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## EVOLUTION OF WATER RESOURCES MANAGEMENT IN YEMEN

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### Introduction

Yemen has an old tradition of irrigation involving comprehensive hydraulic structures such as the ancient Dam in Marib at the fringes of the desert where the Queen of Sheba was residing, and rainwater harvesting on the mountain terraces in the Highlands where the Imams were reigning. For centuries the country managed to maintain a delicate environmental equilibrium making use of the available surface water and groundwater resources.

In the last three decades the country has fallen into a water crisis characterised by very rapid mining of the groundwater resources, which has created water supply shortages in major cities, has resulted in environmental deterioration and abandonment of agricultural grounds and has limited the access of the population to safe drinking water.

The main causes of the water crisis are familiar from other countries of the Middle East: rising demand as population and market-led agriculture develops; groundwater exploitation getting out of hand; and Government policy that has promoted expansion rather than efficient use and sustainability management (World Bank 1996).

The situation in Yemen stands out, however, amongst other arid countries: in no country in the world is the rate of exhaustion of aquifers proceeding so fast. Yemen also stands out because of the still weak capabilities of governance structures. It will not be possible to approach a realistic solution in short time whereby the Government will be in such a control that it will be able to avert further crisis development at every place in the country.

Still the challenge has to be met, if the Highlands are not to be deserted by the population in the coming decades. The results of action will only be partial and should be focussed on hot spots. The results of inaction would be catastrophic.

This paper summarizes the evolution of the water crisis in Yemen, bringing together three elements of water resources management: the natural resources, the triggers for depletion and the management institutions.

It describes the comprehensive water policy framework which has been designed by the National Water Resources Authority (NWRA) to cope with the situation. The central theme is that it is believed that NWRA, as a public body, has an important strategic role in managing the water resources of the country, but that it can only do that by developing an innovative process through which an instrument is developed which identifies and concert actions with end-users. This instrument should be the regional water action plans which NWRA intends to develop with large partnership of the end-users in the region.

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## Scarce water resources

Information on the water resources of Yemen has been rather exhaustively compiled in a summary report with the title "The Water Resources of Yemen" (Van der Gun *et al.* 1995). The report was the last technical report produced by the Water Resources Assessment Yemen (WRAY) project, a series of bilateral projects financed by the Netherlands Government in the period 1982-1995 which contributed significantly in building capacities for groundwater management in Yemen (Negenman 1995). For the compilation of the summary report approximately 600 technical reports and publications related to Yemen's water resources were identified of which the most relevant were studied and summarized. In the following sections a synopsis of the topographic, climatic and groundwater conditions is given following the information in the summary report. The report underlines actually one of the first principles of installation of proper management system namely: availability of essential, uniform, consistent and reliable information about the (ground)water resources in a country. On basis of this information trends in the water resource system can be identified, enabling the verification of the integrity of the resource basis.

The unique location of Yemen on the Arabian peninsula, surrounded by the Red Sea and the Gulf of Aden in combination with the large contrast in elevation, influence strongly the climatic features. The mountain slopes in the west and south-west facing the Red Sea and the Indian Ocean respectively receive more rainfall than the highlands and the zones facing the deserts in the interior. Predominantly the climate of Yemen can be described as semi-arid to arid, with rainy seasons during spring and summer. Average annual rainfall in the most favourable situated locations in the highlands is from 500 to 700 mm, decreasing rapidly from 200 to less than 50 mm in the largest part of the country. Many different landscapes can be distinguished in Yemen: coastal plains, mountain massifs, plateau's and desserts.

The runoff generated by the rainfall creates intermittent surface water flows through otherwise dry streambeds, also called wadis. Water from these wadis constitute the most important source of groundwater recharge in Yemen. Four major groundwater systems can be distinguished in Yemen (see Figure 1): Tihama Quaternary Aquifer bordering the Red Sea and consisting of alluvial material containing predominantly fresh groundwater. This aquifer system is recharged by the wadis descending from the mountains; Southern Coastal Plains bordering the Gulf of Aden with similar features as the Tihama Quaternary Aquifer, only with more limited thickness; Extended Mukalla Complex underlying the central part of Yemen reaching a thickness up to 1000m, with modest depths to the groundwater where Quaternary deposits are lying. This sandstone complex constitutes the largest groundwater system in Yemen; Highland Plains scattered over the mountain massifs constituting favourable areas for groundwater development.

Table 1 lists estimates of annual abstractions, average recharges and volumes of fresh groundwater stored in the four mentioned aquifer complexes. It is clear that a national scale groundwater abstraction is exceeding the rate of groundwater recharge and that the groundwater resources are being mined. The approximate annual abstraction from the aquifers systems is 2,110 Mm<sup>3</sup>. Abstractions are on average approximately 1.4 times of their actual recharge. The most endangered aquifer systems are those of the Highland plains, where most of the population is living. The ratio of abstraction to average recharge is here 5. The Extended Mukalla Complex has a huge volume of water in storage, but is located far from socio-economical important areas. The rate of recharge is relatively low. Recharge in Table 1 is infiltration of surface water from wadis when these are flooding.

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Declining water tables in the aquifer complexes confirm the mining situation. for instance in the Sana's basin the location of the capital of Yemen, groundwater levels have declined some 80 meters over a period of 20 years.

**Table 1. Abstraction rates, recharge rates and groundwater storage for the main aquifer complexes in Yemen**

Aquifer complex	Abstraction (Mm <sup>3</sup> /year)	Average recharge (Mm <sup>3</sup> / year)	Fresh groundwater r stored (Mm <sup>3</sup> )	Remarks
Tihama Quaternary aquifer	810	550	250 000	Quaternary aquifer
Southern Coastal plains	225	375	70 000	several Quaternary aquifer units
Extended Mukalla Complex	575	500	10 000 000	Cretaceous Sandstone with interconnected Quaternary desposits
Highland plains	500	100	50 000	various isolated units with variable lithology

Source: Van der Gun 1995

The quality of groundwater has not been studied in detail in Yemen. Electrical conductivity is the only parameter which has been measured at sites. In coastal areas groundwater has deteriorated as a result of abstractions because of connate or intruded salt water, such as is the case in the old well-fields of Aden. Groundwater pollution in the major cities as a result of increased water use is an actual problem. As central wastewater collectors do not exist in the major cities, and most of the houses have cess-pits, diffuse infiltration of contaminated water is occurring. High rate nitrate concentrations in the deeper groundwater under the city of Sana's confirm this pattern.

## Triggers for rapid groundwater depletion

The medium- and long-term economic development of Yemen is very much dependent upon the appropriate management and sustainability of the scarce water resources in the country. Given the increasing water demand resulting from the combination of several inescapable factors: population growth, higher water supply requirements, increasing deterioration of the water resources both in terms of quantity and quality and the growing awareness of environmental conservation; the water resources potential is becoming alarmingly short to meet socio-economic development requirements.



Table 2 provides some basic facts and figures with respect to the socio-economic situation of Yemen.

**Table 2. Facts and Figures about Yemen**

Title	Value
Population (million - 1995)	16.3
Population growth rate (% 1990-2000)	3.7
Urban population (% of total population)	23.4
Population doubling date at current growth rate	2013
Total labour force (% of total population in 1995)	41.0
Woman labour force (% of total labour force)	14.0
Labour force in agriculture (% of total labour force)	57.0
Labour force in industry (% of total labour force)	17.0
Labour force in services (% of total labour force)	24.0
Total Gross Domestic Product - GDP (BYR 1995)	249.2
Share of agriculture in GDP	21.0
Share of industry in GDP	24.0
Share of services in GDP	55.0
Gross domestic investments as % of GDP (1993)	20.0
Gross domestic saving as % of GDP (1993)	3.0
Tax revenues as % of GDP (1993)	17.0
Government expenditure as % of GDP (1993)	51.0
Export as % of GDP (1993)	5.4
Import as % of GDP (1993)	20.1
Land Area (million ha 1993)	52.8
Arable land as % of land area	2.6
Irrigated land as % of arable land	26.2
Internal renewable water resources per capita (1000 m <sup>3</sup> per year 1993)	0.2
Adult literacy rate (% 1993)	41.1
Life expectancy (year 1993)	50.4
Access to health (% 1993)	38.0
Access to safe water (% 1993)	47.0
Radios per thousand persons (1992)	28.0
TV's per thousand persons (1992)	28.0
Agricultural water demand (1997 Mm <sup>3</sup> )	2,546
Industrial water demand (1997 Mm <sup>3</sup> )	42
Municipal water demand (1997 Mm <sup>3</sup> )	247

Sources: Various issues of UNDP Human Development Reports; National Five Year Development Plan (1996-2000); and Statistical Year Book, 1995.

The severity of the gloaming water crisis was, however, not felt until recently. Initially the available water resources were considered to be sufficient to meet demands. Net abstractions were not much higher than the natural recharge. However, population continued to increase at a high rate and water demands kept growing. The growing population caused rapid expansion in the irrigated agriculture to satisfy the need for food and fast developing

lucrative crops such as *qat*, vegetables and fruits, resulting in high water consumption. It also gave rise to increase in drinking water demands, especially in urban areas where population increased faster as result of migration from rural to urban areas. The magnitude of the problem was not well understood until the aquifer water levels started to decline significantly.

The Government of Yemen is presently pursuing a growth oriented strategy to achieve its national economic development objectives. More food has to be produced to avoid heavy food imports and to improve the balance of trade position; the industrial base has to be expanded to modernize the secondary sector and to avoid dependence on foreign goods; and the urban and rural water supply have to be expanded to accommodate rapidly growing urban and rural population and to improve present health conditions. Such increase will require corresponding large increases at higher cost rate in the volumes of water to support the overall economic development process. There is a growing awareness that sustainable economic development requires efficient and effective management of the country's water resources. At the same time, it is widely recognised that it is a difficult task to accomplish, especially since water resources is traditionally considered as a free good; in many parts of the country, especially the more seriously affected by the water crisis, watermanagement decisions are made locally and are difficult to control.

In essence water has become the most limiting constraint in the development process. This problem is either the consequence of the water policies that have been pursued in the past, or due to the fact that necessary actions were not taken to correct the factors that have led to the present situation. It appears that a number of technological, social, institutional and economic factors have contributed to the present water crisis in Yemen.

The technological aspect is the introduction of modern drilling technology and pumps, which began on a large scale in about 1970. Previously most of the wells were for irrigation and municipal water were hand-dug and were self-limiting in terms of the amount of water abstracted. Now the total number of wells is reported to be more than 40,000, and this number is consistently growing while, on the other hand, water use efficiency in agriculture is extremely low due to poor water management practices.

The annual population growth is 3.7 percent per year. This translates into an increasing sectoral demand further increased by upgraded standards of living of the population, and the specific requirements to curb the deterioration of the water quality. The water demand estimates for the different water consuming sectors for the year 1997 are present in Table 2. The major water consuming sector in the country is agriculture. Since the available water resources are becoming increasingly scarce, it is extremely important to allocate them in a proper way.

From the water resources sustainability perspective, the major source of concern is the continuously increasing demand for water in agriculture. This situation is very critical in some of the regions (e.g. Sana'a, Taiz, Sada'ah, Amran and Marib) where pumping depths have already exceeded the economic limits for most of the crops, except for *qat* and other cash crops. Inadequate government controls and farmers unawareness about the seriousness of the situation are the major reasons for over exploitation of groundwater resources for irrigation purposes. Low irrigation efficiencies and poor water management practices further contribute to rising irrigation water demands.

The number and scale of conflicts among competing water users in Yemen is increasing. The competition between the Taiz municipal watersupply and the groundwater irrigated agriculture in the same well field area resulted in May 1995 in a water crisis in the city. The already limited municipal water supply in city reduced from every two weeks to once every 40

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days, with an atrocious waterquality of more than 2000 uS/cm. The water supply company and the farmers were blaming each other for the depleting the well field, which was located in a alluvial valley with only limited thickness of the aquifer. Another new resource in a sandstone aquifer further located from the city was already identified in 1991, but was not accessible for the municipal water supply because of conflicts with the local population over the benefaction and transfer rights of the groundwater.

According to the Moslem cultural tradition, water is considered to be a free natural resource, an open access resource or "*Mubah*", which means: permissible, free available for all. But the religious teachings have also repeatedly emphasized to make judicious use of it. In semi-arid zones, where water resources are, in any case limited, it is, however, very hard to convince people, that a natural good perceived as God's "gift" should be restricted. To change this perception, a large (and delicate) public awareness campaign is required. At the same time, the population, particularly the rural population, has to be more involved in water resources planning and management decisions through localized consultative processes.

Much of Yemen relies on groundwater for water supplies, over-pumping has led to rapid declines in many locations. No serious efforts were made in the past to augment existing supplies using non-conventional water sources (such as: waste water treatment and reuse, water imports and desalination). Reclaiming municipal waste water for agricultural reuse is an excellent and essential management strategy because it improves the environment by reducing the amount of waste discharged, and conserves water resources by lowering the demand for fresh water abstraction. One possible reason for not pursuing these options could be the need for huge capital investments - much beyond what the country's resources would permit. No consideration was given either to upstream and downstream water users, as well as basin management. Moreover, along the same line, water resources scarcity was never addressed as a part of the land use policy.

In water scarce situations, reallocation among water users is always considered to be an effective alternative for adjusting to water constraints, but no attention was paid to formulate policy on these lines. It is estimated that in the Sana's basin, one of the most water stressed regions in the country, only 20% transfer from agriculture is sufficient to meet the municipal water demand. On the nation-wide basis, only 10% transfer from agriculture is sufficient to meet the overall municipal water demand. Rainfall harvesting is another supply side option to augment existing supplies, but, in the absence of effective central planning, no evaluation of the feasibility of bench terraced lands and water harvesting using advanced technologies have been considered so far.

The demand management side portrays similar picture as has been commented above for the supply side. No comprehensive public awareness programs have been designed and implemented to influence user's behaviour towards water conservation. Similarly, water delivery efficiencies are still extremely low in both the urban and rural water supply and irrigation systems. water tariffs based on cost recovery principles may prove to be an effective policy instrument to enhance water use efficiencies, but, in practice, water is available free of charge (apart from the cost of abstraction) to anyone whose property permits the drilling of wells. No fees are levied on these private developments.

## **Evolution of the water institution**

In October 1995 the National Water Resources authority (NWRA) was established by Presidential Decree. The establishment of NWRA meant the end of years of struggle and the

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formation of a consensus between different parties in the fragmented water sector of Yemen to achieve an independent authority for the management of the water resources. In the following sections a brief description is given of the institutional development process leading to the establishment of NWRA. Only at the end of the process some principles can be distinguished according to which the Yemeni Government guided the decision making about the organization of the water sector.

After the proclamation of the Yemen Arab Republic (YAR, the former North Yemen) in 1962, modern government was established and the country relinquished isolationism. In 1967, the People's Democratic Republic of Yemen (PDRY, the former South Yemen) was proclaimed, after it withdrew from the British Commonwealth.

The two young republics had diverging philosophies on their own social and economic systems. In the Yemen Arab Republic a rather open and market-oriented system was followed, while in the People's Democratic Republic of Yemen a Marxist central planning system was adopted. The two countries merged in 1990. In May 1991 a new constitution was approved in a referendum.

The events in water resources management and development in Yemen in the period 1960-1990 can be characterized chronologically as follows:

- Establishment of new governments in the separate Republics and re-orientation of the national economies;
- Unprecedented and uncontrolled increase of groundwater development in private and government sectors, as a result of the introduction of modern technology financed by the Government of the Yemen expatriate labour force in the Gulf countries;
- Establishment of the National Water Supply and Sewerage Authority, responsible for urban water supply;
- Execution of large water resource development studies to enhance urban water supply and irrigated agriculture with surface water and groundwater;
- Lack of coordination between the different water-related agencies and authorities;
- Water resources assessments studies confirm rapid depletion of the groundwater resources; first attempts to introduce water resource management and control (establishment of High Water Council in 1981);
- First signs of adverse effects of large-scale groundwater abstractions in the highlands become apparent (drying-up of springs and shallow wells, deepening boreholes);
- Continued uncontrolled increase in groundwater abstractions (Sada'ah, Sana's, Rada, Tihama);
- Comprehensive water resources assessment and management studies prove that groundwater abstractions exceed groundwater recharge in most areas; simulations predict critical depletion within 10-15 years;
- Donor coordination attempts to coordinate actions, plans and projects in the water sector.

The present decade (the nineties) can be characterized as follows:

- Continued 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)
  - Growing awareness of the population and of water resources professionals about the gravity of the water resources management issues in Yemen;
  - Identification of a large supra-regional groundwater resource in the eastern part of the country;
  - Donor coordination;
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- Start of the formulation of a National Water Policy: consensus achieved about the institutional reform;
  - Increased coordination between water-related agencies and authorities;
  - Establishment of the National Water Resources Authority in October 1995, responsible for water resources management and control, with far going authorities and powers.

After unification in May 1990 three attempts were made to introduce water resources management:

- The newly formed Ministry of Agriculture and Water Resources (MAWR) was made the responsible for the planning, development, management and control of the water resources. The assignment of all these responsibilities to one ministry met strong opposition, including the GHD, and split the water sector into two camps. Because the MAWR represents and serves the irrigated agriculture sector, which is the largest water user in the country, some were unhappy about making it responsible for the management of the water resources. However, MAWR was supported by the World Bank (Land and Water Conservation Project). In April 1991 a draft Water and Irrigation Law proposed by the MAWR was submitted. In December 1991, a decree was issued giving the MAWR the responsibility to regulate the drilling of wells until the enactment of that law. The law was, however, never enacted and the decree is not being observed. In the Amran area, where it should have been introduced first, no control is taking place.
- In 1990 the Technical Secretariat (TS) of the High Water Council (HWC), which since 1986 has been supported by a Technical Assistance project financed by UNDP, submitted draft National Water Legislation which included a proposal to reorganize the HWC and re-establish the Technical Secretariat. No action was taken. The effort of the TS was reinforced by a Rapid Water Sector Overview conducted in 1991, which set a timetable for moving ahead. Again, no action was taken by the Government.
- In 1992 the MAWR, with support of the FAO, initiated the development of an appropriate institutional and policy framework to enable the government to undertake an integrated, comprehensive and sustainable approach to water resources management. An interdisciplinary team of Yemeni specialists, including various GDH staff, was assigned to participate in the process. The exercise resulted in the presentation of a National Water Policy Document in December 1993. The National Water Policy Group advised that the planning and regulatory functions be organized separately from the water users. The MAWR openly discussed various options and acknowledged that it should not necessarily be vested with the planning and regulatory functions. The consensus created resulted in October 1995 in the establishment of the National Water Resources Authority (NWRA) with far going authorities and mandate for becoming operational but is still far from full control over the water sector.

In retrospective the today water crisis in Yemen can mainly be attributed to the absence of an effective Government role in coordinating sectoral activities in an integrated manner. Consequently, the donors concentrated their assistance in promoting sub-sectoral developments which were not consistent with the national development objectives. Due to lack of national ownership and commitment, much of the donor driven projects somehow proved to be unsustainable in the long-term, especially after the withdrawal of donor assistance. With the establishment of NWRA the Yemeni Government has realized the need for a more integrated and coordinated approach for sector management.

The basic principle followed during the last years of the institutional reform was to achieve a separation between the management of the water resources and the delivery of water to the end users. It was opted to establish an independent central water authority with far going powers directly linked to the Prime Minister.

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## Guidelines for water management in Yemen

### Policy statements

With the establishment of NWRA, a potential powerful authority was formed to address the water crisis in Yemen which has been worsening over the last two decades. NWRA has been vested with a broad mandate and authority to carry out effectively water resources evaluation, planning, development, and management, and to formulate national water policy.

In essence, it is recognized that, under the present conditions, the renewable water resources in all regions of the country are insufficient to meet the current and future demand on a sustainable basis. On the other hand, the demand in water resources continues to grow as a result of population growth and economic development leading to an increased competition for water resources, among the different water sub-sectoral users (agriculture, industries, rural and urban water supply and sanitation, municipal and others).

It is realized that the present water crisis is largely the result of more than 30 years of ad-hoc water policy which focussed on water supply development projects for various users with little or no consideration of water resources demand management or sustainability of the water resources. This policy has proved to be counter-productive as it led to depletion of aquifers in many regions to an extent that jeopardizes agriculture investments and disrupts the daily life in several cities.

Eventually, the Government has recognized the need for efficient water resources management in its national development priorities outlined in the Five-Year Development Plan (1996-2000).

Policy requirements should reflect the specific context of the water sector in Yemen and the present conditions of water resources management and the draft water legislation should provide the framework for the enforcement of the water policy. Accordingly, the National Five-Year Development Plan has outlined the following guiding principles within which specific measures and policies could be designed to optimize the use of water in order to maximize benefits to the society:

- 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 stakeholders 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;
  - 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
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quantity, as well as enforcement mechanisms for restitution in the event that allocated water rights are infringed;

- 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 inter-sectoral 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. Sectoral allocation of water and its usage should be governed subject to the enforcement of effective management plans by 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 outrightly 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;
- In situations when water management objectives are in conflict with each other, the water allocation or transfer decisions should be based on the notion of equity or fairness. The principle of compensation to those surrendering rights should be considered;
- Both in irrigation and municipal water supply projects, cost recovery policy can be varied to allow poorer people to pay less, and better off can pay proportionally more. Similarly, water charges for crops could be adjusted based on relative profitability of crop.

The ultimate goal is to attain sustainable socio-economic development through 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.

## Sustainable groundwater strategy outline

On the basis of the policy statements in the Five Year Development Plan a national programme for sustainable water resources management has been defined. The national programme strategy takes into account the specific of the natural water resources system in Yemen, the institutional setting, the constraints inherent to prevailing socio-economic features, guiding principles resulting from local customs and experiences, and experiences gained elsewhere in similar conditions. A strategy is outlined which mainly focuses on halting the process of groundwater mining. In this context, the chief intent is: (i) to define a target date to reach an equilibrium between net water withdrawals and renewable water availability in the future, (ii) to define the amount of groundwater mining which is to be permitted between the present and the target date. The following general measures have been defined to constitute the programme strategy:

### General measures:

- 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 programme 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.

### The following specific measures are considered:

- Examine the structure of subsidies on production inputs and adjust it to reflect conditions conducive to water conservation;
  - Introduce stiffer import duties on pumps and other imported equipment used for groundwater abstraction. Provide economic incentives important for water conservation (e.g. subsidies, tariff concessions and tax incentives for investment in effluent treatment plants and recycling equipment installed by private sector);
  - Promote a system of water pricing that should encourage water conservation. This includes introduction of crop-based charges in the agriculture sector; a structure of progressive tariff rates based on production cost of water in the urban water supply system; and pollution charges based on the volume of wastewater produced;
  - Control groundwater exploitation by regulations for well registration, spacing, depth, horsepower and annual abstraction volume according to zones and uses; by permits and taxes for well operators; and by the institution of protection zones;
  - Implement measures so that farmers achieve greater irrigation efficiency. Measures proposed in this context may include special credit facilities for farmers for the acquisition of the materials and equipment needed for efficient use of water;
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- Implement research and extension services to teach and advise farmers on techniques to achieve higher productivity, especially as related to water conservation. Also implement measures to discourage expansion of irrigated area (especially under qat);
- Reuse treated water, charge for disposal of effluent so industries may consider recycling water;
- Provide technical information on water saving technologies to the water consumers in the industrial sector.

In summary, the main intent of the strategy for the sector is to provide necessary basis for sustainable economic and social development by implementing a comprehensive program of water resources management at national and regional levels. This involves , inter-alia, planning and implementation of efficient water resources management policies in relevant sectors, involving local communities in water resources management decisions, and integrating the management of several consuming subsectors at different levels. Measures outlined above will only yield until water legislation is forced in its entirety.

## 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 scrutinised at different levels of the Government. The Draft Water Law consists of 98 articles under 9 sections.

In 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 organising the utilization development and management of water management as an integrated and indivisible sector of economic development. The third issue deals with 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 (II) - 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 (III) - Water Resources Planning - states the requirement that NWRA has to prepare a 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.

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Section (IV) deals with the various aspects of water use. It authorises 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, treated municipal wastewater and industrial wastewater.

Section (V) - 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 (VI) - 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-warning 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 (VII) - Means to Enhance the Development of Water Resources - started by creating or recognising 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 (VIII) - Enforcement Procedures and Penalties - authorised 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 (IX) - 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.

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## Water resources management instruments

The tasks, responsibilities and duties which NWRA intends to perform following the outlined principles and strategy to actually get hold of the water crisis are enormous. They are also highly risky and little track record is available to anticipate if the strategy can be actually successful.

Policy sense, strategic view and a focus on implementation will be very important to turn the tide, before damage is too great. An innovative tool or instrument must be developed the coming years in Yemen which can be used to introduce adequate water resource management. NWRA will develop the coming years regional water resources management plans. The regional water action plans, as a result from these planning studies, will have to form the basis on which NWRA has to implement and establish water resources management and control, and well may be the innovative instrument we are looking for.

Similar planning studies were carried out in Yemen during the past years and intended to contribute to a proper use and protection of the water resources, without an intended bias towards any of the possible uses and users of the water resources. These studies were very much pioneering in the field of water resources management and the approach was very much at the strategic level, without going into the detail of proposing actual measures to be implemented to get hold of the situation (Van der Gun and Wesseling 1990; and Saif, Gieske, Brouwer and Negenman 1993). The studies were also developed during a period when the water institution in Yemen was not yet available. Furthermore, they were approached "top-down" with little attention for stakeholder participation in the decision process.

Law and enforcement oriented measures will be very difficult to implement in Yemen because of the prevailing power structure in the country, limited public awareness, insufficient legislation and the absence of capability to monitor and control measures at the field level. Therefore "top-down" approaches in the water resources management planning may meet difficulties at the level of implementation whenever the proposed measures are of a restrictive nature.

Decentralized- and stakeholder self-management approaches which operate "bottom-up" may not be complete and sustainable as the "common pool resource" aspect is not addressed adequately. For Yemen a planning methodology for water resources management has to be tried out which combines the merits of the strategic "top-down" with the decentralized "bottom-up" approach.

The implementability of the plans will depend on the availability of a comprehensive legal framework of laws and by-laws, strong and competent institutional capabilities of NWRA at the central and regional levels, and acceptance of the plan by the stakeholders after the formal approval of the plan by the central and regional government.

Finally, this all is only possible if the people of Yemen, including leaders, politicians, scientists, engineers, farmers, civil servants and citizens accept their true destiny and also become aware of their duty towards management of their living environment for their own generation and the ones to come as it been described in the inspired old arabic verse: *Cultivate your world as if you would live forever; Prepare for the hereafter as if you would die tomorrow.*

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