
- non-controlled irrigation (commonly in the highlands and wadis), which is practiced by the farmers themselves to grow corn, fodder in some areas (Ta'iiz), and to grow restricted and non-restricted crops, such as vegetables (tomato, carrot) and fruits (in Sana'a area).

An undefined quantity of brackish water is used in the rock cutting industry, mainly in the highlands, as well as for irrigating some salt-tolerant crops, mainly in the coastal plains (Al-Asbahi, 2005).

IRRIGATION AND DRAINAGE

Evolution of irrigation development

A global figure for irrigation potential is not available. In 2004, the total water management area was estimated at 679 650 ha, an increase of around 41 percent compared with 1994 (Table 4). Three main types of water management exist:

- Full/partial control irrigation: this concerns an area of 454 310 ha (2004), all irrigated from groundwater, of which 420 386 ha from tube wells and 33 924 ha from spring water. In general, the area irrigated from wells has decreased as many wells have gone out of production due to declining water tables.
- Spate irrigation: the area actually irrigated by spate water varies considerably from year to year, depending on the availability of spate water. It is estimated that the area equipped for

spate irrigation (command area) may be as large as 217 541 ha, which was the area also actually irrigated in 2001 (Al-Asbahi, 2001), while in 2002 only 124 683 ha were actually irrigated and in 2004 only 89 363 ha. The government constructed many spate water diversion and canal control structures in some of the main wadis, such as wadi Zabid, Tuban, Abyan, Mowr, Seham and Bayhan. Moreover, spate irrigation structures have been maintained and improved for enhancing spate water management and distribution along these wadis. The Irrigation Improvement Project (IIP) has been established recently to introduce the participatory spate irrigation management approach on two pilot wadis (Zabid and Tuban). This project created 'water user associations' (WUAs) to manage the spate structures on the wadis and to take over the operation and maintenance of the spate structures. The project also created the Water Council (WC) from the members of those associations and the local authorities.

- Small-scale irrigation: 347 dams were recently constructed in the different governorates especially in the uplands to capture rainwater for complementary irrigation purposes in inland valleys. Moreover, 519 small reservoirs and water cisterns have been constructed in different upland villages. The main purpose of these water harvesting or small-scale irrigation schemes is to use the water for complementary irrigation. The total area irrigated by these systems was about 7 799 ha in 2004, including 4 215 ha from dams. It increased to 8 526 ha in 2005 thanks to the construction of new dams.

Irrigation efficiency is low, between 35 and 45 percent depending on field levelling and the water conveyance system used. Localized irrigation systems (drip and bubbler) are introduced through several projects on limited demonstration areas and 485 ha have been realized up to now. Because of the high cost of sprinkler irrigation systems, they have been installed in very limited areas only, such as the governmental farms and the big investment farms mostly used for fodder crop production. To enhance water conveyance and distribution efficiency, the government introduced PVC buried pipes and GI pipes to the farmers to replace the earthen distribution canals and offered subsidies reaching 50 percent of the equipment costs. It is estimated that irrigation efficiency could be increased to 60 percent by installing the conveyance pipe system and to over 80 percent by adopting localized irrigation systems. Average yields of crops growing under the improved conveyance pipe system and localized irrigation systems are assumed to increase by 5 percent and 10 percent respectively. In 2004, 99.9 percent was surface irrigation and 0.1 percent was localized irrigation (Figure 4).

FIGURE 4
Irrigation techniques
Total 454 310 ha in 2004

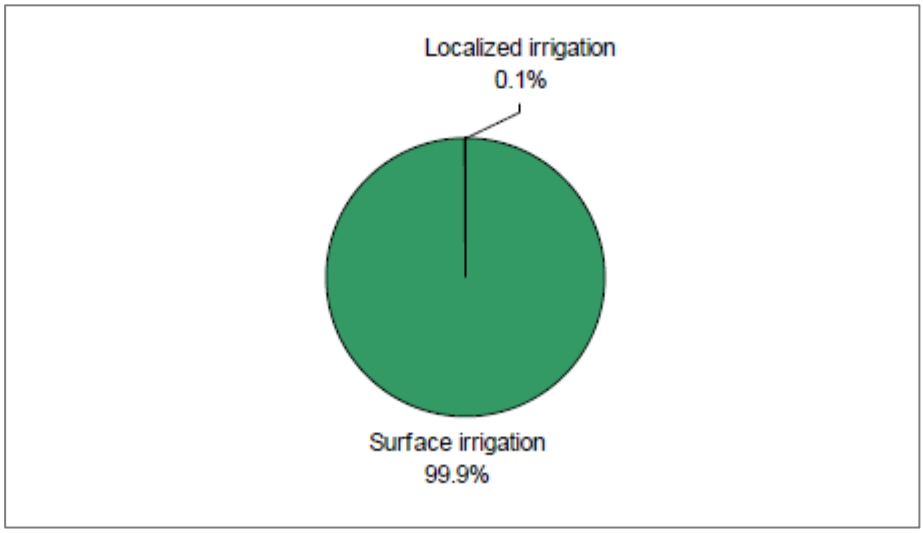


TABLE 4
Irrigation and drainage

Irrigation potential		-	ha
Irrigation			
1. Full or partial control irrigation: equipped area	2004	454 310	ha
- surface irrigation	2004	453 825	ha
- sprinkler irrigation		-	ha
- localized irrigation	2004	485	ha
• % of area irrigated from surface water	2004	0	%
• % of area irrigated from groundwater	2004	100	%
• % of area irrigated from mixed surface water and groundwater	2004	0	%
• % of area irrigated from non-conventional sources of water	2004	0	%
• area equipped for full or partial control irrigation actually irrigated	2004	454 310	ha
- as % of full/partial control area equipped	2004	100	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)	2004	7 799	ha
3. Spate irrigation	2004	217 541	ha
Total area equipped for irrigation (1+2+3)	**2004**	**679 650**	**ha**
• as % of cultivated area	2004	57.2	%
• % of total area equipped for irrigation actually irrigated	2004	81.1	%
• average increase per year over the last 10 years	1994-2004	3.5	%
• power irrigated area as % of total area equipped	2004	66.8	%
4. Non-equipped cultivated wetlands and inland valley bottoms		-	ha
5. Non-equipped flood recession cropping area		-	ha
Total water-managed area (1+2+3+4+5)	**2004**	**679 650**	**ha**
• as % of cultivated area	2004	57.2	%
Full or partial control irrigation schemes	**Criteria**		
Small-scale schemes	< ha	-	ha
Medium-scale schemes		-	ha
large-scale schemes	> ha	-	ha
Total number of households in irrigation		-	
Irrigated crops in full or partial control irrigation schemes			
Total irrigated grain production (wheat and barley)		-	metric tons
• as % of total grain production		-	%
Harvested crops			
Total harvested irrigated cropped area	2004	527 038	ha
• Annual crops: total	2004	332 784	ha
- Wheat	2004	41 903	ha
- Barley	2004	11 223	ha
- Maize	2004	19 234	ha
- Millet	2004	7 947	ha
- Sorghum	2004	42 888	ha
- Potatoes	2004	16 870	ha
- Pulses	2004	26 832	ha
- Vegetables	2004	55 494	ha
- Tobacco	2004	7 935	ha
- Cotton	2004	17 246	ha
- Sesame	2004	14 440	ha
- Fodder	2004	70 772	ha
• Permanent crops: total	2004	194 254	ha
- Coffee	2004	18 753	ha
- Citrus	2004	11 252	ha
- Bananas	2004	8 837	ha
- Other perennial crops	2004	155 412	ha
Irrigated cropping intensity (on full/partial control area equipped)	2004	116	%

TABLE 4 (*continued*)
Irrigation and drainage

Drainage - Environment		
Total drained area	-	ha
- part of the area equipped for irrigation drained	-	ha
- other drained area (non-irrigated)	-	ha
• drained area as % of cultivated area	-	%
Flood-protected areas	-	ha
Area salinized by irrigation	-	ha
Population affected by water-related diseases	-	inhabitants

Role of irrigation in agricultural production, the economy and society

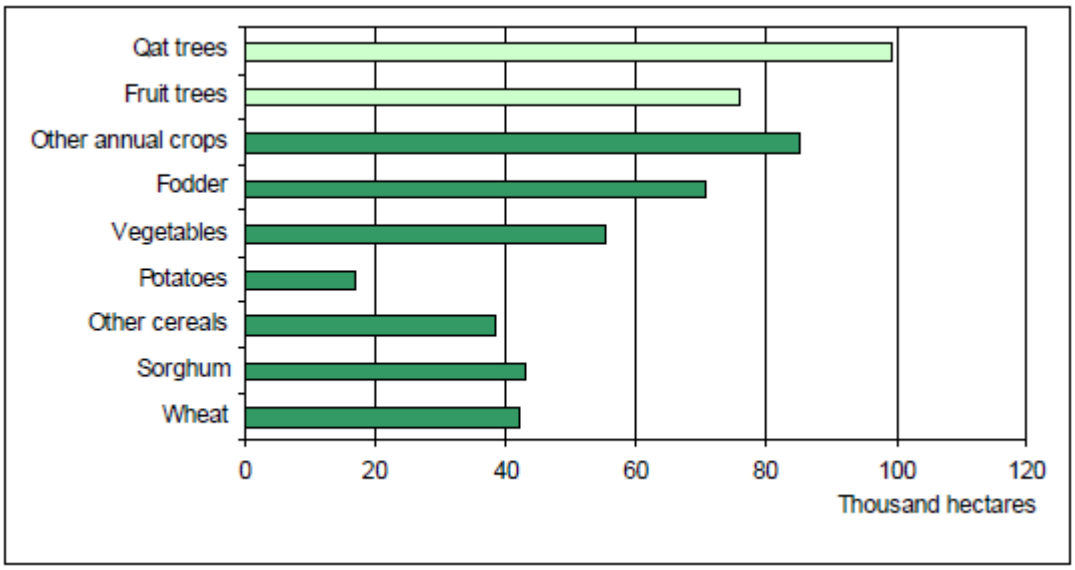
The price of irrigation equipment has increased considerably in recent years. The average cost of a surface irrigation system with a piped conveyance and distribution system is about US$ 800/ha. The cost of a localized irrigation system depends on the type: the estimated cost of a drip irrigation system for fruit trees is about US$ 2 600/ha and for vegetables about US$ 3 600/ha, while a bubbler irrigation system costs about US$ 3 000/ha. A central pivot sprinkler system is estimated to cost about US$ 6 000–8 000/ha. The cost of the operation and maintenance is approximately US$ 120/ha for the piped surface irrigation system and US$ 300/ha for a localized irrigation system. The farmers are responsible for operation and maintenance costs.

Government action focuses on the construction of water harvesting schemes and spate irrigation structures with the participation of the beneficiaries, as well as on the rehabilitation of those structures. The beneficiaries are responsible for operation and maintenance. The cost of small and medium spate diversion works and water harvesting structures is between US$ 1 500 and 2 000/ha.

The crops grown under full/partial control irrigation can be aggregated into six types: cereals, fruits, vegetables, cash crops, pulses and fodders. In 2004, the total harvested irrigated cropped area was 527 038 ha distributed as follows (Figure 5):

- cash crops: 157 878 ha or 30 percent, including 99 504 ha of qat; other cash crops are cotton, coffee, tobacco and sesame;
- cereals: 123 195 ha or 23 percent, mainly sorghum and wheat and to a lesser extent maize, barley and millet;
- fruit trees: 75 997 ha or 15 percent, of which 11 percent is banana and 15 percent citrus; other crops under this category are grapes, palm dates, papaya, apricots, peach, quince, figs, apples and guava;
- vegetables: 72 364 ha or 14 percent, including 16 870 ha of potatoes cultivated particularly in the Dhamar and Amran governorates;
- fodder: 70 772 ha or 13 percent;
- pulses: 26 832 ha or 5 percent; most pulses are rainfed.

FIGURE 5
Irrigated crops
Total harvested area 527 038 ha in 2004 (cropping intensity on equipped area actually irrigated: 116%)



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

Institutions

The Ministry of Agriculture and Irrigation (MAI) is responsible for formulating policies on irrigation, crops, livestock and forestry production and for coordinating public investment and services in the agricultural sector. The General Directorate of Irrigation (GDI) is located within the Ministry and carries out all the duties related to irrigation, particularly the construction of dams and water harvesting and spate structures. Most field services are provided to farmers through decentralized Regional Agriculture and Irrigation Offices (RAIO) in the different governorates of the country. Several projects are working under the supervision of the MAI to provide different services, particularly the introduction of water saving techniques and the construction of water harvesting and spate structures. Other areas of action include wadi bank protection and the rehabilitation of abused terraces, as well as the rehabilitation and maintenance of existing irrigation structures. To support agricultural development at the regional level, three Regional Development Authorities (RDA) have been established in the northern governorates: (i) Tihama Development Authority (TDA), (ii) Sana'a, Sa'dah, Hajjah and Amran Rural Development Authority (SSHARDA) and (iii) Eastern Region Agricultural Development Authority (ERADA). Although RDAs have not been established in the southern governorates, agricultural production in wadis such as Wadi Hadramout, Wadi Tuban, Wadi Beihan has been supported by donor agencies through the Directorates of Agriculture in the respective governorates. In addition to the above authorities, the Agriculture Research and Extension Authority (AREA) is working under the umbrella of the Ministry. The Agricultural Cooperative Union (ACU) was established in August 1991 with 213 societies. Its main objective is to consolidate integration and coordination with the government effort in setting up several common projects, of which the most important ones are infrastructure projects such as water storage, regulation dams and weirs, and agricultural marketing. It also supplies agricultural inputs and means for livestock development. At present the ACU has four general societies with 400 primary societies and 20 branches in all the provinces of the country.

The Ministry of Water and Environment (MWE) was established in May 2003. It is responsible for water resource planning and monitoring, legislation and public awareness. MWE has many sub-sectors and authorities such as the National Water Resources Authority (NWRA), Environment Protection Authority (EPA), General Rural Water Authority (GRWA), Urban Water Supply and Sanitation Corporation, and Rural Water Supply and Sanitation Corporation.

The Ministry of Public Works and Urban Planning (MPWUP) is responsible for observing and monitoring the drinking water purification stations. The Ministry of Local Administration (MLA) is responsible for water supply and sanitation in rural areas.

Water management

According to the Constitution, surface water and groundwater resources are defined as 'res communis'. However, a landowner has 'precedence' for water taken from a well on his land. In spring-irrigated areas water can be attached to land in the form of 'turns', which give rights to divert the canal into the field for a fixed period of time. The 'turn' can, however, be detached from the land and sold or rented separately. This landowner's 'precedence' has permitted the private development of deep tubewell extraction, which is in some ways in conflict with Islamic principles. Islamic and customary law has no precedent for dealing with a new technology that allows landowners to extract (and sell) unlimited quantities of water from deep aquifers, and modern law has not yet regulated it either.

Following the Water Law, water user associations (WUAs), water user groups (WUGs) and water councils (WCs) were established to transfer operation and maintenance (O&M) functions of the spate irrigation and groundwater irrigation schemes from the MAI to the user organizations. Up to now, 65 WUAs, 1 287 WUGs and 2 WCs (in Wadi Zabid and Wadi Tuban) have been established. They have received training on issues such as technical, financial and administrative management, provided by different projects.

Between 2005 and 2006 the International Programme for Technology and Research in Irrigation and Drainage (IPTRID), carried out the Project Design and Management Training Programme (PDM) for Professionals in the Water Sector in some countries of the Near East such as Yemen. The objective of the programme is to strengthen participants' capacities in developing more effective and efficient projects to address pressing water issues in the region (FAO, 2008).

Policies and legislation

The government recognizes the critical water situation in the country and is undertaking different actions to deal with it. Several water sector strategies, legislations and policies have been prepared and implementation of some of them has begun. The Water Law was enacted on 31 August 2002, and amended by Parliament in December 2006. Implementation of this law will give a major thrust to the issue of water conservation. On 19 November 2002, the Cabinet passed a decree proclaiming Sa'dah, Sana'a and Ta'iiz protected areas, as stipulated in Article 49 of the Water Law. The National Water Resources Authority (NWRA) will monitor closely these critical areas.

The following policies and the strategies have been developed after assessment of the water sector and irrigation sub-sector:

- water resources policy and strategy (1999-2000)
- irrigation water policy (2001)
- watershed policy (2000)
- agricultural sector reform policy (2000)
- urban water supply and sanitation sector reform policy (1997)
- wastewater reuse strategy (under development).

ENVIRONMENT AND HEALTH

The successful and sustainable exploitation of water resources is threatened by the rapid depletion of groundwater resources. Almost all the important groundwater systems are being over-exploited at an alarming rate. The socioeconomic consequences of groundwater depletion are dramatic because it will become too expensive for use in agriculture and, as a result, regional agricultural economies based on

groundwater irrigation are doomed to collapse if the water resources are not adequately controlled. Groundwater availability may be further reduced by groundwater salinization in coastal areas and groundwater pollution in urban areas and areas of intensive agriculture. A study conducted by the Tehama Development Authority (2004) reported that the EC increased from 225 to 3 480 µs/cm (at 25°C) in the Al-Jar area as a result of sea water intrusion. The Al-Jar region is located in the northwest of the Yemeni coastal area, 8 km away from the Red Sea. During the last ten years there has been a huge investment in this area, leading to the cultivation of more than 3 500 ha of mango trees and the drilling of about 2 000 wells. In the whole country, the area cultivated with high water consuming crops increased, such as the area under qat, which has more than tripled in 25 years.

The quality of treated wastewater varies from one area to another. While the quality is very good in Hajah, it is very bad in Ta'iiz, depending on the method of treatment as well as the capacity of the station and the operational circumstances. The quality affects the farmers' willingness to use such water for their crops (Al-Asbahi, 2005). Moreover, the outflow of the WWTP stations in the coastal areas becomes a source of groundwater pollution.

Environmental degradation occurs in areas where springs have dried up or where treatment plants are not able to treat oil residues and discharge the raw wastewater directly to the wadis (such as from the Sana'a station). Water scarcity leads to ever-increasing competition which, if uncontrolled, might lead to socioeconomic problems.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Reducing the gap between water abstraction and available renewable resources and improving the efficiency of water management is a priority. Specific objectives of the second Five-Year Plan are: optimal exploitation of available water resources; improving the means and techniques for water resources recovery and for feeding aquifers; and protecting water resources from pollution.

To achieve these objectives, the government plans to make investments in groundwater recharge, water harvesting, encouragement of traditional and modern water management techniques, and application of modern irrigation techniques. Furthermore, it plans to invest in improving water use efficiency, capacity building, public and social awareness, as well as to pursue policies for equitable distribution of available water resources in rural and urban areas.

Strategies dealing more specifically with the various challenges of irrigated agriculture are set out in the National Water Strategy, adopted by the Council of Ministers in 1999, and in the National Irrigation Strategy, adopted by the Council of Ministers in 2001, which highlight the following aspects:

1. ensuring the sustainability of groundwater irrigation: to reduce the rapid overdraft of aquifers, the government strategy will apply macro-economic measures (diesel price increase, increasing import duty on drilling rigs...);
2. ensuring the sustainability of spate irrigation schemes: most of the spate irrigation infrastructure is deteriorating due to poor maintenance caused by budgetary constraints in the public sector. The government strategy is to improve the cost effectiveness of their management and to involve users in the management and paying for O&M;
3. increasing the productivity of irrigated agriculture: by regional standards, returns to water in irrigation in Yemen are low. The government policy is to promote improved irrigation technologies and research on agricultural water use efficiency and conservation;
4. changing the role of the government: the government strategy is to reduce its role to the essential minimum and to involve users more and more in irrigation investment and management.

Concerning O&M of large spate works, decrees have already been issued for Lahej and Abyan governorates to charge an irrigation fee from the farmers on the basis of areas actually irrigated; this

will be used for O&M of the head works and the main canals to be implemented by the Government. Farmers themselves are responsible for O&M of the tertiary canals.

MAIN SOURCES OF INFORMATION

Agriculture Research and Extension Authority (AREA). 2005. *Maps of agriculture and environment resources in Republic of Yemen.* Ministry of Agriculture and Irrigation (MAI).

Al-Asbahi, Q.Y.A.M. 2001. *Yemen: Water resources and treated wastewater.*

Al-Asbahi, Q.Y.A.M. 2005. *Water resources information in Yemen.* IWG-Env, International Work Session on Water Statistics, Vienna, June 20-22, 2005.

Al-Kurasani, M.A. 2005. *Guide of agricultural weather in Yemen.* Ministry of Agriculture and Irrigation (MAI), Agriculture Research and Extension Authority (AREA).

Ateyah, H.H. 2001. *Study on the reuse of the treated wastewater in the agriculture.*

Consulting Engineering Services Private Ltd. 1991. *Land and water resources and irrigation development study.* New Delhi, India.

FAO. 2008. *Project Design & Management Training Programme for Professionals in the Water Sector in the Middle East.*

General Department of Agricultural Statistics (GDAS). 2004. *Agricultural Statistics Yearbook 2004.* Ministry of Agriculture and Irrigation (MAI).

General Department of Irrigation (GDI). 2004. *Steps on the way part (1): Dams and water structures.* Ministry of Agriculture and Irrigation (MAI).

General Department of Irrigation (GDI). 2005. *Steps on the way part (2): Dams and water structures.* Ministry of Agriculture and Irrigation (MAI).

Groundwater and Soil Conservation Project (GSCP). 2003. *Preparation study report for the project.* Ministry of Agriculture and Irrigation (MAI).

Ministry of Oil and Mineral Resources & TNO Institute of Applied Geoscience (Netherlands). 1995. *The water resources of Yemen: a summary and digest of available information.* Report compiled by Van der Gun, J.A.M. and Abdul Aziz Ahmed.

Ministry of Planning and International Cooperation (MOPIC) and Ministry of Agriculture and Irrigation (MAI). 2002. *National Conference on Qat (Technical Study).* In cooperation with FAO and other donors.

Ministry of Water and Environment (MWE). 2005. *National water strategy and implementation plan (NWSSIP).*

TS/HWC-UNDP/DESD. 1995. *Final reports. Volume III: Surface water resources; Volume IV: Groundwater resources; Volume VI: Water supply, wastewater and sanitation.*

Wangnick Consulting. 2002. *IDA Worldwide desalting plants inventory*. Report No. 17. Sponsored by the International Desalination Association (IDA).

World Bank. 1993. *Republic of Yemen, Agricultural sector study: Strategy for sustainable agricultural production.* Report No 11126-YEM.