ASIAN DISASTER REDUCTION CENTER

FINAL REPORT

"How to strengthen technical and institutional capacity water resource management in Yemen including database creation and raising public awareness"

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Acknowledgement

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Interdiction about the water problem around the world:

Water is definitely a security problem in the world.".The main reason of the shortage of the waters over the world is the population growth and lack of justice in the distribution of water, citizen in North America consumes about 500 liters of water a day, and European consumes between 200 and 300 liters, while not available for African only 10 to 20 liters of water a day. In addition to widespread poverty, if we didn't do anything to solve the shortage of the water so it will lead to the desertification of many areas & a lot of poor country. Also the climate change to raise temperatures, this one of the problem that affect shortage of water.

The sustainable management of the world's fresh water resources is one of the most difficult tasks faced by the global community, affecting virtually all areas of socio-economic development, especially food and energy production. Owing to the worsening global water crisis, increasing local and international tensions over the control of water resources may not only cause civil unrest, but also threaten the very foundation of global security. So, Water is the source of life on earth at present and Water is the life blood of our planet. It covers more than two thirds of the earth's surface and comprises more than two thirds of the composition of every human being. Life on earth started in water and without water life as we know it cannot continue.. At present, 1.1 billion people in the world cannot have access to safe drinking water, while 2.6 billion people do not have adequate sanitary facilities there is no question as to the severity of the water resource problem in most parts of the world, particularly those lying in arid and semi-arid zones. It is envisaged that the current water shortages in the Arab Region could soon reach crisis proportion since the Region, besides being mostly dominated by aridity, has one of the highest population growth rates in the world and many of its countries face water deficits as they currently consume more fresh water than is produced naturally within their boundaries. Hence widespread shortages are anticipated within the coming few years. Furthermore, mismanagement has led to the degradation of water quality and the depletion of water supplies. The inadequate supply of clean water quality contributes to public health problems and places severe limits on economic growth. The serious difficulties of allocating water among competing sectors within a country are overshadowed by the problems of allocating water across national boundaries. Few agreements among riparian exist on any of the major rivers in the Arab Region, and conflicts may arise as some users (especially non-Arab countries) claim greater volumes of water. It is estimated that about 50% of the surface water resources in the Arab Region are shared with neighboring countries. Furthermore, there exist several extended groundwater aquifers also shared with neighboring countries. The fact that groundwater aquifers are subjected to severe overexploitation, from within and outside the Region, will definitely result in very serious negative impacts on the available groundwater resources. For these reasons, considerable efforts are undertaken by most Arab countries to mobilize their available water resources to narrow the gap in food security and ensure food self-sufficiency. Water shortages are almost always addressed by increasing water supplies, based upon extensive field exploration and massive investments in water resources development. Over the years, most of the water resources have been developed and the rate of new investments is currently shrinking, to the extent that meeting growing agricultural water demands by developing new supplies is becoming extremely difficult. Hence water resources programmers in the Region are focused on the

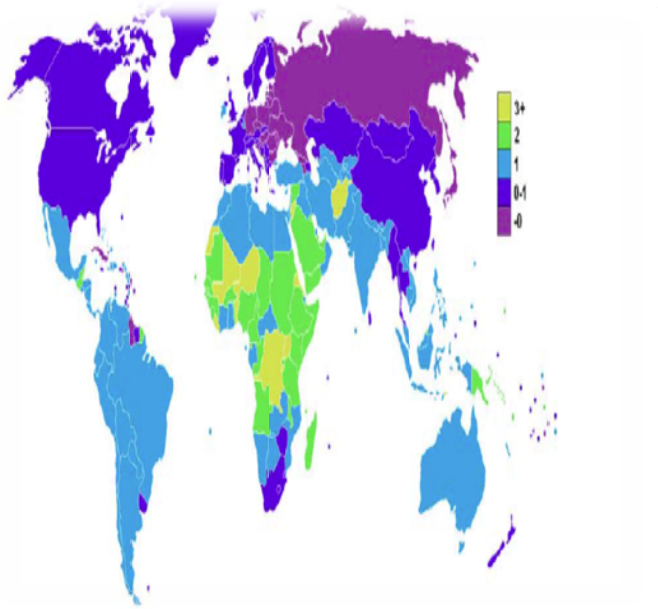
improvement of water management, particularly in the agricultural sector, whose share accounts for about 90% of the total water resources consumption. National and Regional debates initiated by specialized Arab organizations are increasingly being in the spotlight, with a view to preparing a Regional Arab Water Security Master Plan which aims at defining adequate approaches for water resources management and involving integration of sectoral water plans and programmers. Since its inception during the early decade of 1970s, The Arab Organization for Agricultural Development (AOAD) has established a rich portfolio of activities which include preparation of technical and economic studies that focus on the use and development of natural and other productive resources, policy analysis and food security. Similar efforts have been directed to the designing of technical surveys and development of statistical databases and other agricultural information system. Vigorous programmers of training and seminars are also pursued in addition to execution of pilot and other developmental agricultural projects that contribute to the transfer, dissemination and adoption of agricultural technologies. Special care is given to Arab countries with economies that are heavily dependent on agriculture or facing pressing problems of development, or both. Great concern is being given by AOAD to Arab water security since during the last decades the Arab Region has been faced with serious constraints, namely overexploitation in the use of water and deterioration in its quality, as a result of which sustainable irrigated agriculture in the Arab Region is becoming highly threatened. So, Yemen is one of the most water-stressed countries in the Middle East. The capital of Yemen Sana'a it becoming the first capital in the world to run out of a viable water supply. The water table in the city has dropped far beyond sustainable levels, because of an exploding population, lack of water resource management and, most of all, unregulated drilling. Where Sana'a water table was 30 meters below the surface in the 1970s, he said, it has now dropped to 1,200 meters in some areas.

Freshwater Resources

1- Amount of water on the earth: Approximately 1,400 million km3
2- Seawater and so on: 97.5% (approx. 1,300 million km3)
3- Freshwater: 2.5% (approx. 35 million km3)
4- Glaciers and so on: 1.74% (approx. 24 million km3)
5- Groundwater: 0.76% (approx. 11 million km3)
6- Rivers/Lakes and marshes: 0.01% (approx. 0.1 million km3)

Pressures on water supply:

7- Climate change
8- Multinational use of water basins and aquifers
9- Multinational use of water basins and aquifers
10- Water supply infrastructure
1- Intermittency
2- Water quality and environmental assets
3- Degradation of fossil groundwater supplies



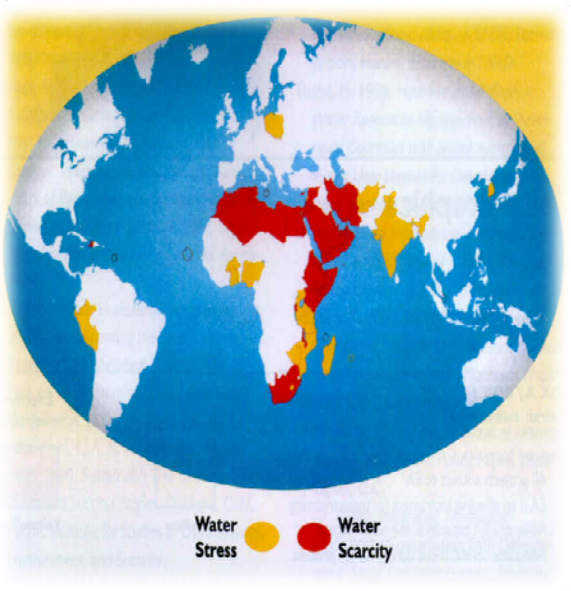


Figure (1) Population Growth Rate, 2005-2010

Figure (2) water scarcity in the world

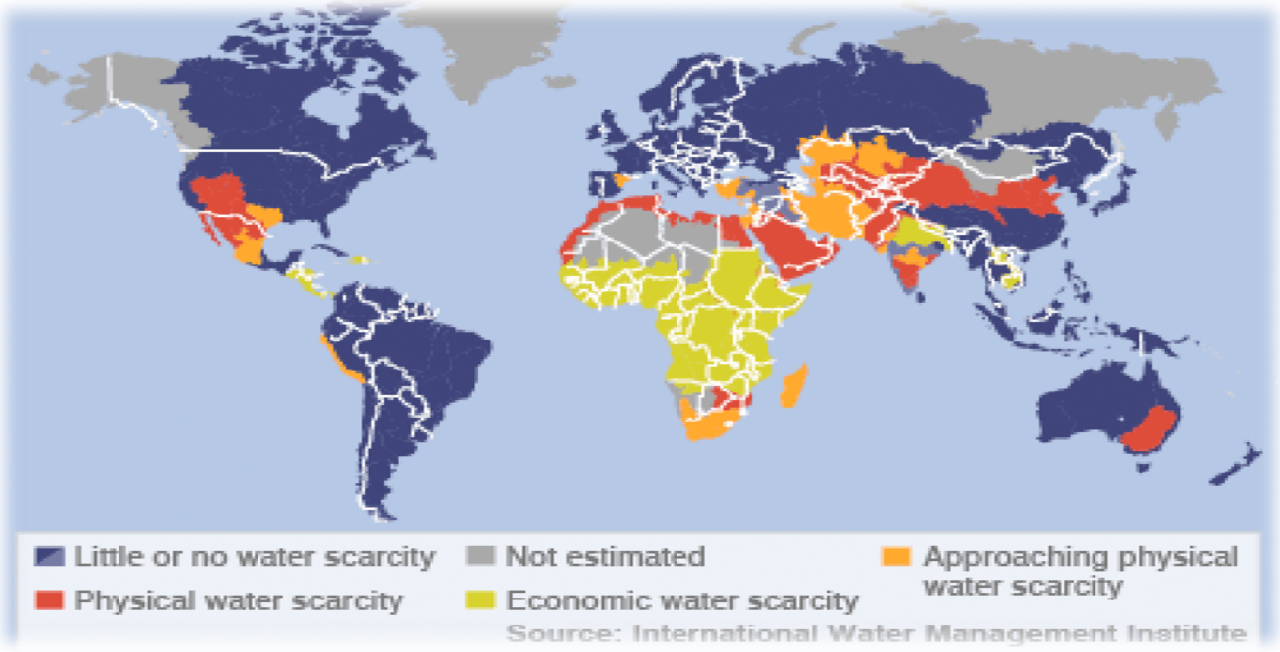
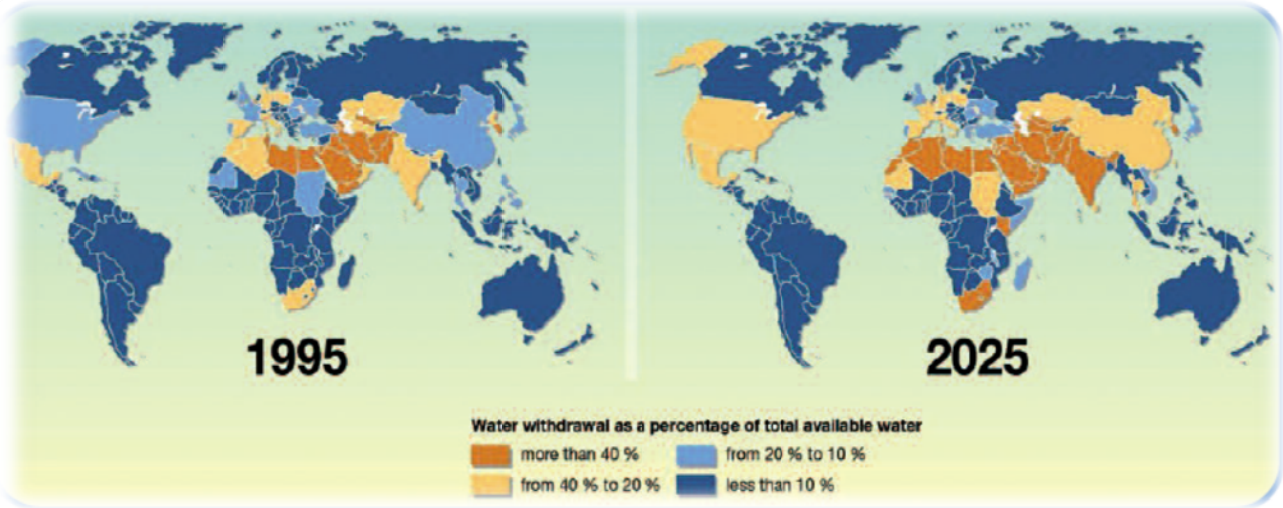


Figure (3) water scarcity around the world



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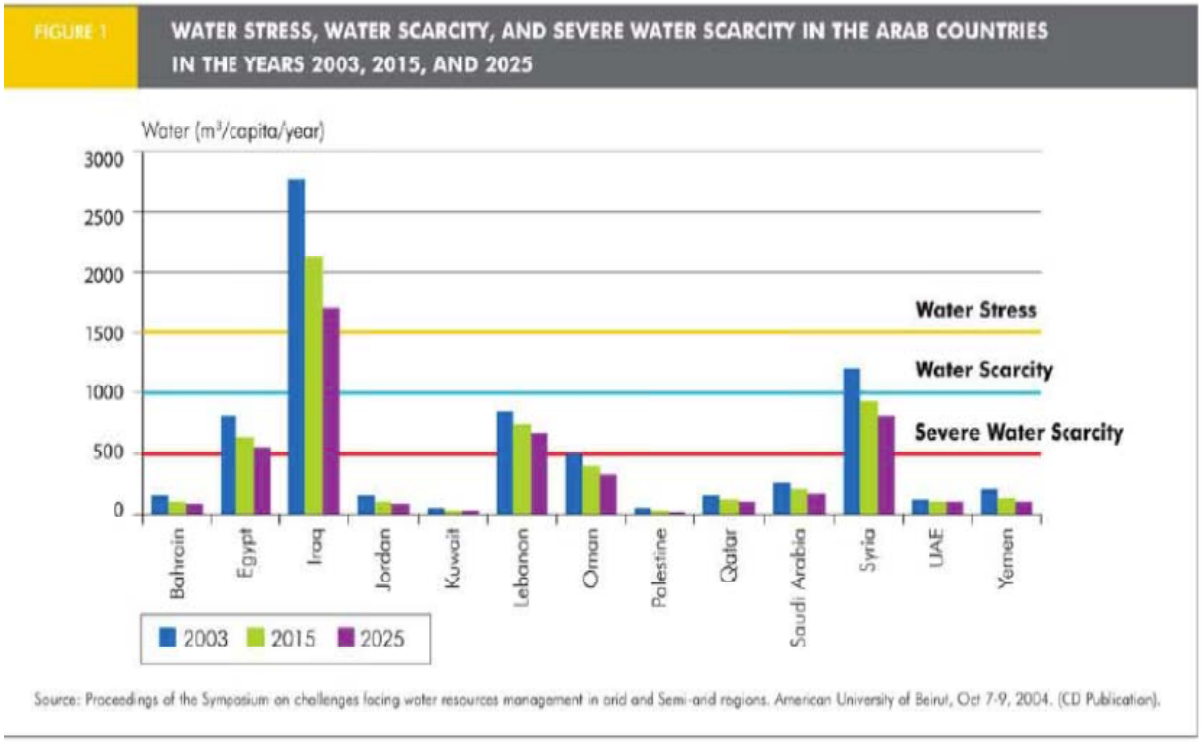

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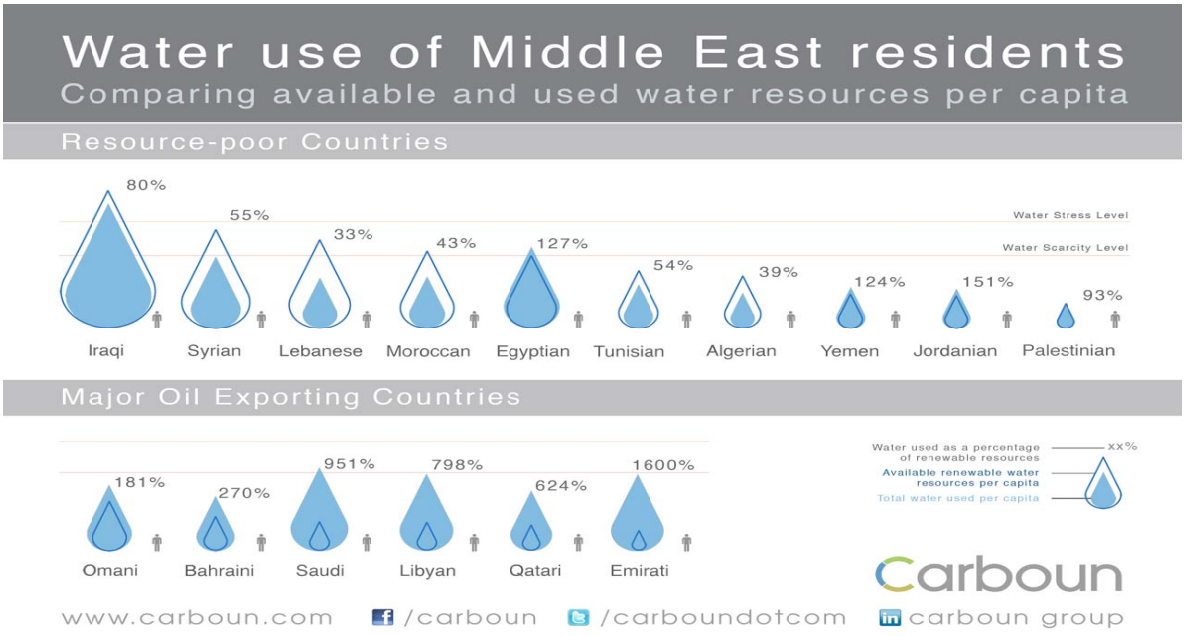

Figure (6) show the water use of Middle East resident

Introduction about Yemen:

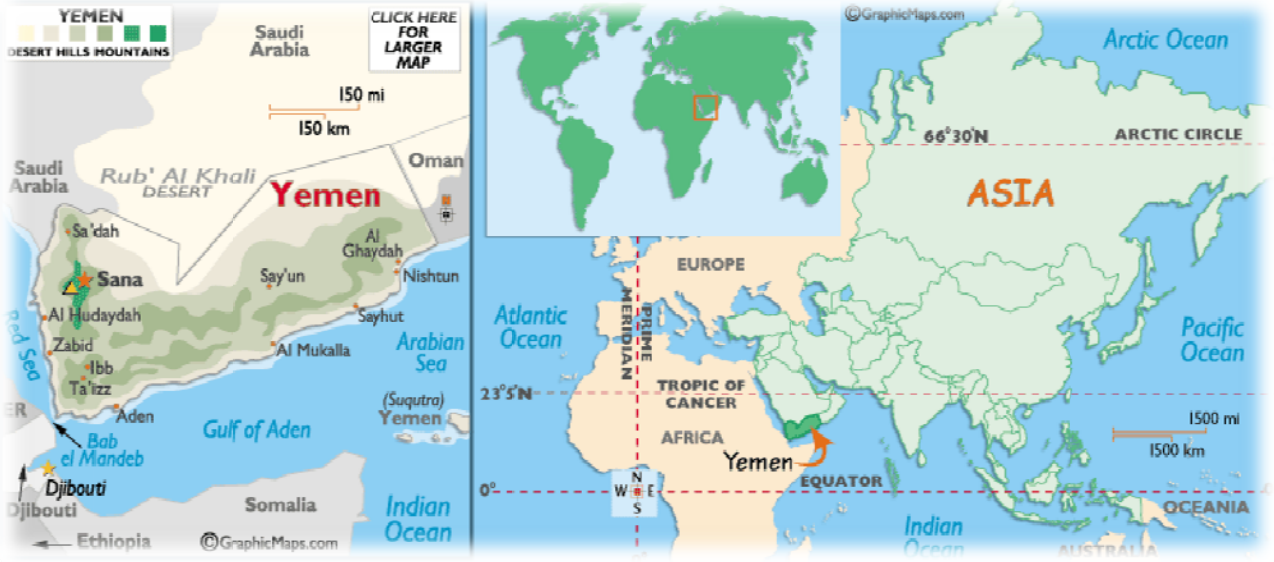

Figure (7) Map of Yemen

Yemen is an arid Middle Eastern country, occupying an area of 527,970 square kilometers at the southern end of the Arabian Peninsula between latitudes 12° and 19°N and longitudes 42° and 53°E. It is bordered to the north by Saudi Arabia, to the East by Oman, and to the South and West by a 2,200 km coastline along the Gulf of Aden, Arabian Sea and the Red Sea. Yemen, historically, had one of the oldest civilizations in the Middle East based on agricultural development, in which the people of Yemen managed to establish the spectacular mountain terraces system on the steep slopes of the rugged mountainous areas, some thousands of years ago, in order to conserve soil and to optimize rainfall water use. Yemen is very old in history, with a ancient tradition of harnessing water for agricultural uses. Archaeologically, the signs of hydrological and hydraulic structures from thousands of years ago are monumental. They reflect the concern of past civilizations throughout history that water is the principal, economic and social sustaining element of civilization; a principle now long forgotten. One of the earliest irrigation civilizations was established in the Kingdom of Sheba, in what is now the country of Yemen. This civilization was made possible by developing various rainwater harvesting techniques, including the construction of dams such as the Marib Dam, and associated irrigation works, as far back as about 1000 BC, and it reached a peak during the reign of the Queen of Sheba. This era was known as 'The Yemeni Famous Hydraulic Civilization'. Additional water harvesting works were constructed in the region around AD 100 to augment the system. However, the Marib Dam was breached in AD 575, and the local civilization rapidly declined. The Marib Dam was

not rebuilt until recently. In 1980, a new storage dam with capacity of 400 000 m3 was constructed just below the location of the old Marib dam. In the last decades, the pressing need to increase agricultural output and provide for the needs of a population growing at the very high rate of 3.8%/year, has been compounded by a national policy that had promoted expansion rather than efficient use and sustainable management. And Yemen depends on rainfall to cultivate and produce crops, so that Yemeni people cultivate their land under rainfall conditions at large scale, and they efficiently use and control flood water and spring water. Water rights of flood water and springs were well established and efficiently used to cultivate farmland according to its location from the source of water and to agreements between land owners. It (water right) became well-known among the people, due to continuous practices and/or according to written documents which were transferred from generation to generation till today. And consumption pattern of the increasing population, which in turn caused increasing demand on food, water and other daily requirements. These changes encouraged the people to turn to internal and external migration, which caused abandonment of terraces and their maintenance, as well as the absence of traditional cooperation among farmers due to migration of men and shortage of labor forces and increasing labor wages (MAI, 2000). Increased water scarcity and reduced water quality – leading to increased hardship on rural livelihoods; Increased drought frequency, increased temperatures, and changes in precipitation patterns. Yemen could be the first nation to completely run out of water in a few years, a prospect that does not bode well for its young population of 25 million that is expected to double in 20 years, or anyone worried about the rising influence (and ability to get bombs on planes) of an al Qaeda branch in one of the Middle East's poorest nations. In Sana'a, which could be the world's first capital city to go dry, the population is growing at a rate of 7% per year as people flee from the parched outer reaches of the country. Part of the problem is qat, an addictive plant like chewed by about 75% of men in Yemen that takes a whole lot of water to grow. In places where vineyards used to be, farmers now are growing the more lucrative qat, which uses five times the amount of water as grapes but can be harvested and sold relatively quickly after it's planted. Farmers' ambition to better their lot is more than understandable in a nation where five million people — over a fifth of the population — go hungry each day. And though Yemen's qat farmers are estimated to now be using some 40% of the nation's domestic water supply, they are hardly the only actors in this looming crisis. Yemen's water table is falling about 6.6 feet per year, yet the central government has been ineffective at managing the piecemeal drilling of water wells (the government itself estimates an

astonishing 99% of water extraction in Yemen is unlicensed) or regulating water management in more far flung parts of the country. Instead, as Sana'a gets more and more water migrants, authorities have discussed relocating the capital to the coast where they might be better able to take advantage of desalination as other Middle Eastern countries have. The water shortage is also a global problem, because, like Somalia across the Gulf of Aden, where desertification has been linked with that county's ongoing conflict, fights and desperation over water in Yemen would be exactly the kind of destabilizing factor that insurgents will need to continue to strengthen their base in remote areas far from the halls of power. As the water crisis has gotten worse, observers have noted that the government has concentrated its efforts to manage water resources in urban centers where it has (and wants to keep) political support, and many of the outlying areas not receiving help have been overlooked before Yemen could be the first nation to completely run out of water in a few years, a prospect that does not bode well for its young population of 24 million that is expected to double in 20 years, or anyone worried about the rising influence (and ability to get bombs on planes) of an al Qaeda branch in one of the Middle East's poorest nations. In Sana'a, which could be the world's first capital city to go dry, the population is growing at a rate of 7% per year as people flee from the parched outer reaches of the country. Part of the problem is qat, an addictive plant like chewed by about 75% of men in Yemen that takes a whole lot of water to grow. In places where vineyards used to be, farmers now are growing the more lucrative qat, which uses five times the amount of water as grapes but can be harvested and sold relatively quickly after it's planted. Farmers' ambition to better their lot is more than understandable in a nation where five million people — over a fifth of the population — go hungry each day. And though Yemen's qat farmers are estimated to now be using some 40% of the nation's domestic water supply, they are hardly the only actors in this looming crisis. Yemen's water table is falling about 6.6 feet per year, yet the central government has been ineffective at managing the piecemeal drilling of water wells (the government itself estimates an astonishing 99% of water extraction in Yemen is unlicensed) or regulating water management in more far flung parts of the country. Instead, as Sana'a gets more and more water migrants, authorities have discussed relocating the capital to the coast where they might be better able to take advantage of desalination as other Middle Eastern countries have The water shortage is also a global problem, because, like Somalia across the Gulf of Aden, where desertification has been linked with that county's ongoing conflict, fights and desperation over water in Yemen would be exactly the kind of destabilizing factor that insurgents will need to continue to strengthen their

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Chapter 1

Water in Japan

Introduction:

Japan is not a water abundant country. It has a narrow surface area, rapid run-off of precipitation, and high population density 1.The quantity of annual natural renewable water resources per capita in Japan (about 3,372 m3 per capita) is only one half of the world average. In addition, there are great fluctuations in rainfall—both seasonally and between the years. As a result of both of these factors—an absolute shortage of water and considerable variability over time — Japan has suffered severe water shortages several times in the recent past. For example, the Tokyo metropolitan area experienced water scarcity in the early 1960's when the city of Tokyo was forced to restrict water supply for 42 months, from October 1961 to March 19652. In order to solve the water scarcity problem, Japan has aggressively developed its water resources, mainly by constructing new water storage facilities (largely dams). at present, the amount of "newly developed" water sources accounts for 16.6 billion m3 of water per year, which amounts to 55% of total water consumption for domestic and industrial (urban) use3 In the Tokyo metropolitan region the volume of bulk water stored in reservoirs doubled from 185 million m3 in 1964 to 371 million m3 in 1996. In 1996, water supply was restricted for only 41 days, although annual precipitation in 1996 was lower than in 1965 (a major drought year) and Tokyo's population has increased from 8 million to 11 million between 1965 and 1996.

Figure (8) Map of Japan

Water resources in Japan:

Japan's water resources are characteristically plentiful mainly during the tsuyu, typhoon, and spring thaw seasons. Although annual precipitation far exceeds the world average, this does not mean abundance of water resources. Due to Japan's dense population the per capita precipitation in Japan is only about one-sixth of the world average. Furthermore, since the rivers have small basins and steep channels, rivers flow erratically and relatively little of their water is actually available for use. Compared with cities in other countries, Japan's major cities store surprisingly little water reserves, and every year there are water shortage problems somewhere in the country. The annual volume of water for municipal and agricultural use taken from rivers is estimate at about 78.21 billion cubic meters, and that from groundwater about 13.15 billion cubic meters. It is apparent from these figures that river water is the important water resource in Japan and that its efficient use is essential. It is expected that the severity of droughts will increase because of climate change which will reduce the amount of water stored in the form of snow, increase evaporation from reservoirs and reduce rainfall. Most of the water for domestic use comes from surface water. About 45% of the total comes from reservoirs regulated by dams, while 27% comes directly from rivers, 1% from lakes and 4% from river beds, totaling 77% from surface water. 23% of domestic water supply comes from groundwater, which is over-exploited in parts of the country.

Precipitation

- Annual precipitation in Japan is approximately 1,718 mm, roughly two times as much as the world average of about 810 mm.
- Annual precipitation per capita is approximately 5,100 m3 in Japan, roughly 1/3 of the world average of about 16,800 m3

Existing Amount of Water Resources (Amount of Precipitation less Amount of Evaporation/Transpiration)

- Amount of precipitation in an average year in Japan is approximately 650 billion m3. After deducting about 230 billion m3 lost in evaporation/transpiration, the existing amount of water resources is roughly 420 billion m3 (65% of precipitation).
- The existing amount of water resources in Japan in a year of low rainfall occurring about once in 10 years is approximately 280 billion m3.
- Amount of water resources per capita in Japan (approximately 3,300 m3) is less than half of that in the world (about 7,800 m3).

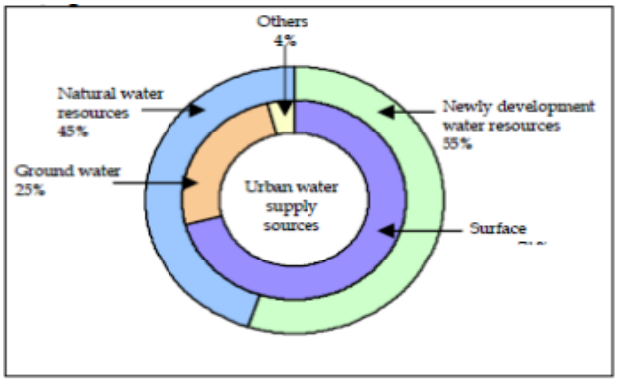


Figure (9) Sources of urban water supply in Japan

Water storage:

While there are more than 2,500 dams in Japan, their total storage is low because rivers are short and steep. Total active storage of all dams is only 20 km 3, corresponding to less than the storage capacity of Hoover dam. In addition, lakes have an important storage function and their water levels are regulated through weirs. The largest lake is Lake Biwa that provides drinking water to more than 15 million people in the Keihanshin (Kyoto-Osaka-Kobe) metropolitan region.

Developed Amount of Water

The amount of water resources developed through construction of dams and so forth is 11.9 billion m3 for tap water (approx.73% of the amount of water used) and 5.9 billion m3 for industrial water (approx.49% of the amount of water used). The amount of unstable water intake (amount available only when river water is affluent, because water resources development facilities to serve as reservoirs are not yet completed) for urban water (domestic water + industrial water) in the metropolitan area (coastal area of Kanto) is 820 million m3, accounting for about 15% of the total amount of water used.

Figure (10) The Highest Dam of Japan: Kurobe

Figure (11) Yodo River, Osaka.

Figure (12) show water resources development facilitates under control of JWA

Organization and Legislation Related to Water Resources Policy: In Japan, measures concerning water resources are implemented by a number of government ministries and agencies in cooperation, based on numerous laws. The Water Resources Department of the Ministry of Land, Infrastructure, Transport and Tourism(MLIT) acts as the overall coordinator in adjusting measures for water supply and demand reservoir area development by related ministries and agencies as well as bureaus and departments

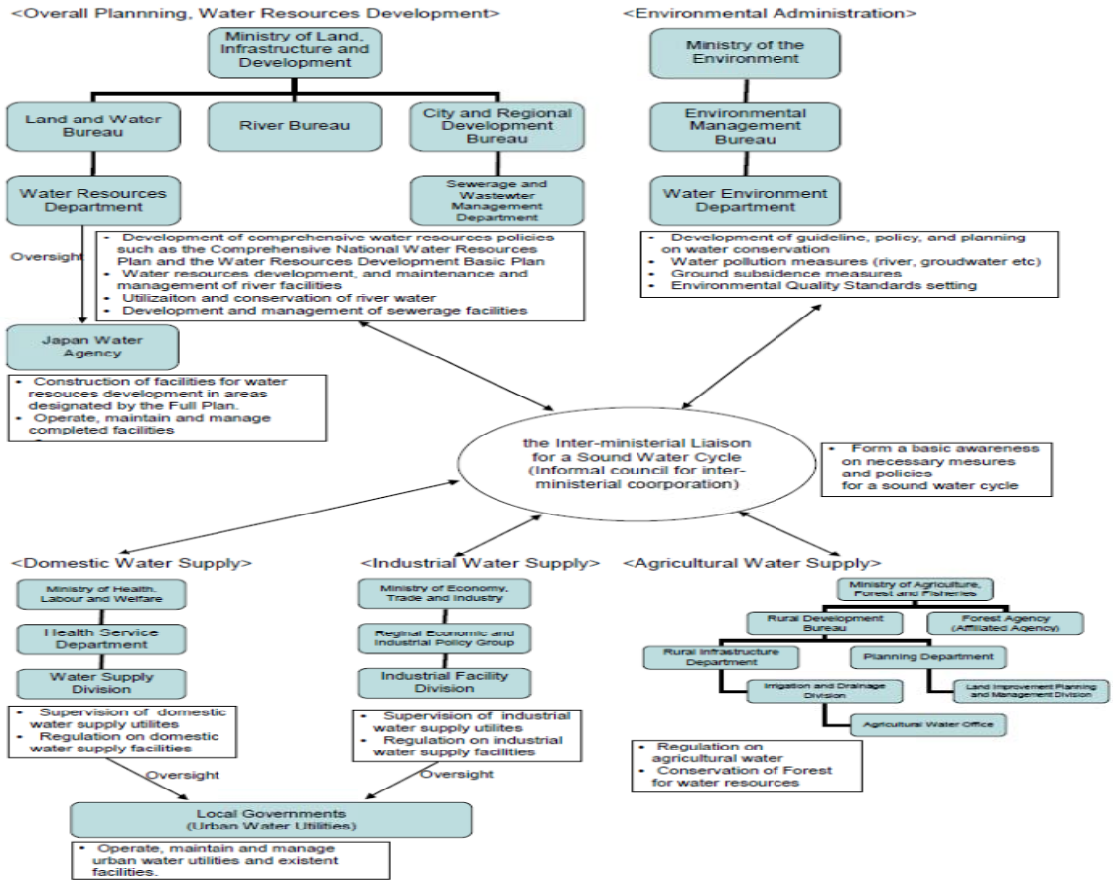


Figure (13) Japanese Government Organization

Water Supply for Domestic Use — **Ministry of Health, Labour and Welfare**
- Water Supply Law
- Law to Promote the Implementation of Programs to Preserve the Quality of Source Water for Public Water-Supply, etc.

Water Supply for Agricultural Use, and Development of Forest for Water Headwaters Conservation — **Ministry of Agriculture, Forestry and Fisheries**
- Land Improvement Law - Forest Law, etc.

Water Supply for Industrial Use, and Hydroelectric Power Generation — **Ministry of Economy, Trade and Industry**
- Industrial Water Law - Industrial Water Supply Business Law, etc.

Water Quality and Environmental Preservation — **Ministry of Environment**
- Water Pollution Control Law
- Law to Take Special Measures for the Preservation of Water Quality in Head Waters Areas for the Purpose of Preventing Specific Trouble in the Drinking Water Supply, etc.

Sewerage — **Ministry of Land, Infrastructure, Transport and Tourism**
Sewerage and Water Waste Management Department
- Sewerage Law, etc.

Flood control, River Water Utilization, and Dam Construction, etc. — **River Bureau**
- River Law - Specified Multipurpose Dam Law, etc.

Overall Coordination, Water Supply and Demand Planning, and Reservoir Area Development — **Water Resources Department**
- Water Resources Development Promotion Law - Japan Water Agency Law
- Law Concerning Special Measures for Reservoir Areas

Organization of the Water Resources Department
- Water Resources Policy Division : basic policy, Japan Water Agency, groundwater, waste water reusing, etc.
- Water Resources Planning Division : long-term planning, establishment of sound hydrological cycles, issues of international water resources, etc.
- Reservoir Area Development Division : reservoir area development, 100 Selected Water Spots, etc.

Figure (14) show the organization of the water resources department

	Water rights		
	Domestic water	Industrial Water	Agricultural Water
River water	River Law		
Ground water	Law for Ground Water Use in Buildings	Industrial Water Law	No regulation

Figure (15) Regulations allocating water rights (surface and ground water)

Water resources development and bulk water supply

The Japan Water Agency (JWA) under the Ministry of Land, Infrastructure, Transport and Tourism constructs dams, estuary barrages, facilities for lake and marsh development, and canals. It also operates and maintains these facilities, supplying bulk water to other entities, such as utilities, that distribute it to end users. JWA was created by law in 2003 to succeed the Water Resources Development Public Corporation (WARDEC) that had been created in 1962.

Water Resources Management Policies and Actions:

In Japan, the national government is responsible for formulating and implementing water resources policies at the national level. It formulates an overall plan of water resources development and environmental conservation. The Comprehensive National Water Resources Plan is the national basic plan for water resources development under which dams and water systems are developed The Basic Environment Plan clarifies long-term and comprehensive environmental policies related to water quality and quantity.

The Comprehensive National Water Resources Plan (the Water Plan)

The Water Plan, prepared by the Ministry of Land, Transport and Infrastructure, is formulated and revised in accordance with the Comprehensive National Development Plan, which is stipulated in the Comprehensive National Land Development Act and approved by the Prime Minister's cabinet. The Water Plan is a multi-year plan and addresses basic medium to long-term planning issues regarding water resources development, conservation and utilization, as well as makes forecasts of long-term water demand. The Ministry of Land, Transport and Infrastructure uses the Water Plan to formulate more detailed annual development plans and their related budgets .The latest Water Plan, Water Plan 21, stresses the efficient utilization of existing water resources facilities rather than the development of new water resources

The Basic Environment Plan

The Cabinet, under the Basic Environment Law, approves the Basic Environment Plan in December 1994.31 In 2006, an outline of the revised Basic Environment Plan has been published, in which the government gives priority to 10 priority fields for implementation

Among the 10 priority fields mentioned in the new Basic Environmental Plan, the government plans to put efforts to secure an environmentally sound water cycle, more concerns on:

• Conservation and sustainable use of the water environment including water quality, water quantity, aquatic life and waterside areas, and creation of a rich community through contact with accessible water environments.

• Formulation of a plan by regions that is consistent with water utilization and flood control;

• Maintenance and improvement of storage penetration and recharge performance throughout all basins; and International dissemination of the efforts and contribution to solving the world's Water problems.

Examples of actual indicators:

• Maintenance and achievement status of environmental quality standards of public Water and groundwater

• Number of creation and revision of the plan on the building of an environmentally sound water cycle by basins

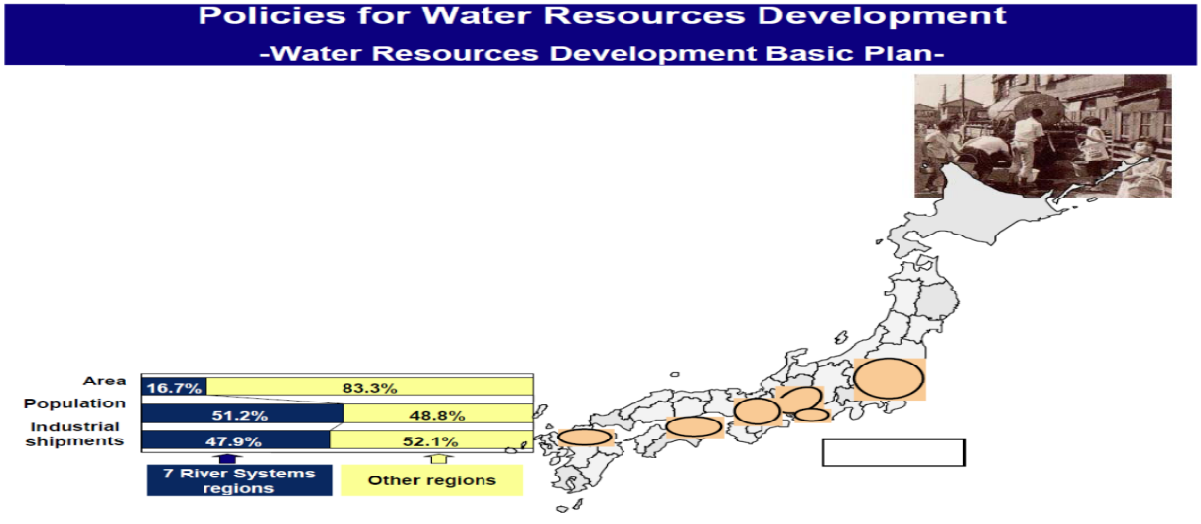


Figure (16) show policies for water resources development basic plan

Prolonged droughts are expected due to climate change

River Basin	Dam	Irrigation period pattern	Drought periods at present state (days/10yrs)	Drought periods at around 2050 (days/10yrs)
Ishikari	Taisetsu	Advanced by 0-10 days	About 60 days	About 30-70 days
	Chubetsu	Advanced by 0-10 days	About 30 days	About 130-180 days
Tone	8 dams	Advanced by 0-40 days	About 30 days	About 100-110 days
		Deferred by 0-60 days	About 30 days	About 90-120 days
Chikugo	Matsubara/ Shimouke	Advanced by 0-5 days	About 50 days	About 70 days
		Deferred by 0-30 days	About 50 days	About 70-80 days

Droughts mitigated Droughts exacerbated

Figure (17) show the prolonged draught are expected due to climate change

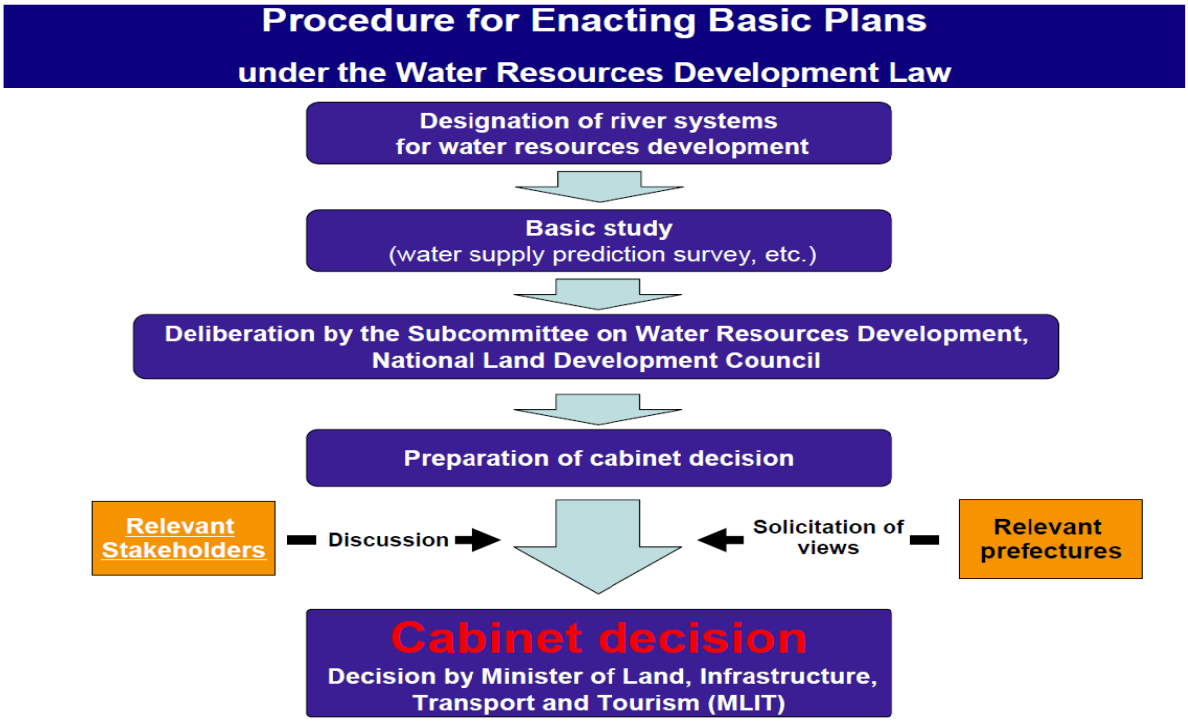


Figure (18) show the procedure for enacting basic plans under the water resources development law

Water resource allocation: water rights/permits

The River Law stipulates a formal allocation procedure for rights to river water. The law defines river water as public property, and a certain amount of river water can be withdrawn for a defined use by obtaining a "water right" through specific administrative procedures. Under the River Law, water rights for major rivers have been allocated to various uses: agricultural, domestic, industrial water supply, and hydropower generation. On the other hand, there is no comprehensive law regarding ground water use. In general, there are no restrictions on withdrawing groundwater, the ownership of which belongs to the landowner. However, ground water extraction has had a serious potential impact due to ground subsidence in urban areas such as the Tokyo and Osaka. To control this problem the Industrial Water Law and the Law for Ground Water Use in Buildings were enacted in 1956 and 1962 respectively. These laws require permits from local governments in order to withdraw ground water in certain designated areas where land subsidence is an issue or where ground water resources are scarce.

River management in Japan:

The River Law was enacted in 1896, and the Sabo Law and the Forest Law in 1897. These laws were the inception of modern flood and erosion control in Japan.
The original River Law remained the basis for river administration until it was completely
Revised in 1964. The first river law stipulated matters only related to flood control. Later, the Law was revised twice, in 1964 and 1997 respectively. In 1964, the provisions on water usage were incorporated into the law and in 1997 an natural environmental aspect was added to it. The revision in 1997 has necessitated each river manager to make basic river management policies and river improvement plans for all rivers it manages. The 1997 revision was a big paradigm shift. Prior to it, river managers put an importance on flood risk mitigation. And which justified building dams that have great negative impacts on the ecology. After the revision, the importance shifted from flood control to the environmental protection. As a result, we have been having difficulties in building dams since then. At the same time, any structural measures to prevent flooding have to be done very carefully so that the existing nature is preserved. Even worse, we are sometimes forced to improve the existing environment when we implement those river projects. There are two kinds of plans which river managers have to make. One of them, a basic river management policy, is a long term plan in which each river manager refers to the objectives of how to manage a river during the next 100 to 200 years. As opposed to the basic river management policy, a river improvement plan is a short term and clear plan in which

specific measures in the next few decades are to be written. Both of them mainly consist of three factors, flood risk management, water resource and the ecology.

Figure (19) Tone River System and Ara River System control by Japan water agency (JWA)

Sewerage and Wastewater in Japan:

Sanitation coverage in Japan is over 70%. and there are about 2100 wastewater treatment plants in Japan.

- Most plants adopt aerobic treatment methods such as conventional activated sludge process or oxidation ditch process.
- Most of sewage sludge is used for cement material and so on, but the rate for use of biogas and sludge fuel is small
- There are digester tanks in about 300 treatment plants. About 70% of the biogas generated by digestion (218 million m3) is utilized, for example, about 20 % of biogas(66 million m3) is used for the power generation, but the rest(86 million m3) is incinerated in2010

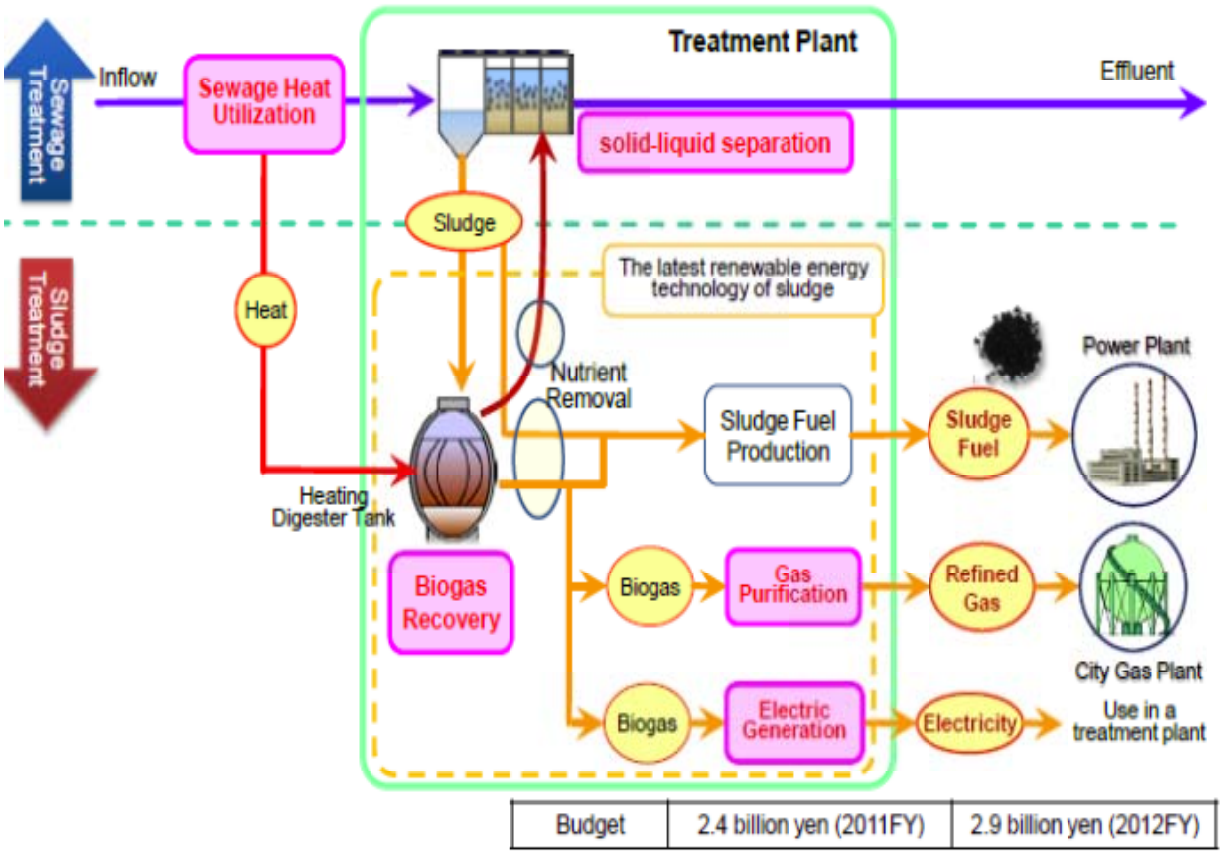


Figure (20) Wastewater system in Japan

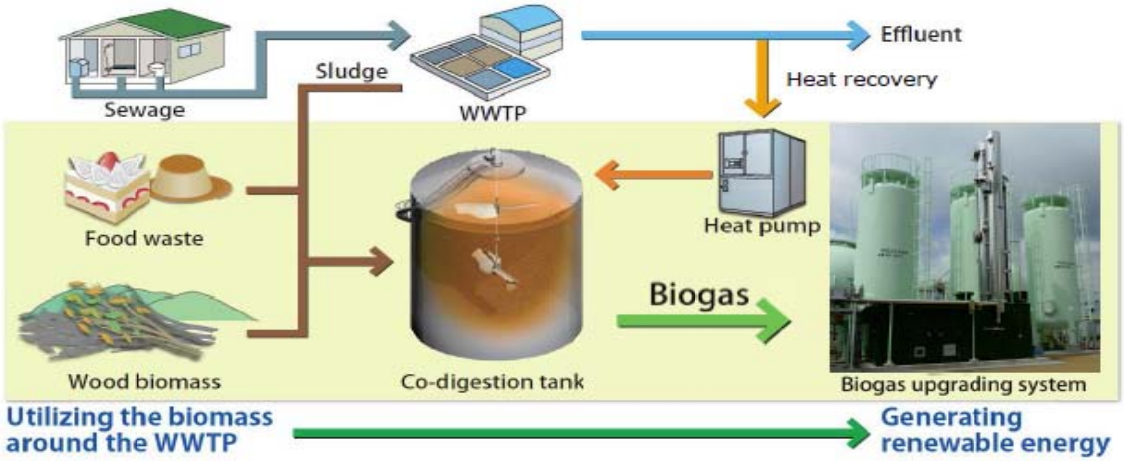
Accelerate the government-led development of new technology and its practical application by promoting technical validation through installation of actual size plants and by formulating guidelines. Achieving cost reduction in the sewerage projects and generation of renewable energy.

Figure (21) Sewerage system in Kobe – Japan

Demonstration Research 2 in Kobe City

MLIT

Flow diagram



Feature

- Biogas production can be significantly increased by co-digesting sewage sludge with suitable biomass
- Biogas produced can be fully utilized by using heat pump to heat digester

Demonstration Research 2 in Kobe City

MLIT

Outline of Project

- NILIM (National Institute for Land Infrastructure Management) contract research
- Research conducted by
  Consortium consisting of Kobelco Eco-Solutions and Kobe City
- Demonstration Field
  Higashinada Sewage Treatment Plant, Kobe
- Objectives
  - Reduction of CAPEX and construction period of sewage sludge digestion facility by using digestion tank made of carbon steel
  - Reduction of OPEX and construction period by using advanced biogas upgrading system which refines biogas into methane by 97% purity
  - Reduction of OPEX of sewage sludge digestion facility by increasing revenue from biogas
  - Reduction of GHG emissions by increasing biogas utilization (injection into gas grid and use as NGV fuel)
- In operation since January 2012

Figure (22) show flow diagram in Sewerage system

Water Shortage in Japan:

Previously, Japan repeatedly experienced major water shortages; for example, 1939 in Lake Biwa, 1964 in the year of Tokyo Olympics, 1967 in Nagasaki, 1973 in Takamatsu, 1978 in Fukuoka, and so on. Though occurrence of water shortages has become rare in recent years the shortage in 1994 covered almost all Japan, when approximately 16 million people were affected at least once by suspended or reduced water supply, and agriculture suffered production losses of 140 billion yen.

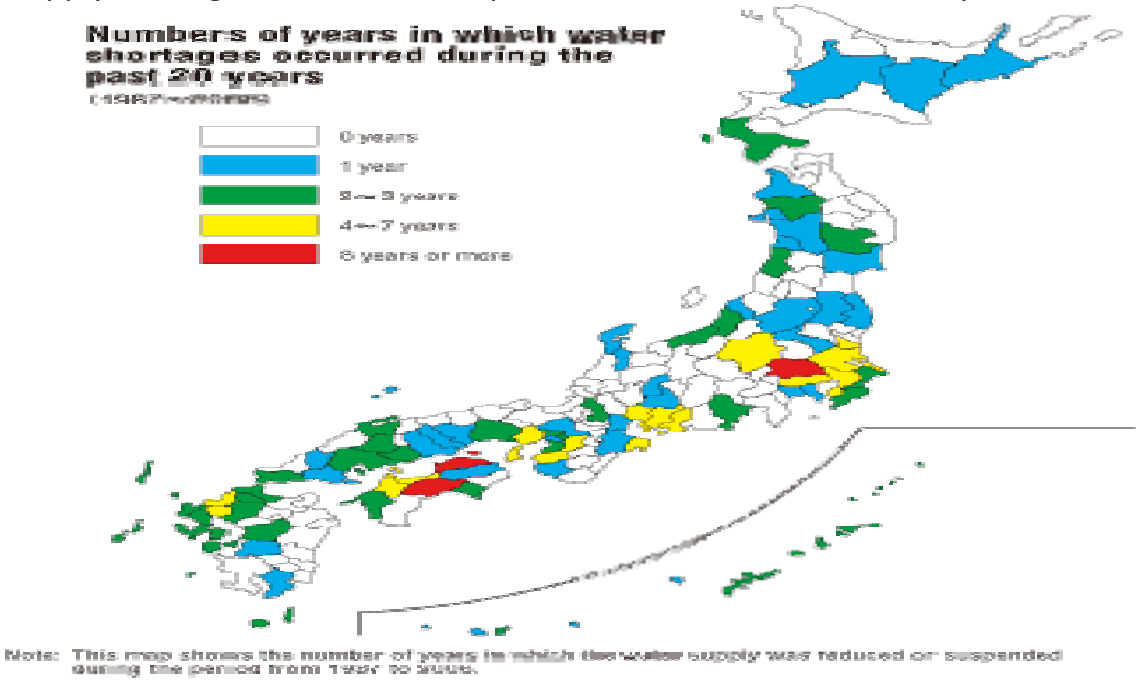


Figure (23) show the numbers of years in which water shortage occurred during the past 20 years

Effects of Water Shortage

Modern society offers comfortable lifestyles and high quality services based on stable water supply. Therefore, suspended or reduced water supply would have a serious impact one very day home life and social activities as it disables people from preparing meals, using flush toilets and doing other everyday activities. Also, shortage of industrial water results in damages such as reduction or suspension of operations. When shortages of agricultural water occur, farmers save water by means of "water-sharing (method of distributing water in accordance with designated times and turns)", intensification of repeated use and so on, though this requires a lot of labor and cost. For example, at the time of water shortage in 1994, the cost was about three times as much as that in an average year. In addition, when the whole amount of water becomes insufficient, crop growth is reduced or completely hindered.

Drought in Japan:

In the past Japan face drought because the change climate all the countries around the world have problem with water especially for drought in Japan they have in 1939 drought on the markets for rice and electricity in Japan. The authorities were ill-prepared for such a disaster but willing to use it for the purpose of covering for other problems. The drought thus accelerated the move of Japan's economic system towards a managed economy. A lower total rainfall in Japan in 1940 did not generate similar problems, suggesting that the broader political, economic, and social context is crucial to the identification of short-term climate fluctuations as crises.

1- Fluctuation of Precipitation in Japan due to Climate Change:

As the long-term trend of temperature change in Japan, the average annual surface air temperature has increased by approximately 1oC over the past 100 years. Concerning precipitation, years of low rainfall have become frequent since around 1970, and the amount of precipitation was much below average in 1973, 1978, 1984, 1994, and 1996, when water shortages caused damage. Recently an increasing trend of fluctuation between extremely low rainfall and extremely high rainfall has been observed. In addition to the above-mentioned decrease in precipitation and frequent occurrence of extremely low rainfall years, due to climate changes accompanying global warming, trends of decreasing snowfall and increasingly earlier thaw have been recognized

2- Declines in Water Supply Stability

When constructing dams in Japan, they are designed so as to secure the necessary water supply even in a year of relatively low rainfall (base year for water supply). When annual precipitation is much lower than in the base year, the river flow also decreases more than in the base year. On the other hand, since the storage capacity of water remains fixed, it would be impossible to secure stable intake of water throughout the year, even with replenishment from dams. For 60 % of the dams now in operation, the base year is selected from between 1956 and 1975. Assuming that 1960 is the base year for water supply, in 9 out of about 40 subsequent years, annual precipitation was lower than that in the base year. It means that water short ages occurred frequently. It is thus considered to be a problem that stable water supply has been impaired in many places in recent years.

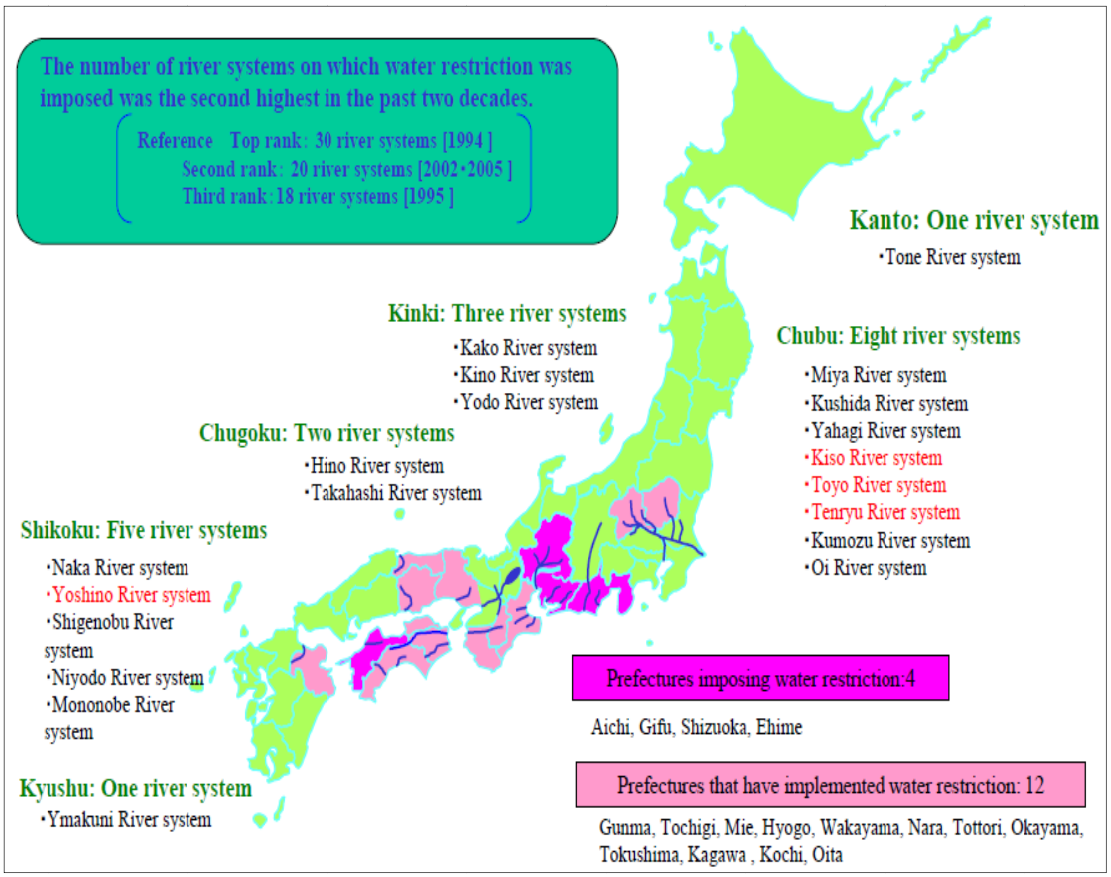


Figure (24): The river systems and rivers affected by droughts

Water resources affected by climate changes:

The group II reports (impacts, adaptation and vulnerability) released by the "Intergovernmental Panel on Climate Change" (IPCC) in April 2007 states that climate changes from global warming etc. will greatly impact water resources of regions. By the middle of this century, annual average river flow rates and water availability will increase by 10 to 40% in high latitude regions and some humid tropical areas, while they will decrease by 10 to 30% in medium latitude regions and dry / dry tropical areas. In medium latitude regions and semi-dry low latitude regions, water availability will decrease and drought will increase, causing serious water shortages for several hundred millions of people.

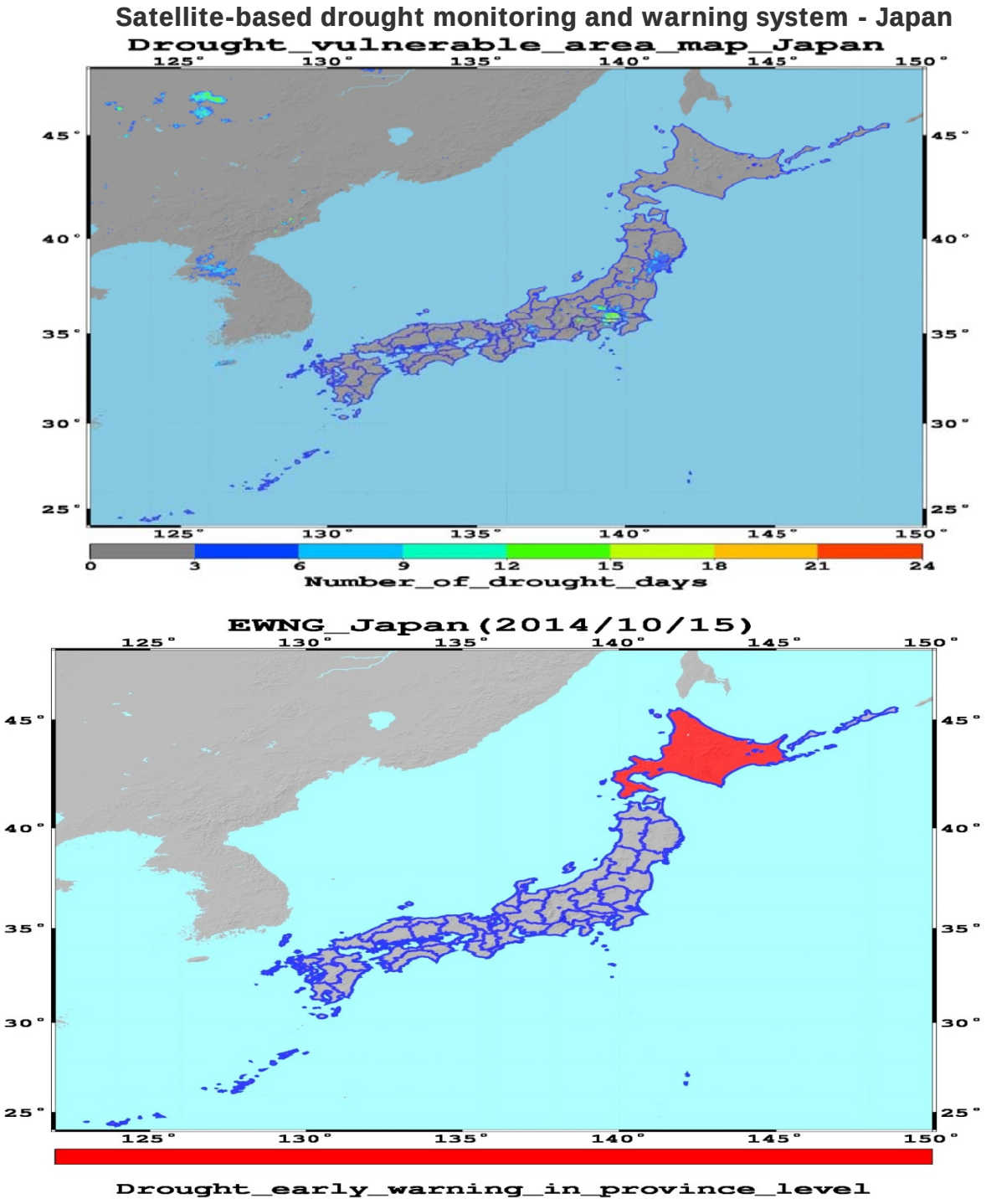


Figure (25) show the drought early warning and the number of drought days

Revival and Fostering of Water-Related Culture

Water Day and Water Week

In order to raise public awareness of the preciousness of water and the importance of water resources development, August 1 of each year was declared Water Day. Also, the week starting from this day was designated as Water Week. During this week, various events are staged jointly by the government, local authorities are related groups.

United Nations' World Water Day

The 47th General Assembly of the United Nations held on December 22, 1992 declared March 22 of each year to be World Water Day. It was proposed that promotion of and enlightenment about development/conservation of water resources and actions based on Agenda 21 are to be carried out on this day. Accordingly, "Water Resources Study Symposium" has been held every year in Japan to raise the public awareness concerning water.

100 Selected Water spots

In order to form a pleasant society colored by land with beautiful water and green, it is necessary to reassess relationship between water and people distinctively founded on local features. 107 areas, which have been particularly successful in sustaining and developing local tradition or unique life styles around water and advancing local development by preserving and making use of water environment, as "100 Selected Water Spots" in Fiscal 1994 and 1995, and has been diffusing their information by introducing their activities on its website.

Water Week event:
Regatta in Sumida River

Water Week event:
Water-related Exhibition

Figure (26) show the water activities

Genbe River improved in the Creek Improvement Project

Preservation of water springs through Small Forest Dam Development

Figure (27) show the water activities

Chapter 2

Water Resources in Yemen

1- Rain full:

The rain only source of water renewable in Yemen, where the average rainfall of 50 mm in the desert areas in the north and north-east and southern coasts to more than 600 mm per year in the Central Highlands, Western and despite the large quantity, estimated at 60 billion cubic meters per year However, more than 65% of this amount is considered ineffective rain does not occur, including runoff or groundwater feeding. The flood waters and Algiul cross-flow valleys or the eyes of so-called surface water and renewable estimated 2.1 billion cubic meters per year, which represents 10% of the total effective rainfall, estimated leakage of rain to 4.5%, which contributes to the feed water reservoirs which are the primary source of water drinking and household use and industrial .

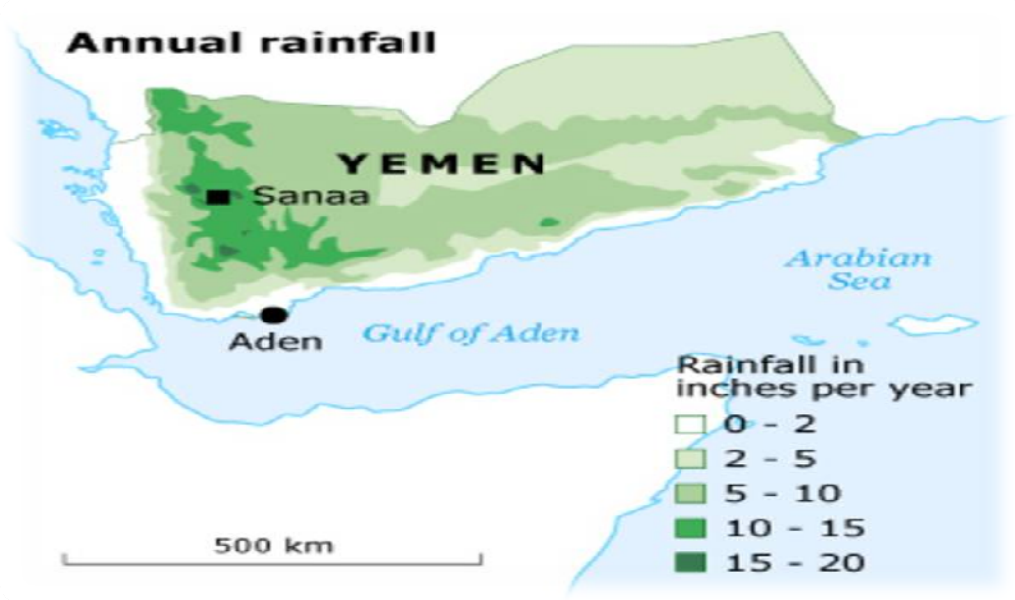


Figure (28) Annual rainfall

With renewable water resources of only 125 cubic meters per capita/year Yemen is one of the most water-scarce countries in the world. This level is less than one tenth of the threshold for water stress, which is defined at 1,700 cubic meters per capita/year. Total water demand of 3,400 million cubic meters per year exceeds renewable resources of 2,500 million cubic meters per year, thus leading to a steady decline in groundwater levels, varying between 1 m per year in the Tuban-Abyan area

and 6–8 m per year in the Sana'a basin. Today, there are between 45,000 and 70,000 wells in Yemen, the majority of which are under private control. No one can be certain of the exact number, as almost all were drilled without license. Agriculture takes the lion's share of Yemen's water resources, sucking up almost 90 percent, and it is estimated that Qat production accounts for 37 percent of all water used in irrigation. Furthermore, climate change has apparently led to a reduction in the level of rainfall. For example, in Sana'a the average rainfall has declined by one third from 240mm (average 1932–1968) to 200mm (1969–1982) and 180mm (1983–2000).

Water Resources Use:-

Water Use	1990	2000	2005	2010
Agriculture/Irrigation	2600	3145	3,235	3,328
Domestic/Urban/Rural	168	210	265	552
Industrial & Mining	31	45	65	90
Total	**2,799**	**3,400**	**3,565**	**3,970**

Figure (29) ***Use of Water for a Period of 20 Years (1990-2010) in Different Water Use Sectors (Mm3/yr)***

Harvest rain water:

Yemen is a country suffering water shortage. Therefore rainwater harvesting is a common practice since the antique. Ruins of dams and reservoirs as well as the unique, spectacular mountain terraces, cistern (rocky tanks) , water pools, dams and the most famous is great Marib dam confirm the long history of water harvesting. Villagers in the mountainous areas are well acquainted with ware harvesting systems for hundreds of years. They use the collected water for drinking, animal watering and supplementary irrigation particularly in the drier seasons

Figure (30) The great Marib dam

Harvests rainwater in cisterns (Rocky Tanks):

Figure (31) Traditional water harvesting in Aden city cistern

The Tawila Tanks, also known as 'Aden Tanks', the 'Cisterns', 'Queen of Sheba Tanks' or 'Solomon's Tanks', are located at the head of Tawila Valley in the southwest sector of Crater. They are considered one of the greatest historical engineering feats in South Arabia, likely built and developed during the rules of Banu Zuraia', the Roulades, the Tahirides and the Ottomans and mentioned in the ancient Al- Musnad inscriptions. However, not much is accurately known of their history . the system of tanks were designed both to collect the scarce rainwater and divert runoff to protect the city in case of heavy rains and sweeping floods.

Figure (32) the water pool kind of harvesting water

Figure (33) 3000Years old of Rain water Harvesting system

Figure (34) Rain fed Terraces

Figure (35) Clay House at Sana'a, with water Harvesting/saving system

Figure (36) Terraces are Yemen's greatest dams

Runoff water harvesting in Yemen:-

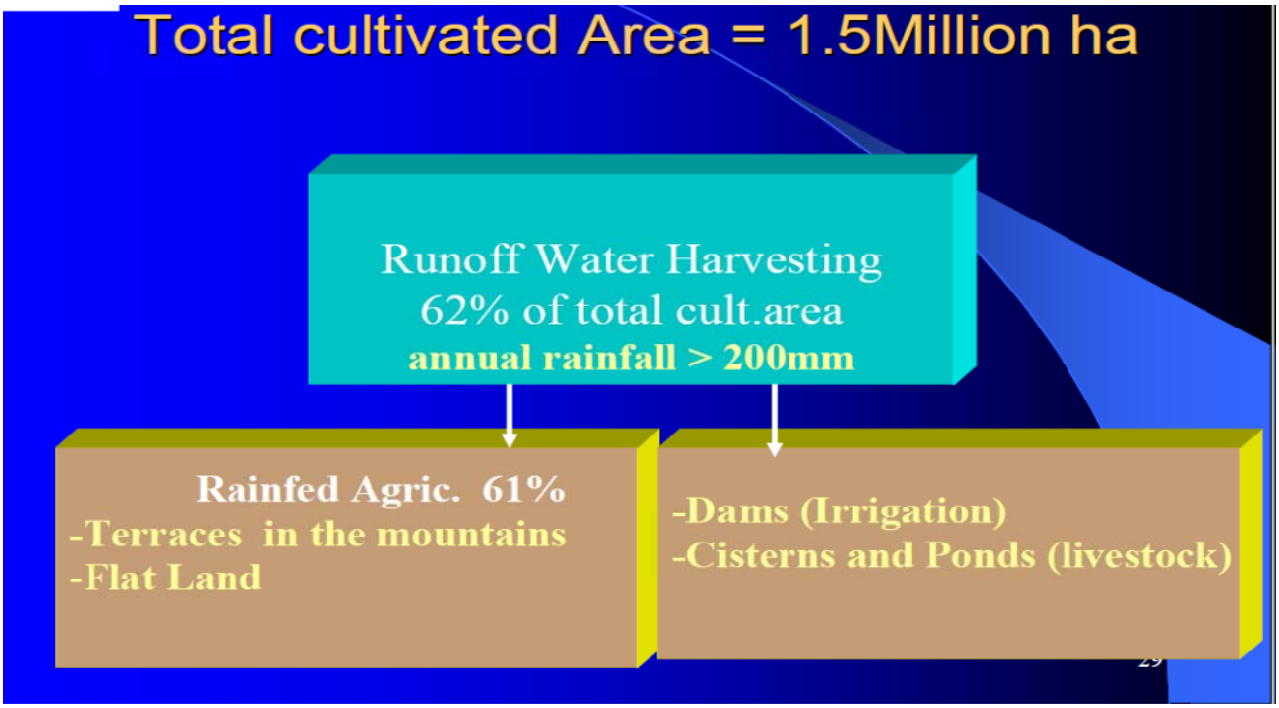
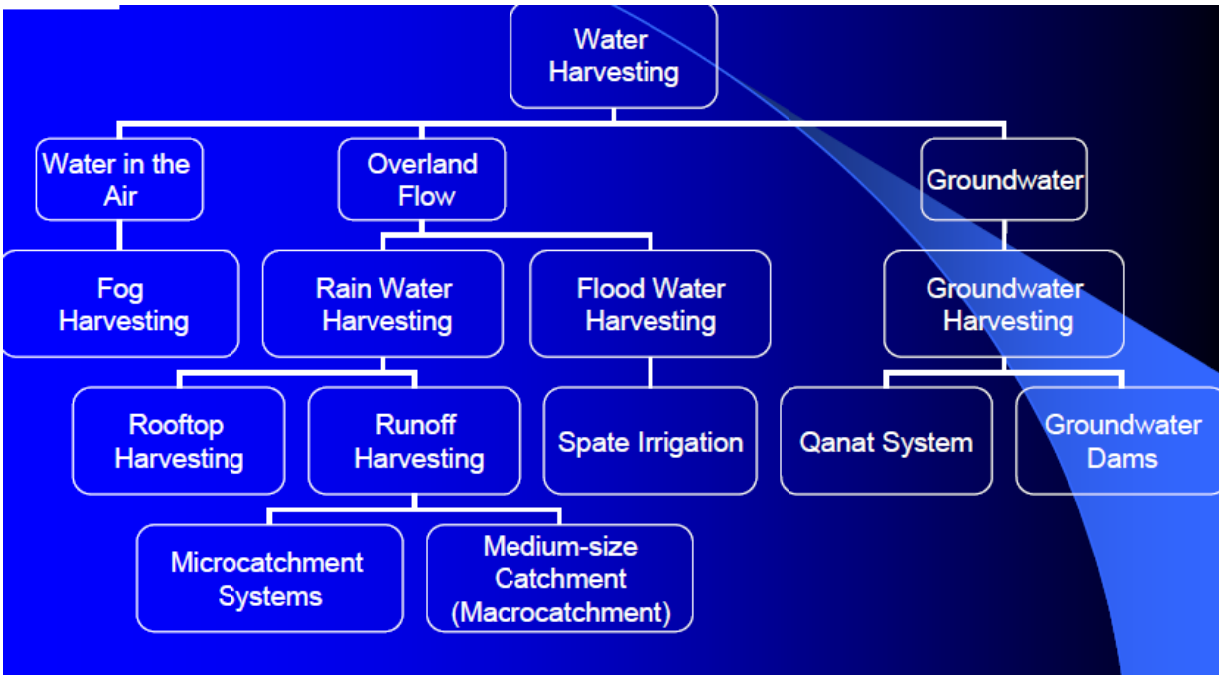


Figure (37) show the total cultivated area

Figure (38) Classification of water harvesting techniques



2- surface water

Yemen is divided into four major basins Basin consists of all of them from a group of valleys and streams and sub-surface water and the estimated quantity by about 2.5 billion m3 / year as follows :-

- Red Sea basin area is estimated at 33,000 km 2 average this quantity 431 mm and the total annual flow of 741 million m3.
- Basin area of the Gulf of Aden is estimated at 46680 km 2 average this quantity 207 mm and the total annual flow of 535 million m3.
- Khali basin area estimated at 90900 km 2 and the average total annual flow 67 million m3
- Arabian Sea Basin and the Great Basin is divided into three main sections :

1- And Diane R. seventy religion: an area of about 45,000 km2 and an estimated annual average of 119 mm and an annual influx of an estimated 40 million m3
2- Wadi Hadhramaut / gas forest: an area of about 46 075 km 2 and an estimated annual average of 57 mm and an annual influx of an estimated 18 million m3
3- Ghaida basin: an area of about 115 375 km 2 and an estimated annual average of 58 mm and an annual influx of an estimated 77 million m3.

- **Valleys in Yemen (Wadis)**

Yemen does not have any permanent rivers, but does have numerous wadis, which is an either permanently or intermittently dry riverbed. This is a list of wadis in Yemen. This list is arranged by drainage basin, with respective tributaries indented under each larger stream's name.

1- **Red Sea (Tihama) include** (Wadi Harad , Wadi Mawr , Wadi Siham , Wadi Zabid, Wadi Surdud, Wadi Rima , Wadi Mawza , Wadi Bani Khawlan, Wadi De wadi , Wadi De Nachib , wadi alwoja raimah)
2- **Gulf of Aden include** (Wadi Harim , Wadi Tuban, , Wadi Ahwar (Wadi Jurrah), Wadi Milh (Wadi Ar Ruqub , Wadi Mayfa'ah , Wadi Amaqin , Wadi Hada, Wadi Hajr , Wadi Huwayrah , Wadi Hibun , Wadi Hamir , Wadi Hayfari ,Wadi Tabaqim, Wadi Sana , Wadi Adim , Wadi Hadhramaut (Hadhramaut) , Wadi Sarr , Wadi Amd, Wadi al Jiz , Wadi Dawan (Dhahawn), Wadi Kidyut, Wadi Mahrat, Wadi Tinhalin)
3- **Rub' al Khali include (**Wadi Jawf ,Wadi Raghwan, Wadi al Kharid, Wadi Abrad , Wadi as Sudd , Wadi Harib , Wadi Markhah, Wadi Bayhan , Wadi Makhyah , Wadi Qinab , Wadi Aywat al Manahil , Wadi Armah , Wadi Dahyah , Wadi Arabah , Wadi Rakhawt , Wade Mitan , Wadi Shihan ,Wadi Hat) .

Wadi Name	Bana	Zabid	Surdud	Mawr	Adhana	Masila	Tuban	Jaza'a
Catchment Area (km^2)	6200	4632	2370	7912	8300	22500	5060	15000
Average Annual flow (Mm^3)	169.9	125	69.3	162.3	87.5	51	109.4	60

Figure (39) Mean catchment yield for gauged Valleys (wadis) in Yemen

3 - Springs:

1- Fresh water springs: there ia a lot of permant and seasonal springs considered as an important source for drinking and irrigation.
2- Hot water springs : this kind is found in several areas in Yemen .it is usually used in healing and irrigating some plant

4 - Ground water :

The people of Yemen must rely on a combination of surface water and groundwater resources for their domestic, agricultural and industrial needs. Approximately 45% of the nation's agriculture is fed by rainfall, with the remaining 55% dependent on either irrigation with groundwater or seasonal

flooding Domestic water supplies come almost entirely from ground water. The total water stored about 10370 billion m3 of which 1525 million m3 of renewable water or 0.02% of the total groundwater. In Mukalla (space preservation) + Ramlah seventy owns stock aqueous estimated 10 thousand billion m3 which accounted for 96.4% of the total ground water

Agricultural well, Haninah, Hodeidah Governorate

Figure (40) **"the race to the bottom of the aquifers is continuing at an exasperating speed"**

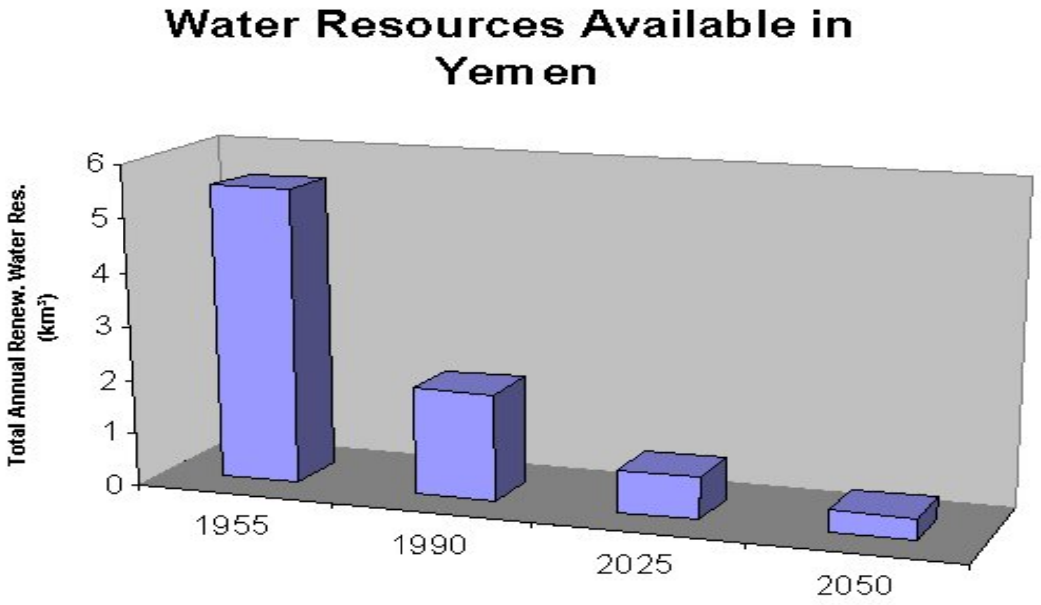


Figure (41) water resources available in Yemen

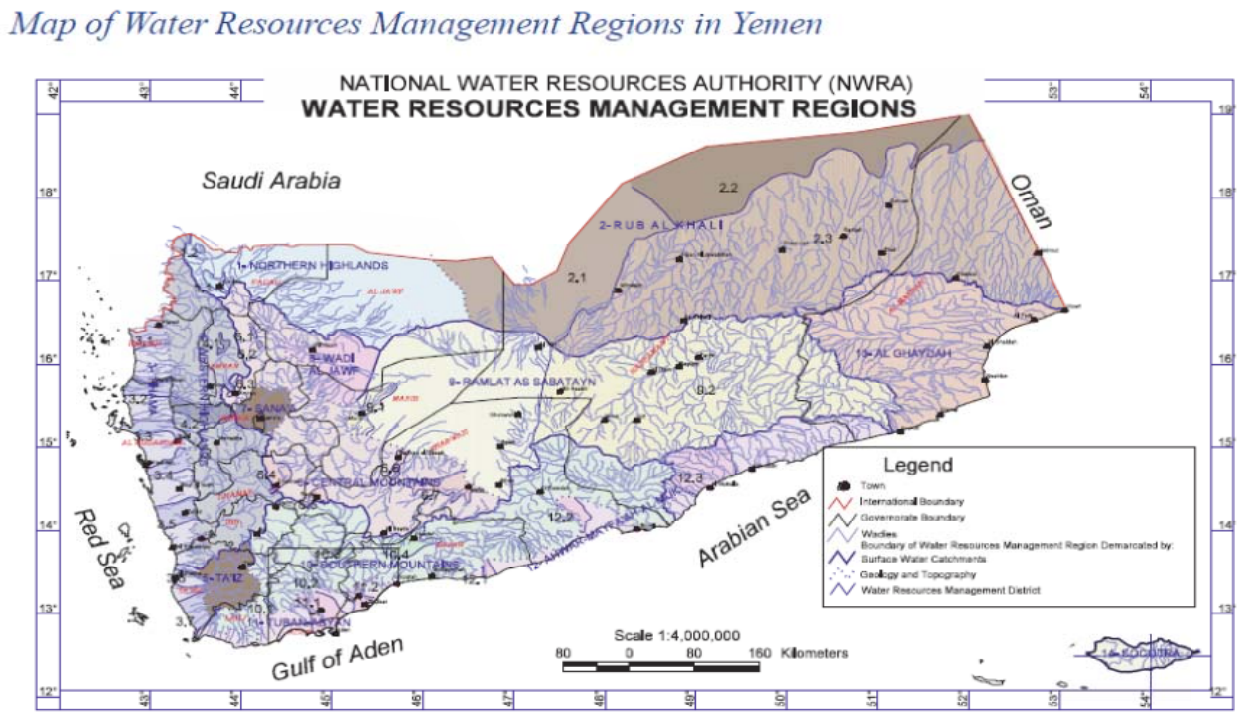


Figure (42) map of water resources management regions in Yemen

Wastewater treatment in Yemen:

According to a 2002 report by staff from the Yemeni Environment Protection Agency, there were 10 wastewater treatment plants in Yemen at the time in Sana'a, Taiz, Ibb, Hajaa, Aden, Amran, Al Hodaida, Dammar, Yarem, and Radaa. Most of the plants use the stabilization pond technology, a low-cost technology particularly suitable for a hot climate. Some use Imhoff tanks or the activated sludge procedure commonly used in many developed countries. While data on the quality of treated effluent are limited, those data that are available show that the effluent of at least two plants complies with the relatively lenient national standard of 150 mg/l of Biological oxygen demand, a measure of organic pollution. However, none of the four analyzed plants complied with the standard for fecal coli form, a measure of biological contamination. Reuse of treated and untreated wastewater in agriculture is common in Yemen.[Wastewater from hospitals and medical laboratories is discharged into the sewer system, but cannot be adequately treated in the existing municipal wastewater treatment plants. The largest wastewater treatment plant in the country, located in Sana'a, was completed in 2000, but it had to be upgraded between 2003 and 2005 due to

"deficiencies in its operation, unacceptable odor emissions, and inadequate management of the generated sludge.

- the treated wastewater from the STPs is around 125,000m3 per day, or around 45.5 Mm3/year
- The quality of the outflow is highly variable, while it is very good quality in Hajah, it is very bad in Taiz, depending on :

1- The method of treatment

2- The capacity of the station

3- The operational conditions.

Water pollution of underground wastewater:

As it is still the ability to regulate the discharge of Wastewater very modest operations where a lot of houses, factories and water is discharged untreated into groundwater basins in urban and rural areas .

Critical shortage of water resources in Yemen:

REVIEW OF THE CURRENT SITUATIO:

Yemen is favorably located within the Indian Summer Monsoon. Moist SW winds rising from the Indian Ocean and travelling across the Red Sea and Gulf of Aden bring heavy rains, which normally fall between March and September. The sharp escarpments dominating the western part of the country, where mean annual precipitation is generally of the order of 400 to 700 mm, intercept most of this rain. An estimated 2 100×106m3 of water is annually renewed in Yemen, 60% of which, some 1 300×106m3, becomes available through recharge processes to groundwater aquifers.

With a current population of over 15 million, the volume of water available to each individual in Yemen on an annual basis is only 130 m3. This amounts to a mere 12% of the average in the Middle East and North African countries (1 250 m3/person) and 2% of the worldwide average of 7 500 m3. In fact, 90% of the population receive under 90 m3 annually, which, according to international norms, is barely adequate for domestic use requirements alone (considered to be a minimum of 100 m3 person/year). Hence the country is already overdrawing its resources of 2 100×106m3/year by almost 30%, with a current estimated water use of 2 800×106m3/year.

This critical shortage of water is most clearly demonstrated by the rapid depletion of groundwater reserves, extreme water supply shortages in the major cities, and

limited access to safe, drinking water for the population. The gravity of the water problem in Yemen is perhaps best described by a recent World Bank publication: "Yemen however stands out among countries in water crisis, first because of the gravity of the problem - in no country in the World is the rate of exhaustion of aquifers proceeding so fast, in no country in the world is the capital city of the nation literally going to run out of water in a decade." Yemen faces a chronic imbalance between population and water resources, resulting from high population growth and continued scarcity of water resources. Annual per capita consumption of 120-150m³ is far below the regional average of 1,250m³. Indiscriminant water extraction, of which 90% goes to agriculture, is largely responsible for the depletion of groundwater. Annual water deficit exceeds one billion m³. The country's 250 mm average rainfall is simply insufficient to re-charge aquifers and meet the demands of both rural and urban populations. Water tables are declining in various regions by as much as eight meters per year, some of which reaching critical situation .Yemen MDGs Needs Assessment Report 35 Coverage of water supply and sanitation services is low, especially in rural areas. The sanitation infrastructure includes the public networks, covered pits and open pits The public network services are limited to urban areas and the only means of sanitation Services in rural areas is in the form of open pits. The MDG target is "to half by 2015 the proportion of rural population without access to water supply and sanitation". In 2004, the estimated rural population was about 15.35 million inhabitants, which is approximately 72.8% of the national total. Only 32% of rural settlements have access to improved water supplies, while 23% have similar access to safe sanitation services At the current growth rate of between 3.1-3.3%, rural population will reach 18.9 million by the year 2015 Inadequate access to safe rural water has its greatest impact on women, Inadequate access to safe rural water has its greatest impact on women, girls and adolescents. In search for water, they are forced to travel long distances (84.3% of women bring water from remote sources). Also, time spent in fetching water does not allow for educational advancement, skill development, economic participation and social interaction. Water fetching is in part responsible for the low school attendance rates .Urban population is estimated at 5.75 million. At an average growth rate of 4.3-4.6%, it will reach almost 8.1 million by 2015. Currently, only 54% of urban population has access to piped water and 26% to safe sanitation services. Most water supply systems in urban centers suffer from interruptions due to absence of standards for construction and design, poor contracting works, lack of qualified supervisors, and deficiencies in the supply of spare parts. Water consumption has been on the increase. In May 2003, the Ministry of Water and Environment (MWE) initiated the National Water Sector

Strategy and Investment Program (NWSSIP) that incorporates the requirements for achieving its objectives over the period 2005-2009. As regards to sanitation services, the situation has improved. In 2004, the coverage has increased to 26%, 38% and 7% in urban areas for public network, closed pits and open pits, respectively. In rural areas, sanitation coverage rose to 23% for closed pits and 34% for open pits. About 43% of households in rural areas remain with no means of sanitation services.

Basin	Decline Level
Sana'a	6.0-8.0
Ta'iz	1.5-2.0
Amran	3.0
Sa'adah	5.0-6.0
Rada'a	5.0
Tuban-Abyan	0.2-1.0
Tihama	1.0- 3.0

Figure (43) Water level declining (m/Yr)

Water Consumption (million m^3)	2000	2001	2002	2003	2004
Urban	66	65	75	76	79
Rural	89	93	97	101	108

Figure (44) Water Consumption

Causes of the Water Crisis in yemen :

Population Growth

Yemen has one of the highest population growths in the world – and with more people comes the need for more water since 1990, the Yemeni population has nearly doubled The World Bank estimates that in 1990, the population was 12.3 million. The population today is 24.1 million The population is increasing most rapidly in cities; hence, water availability is decreasing most rapidly in cities. It is evident that the majority of the population is clustered in cities like Sana'a, Aden and Ta'izz.

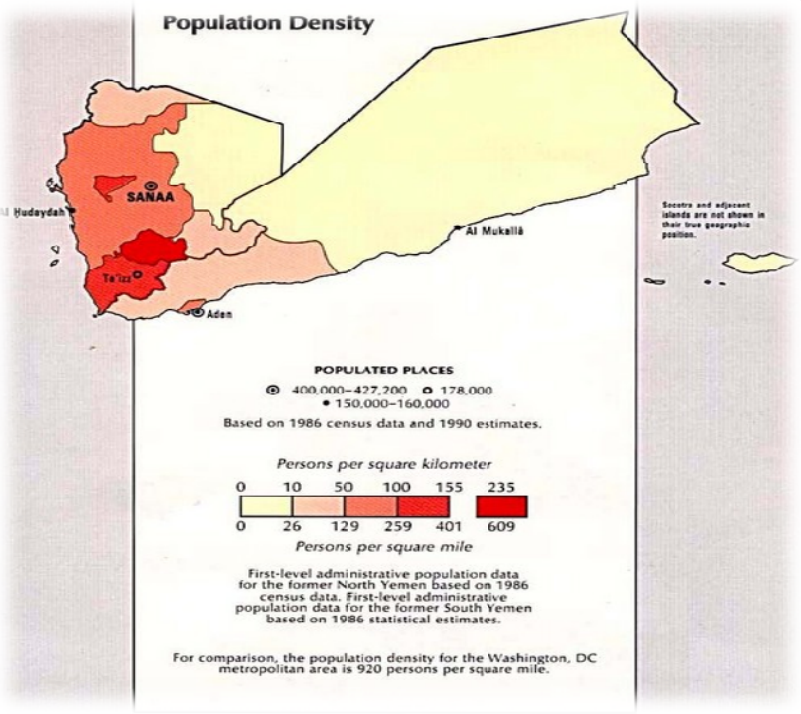


Figure (45) show Population Density in Yemen

2. **Misguided Agricultural Development and Policies**

In recent years, many Yemenis migrated to neighboring countries, like Saudi Arabia, to work in the oil industry. This stimulated the growth of the Yemeni market, which allowed agricultural technology to develop rapidly. Tractors, chemical inputs and tube well technology were introduced, which steered Yemen away from traditional farming practices and systems of water management. The country could no longer live in balance with its natural resources when these technologies were used. Furthermore, the government failed to prevent the sinking of wells and regulate groundwater extraction. It implemented policies that encouraged the use of water, including low-interest loans, cheap diesel pricing and public investment in surface or spate

irrigation. Because of this, groundwater and surface irrigation have been significantly under priced, causing Yemenis to be wasteful in their use of water.

3. Qat and Its Effect on the Crisis

More than half of Yemen's water is used to grow qat (or Khat). Qat is a narcotic drug that is chewed by 80 percent of the Yemeni population. Weir (1981) discusses the impact of qat on the people, the region and water in Yemen. Qat, in the form of chewable leaves, is used to produce excitation, forgo sleep and enhance communication between people. It also reduces feelings of hunger and fatigue – both of which are common in a country as impoverished as Yemen. Addiction to qat is similar to an addiction to cocaine – it is difficult to give up once an individual has started using the drug. Most Yemeni men and some women chew the leaves of this plant every day for its narcotic effect. It is a way of life in Yemen. Qat chewing starts after lunch, the main meal of the day, and continues for The rest of the day . It is a highly social event – families and friends gather in private homes, each bringing their own qat According to Worth (2009), farmers harvest this plant to make profit – and use the already-scare supplies of water to do so. Although the government has tried to limit the growth of qat, to preserve water – no one is listening. Farmers are unwilling to give up this crop because it is often their only source of income, and the majority of the population is addicted to this drug. Qat is one of the major causes of the water crisis because the crop is sucking up most of Yemen's groundwater. About 90 percent of the nation's groundwater is currently used to irrigate qat

Figure (46) show Qat tree

4. Lack of Law Enforcement

The Yemeni government also lacks law enforcement to prevent water from being wasted. Wells are being drilled illegally into natural groundwater aquifers. This is happening at an alarming rate. Leaky pipes are common, sometimes wasting up to 60

percent of the water passing through them . In some basins (like the Sa'adh basin), Yemenis must drill up to 800 m in depth to reach any water. In any case, it is clear that the lack of law enforcement and flawed policies have contributed to the water crisis – which could have been prevented, or at least be less serious, if the government had implemented laws and policies that would have limited water use.

5. Climate Vulnerability

Climate change is drastically affecting Yemen's water availability. The summary of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2008) came to the conclusion that the climate in the Middle East and North African region will become even hotter and drier. , this will increase the occurrence of droughts, potentially destroy agriculture, reduce tourism and cause rising sea levels and flooding in coastal regions. To reduce the severity of climate change in this region, which includes Yemen, the World Bank will partner with affected nations to help them adapt in three ways:

- The first is infrastructure investment. Projects must be completed in ways that will limit their vulnerability to climate change. For example, buildings must be designed so that they will survive the changing climate. Building near the coast is discouraged, to avoid destruction due to flooding. The World Bank has $1.1 billion in its budget to help affected countries with their infrastructure investment.
- The second is building awareness and knowledge. The public needs to be informed of climate change and how to adapt to it. The World Bank is currently building a program in the Middle East and North African region for technical assistance on climate change adaptation.
- The third is policy reform. Countries that are severely affected by climate change need to change some of their policies in order to adapt. Fiscal reform (government spending and revenue collection) would be useful in improving efficiency of land use and the use of water and energy. Not only would this make for a more sustainable environment, but it would also free up public funds that could instead be used to protect the most vulnerable social groups from climate change (like the poor). Agriculture constitutes 15 percent of Yemen's GDP. The government is worried that climate change will decrease the frequency and amount of rainfall, thereby destroying the country's agriculture. This would not only be a water crisis, but also a food and economic crises. The World Bank is helping farmers in Yemen by teaching those strategies to conserve and use biodiversity to make agriculture less vulnerable to climate change. The strategy emphasizes the conservation of agro biodiversity and developing coping mechanisms with climate change

Figure (47) Use of Water for a Period of 30 Years (1990-2010) In Different Water Use Sectors (million cubic meters per year)

Water Use	1990	2000	2005 (estimated)	2010 (estimated)
Agriculture/Irrigation	2,600	3,145	3,235	3,328
Domestic/Urban/Rural	168	210	265	552
Industrial & Mining	31	45	65	90
Total	**2,799**	**3,400**	**3,565**	**3,970**

Drought:

Yemen is set to be the first country in the world to run out of water, providing a taste of the conflict and mass movement of populations that may spread across the world if population growth outstrips natural resources. Government and experts agree that the capital, Sana'a, has about ten years at current rates before its wells run dry but the city of two million continues to grow as people are forced to leave other areas because of water shortages Drought has caused the displacement of thousands of people s from mountainous villages in 2009, the first time in Yemen; the Investment Authority in Yemen has called on the private sector to compete for projects to desalinate seawater in order to face the current issue of water scarcity in Yemen as well as the future fear of drought

Figure (48) land drought in Yemen

The Institutional Framework of the Water Sector:-

The Ministry of Water and Environment (MWE) which was established in May 2003 is highest authority in charge of water affairs in Yemen, the mandate of the ministry to reorganize the water sector, with the aim of creating an institutional structure for integrated water management and to prepare the necessary institutional and investment conditions to face the exacerbating water problem in Yemen. The MWE was charged with one of the most complex development problems in Yemen and its most challenging tasks, namely: the water scarcity problem and the challenges of providing drinking water to the urban and rural population, treating wastewater, managing water resources and planning its use in light of the water law. The importance of water is well known, not only for drinking and food production, but also as a basis for sustainable development, especially given the strong interrelationships between the availability of water on the one hand and public health, unemployment, poverty, female education, and development in general on the other. Another challenging task of the MWE is abating environmental degradation manifested in exhausting, depletion and pollution (to various degrees) precious natural resources: vegetation, air, soil and water and taking appropriate measures to protect and conserve such vital resources as a basis for sustaining. And encouragement of the local society civil institutions private sector and women societies in the efforts of water and environment reform. Also, conserving the natural resources and rationalizing their uses through adoption and activating related legislation implementing awareness campaign.

Economic activity, upon which the development and population stability depends (particularly in the rural areas). In addition, the MWE is charged with protecting and conserving biodiversity, marine environment, nature reserves and protected zones; and with the follow-up of Yemen's commitments as party to 12 regional and international environmental agreements. As a new ministry, it was natural for the MWE to start by initiating a participatory process which involved all stakeholders and which aimed at elaborating a clear and shared vision of its priorities and the needed approaches to address water and environmental issues based on an objective evaluation of the conditions of the five sub-sectors (water resources, urban water, rural water, irrigation and environment), to arrive at an accurate determination of the needed actions or measures and institutional, legislative and investment requirements. This evaluation and determination of the main actions and requirements was carried out through a participatory process that involved all stakeholders.

The ministry's mandate includes a number of implementing institutions:

- The National Water Resources Authority (NWRA) , in charge of water recourses management and development
- The General Environment Protection Authority (EPA) in charge of environment protection and natural resources conservation.
- The General Authority for Rural Water Supply Projects (GARWSP) in charge of water supply services in rural areas.
- The National Water and Sanitation Authority (NWSA) in charge of water and sanitation services in the branches.
- The Local Water and Sanitation corporations. These corporation used to be branches of the National Water and Sanitation Authority, but within the water sector reform process and separation of the executive tasks from the regulator ones , they became autonomous local corporations managed by a board of directors from the local councils. The number of local corporations is 15.
- As for the strategic of projects funded by international agencies they are under the direct control of MWE, projects are:
    - The Technical Secretariat for Water and Sanitation Reform.
    - The Urban Water and Sanitation Project.
    - The Rural Water and Sanitation Project
    - The Development Project of Socotra Archipelago.

Figure 3.1: Organogram of the Ministry of Water and Environment (MWE)

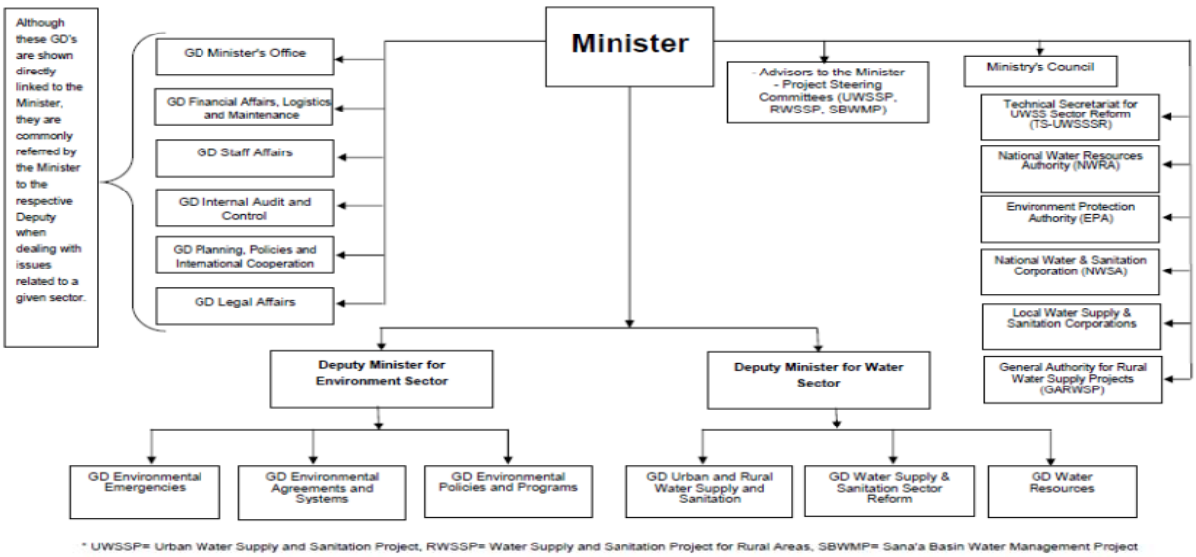


Figure (49) Organization structure

Integrated water resource management (IWRM)

Integrated water resources management (IWRM) calls for the integrated management of land and water resources and other related natural resources in a coordinated approach that aims to maximize socio-economic welfare in an equitable manner without sacrificing the sustainability

Of the ecological systems

IWRM tools are grouped into three main categories, namely the:

• Enabling environment – which consists of three sets of tools; namely: policies, legislation and financing structures.

• Institutional roles – which consist of two sets of tools, namely the organizational framework and institutional capacity building for developing human resources.

• Management instruments – which consist of eight sets of tools, namely: water resources assessment, plans for IWRM, demand management, social change instruments, conflict resolution, regulatory instrument, regulatory instruments, economic instruments and information management and exchange.

The water resources challenge is extreme. The Update therefore contains strengthened elements with particular emphasis on integrated actions and on decentralized and bottom up approaches designed to begin to impact on the critical groundwater balance.

The programme strengthens NWRA's capacity for integrated water resource management (IWRM), and promotes integrated planning and cooperation. Considerable investment is to be made in knowledge building and monitoring in order to provide better support to planning. Groundwater monitoring and regulation will be strengthened. Partnerships amongst stakeholders will be consolidated, with particular emphasis on partnerships for decentralized management with basin committees and water user associations at the basin and local levels. NWRA will strengthen decentralization of responsibility to its branches, and all stakeholders at the decentralized level will be better empowered to implement basin plans more effectively. There will also be improved partnership and joint work with MAI and its programmes and projects, particularly the proposed National Irrigation Programme (NIP), on water resources management at the local level, on WUA development and responsibilities, on cooperation in basin planning and the basin committees, and joint work on water use efficiency and groundwater management for irrigation. There will be reinforced efforts on water rights, on prioritization of water uses, and on the development of equitable transfer mechanisms

Several challenges confront the water sector in Yemen in management water:-

Challenges of the water sector:

- Yemen is water – scarce country, Situated in an arid region with no permanent rivers, historically, the population depended on rainfall. Springs, hand –dug wells and water harvesting in ponds, and dikes and dams of various sizes maximum well depths didn't exceed tens of meters and their water was lifted, in small quantities, by animal or human effort. No mechanical drilling rigs or pumps were used until the 1960s.
- Because Yemen is situated in an arid region, the annual per capita share of renewable water resources dose not exceeds 125 m3 (the international figure is 7500 m3). This water scarcity gave water a prominent role in shaping Yemeni consciousness and civilization throughout history. The Marib dam is one symbolic example of the vital of water, another example being the mountain terraces. there terraces ,which over more water harvesting structures invented by Yemeni farmers to retain scarce rainwater along with the precious fertile soil that sweep down the barren mountain – sides . The designing and construction techniques of these terraces are a clear testimony.
- The opening of Yemen to modern well – drilling technology in the early seventies, coupled with large cash inflow that followed during the oil boom led to an extensive expansion of irrigated farming a rush to drill water wells and buy pumps. In the absence of any regulatory controls for drilling. These development highland plateaus and in the coastal plans. This mining is still going on.
- Although the symptoms, causes and even the required remedies for the water crisis in Yemen have been diagnosed and became well known since the mid 80s ,as a result of numerous studies that mapped the water basins and estimated the rainfall replenishment and quantity of water use ,this did not stop the problem from continuing and worsening , unabated ,to reach an all time serious level today . That is why the prevailing impression in informed circles about this problem is that failure lies in implementing the solution rather than in diagnosing the causes of the problem and prescribing measures to solve it.
- In should be noted that establishing the MWE in the cabinet of 2008 reflects apolitical awareness of these problem and a commitment to tackle them especially as the water shortage problem is worsening day after day and its

impact is being felt not only for drinking water but also development in general and agricultural activity in particular, which is threatened in a number of regions (Sana'a, Sadah, Rada, and other areas). However , the mere existence of the MWE is not sufficient by itself to solve water and environment problem , which have accumulated over long years of fragmented responsibility scattered among numerous bodies , coupled with the lack of sufficient fund to address these strategy and investment programs . Here lies the importance of the of the strategy and investment program in formulating a vision for the required measures and necessary investment to implement the policies and laws that exist only on paper.

- 5-The system of water rights should acknowledge traditional and existing rights, provide for clear rules governing appropriation, expropriation and reallocation of allocated rights, and allow for transferability. Consistent with the system of water rights, responsibility of all users should be defined to avoid damage to water quality and quantity, as well as enforcement mechanisms for restitution in the event that allocated water rights are infringed;
- 6-Water shall be recognized as an economic good; maximizing the value of water use may be a key element of the national water policy. This requires that water should be allocated to its competing uses based on its economic value. The allocation mechanism should ensure that water is transferred without conflict and with fairness from low value uses to the ones which society places the highest value;
- Water shall be recognized as an economic good; maximizing the value of water use may be a key element of the national water policy. This requires that water should be allocated to its competing uses based on its economic value. The allocation mechanism should ensure that water is transferred without conflict and with fairness from low value uses to the ones which society places the highest value.
- While making intersect oral allocation decisions, first priority in the allocation of the nation's water resources should be given to meeting the reasonable needs of the population for human and domestic consumption. Second priority should be given to industry, tourism and other service sectors. Third priority should be given to the agriculture sector. Scrotal allocation of water and its usage should be governed subject to the enforcement of effective management plans buy the public and private entities concerned, as well as proper assessment of social and environmental impacts of water usage.

- Since water usage leads to changes in the quality and quantity of water, issues related to water quantity and quality should be treated together within the context of water resources planning and management.
- Distinction between the management of the resource and the delivery of water services needs to be out rightly recognized. With respect to planning, management and allocation of water resources, the NWRA should retain full responsibility, adopting approaches to management and regulation that recognize the unitary nature of the resources, the pervasive existence of externalities and the close interaction of quantity and quality issues. In this context, institutional and technical capabilities of NWRA should be strengthened to enable it to play an effective role in managing Yemen's scarce water resources. On the other hand, responsibility with respect to provision of water services or for that matter execution of water related projects should stay with the existing entities.
- All water resources in the country shall be considered as state owned property and utilized in compliance with the national water legislation. Drinking water supply has a priority over any other use. Government authorization is required for all significant water withdrawals from common resources: surface water, groundwater, recycled water, and other.
- Groundwater mining shall be evaluated on the basis of sustainability and regulated in a manner that does not hamper the well-being of future generations.
- In view of stakeholder's conflicts arising mainly from water scarcity, the process for water resources management and development shall be based on full participation of water users, communities, planners and policy makers in decision making. Raising Public awareness about water related issues to mobilize public support for water management policy is a must.
- In view of the fact that Yemen is a country of many hydrological units, the resource management shall be exercised on well defined hydro-geographic units.
- Low coverage of sanitation services in both urban and rural regions and inadequate human, financial and institutional resources and capabilities.
- Valuing Water: increased awareness on water cost; setting water tariffs for all consuming sectors including irrigation; gradual implementation of cost recovery; tariffs should accommodate low income population; pollution fines should be imposed on manufacturing, agriculture and oil industries; broader role for finance through donors and private sector

- Markets in water services are not based on a recognized system of water rights
  Both in the rural and urban/industrial sectors, there are thriving markets in water services: irrigation water services, urban privately owned bulk-water outlets which sell water to tankers and also private sector water supply networks, tanker delivery services for water, and supply of dabba (jerry can) and bottled water. These markets are essentially based on resource capture because the sellers of these services have neither a restriction on access to water or quantity to pump nor a recognized right over the water they access.
  Essentially, it is the lack of clear water rights that causes unsustainability because higher demand for water services drives a 'race to the bottom of the aquifers' in the absence of prices which reflect the scarcity value of water and which could induce conservation (common resource or common pool dilemma

Figure (50) tanker delivery services for water

Difficulties

- Continuous uncontrolled groundwater abstractions and drilling;
- Deepened and dry wells in highland plains: Several new attempts to introduce water resource
- Management and control (draft legislation submitted to Parliament)
- Low level of extension services: The continued use of traditional agriculture techniques is blamed on inadequate inputs and support services provided to farmers.
- Furthermore, there is little public investment in agricultural research and extension services Water scarcity and inefficient irrigation system: Water use is inefficient due to dominance of traditional flooding and gravity irrigation, despite existing water depletion in almost all water basins.
- Low productivity: Fragmentation of land holdings, inappropriate inputs, and water scarcity lead to low productivity, which is reflected in low labor wages. Yields for many crops are well below technical potential compared to that in other countries. The yield gap can be as high as 40% for potato and tomato,

60% for banana, and 20% for oranges. Post harvest losses are high due to harvesting techniques which are seen to reflect rough handling, poor packaging and weak transport networks. Also, lack of quality control undermines competitiveness of agriculture exports.

- Growing Qat production: it is inevitable that any interventions or solutions will have to touch upon all various aspects of Qat production and consumption, making use of advantages and overcoming negative aspects. The GoY, having convened a national conference in 2003 to address these issues, is drafting a strategy and an action plan which builds consensus around the various qat issues.
- Water scarcity and inefficient irrigation system: Water use is inefficient due to dominance of traditional flooding and gravity irrigation, despite existing water depletion in almost all water basins.

Water sector perform:

Institutional, legal and government performs

Yemen has been moving towards an institutional structure that will allow integrated management of water resources. This began in 1995 with consolidation of water resource management function under one entity (NWRA) and the start of basin planning.

The institutional, reform process has received powerful new impetus from the creation of the NWE, reflecting commitment to establish a consolidated sector management structure. For the first time all agencies dealing with water and environment (NWRE, NWSA, LCS, GARWSP, EPA), except for irrigation, came under the auspices of the new ministry.

On the legal front, the water law was passed in 2002 after extensive national and international consultation. Following the establishment of the MWE, few amendment were introduced into the law and the await parliamentary approval by- laws have been prepared and await the passage by the Parliament of the amended law. Meanwhile, several measures to initiate implementation of the water law have been undertaken.

1- Water Resources Management Reform

NWRE has made a start on integrated resources management, with several basin plans prepared. Innovative water resources management approaches are being tested, including basin management approaches and self – regulation by groundwater users. Technical support is needed from countries which have successfully implemented such approaches.

2- Water Supply Reforms

- In water supply and sanitation, major efforts have been made to expand the coverage and quality of service.
- Reform efforts in urban water and sanitation are well underway and reform policy for rural water and sanitation is currently under preparation .the major challenge is that service converge has not kept up with population growth .
- The general orientation of reform in this respect in this respect is the gradual departure of the government from its traditional role as an exclusive investor and service provider to a role of sector, facilitator and regulator.
- In the urban water sub- sector, the government maintains a strong participation, in view of the commitment poverty alleviation; however, it increasingly encourages decentralization and cost sharing with beneficiaries, who are also made responsible for scheme operation and maintenance.

To strengthen technical and institutional capacity water resource management in Yemen:

Strengthening the institutional framework by: institutional strengthening and sector coordination (including delegation to local authorities); strengthening community-based organizations; water resources management planning (especially basin planning); and human resource development including:

1- Managing water quality

The formulation of a clear policy is required on institutional responsibility of each concerned entity with respect to water quality and suitability for various uses, and for the assessment and control measures of such quality. Then we will adopt and follow-up establishing water quality coordination group, to engage various institutions, and to agree on the role of each institution.

2- Recovering control over groundwater

The biggest challenge threatening Yemen's water resources is overdraft of groundwater. The introduction of motor pumps and tube-well technology allowed farmers to tap deeply into groundwater aquifers. Traditional water rights allow unlimited access from a farmer's private land, and there is a race by each farmer to capture as much of this common pool resource as possible.

The current incentive structure (particularly the lack of limitations on extracted quantities and the subsidized diesel) promotes rather than discourages groundwater overdraft. The nation recognizes the need to deal with the problem, which a number of initiatives have tried to tackle. Few communities have imposed self-regulation rules, either on new drilling or on transfer and sale of water outside the extraction area. The MAI has piloted a range of technical efficiency and watershed management innovations, and is currently adding water user organizations and technical advisory

services to its approach. On the other hand, NWRA has carried out water-well inventories in a number of basins, and the new water law has introduced all the regulatory instruments required. Three critical basins as well as the well fields which supply the major and some secondary cities have been declared protected. Projects are underway in the Sana'a and Sa'ada basins to test integrated packages of incentives and measures to reduce overdraft of aquifers. Ultimately, the overdraft problem will have to be dealt with by a comprehensive "package" of measures, including:

1) Economic incentives, including trade and agricultural policy measures
2) Regulatory measures, including self-regulation by the community
3) Clear assignment of water use rights (linking them to specific uses)
4) Technology packages that help farmers earn more income using less water.

The MWE and the MAI propose to progressively develop and test the elements of this package. National policy will essentially decentralize these key issues of water resources management to the water basin committees, within basin plans. The preparation of basin plans is therefore top priority.

NWRA will coordinate information, education, public awareness, licensing, 12 monitoring and enforcement. NWRA will work closely with other concerned agencies, open more decentralized branches at governorate level, and cooperate at the field level with local authorities, especially regarding water law enforcement. NWRA will also closely work with farmers through its community mobilization teams and will coordinate its programs with the groundwater-related actions of MAI. The programs in Sana'a and Sa'adah Basins are piloting integrated packages based on water use efficiency investments and practices, identifying enhanced supply options, and defining farmer responsibility and encouraging self-regulation. These programs will be closely monitored through regular workshops, and lessons will be drawn and applied in other basins. A study on options for changing the economic incentive structure, particularly for groundwater management, will be carried out. This study will cover both positive incentives like investment cost sharing as well as negative incentives like pricing. It will also cover the overall incentive regime for irrigated agriculture that results from macroeconomic and agricultural policy, fiscal policy regarding taxation, water charges and subsidy on water-related equipment, and the role of public investment, including that of the AFPPF. Furthermore, pilot projects will be undertaken, including a pilot project to test a system of tradable water rights in Taiz. Other actions will be identified through a stakeholder symposium that will review the results of the study on incentive structure. As sustainability is no longer attainable in the overexploited areas, and as some mining is unavoidable, NWRA will also propose

a “rational groundwater policy” to set out expectations and benchmarks regarding the use of the groundwater resources

3- **Creating an enabling institutional framework :**

With the Water Law becoming effective in 2002, the legislative framework for the water sector is already in place. Moreover, considerable progress has been made in consolidating water management functions and building implementation capacity as noted in the previous chapter. Capacities to regulate water use need to be further strengthened. This would require rationalization of mandates of agencies performing regulatory and project implementation functions.

The technical capacities of key water sector agencies also need to be enhanced, especially regarding technical aspects of water resources. This would require substantial investments in human resources development for filling what is at present a large gap in qualified personnel for the regulatory and service providing agencies. There is also the need to establish better linkages between water sector agencies. It is particularly important that decentralization is pursued and extended as a policy priority and authority is devolved at the lowest appropriate level.

Furthermore, it is important to enable community-based organizations to play their due role in co-management and to build their capacity for joint management of groundwater resources. The government has to assume the role of a catalyst for creation of such organizations and for building their capacities.

4- Information provision, awareness raising and creation of water management vision

Despite the increasing importance of groundwater in meeting the overall water demand, the updating of information about the resource is generally not done on a regular basis and remains inadequate. This is partly because the assessment and monitoring of groundwater, being a hidden resource beneath the surface, is more difficult technically and is more costly than surface water. The MWE will take steps to create an adequate national water resource information base, and strengthen the hydro-meteorological monitoring network to keep track of evolving resources use and resource quality situation. The ministry will also ensure that the information systems mentioned above are capable of processing and analyzing the regularly collected data and making it available for water policy formulation and for dissemination to the public as another means for awareness raising. This will entail strengthening the National Water Resources Information Center at NWRA and establishing water quality laboratories. The final component is the creation of a shared vision among stakeholders that would guide water resource management efforts. This can be accomplished through formulation of water resources management plans that would

be prepared through a participatory approach. The plans would heavily rely on the technical information obtained through systems mentioned above as well as on the input from professionals and their participation in the preparation process. The water resource information and technical solutions generated by water professionals would be disseminated among stakeholders who would be involved in the selection of water management strategies to be implemented. This approach was successfully piloted in the formulation of Taiz water resources management plan

5- Protection of water rights, implementation of the water law, and creation of an enabling environment at the macro-economic level.

Yemen needs a system of water and environmental rights in order to control groundwater overdraft, reverse the growing trend towards inequity in access to (or allocation of) surface water, and to protect water and land resources from quality degradation. In collaboration with stakeholders, the government would help put in place a system of water rights, and enforce contracts involving voluntary transfers of such rights between consenting parties. Subject to the results of a pilot project on rights-based water transfers, the MWE would work (long term) on defining and gaining social and political acceptance of a system of water rights that would allow recognition of formalized water markets and trade in water rights. Moreover, the MWE would enforce the water law, particularly the provisions relating to licensing and registration of wells and drilling rigs, and will endeavor to build control regimes for the protection of water stressed catchments. Finally, as the macroeconomic policy has an important bearing on resource use, the government would endeavor to achieve a better integration of water resource management issues and concerns on the one hand, and macroeconomic and trade policies on the other. This, however, requires strengthening national capacities in the field of economic development within the sector, as well as in other relevant ministries, through human resources development and by mobilizing more investments for improving information on linkages between macroeconomic policy and water resources, and developing the needed analytical tools to support decision-making during formulation of development policy.

6- Building capacity and improving performance

Performance indicators in the decentralized utilities are improving, but are still well short of international norms. Capacity building programs are underway to improve performance. Topics include loss reduction, improved operation and maintenance, improved financial management, senior management programs, project management and project implementation.

7- Enhancing community participation

Community participation in the choice of technology and in selecting the level of service it can afford, is a possible means to reduce costs and, hence, to expand coverage to a larger population. This approach is being adopted systematically in the rural water sector. However, other community participation measures, which apply to both urban and rural communities, include public awareness campaigns on such issues as water conservation and the basis and importance of tariff setting in sustaining the utility/service

Figure (51) awareness community program

8- Desalination

Desalination technology has made considerable advances during the last few decades, which have added to its importance as a source for meeting drinking water needs in rural and urban (arid or semi arid) regions. Such advantages have also led to a substantial reduction in desalination costs, largely due to additional savings made in the amount of energy consumed in the desalination process and to the reduction of environmental impacts of desalinization, which previously required high mitigation costs Desalination is often looked at by some as a magical solution to water scarcity, while others look at it as an expensive technology, especially when the desalinated water needs to be transported over long distances or pumped to high altitudes. In such cases, the energy cost for the transport, rather than desalination cost, becomes the deterring or constraining factor.

The following paragraphs will shed some light on desalination, and the MWE policy in this respect:

A) Discourse about desalination should be limited at the present time to coastal towns, or to highland towns with sustainable reserves of brackish groundwater that can economically be desalinated as a supplementary source for fresh groundwater. The reason for this being the prohibitive cost of pumping desalinated water over long distances or to high altitudes.

B) It will be a mistake to delay the introduction of desalination until all groundwater resources are depleted. Then, people cannot afford the sudden large increase in the water-tariff, which would be brought about by

the high cost of desalinated water compared with the relatively cheap groundwater

C) Desalinated water should be gradually introduced as a supplementary source to supply coastal towns', so as to allow gradual, rather than sudden, increase of the water tariff18. This will also help to maintain the implementation of the national policy on water tariff which stipulates that the tariff should allow recovery of the operation and maintenance cost in addition to part of the depreciation cost; a policy, which has been achieved in most water utilities. In other words, it is important that the introduction of desalination should not lead to a large and sudden increase in the production cost, that cannot be recovered except by big changes in the tariff, which cannot be afforded, given the economic conditions and low per capita income19.

D) Institutionally, desalination constitutes a unique opportunity for the private sector to enter into investment partnership with the public sector, as the water produced can be sold in bulk to water utilities which in turn will pump it into its networks and bill it to its consumers.

E)) For desalinization to be economical, the losses in the water distribution networks should be very small (not exceeding 15%). This entails considerable investment to rehabilitate large segments of the water distribution networks in several Yemeni cities.

The NWSSIP I action plan provided for thirteen actions grouped under four strategic heads:

- Sustainability through water resources protection and allocation through: reducing groundwater mining, securing farmers' water rights, and getting incentives right.
- Increasing farmer incomes through increased water use efficiency by: refocusing agricultural research and extension, cost recovery on public irrigation schemes, developing water user associations (WUAs) as principal partners, and treating qat as a crop.

-Enhancing resource sustainability and quality through watershed management by: reviving watershed/water basin management with an integrated approach, and reviewing and revising the dams program.

- Improving targeting and sustainability by: adopting bottom-up approaches throughout and mainstreaming gender issues; promoting sustainability through broadening the range of partners so as to include, for instance, more NGOs and community institutions; and directing available finance to the greatest need (targeting).

Figure (52) the National Water Sector Strategy and Investment Program (NWSSIP)

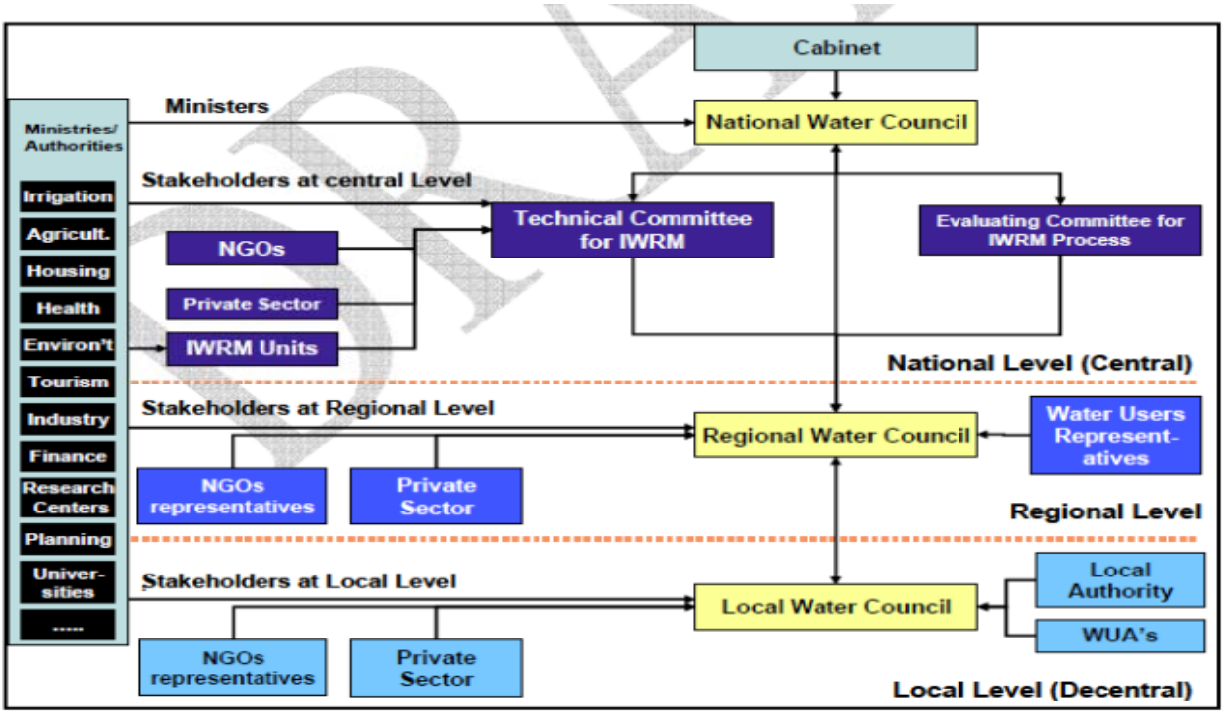


Figure (2) Proposed Institutional Structure for implementation of IWRM plans at the national level in the ESCWA countries

Figure (53) proposed institutional structure foe implementation of IWRM plans at the national level in the ESCWA countries

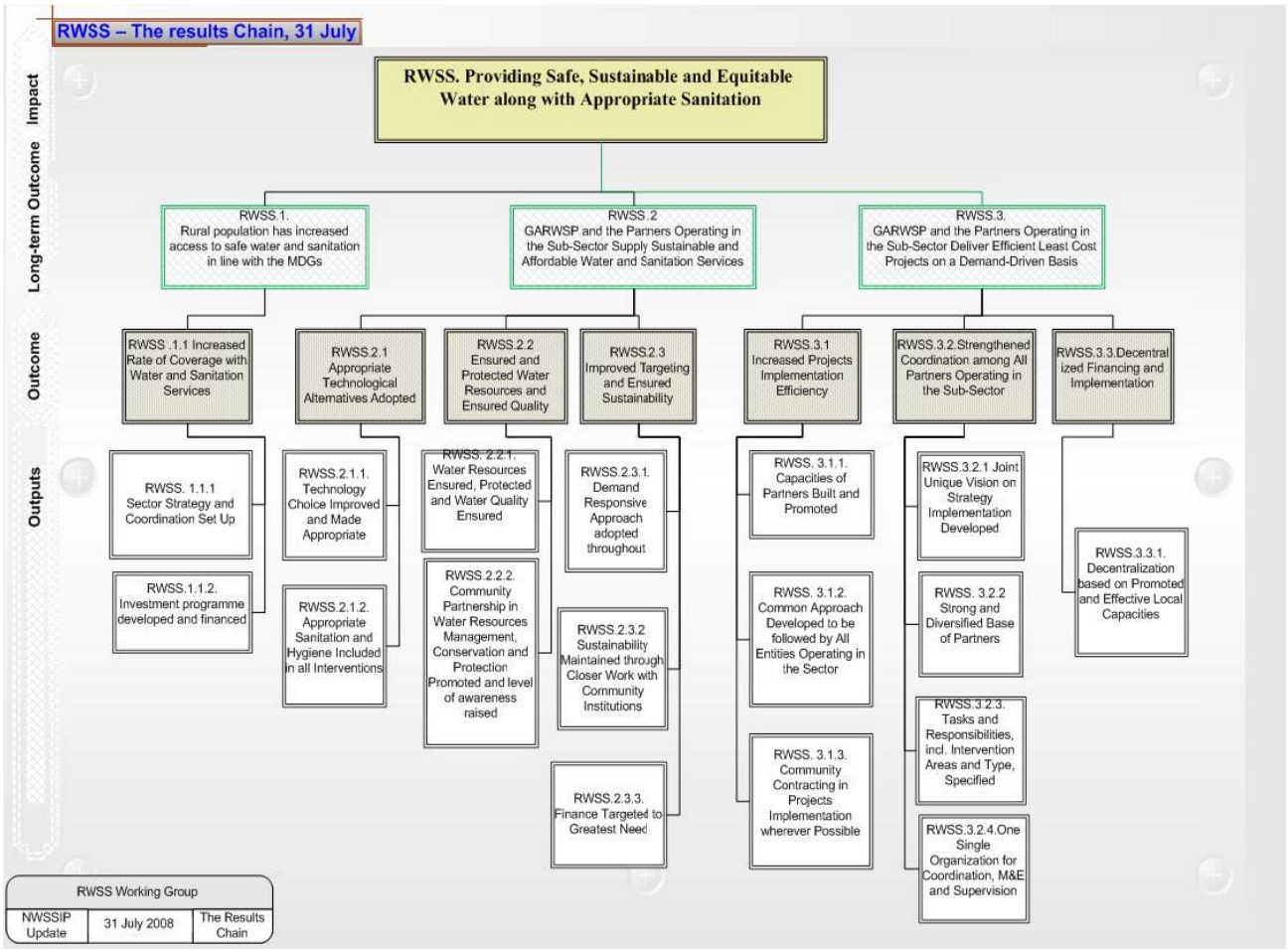


Figure (54) providing safe sustainable and equitable water along with appropriate sanitation

Figure (55) example of NWSSIP activities requiring inter-agency approaches:

Cross cutting topic	Agencies	Joint actions	Reference
1. IWRM at the basin level	**NWRA**, basin committees, local authorities, MAI, users	▪ studies of priorities at basin level ▪ preparation and implementation of basin plans ▪ support to basin committees ▪ establishment of protection zones ▪ water rights registration and water transfer	IWRM 3.2.1 IWRM 1.1.4 IWRM 1.1.7 IWRM 1.3.3 IWRM 3.2.2
2. Developing WUAs as the building block for water management	**NWRA**, basin committees, local authorities, MAI, users	▪ *National Conference on Community Water Management and Water Rights* ▪ development of water users associations as the lower level building blocks of water resources management	IWRM 1.1.4 IWRM 1.1.7
	RWSS agencies, NWRA, MAI, NGOs, WUAs	▪ capacity building of effective and sustainable user organizations for rural water	RWSS 2.3.2
	MAI, **NWRA**, basin	▪ development of water user organizations for	IRRIG 2.1.1

	committees, local authorities, RWSS agencies, WUAs	irrigation, including a study and strategy for scaling up	
3. Sourcing water	**MWE/utilities**, NWRA, basin committees, WUAs, private sector	▪ identify resources within basin plans ▪ develop equitable and sustainable models for resource transfer, recognizing water rights and "no uncompensated harm"	UWSS 2.2.1 UWSS 2.2.1
	RWSS agencies, NWRA, basin committees, local authorities, WUAs	▪ map, identify and monitor resources within basin plans ▪ sustainable management of RWSS sources	RWSS 2.2.1 RWSS 2.2.2
4. Developing alternative water sources	**NWRA**, MAI, urban utilities, private sector, NGOs	▪ developing desalination, rainwater harvesting and other options	IWRM 1.2.5
	MWE/utilities, **NWRA**, private sector, NGOs	▪ desalination study for coastal cities	UWSS 2.2.1
	RWSS agencies, NWRA, SFD, private sector	▪ development and distribution of low cost technologies for drinking water supply	RWSS 2.1.1
Cross cutting topic	**Agencies**	**Joint actions**	**Reference**
5. Improving water use efficiency	**NWRA**, MAI, rural water agencies, urban utilities	▪ technology and pilot programmes in water use efficiency ▪ irrigation water management ▪ irrigation technology	IWRM 1.2.2 IWRM 3.1.1 IWRM 3.1.2
	MWE/utilities, NWRA, private sector	▪ implementing a loss reduction programme ▪ improving network management and efficiency	UWSS 2.1.1 UWSS 2.2.2
	MAI, NWRA	▪ Research on water use efficiency, technology and pilot programmes in water use efficiency	IRRIG 3.1.1
6. Water quality	**NWRA**, EPA, Water Quality Committee, urban utilities	▪ updating water quality standards and finalizing water quality policy ▪ water pollution monitoring ▪ establishment and enforcement of protection zones	IWRM 1.3.1 IWRM 1.3.2 IWRM 1.3.3
7. Water reuse	**NWRA**, MAI, urban utilities	▪ cost effective and safe treatment/reuse of irrigation drainage water ▪ urban wastewater treatment and reuse	IWRM 2.1.1 IWRM 2.1.1 UWSS 1.2.3
8. Policy environment	**NWRA**, MAI, MWE, other government agencies	▪ the policy framework for groundwater management	IWRM 1.2.3

9. Environmental Impact Assessment (EIA)	NWRA, **EPA**, MAI, all water agencies	▪ updating and improving the EIA mechanism ▪ ensuring consistent application of EIAs to water programmers, including dams	IWRM 2.1.3 IWRM 2.1.3

Strengthen the technical and institutional capabilities of NWRA:

- Approve and implement a new water law, together with the associated regulations, especially those for drilling and import of drilling equipment.
- Develop a water resources data base accompanied by institutional capabilities at national/regional levels to analyze water supply/demand relations at the basin level
-Formulate and evaluate rational water management strategies for the regulation and control of water use; Integrate water resources management with the national economic development process in an interactive mode; Initiate a programmer to monitor the performance of activities in terms of water withdrawals, waste discharges, efficiency of water use, and continuous monitoring of water table levels and of water quality; Create awareness among the general public and policy makers about the seriousness nature of the water resources problems facing the nation through educational and public information campaigns; Coordinate donor activities in the sector to avoid duplication of efforts and to ensure best utilization of resources available through external assistance.

Legislation

Water legislation has been studied over the last decade without achieving a consensus of the parties concerned. Recently the government decision to create NWRA gave a new impetus to the formulation of appropriate water legislation and related regulations. The draft document was prepared in March 1996 and presented to the Cabinet. It is presently being scrutinized at different levels of the Government. The Draft Water Law consists of 98 articles under 9 sections.

Section (I)

General Provision and Goals - the basis and goals of the law were declared.
The most important issues in this section are three. The first is that all water resources which exist within the boundaries of the Republic were considered natural resources. Which means that they are owned as public property (as per Constitution)? The State's role is to orient and organize their exploitation so as to serve public welfare. The second issue is that of the concept of organizing the utilization development and management of water management as an integrated and indivisible

sector of economic development. The third issue deals whit groundwater which, according to the law, were considered natural resources shared among their beneficiaries. This means that all benefactors shall share the duties and responsibilities to protect these resources against depletion and pollution so that the individuals will not harm

The interest of the society. For this purpose, the State's intervenes to organize the utilization of these resources and prevent their exploitation except by prior permit.

Section (2) Water Resources Management - deals with the basic principles of water resources management. As for the basic principles of water resources management, it was declared that water resources shall be managed and developed in such a way a to satisfy the intent of this law and in the light of the general policy proposed by NWRA ad issued through cabinet resolution. Then, for the purpose of water resources management the country is proposed to be divided into basins. The basins should have Basin Committees linked to the Branch of NWRA in this region.

Section (3) Water Resources Planning - states the requirement that NWRA has to prepare water plan for each basin. After ratification the plan becomes part of the National Water Plan (to be prepared every five years). This section also gives NWRA the authority to review water-related development projects and give opinion of these plans prior to their implementation.

Section (4) deals with the various aspects of water use. It authorizes NWRA staff to enter any private land or farms or any other establishment to make various water measurements or to undertake field studies. This section also requires NWRA to register water rights and water wells, and to issue permits for drilling when the water action plans allow. The section also requires NWRA to develop criteria and standards for various works relating to water wells, protection zones around water wells, well fields, springs and stream flows. This in addition to criteria and standards for drinking water, for water used in the food industry, irrigation water.

Section (5) Water Resource Conservation and Protection - deals with two aspects; namely water resources conservation against depletion and protection against pollution. The law requires NWRA to adopt techniques and measures to conserve water uses. The issue of water transfer within and between various basins was also regulated; the law granting NWRA the power to recommend to the Cabinet the permission of water transfer between basins. Regarding water pollution of the water resources (including the sea). The law regulates in this section also the system of waste discharge permits

Section (6) Flood Control - outlines the role of the State in protecting the population and property against flooding disasters through various measures, including the installation of early warning stations, land use zoning, prevention of housing construction in flood zones, periodic inspection of flood protection structures to ascertain their safety. The particular role of NWRA is to provide the necessary technical advice regarding the locations of the early warming stations, to submit recommendations to concerned authorities so as to ensure the protection of flood prone regions against disaster and to carry out the periodic inspection of the flood protection structures.

Section (7) - Means to Enhance the Development of Water Resources - started by creating or recognizing a water sector as one of the sectors of development planning. The budgetary allocations for this sector shall be part of the State's investment budget so as to enable the development and management of water resources as an integrated and indivisible sector of economic development. In this Section a special fund "The Water resources Development Fund" was established. The financial resources of this fund consist of the allocations made by the Government to support water resources development, fees and charges approved by the Cabinet; such as:
- Water benefaction fee, on drinking and household consumption and on commercial and industrial use
- Water sale fee or charge on water sales whether directly from wells or via private networks or after bottling by individuals and private companies;
- A water resources quality-protection fee, for protection against pollution due to sanitary wastewater as well as commercial and industrial liquid wastes; etc.

.In Section (8) - Enforcement Procedures and Penalties - authorized staff of NWRA who are charged with monitoring and inspection are granted the powers of enforcement officers through a resolution issued by the Attorney General upon nomination by NWRA. These enforcement officers or security officers are charged with the task of identifying infringements and offences against the provisions of the law and preparing reports describing the violation or offence

In Section (9) - General and Concluding Provisions - it is stated that NWRA is the State's sole institution responsible for the drafting of water resource policies and the strategies for their development as well as the study, planning and management of these at the national level.

The investment plan for water and sanitation identified three major areas of focus, which are:

Integrated water resources management: targets five objectives, which are:

- ensure greater degree of sustainability
- give priority to domestic needs of rural and urban population
- improve water allocation while considering just distribution and social norms
- promote efficient water use and maximize economic benefits; and establish a realistic and holistic water approach among the general public Those objectives are translated into an investment programmer that includes :

• Developing regional water resources plans.
• Supporting water use associations, community-based organizations and water basin committees.
• Implementing, monitoring and enforcing the law.
• Strengthening and improving institutional and sector coordination.
• Designing and implementing NWSSIP monitoring systems.

Rural Water Supply and sanitation: The proposed approach to achieve the rural water and sanitation objectives are:

- Improving project/scheme implementation
- Broadening the range of partners; (iii) Widening technology choice and adapting appropriate ones;
- Integrating sanitation and hygiene in rural water schemes;
- Ensuring and protecting water resources and their quality;
- Improving targeting and sustainability
- Directing available finance to priority needs important I have t read it.

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	1994/2000 *		2014		2015	
	Rural	Urban	Rural	Urban	Rural	Urban
Water supply coverage %	24	50	32	54	62	75
Sanitation services coverage %	17	25	23	26	58.5	62.5
Population served with water supply (millions)			4.9	3.1	11.7	6.1
Population served with sanitation services (millions)			3.5	1.5	11.1	5.1
Total Population (millions)			15.4	5.7	18.9	8.1

Figure (56) 1994 coverage data were taken as reference to calculate the MDG-target for rural WSS; 2000 coverage - Data were taken as reference to calculate the MDG-target for urban WSS

Awareness public in the field of water:

When any talk about tools and strategies for integrated management of water resources, clearly referred to awareness as the first step in the management of water resources and the basic requirement for effectiveness. Consequently, the communication and awareness of water issues is not a goal in itself, but a means to achieve the objectives of integrated management of water resources, and therefore they are an integral part of the overall strategy for the management of water resources. But the richest on the participation of the local community. Obviously, to achieve integrated management of water resources requires the direct participation of the leaders and all water Users alike; hence, raising the level of awareness among all social strata and political represents basic elements of the national strategy for water. We live in a new era of scientific progress, where the humanitarian community is witnessing the amazing developments of the discovery of the genetic map to the technological revolution of communication and media, and the stream of news has become the most prominent features of the current era control of the means of

communication and community by means of mass media. And led the modern means of communication and transportation to accelerate the dissemination of information. And, media are many and varied, and each type of media properties and features unique to the other such as TV Newspapers and magazines, Publications (posters, brochures, etc ...), Flashes and documentaries, Mobile phones and Internet

Role the ministry of water and environment in spreading awareness of water issues:

Role the community participation in spreading awareness of water issues:

The local community and rural communities most affected by water scarcity and depletion, and where it is more the beneficiaries of the water in the area of agriculture and animal husbandry were the lives of these communities depends on the water. Therefore, it is necessary to be aware of these communities grave situation of water in Yemen and to contribute at the same time in finding solutions to these problems by spreading awareness among the segments and cultural backgrounds

Figure (57) a girl holds assign the sign says (water is everything) in Sana'a city

Figure (58) boy holds assign the sign says (Water is the future) in Sana'a city

Means of raising awareness in local communities in Yemen:

- Establish leadership meetings and legal persons in local councils
- Raise awareness of proper irrigation methods and the exchange of opinions through established council's afternoon.
- During the work on the farm.
- Books used in primary and secondary schools in Yemen, looking for mentions of water resources and advice for proper use of this scarce resource.
- Awareness of the importance of water in mosques in schools
- we can raise people's awareness by Awareness movie - TV and radio spots - Street posters - Water songs - Wheel covers - Et

Figure (59) Awareness about water in the rural carried out by the administration public awareness General Authority for Water Resources

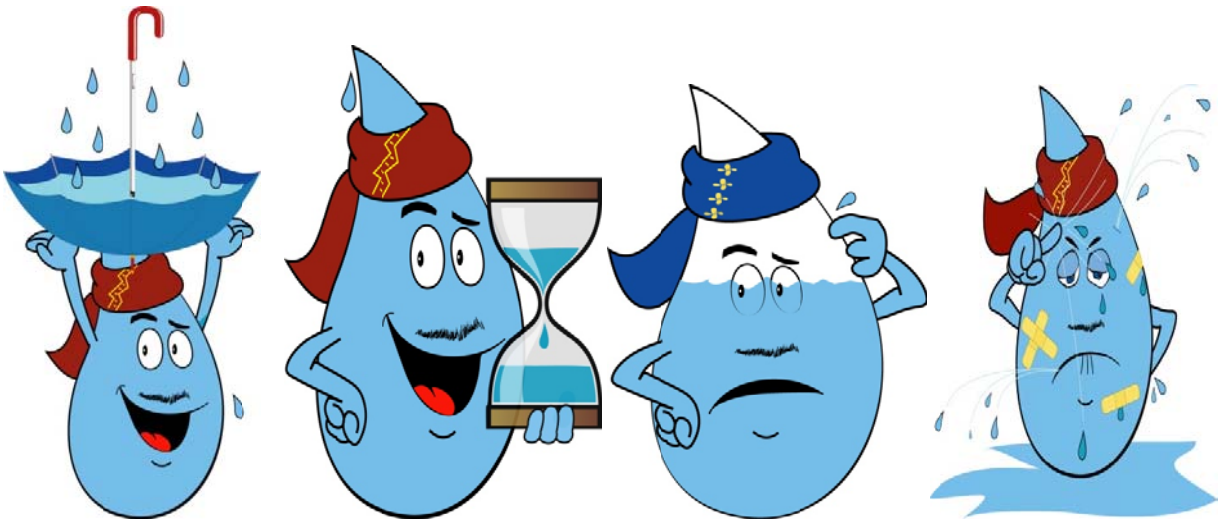

Figure (60) Raindrop shape used for awareness people about water issues

In the Management awareness in the General Authority for Water Resources in cooperation with the Organization (GIZ) created a smart and charming Yemeni cartoon

character who could, in a playful manner, communicate complex and unpopular messages on water issues appealing to adults and children, literate and illiterate alike. Rauian is known across the country so are his messages Daily appearance of water related topics in public communication e.g. national TV, Radio, Newspapers.

Figure (61) Yemen celebrate World Water Day

The challenge in awareness about water issue in Yemen:

- water is not an issue of public concern
- Conventional means of communication have not proved successful to reach decision - makers and the public.
- as water policies promote expanding use of the scarce resources there is little interest to communication the corresponding pressing problem

CONCLUSIONS: The ultimate goal is to attain sustainable socio-economic development trough management and development of the water resources of the country in an efficient, equitable and sustainable manner. Specifically, the following immediate objectives have been identified in the Five Year Development Plan: Protect water resources from over-exploitation, quality degradation and irreversible damage; Allocate water resources among different users to sustain economic growth with equitable distribution of benefits and balanced demographic distribution, and; Satisfy society's need for water, food and ecological stability by meeting drinking water requirements, by providing for safe disposal of wastewater and solid wastes, by

increasing productivity per units of land and water, and by maintaining an ecological balance.

1- Protect water resources from overexploitation, quality degradation and irreversible damage
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3- equitable distribution of benefits and balanced demographic distribution, and;
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Recommendations:

- Support is still needed to steer the attempts of the National Water Resources Authority to have country wide organized information system.
- Need to develop water resources information guidelines.
- Need to develop guidelines for predictions, estimations and indicators in Yemen water resources information.
- Need to develop and improve data base information system.
- Need to specific and targeted training programs.
- Need for donors coordination to support water resources management programs.
- Need for proper capacity building.

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- National Water Sector Strategy and Investment Program, 2005-2009 (NWSSIP) - Republic of Yemen – Ministry of Water and Environment.
- The National Water Sector Strategy and Investment Program (NWSSIP**)** – Ministry of Water and Environment
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