REPUBLIC OF YEMEN
NATIONAL WATER RESOURCES AUTHORITY
POLICY AND PROGRAMMING SECTOR

WATER RESOURCES MANAGEMENT ACTION PLAN FOR THE TA'IZ REGION

(Upper Wadi Rasyan)

Second Edition

October 2004

Acknowledgements

The Ta'iz Water Resources Management Action Plan (TWRMAP) is prepared by the Policy and Programming Sector (PPS) of the National Water Resources Authority (NWRA, under the overall guidance of Mr. Jamal Mohamed Abdo, Chairman, NWRA. This plan is the culmination of planning-related activities carried out by the PPS under the leadership of Mr. Abdullah M. Al-Thary, Sector Head of PPS and the Head of the Ta'iz Water Resources Management Planning Team.

The Ta'iz water resources action plan is the work of Khalid Riaz, Water Resources Economist, PPS and Jac Van der Gun, Consultant to NWRA. In preparing this action plan, the authors draw on a number of studies done by NWRA, particularly, the report *Water Resource Management Strategies in the Ta'iz Region.*

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Abdullah Ali Al-Shami,	Workgroup member (GIS, Policy simulation modelling)
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1 INTRODUCTION

1.1 Water resources situation in the country

Yemen is one of those few countries in the world that have an 'extremely sever water scarcity problem'.[1] The total renewable water resources are estimated to be 2.1 billion m^3 per annum.[2] The country's population was nearly 16 million in 1994, which means that per capita availability of renewable water resources was no more than 133 m^3 in that year. This does not compare favourably with average availability of 1,250 m^3 in Middle East and North Africa region, or with the 7,500 m^3 for all countries. The water use in the country was 2.8 billion m^3 in 1994[3]. Thus water consumption exceeded the annual renewable resources availability by 0.7 billion m^3. This gap is probably much wider now. If the present rate of population growth were not slowed down, the country would have twice as many inhabitants by the year 2016.[4] As a result the per capita availability of renewable water resources would become dangerously low, forcing an even higher rate of depletion of groundwater storage. The situation would become much more precarious in the central highlands where the population density is high.

Already there is not enough water to meet the competing needs of agriculture, industries and the cities. Agricultural is the largest water-consuming sector in Yemen. Irrigation accounts for 90% of the total groundwater abstractions.[5] Increasing agricultural water use has been aided at least in part by the availability of pump technology, remittances from Yemenis working abroad that helped finance private groundwater development, and government policies aimed at increasing self sufficiency in agricultural products such cereal foods, fruits and Qat.

With an expanding industrial base, Yemen requires more and more water to meet industrial requirements. Although the share of industrial water use is small compared to agriculture, industries in Yemen generally do not treat wastewater. This results in degradation of groundwater and land resources. Recycling is not a norm in this sector leading to increase in industrial water demand that would be largely avoidable in an appropriate regulatory environment.

The share of water resources going to direct human consumption (domestic use) is also relatively low, although water supply constraints are responsible for limiting the domestic water use. In rural areas of Yemen where most of the county's population lives, the household members, particularly the women, have to haul water from as far as 2 kilometres away. The average daily per capita water consumption is only between 20-25 litres in these areas. The urban water consumption ranges from 30-70 litres/capita/day but is significantly less than the average 200 litres per capita per day for developed countries and the global average of about 100 litres per capita per day. Water supply constraints ration urban consumers too. The cities

[1] See p.6, 'Regional water Requirements of different water consuming sectors: Final report'. Volume-V. High Water Council. 1992. This conclusion is reached by Cestti (1989) based on three alternative definitions of water scarcity. According to these definitions a country can be classified as water scarce if: (a) the water deficit exceeds 1,000 mm/year and variability of rainfall is more than 40 percent; (b) more than 1,000 persons compete for one flow unit of water, which is equal to one million cubic meters per year; and 9c) withdrawals are 20% or more of its available water.

[2] Yemen: Towards a water strategy, World Bank, 1997.

[3] Yemen Human Development Report (1998).

[4] Ibid.

[5] Chris Ward . 'Agriculture and irrigation policy for water conservation', discussion paper in 'Yemen: Water Strategy: discussion papers'. December, 1995. Multi-Donor group in Yemen Water.

generally are unable to get the water they need because of limited water resources of local catchments and competition with other sectors, notably agriculture. Increasing transfers to urban areas diminish farm incomes because water scarcity reduces crop yields and higher pumping lifts associated with higher abstractions to accommodate urban demand, raise irrigation costs. The rural communities as a rule strongly oppose and often succeed in completely blocking or delaying such transfers. Some cities such as Ta'iz have faced severe water shortages in the past in the past, which caused extreme hardship to the urban population. An another problem is that like the industries, the cities also do not treat their wastewater, adding to environmental degradation.

The implications of competing demands from different sectors go beyond the simple arithmetic of water balance calculations. For instance, agriculture is the largest consumer of water but the efficiency of water use in this sector is quite low. The returns per cubic meter of water used for irrigation are one order of magnitude lower, for most crops, compared to what the urban domestic and industrial consumers are willing to pay at the margin of use. This situation arises because the opportunity cost of water to farmers, in most cases, is only the cost of pumping groundwater. This cost does not reflect the true scarcity value of water. Therefore the farmers, except in some extremely water-scarce areas, do not have adequate incentives for conserving water by adopting improved irrigation technologies and practices.

Even the other sectors, which face much higher levels of scarcity, are not efficient users of water. Distribution losses can range from 40-50% in urban water supply networks. Neglected maintenance, because of lack of adequate funds and poor management, is usually responsible for this. As mentioned earlier, industries do not recycle water, adding to their water requirements. The main reasons for this inefficiency are the absence of an appropriate regulatory environment and lack of technical advice to industries regarding treatment/recycling options available to them.

An important but often neglected dimension of water scarcity is that untreated industrial and municipal wastewater contaminates aquifer and further reduces the availability of freshwater resources. Many of these aquifers are located in area of high recharge and the amounts of water thus lost can be significant. The impact of water quality degradation due to human activities on the overall water scarcity is not highlighted enough in regional water balances. The quality degradation means that the groundwater becomes unusable and, without appropriate intervention, the trend will be for this degradation to accelerate and result in even worse scarcity.

1.2 **Government response to emerging water situation**

The government of Yemen is aware of the challenge posed by growing water scarcity and its implications for the future of the national economy and of the country as a whole. The government has accorded very high priority to water security. In line with this priority, it has made a strong commitment to improving the legal and institutional environment in which future water resources management efforts will take place.

One key decision regarding improvement of the institutional environment for better water management is the rationalisation of mandates of public entities in the water sector. Until only a few years ago, several different agencies had mandates for dealing with various aspects of water resources. In view of the need for adopting an integrated and co-ordinated approach for sector management, the National Water Resources Authority (NWRA) was created in 1996. NWRA is

responsible for policy formulation and planning in the water sector at the national and the regional levels. By creating NWRA, a clear distinction has been made between the management of the resource and delivery of water services. NWRA has full responsibility with respect to planning, management and allocation of water. It aims at discharging this responsibility while recognising the unitary nature of the resource, the existence of pervasive externalities[6], and the close interaction between water quality and quantity issues. The responsibility regarding provision of water services or execution of water projects continues to remain with the existing water sector agencies. One advantage of this institutional restructuring is that NWRA will have the opportunity to play the role of 'honest broker' with regard to water allocation --- an issue that has been very contentious in Yemen in the past.

One of the earliest initiatives of NWRA was to prepare the draft water law. This law has been submitted to the cabinet and is currently under review of a parliamentary committee. NWRA also formulated the National Water Strategy that has been approved by the cabinet. In addition, water quality standards have been formulated, which have been also approved by the cabinet. An important work performed by NWRA is the division of the country into water resources management regions and district (see map below). This would serve as a basis for future water resource management planning.

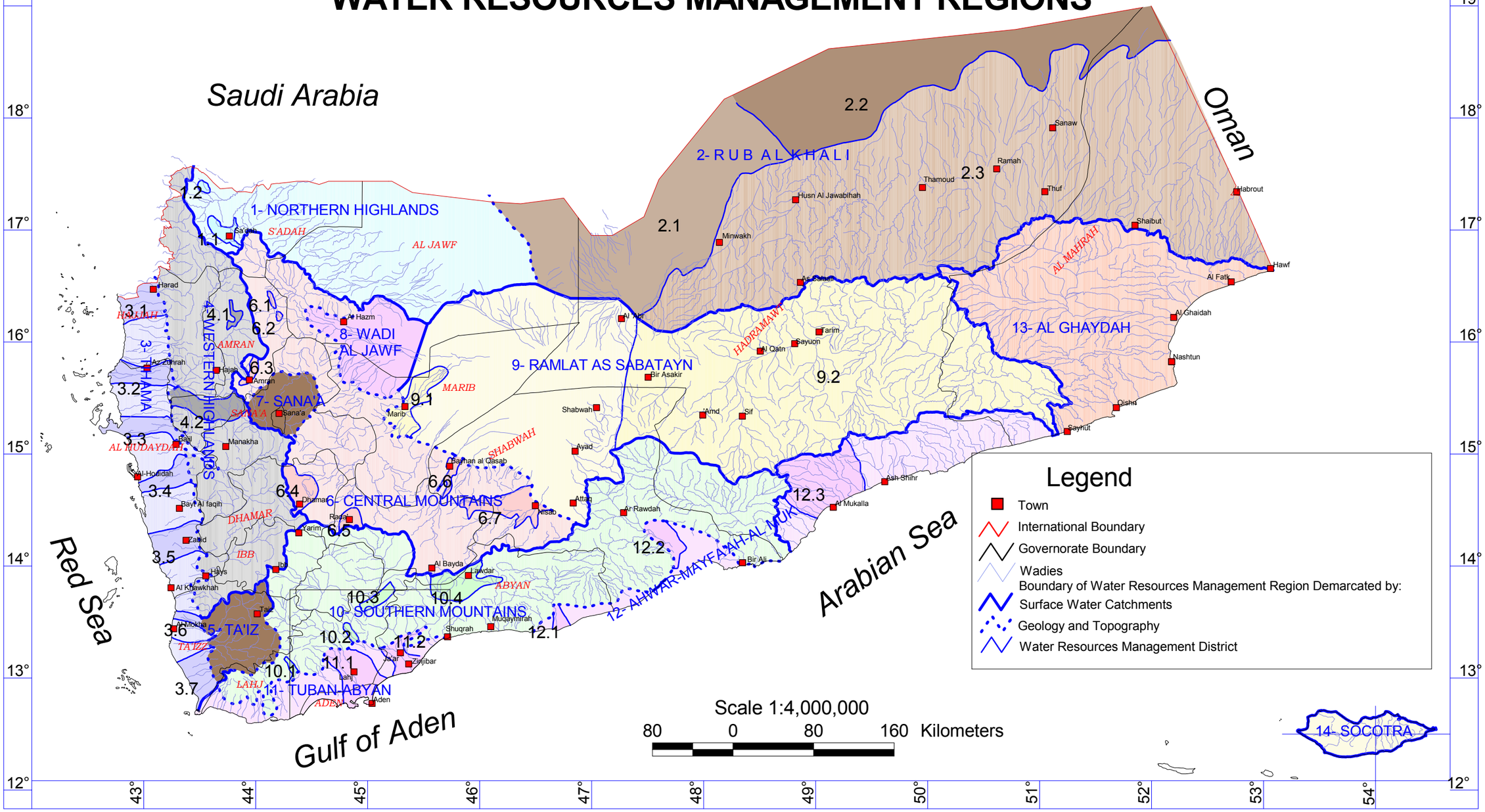
Currently, NWRA is engaged in preparing a series of regional plans for water resource management. The action plan for the Ta'iz region has been completed. The other region for which the action plans are under preparation are Sana'a, Hadramawt, and Abyan-Tuban. All these regions are shown on the 'Water Resources Management Regions map (below).

The rest of this document presents the Ta'iz water resources management action plan. The next chapter provides some background information about the Ta'iz region (Upper Wadi Rasyan). Chapter 3 discusses why this action plan has been prepared. It looks at the pressing water resources management issues in the region including the urban water crisis, depletion of aquifers and its implications, the competing sectoral water demands and associated inter-sectoral conflict, and environmental aspect of current water use and wastewater disposal practices. Chapter 4 presents the main components of the water resources management strategy for Ta'iz. The final chapter deals with some activities that would need to follow the planning exercise.

[6] For example, lowering of water table due to pumping by one farmer raises costs of pumping groundwater for all the others. Since the farmer's actions impose costs on others that are not compensated, this constitutes an externality.

NATIONAL WATER RESOURCES AUTHORITY (NWRA)

WATER RESOURCES MANAGEMENT REGIONS



AVAILABLE WATER RESOURCES AND CURRENT WATER USE

#Reg	Name	SURFACE WATER RESOURCES, Mm3/Year	Recharge, Mm3/Year	Usable Storage, Mm3	Net Abstraction, Mm3/Year	Natural Discharge, Mm3/Year
1	NORTHERN HIGHLANDS	66	31	3800	NO DATA	NO DATA
1.1	SA'DAH	30	6.6	1,446	66	NO DATA
1.2	BAQIM		12	1,745	4.8	NO DATA
2	RUB AL KHALI	135	NO DATA	NO DATA	1.4	NO DATA
2.1	Zamakh	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
2.2	Norther	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
2.3	Thamrud	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
3	TIHAMA	505.5	524.1	20,820	787	538.5
3.1	HARAD/HAYRAN	28	44.9	2,660	89.3	71
3.2	MAWR	129	106.4	2,430	117.2	87
3.3	SURDUD	82	71.5	2,930	85.7	62
3.4	HODEIDAH/SIHAM	73	70.7	2,620	99.2	72
3.6	RIMA/ZABID	143	172.9	6,620	311.8	196
3.6	RASYAN	32.5	42.3	2,500	61.8	32
3.7	MAWZA/DHUBAB	18	15.4	1,300	22.5	18.5

#Reg	Name	SURFACE WATER RESOURCES, Mm3/Year	Recharge, Mm3/Year	Usable Storage, Mm3	Net Abstraction, Mm3/Year	Natural Discharge, Mm3/Year
4	WESTERN HIGHLANDS	421	304	170	NO DATA	NO DATA
4.1	AL ASHEHAH	42.6	NO DATA	NO DATA	4.8	NO DATA
4.2	AL MAHWIT	136.6	NO DATA	3.6	66.8	NO DATA
5	TA'IZ	34.6	20	9,210	42	NO DATA
6	CENTRAL MOUNTAINS	285	NO DATA	NO DATA	NO DATA	NO DATA
6.1	AL HARF	6	NO DATA	NO DATA	1.3	NO DATA
6.2	AL HAMRA	NO DATA	NO DATA	NO DATA	3.6	NO DATA
6.3	AMRAN-ATTAF	NO DATA	26.8	1600	74	NO DATA
6.4	DHAMAR-MA'BAR	NO DATA	17	1,245	52	NO DATA
6.5	RADA	NO DATA	8	840	20	NO DATA
6.6	BEYHAN	21	53	190	64	NO DATA
6.7	MADKHAH-NISSAB	54	NO DATA	794	28	NO DATA
7	SANA'A	11	62	2,875	182	3
8	WADI AL JAWF	116	47	1,035	40	NO DATA
9	RAMLAT AS SABATAYN	NO DATA	NO DATA	360,000	NO DATA	NO DATA
9.1	MARIB	87 (Reservoir capacity 400 Mm3)	NO DATA	3,160	144	NO DATA
9.2	WADI HADHRAMAWT	161	180	NO DATA	144	NO DATA

#Reg	Name	SURFACE WATER RESOURCES, Mm3/Year	Recharge, Mm3/Year	Usable Storage, Mm3	Net Abstraction, Mm3/Year	Natural Discharge, Mm3/Year
10	SOUTHERN MOUNTAINS	604	NO DATA	NO DATA	NO DATA	NO DATA
10.1	MA'ADIN	23	3.4	NEGLIGIBLE	3.4	NO DATA
10.2	RABWA	5.8	7.5	NEGLIGIBLE	6	NO DATA
10.3	LABOOS	NO DATA	3.4	NEGLIGIBLE	NO DATA	NO DATA
10.4	LAWDER-MUDIA-MUKEYRAS-DEMAN-GUBHAN	NO DATA	10.7	420	8.6	NO DATA
11	TUBAN-ABYAN	311	NO DATA	NO DATA	137	NO DATA
11.1	LAHJ-ADEN	109	98	NO DATA	100	1
11.2	ABYAN DELTA	202	105	NO DATA	65	40
12	AHWAR-MAYFA'AH-AL MUKALLA	126	NO DATA	NO DATA	NO DATA	NO DATA
12.1	AHWAR DELTA	71	24.6	NO DATA	6.6	18.7
12.2	MAYFA'AH	24	60.8	NO DATA	2.4	NO DATA
12.3	AL MUKALLA-FUWWAH	31	176	NO DATA	12	NO DATA
13	AL GHAYDAH	77	NO DATA	NO DATA	NO DATA	NO DATA
14	SOCOTRA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA

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2 WATER AND WATER USE IN THE TA'IZ REGION

2.1 The area

The planning area is located in the upper part of the *Wadi Rasyan*, which is one of the major Wadis draining the highland and midland regions of the Red Sea Basin. Ta'iz City, currently suffering from one of the most acute water crises in the country, is located inside the planning area. According to the 1994 Population Census, the city's population was 317,000 inhabitants while that of the planning area as a whole was around 650,000. There is a concentration of industrial units on the periphery of the city. Agriculture, practised mostly in the main wadis and in the highlands, is the primary means of livelihood for the rural population.

2.2 Rainfall and Wadi Flow

Water resources of the area are heavily dependent on rainfall, which varies quite a lot from one sub-area to another within the same catchment. While the mean annual precipitation for the whole area is around 568 mm, the highlands receive a significantly greater amount. For example, the annual rainfall in the Dhi Sufal highlands is 826 mm on average and Mount Saber sub-area receives about 621 mm. The pattern of rainfall in the region is bimodal with one peak occurring in April/May and the other in August/September. The intermediate months of June and July have fewer rains. The dry period lasts from mid October to mid March.

Heavy rainfall on the highland areas generates run-off that flows into the wadis, causing flooding in the case of intense rainfall events. The surface water flowing into the wadis is diverted for irrigation by means of *Sawaaqi*. These are excavated channels on both sides of the wadi, which irrigate the adjacent fields. Wadi Al-Haima receives about 3 million cubic meters of lateral surface inflow annually. Most of it is from the high rainfall area Dhi Sufal. Wadi Dhabab receives about 0.5 million cubic meters of run-off water from both Jabal Habashi and Jabal Saber. Some of the run-off from the latter also finds its way into the Hawban zone which receives about half million cubic meters of run-off annually. The Central zone receives surface water flows from all zones in the upper wadi Rasyan catchment. The estimated volume of these flows is about 9 million cubic meters per year. The total volume of flow leaving the upper Wadi Rasyan catchment every year does not exceed 12 million cubic meters. However, the surface water flowing from the Central zone into the lower Rasyan catchment is highly polluted because of mixing with the untreated industrial and domestic wastewater.

2.3 Groundwater: hidden under our feet

Although much of the rainwater is lost to the atmosphere as evaporation, a part seeps into the ground and recharges the aquifers. The volume of water stored in a typical aquifer is considerably greater then the annual recharge. This indicates that the process of storage accumulation in the aquifers takes much longer time --- thousands of years in some cases. For exploitation of the groundwater resources to be truly sustainable, it is necessary that groundwater abstractions do not exceed the annual recharge. In this way, the storage would not be affected and water will be available for use forever. If this condition is not met and groundwater abstractions exceed recharge, the aquifer storage will be depleted. If the abstractions were much in excess of recharge, the process of aquifer depletion would be fast. In some cases, the storage that accumulated over thousands of years would deplete in just a few decades.

National Water Resources Authority (NWRA)
Policy and Programming Sector (PPS)

Taiz Water Resources Planning Team

Ta'iz Region

Upper Wadi Rasyan Catchment

375 380 385 390 395 400 405 410

1535 1530 1525 1520 1515 1510 1505 1500 1495 1490

43°50' 43°55' 44°05' 44°10'

13°50' 13°45' 13°40' 13°35' 13°30'

N

Dhi Sufal

Dhi Sufal

Al Qa'idah

Haimah
Al-Haima

Sha'ara
Shara'b

Al-Janad
Janad

Central
Center

Al-Hawban
Hawban

To Hodaidah

Ta'iz

Sabir
Saber

Ad Dhabab
Dabab

KM
0 2 4 6 8

Legend

- Main wadis/ plains
- Wadi tributaries
- City /villages & indust. parks
- Road (asphaltic)
- Road (loose surface)
- AL Janad Airport
- Altitudes
- Zones boundary
- Regions

d:\GIS files\pps\Topo.prj

The Ta'iz region has three main aquifer systems. They are (a) alluvial aquifers, (b) volcanic aquifers, and (c) Tawilah sandstone aquifers. To exploit these aquifers, a total of 1993 dugwells and 306 boreholes had been constructed until 1996, some of which have become dry due to high rate of abstractions.

The alluvial aquifers are the uppermost layer. They are composed of sediments of varying sizes, ranging from boulders to silt, found along the wadi beds and filling up depressions or *Q'as*. The primary means of alluvium recharge is from floods and from irrigated areas. The alluvial aquifers are quite shallow. In most areas, their thickness does not exceed 30 to 40 meters although, locally, they can be up to 70 meters thick. The thickest alluvium is found in Dhi Sufal/Al-Haima and Ad-Dhabab areas. The depth to water in alluvial aquifers is less than 20 meters but in most cases, water can be found 11 to 13 meters below the ground surface. The smaller depth to water makes this aquifer exploitable by dugwells, which are found in abundance in the area. In many zones, the alluvial aquifers are prone to over exploitations. The quality of water is generally good especially in the alluvial wells in Dhi Sufal, Al-Haima, Ad-Dhabab and in upstream areas of Shara'b zone. However, being the uppermost water bearing formation, the alluvial aquifers are vulnerable to man made pollution. This is specially the case in Al-Hawban and Central zones.

In addition to the alluvium deposits, water is also found in fractures in the volcanic rocks that dominate the sub-surface in the study area. The thickness of these rocks in the study area is estimated to be 600-700 meters. The volcanics are generally not a very productive source and yields of wells dug in these strata are low. The water is also of poor quality. This is specially the case where the fractures are connected to overlying alluvial aquifers in the polluted zones, although poor water quality in the volcanics also has natural causes (e.g. naturally occurring salinity in some zones).

Table 1: Wells & springs in Ta'iz Region (Upper Wadi Rasyan)

Well Type	Number of wells
Dugwells	1993
Boreholes	306
Springs	88

Source: Data files of NWRA well inventory, 1996

Another major source of groundwater in the area is the deep-seated Tawilah sandstone. This formation has proved very productive elsewhere in Yemen and is the focus of exploratory efforts in Ta'iz region as well. However, the sandstone aquifer in the planning area is not fully exploited except in Dhi Sufal zone where NWSA wells, in addition to some farmers' wells, tap into this aquifer. These wells have high yields and quality of water is also good. In other areas, the presence of the sandstone aquifer is indicated by studies. However, exploratory efforts in other locations have not met with a lot of success. This is at least in part due to the difficulties in carrying out exploratory drilling in the face of growing opposition from local communities.

Table 2: Annual natural recharge and water use in Ta'iz Region (Upper Wadi Rasyan)♣

Type of use / recharge	Volume
A. Natural groundwater recharge	**15.4 Mm^3**
B. Total water use	**42.9 Mm^3**
Total surface water use	**2.0 Mm^3**
Total groundwater use	**40.9 Mm^3**
•	27.1 Mm^3
•	2.7 Mm^3
•	6.8 Mm^3
•	4.3 Mm^3

♣ All figures correspond to the year 1996.

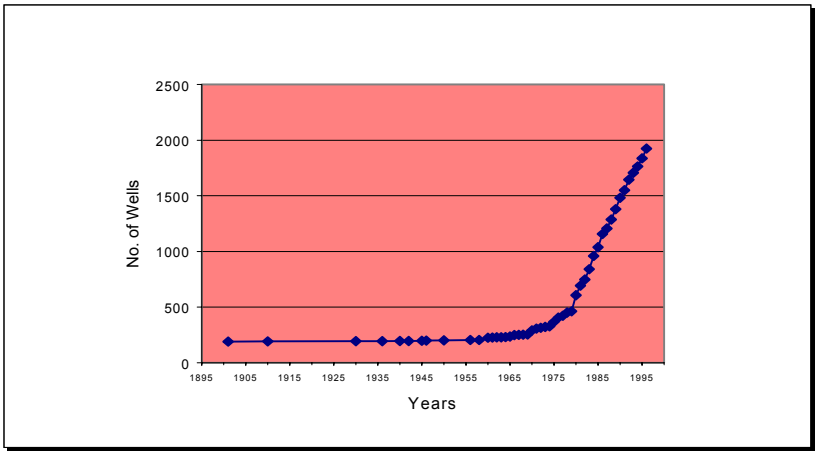
Sources: (a) Van der Gun, J., "Towards Ta'iz water resources management action plan" Mission report No. 5, submitted to NWRA. June 1999., (b) Ali Kasem As Sayagh, 1998, "Industrial water requirements for Ta'iz region (Upper Wadi Rasyan)". PPS Technical Note Series, No. TN-98-02, September 1998. (c) The Rural domestic water use is taken from revised calculations, based on methodology of Mahmood Sultan, "Domestic water demands and waste water loads in Ta'iz region", PPS Technical Note No. TN-98-03, September 1998. (d) Urban domestic water use figure is Adjusted from that reported in Van der Gun (1999) above, and adjusted for production of private wells located inside Ta'iz City. The production of city wells was estimated form information obtained from NWRA's Ta'iz Well Inventory database, 1996.

2.4 Large quantities of water are used in agriculture

Nearly half of the population of the planning area lives in the rural countryside, heavily dependent on agriculture. Traditionally, agriculture relied on spate irrigation and rainwater harvesting methods. Some dugwells were also used for irrigation but these abstractions were quite limited. With the availability of motorised pump technology, it became possible to exploit groundwater resources on a scale unthinkable before. This trend was aided by at least two other factors. First, the boom in remittances from Yemenis working abroad helped finance the investments in new wells. Second, the government subsidies on fuel and drilling equipment made these investments more attractive. Between, the mid-seventies and 1996, the total number of wells in the study area increased from 180 to nearly 2400. About a thousand of these wells had motors on them. The increase in the number of wells was accompanied by expansion in area under cultivation and higher cropping intensities on existing agricultural land.

The combined effect of these developments is that water use in the agricultural sector has increased very substantially. According to estimates, the total water use in the sector is nearly 28 million cubic meters per year. This constitutes about 68% of the total groundwater use in the area. Roughly half of the groundwater use in agriculture takes place in Al-Haima and Shara'b zones. In these areas, a significant proportion of land is under *qat,* which is a profitable crop but has high water requirements. Indeed, increasing dominance of qat in the regions cropping pattern has been one of the reasons behind higher water use by the agricultural sector.

Figure 1: Construction of wells in Ta'iz Region (Upper Wadi Rasyan)



Source: Data files of NWRA's Well Inventory carried out in the Ta'iz region during 1996

Note: The date of construction for some wells is unknown. Those have not been included in making the above graph. While the graph does show trends in construction of wells overtime, the total number of wells depicted by it is less than the actual number of wells in the upper Wadi Rasyan.

2.5 Water is also used to quench Ta'iz city's thirst

Apart from agriculture, water is also required for meeting the domestic water needs of the population. As mentioned earlier, the Ta'iz city is located inside the planning area and constitutes the major source of domestic water demand. According to the population census carried out in 1994, the city's population was about 317,000 inhabitants. Assuming the historical growth rate of population (7.9% per annum), this number has grown to about half million now. The annual water demand for the city as a whole was estimated to be over 6.3 million cubic meters in 1996. The public water supply utility, NWSA, is finding it difficult to meet this demand. Although tankers also serve the city, their contribution, as a percentage of the total urban water supply, is relatively modest while the price they charge is much higher compared to NWSA.

Table 3: Ta'iz urban population and water demand projections

Year	Scenario-I		Scenario-II	
	Population	Water requirements (Mm3)	Population	Water requirements (Mm3)
2000	502,556	7.8	494,966	8.2
2005	736,370	11.5	702,495	12.5
2010	1078,976	16.8	980,621	18.9
2015	1,580,958	24.7	1,347,351	27.9
2020	2,316,501	36.2	1,823,467	40.7

Notes: Information on city population is obtained from Population Censuses 1994 and 1986. Urban water demand projections are based on NWRA's water use estimates for Ta'iz city and population projections.
Scenario-I is based on constant population growth rate (7.9%) calculated from population censuses (1994 & 1986) and constant per capita daily water consumption of 35.6 litres.
Scenario-II allows the population growth rate to decline by one percentage point every year. It also allows per capita daily water consumption to increase by 1.5% every year.

Supplying adequate quantities of water to Ta'iz city is likely to become a great challenge in the future (see Table 3). The main reason is that the population of the Ta'iz City is growing at an

alarming rate of nearly eight percent per year. What makes matters worse is that the expectations regarding a slow down in the population growth have not been realised to any significant extent. According to projections, the population of the Ta'iz City will increase from the present 0.4 million to nearly between 1.8 million to 2.3 million inhabitants in the year 2020. A city of this size would require from 36 to 41 Mm^3 of water annually. It may be extremely difficult to find such quantities of water. Adequate measures for demand management would have to be put in place in addition to making serious efforts for slowing down the overall population growth rate and, in particular, arresting the pace of rural urban migration. Regardless of the management measures adopted, it is clear that large amounts of water would need to be transferred in the future from areas further and further away from the city, possibly from outside the catchment are tapped (e.g. Wadi Ghayl, Wadi Warazan etc.). Such transfers would compete with groundwater abstractions for irrigation in those areas and hence incur the wrath of farming communities unless a mutually acceptable mechanism is found for effecting them.

2.6 Industries cannot be without water

Ta'iz is one of the hubs of industrial activity in Yemen. A large number of industrial plants are located in and around Ta'iz city. These industries generate additional demand for water that has to be met from the water resources of the area.

Table 4: Industries in planning area and their gross value of production (1995)

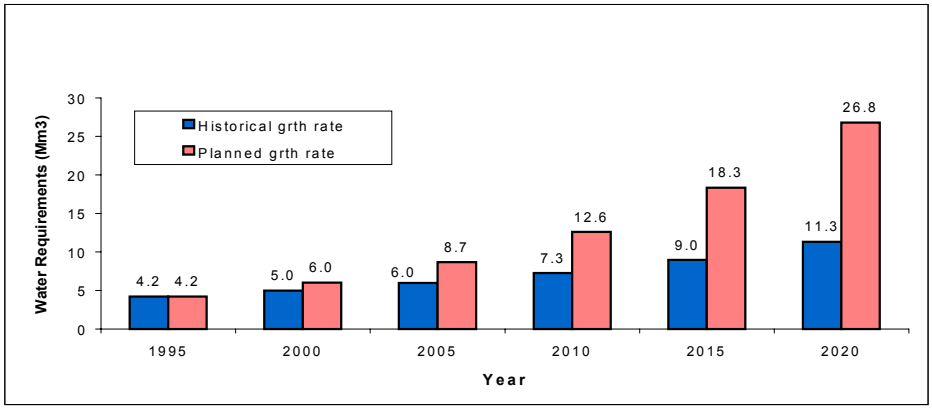
Type of industry	**Gross value of production** (million Riyals)
Extracting industries	395.8
Food and beverages	25,798.1
Textiles	1.3
Wood products	60.5
Leather products	355.6
Paper and Printing	3,735.8
Metallic industries	3,810.5
Non-metallic industries	2,503.8
Chemical industries	6,587.5
TOTAL	**43,248.9**

Source: Ali Kasem As-Sayyag, "Industrial water requirements in Ta'iz Region". NWRA, Policy & Programming Sector, Technical Note Series No. TN-98-02, 1998. see Table A.II. The estimates are based on information obtained from Survey of Industries in the Ta'iz region, (1995), Central Statistical Organisation and Ministry of Industries.

In 1996 the gross value of output for plants located within the Ta'iz planning zone was estimated to be 44,408 million Riyals. These industries used up nearly 4.3 million cubic meters of water during that period. As industrial development continues in the future, more water will be required. Just how much more, depends on the pace of industrial development. If the historical rates of industrial growth continue into the future as well, nearly 7 million cubic meter of water would be needed annually, by the year 2010. This amount would increase to 11 million cubic meters per annum in the year 2020.

However, the government plans call for acceleration of the pace of industrial development. Suppose the industrial water demands are projected into the future based on the growth rate assumed in the First Five-year Plan (1996-2000). In this case, the total water requirements of

Figure 2: Industrial water requirements at planned and historical growth rates



the industries located in the Ta'iz planning zone would be, approximately, 13 million cubic meters in year 2010. This would increase to a staggering 27 million cubic meters by the end of planning period in year 2020. It appears that the water availability constraints would make it extremely difficult to achieve a sustained, high growth rate of industrial output in the area.

2.7 Is there enough water for all

As mentioned earlier, *strictly* sustainable water resource use requires that groundwater abstractions net of the return flow do not exceed the annual recharge. It may be possible to deviate from this principle for a limited period. In the end, however, the aquifers are depleted and the only water available for use from then on is the annual recharge.

In the Ta'iz planning area, annual groundwater abstractions for agriculture, industry and domestic use (both urban & rural) are taking place at such a high rate that sustainability criteria is not met. The natural groundwater recharge in the planning area (Upper Wadi Rasyan Catchment) is only around 15 million cubic meters. According to estimates made using information collected in 1996, the total groundwater abstractions were approximately 41 million cubic meters in that year. In other words, the groundwater abstractions are more than 250% of the annual natural recharge.

In a purely physical sense, of course, not all the groundwater abstracted in any given year is lost. A certain part of the water used for irrigation as well as the wastewater from domestic and industrial uses percolates back into the aquifers. Indeed, nearly 17 million cubic meters of used water were returned to the aquifers of the region in 1996. However, much of the return flow, especially from industrial and domestic uses, is of bad quality because adequate treatment is not available for it. Therefore, instead of easing the rate of depletion, this water contaminates the aquifers and further reduces the quantity of fresh water available for future use.

As agriculture continues to draw a large amount of groundwater for irrigation, urban population grows and industrial expansion takes place, total groundwater demand is going to increase very sharply. With natural groundwater recharge remaining more or less the same, an increasing part of future water demand will be satisfied by depleting the aquifers. Moreover, progressively larger volumes of untreated wastewater would be dumped into the aquifers, further reducing the availability of freshwater. If these trends persist, the aquifers will be depleted of usable freshwater and environmental degradation will assume catastrophic proportions. It would no longer be possible to meet the competing water demands of various sectors. This would not only undermine the economic base and prosperity of the region but also have serious implications for the existence of civil society.

3 WHY THIS ACTION PLAN HAS BEEN PREPARED?

3.1 Crises in urban water supply

The explosive population growth in urban Ta'iz over the past several decades has forced the water supply agencies to follow a catching up approach for urban water supply management. New sources of water needed to be on line every few years to meet growing water demand. Because of the difficulties inherent in source development, this process has been far from smooth. The resulting imbalance between water supply and demand has led the city to serious water crisis, more than once

After commissioning of the 'Kennedy Memorial' water supply system in 1965, when the population of the city was 60,000, the Hawjala well fields had to be developed only 5 years later to meet growing water demand. By mid seventies, it was clear that suitable water resources were no longer available in close proximity of the city so the development of Al-Haima well fields began in 1977. These were located several kilometres away from the metropolitan area and mains had to be constructed to bring water to the city. The Al-Haima area was one of the prime agricultural zones in upper Wadi Rasyan where considerable groundwater abstractions were also taking place for irrigation. By 1987, water resources of the area were significantly depleted and the city was faced with its first water crisis.

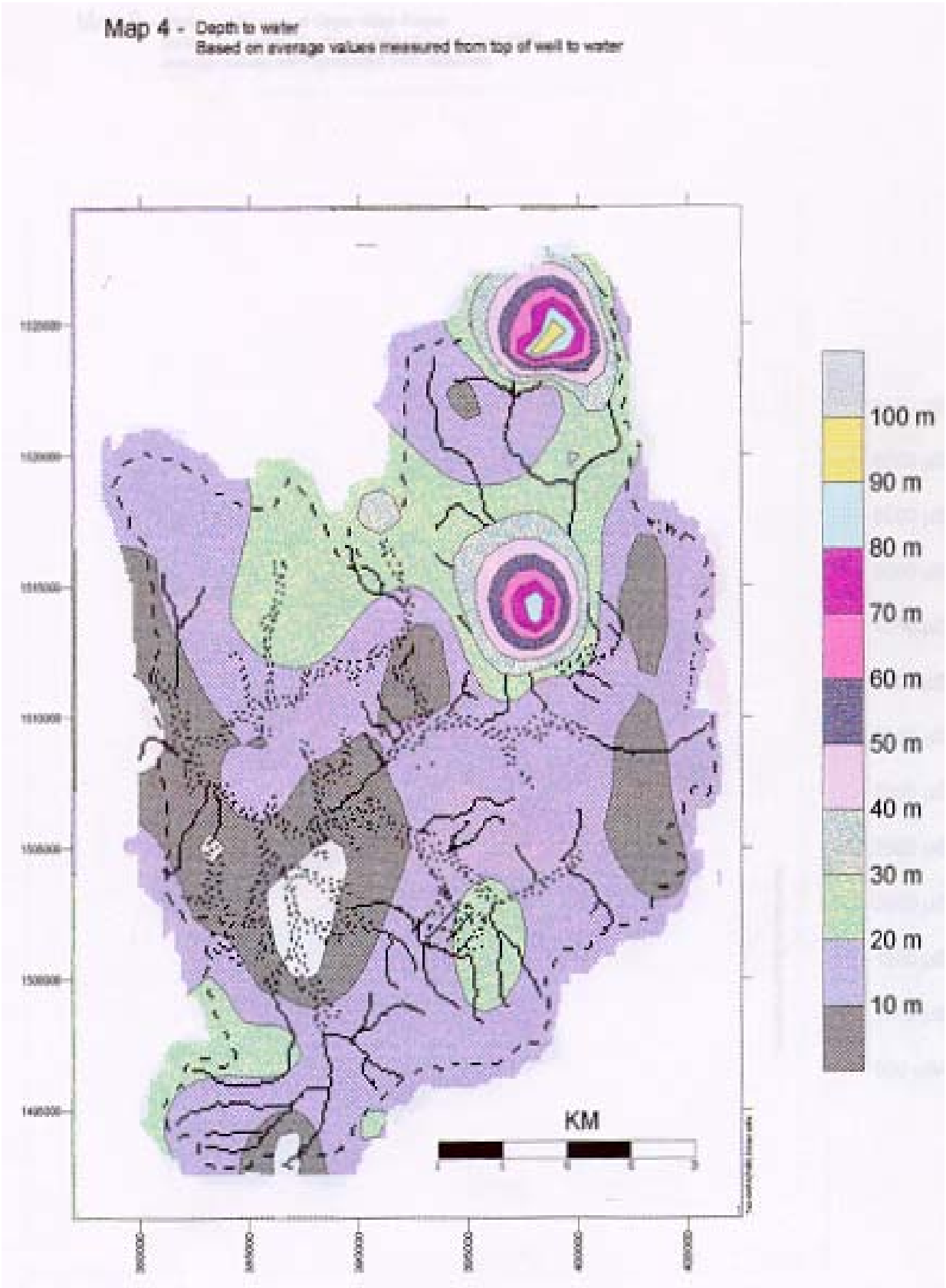
The emergency drilling program of 1987-1988 restored, temporarily, the balance between water demand and supply. As urban water demands continued to grow, negotiations with the local *Sheikhs* for drilling of more wells remained bogged down. By 1995, the city was hit by another water crisis. This was much more severe than the one before. The frequency of supply by NWSA dropped to only once in 40 days. There was considerable water stress among the consumers and tension in relations between them and the public water supply agency.

A second round of emergency drilling was carried out, starting in 1995. Thirteen new wells were drilled in the city. In 1996, six more wells were drilled in Habir area, out of which three are connected to the system. The water supply frequency improved to once in about 20 days in 1998 and perhaps, the interval has become a bit shorter ever since, but it is still very inadequate.

The yields from the Habir wells have been lower than originally anticipated. The increased water deliveries were made possible only by increasing supply from the Hawban-Hawjala well fields. These wells tap into aquifers heavily polluted by cesspits and the city's leaking sewers. The higher supply frequency has been achieved by compromising water quality. However, even this is a temporary solution. If present trends continue and new water sources are not found, it is only a matter of time before the demand outstrips supply again and another urban water crisis is created.

3.2 Groundwater levels are falling

Because of continued groundwater abstractions much in excess of the annual recharge, the water tables have been falling. Some areas are worse hit than the others are. It is common knowledge that a large number of wells in the Southern Al-Haima have dried up, leading to near disappearance of irrigated agriculture in that area. For the Al-Haima zone as a whole, the average decline in the groundwater level has been nearly half meter per year in the alluvial aquifer and more than 3 meters in the volcanic aquifer. The map on the next page shows


Map 4 - Depth to water
Based on average values measured from top of well to water
100 m
90 m
80 m
70 m
60 m
50 m
40 m
30 m
20 m
10 m
KM

that there are two cones of depression, in Al-Haima and Dhi-Sufal respectively, indicating high rate of groundwater abstractions. These cones are roughly located near the areas where both NWSA and the farmers are engaged in competitive abstractions.

Groundwater levels have been falling in other zones as well. In Dhabab zone, which has good quality water in the alluvial aquifer, the water table fell nearly two meters in 1996. Similarly, in the Shara'b zone, the groundwater level declined roughly four meters in the volcanic aquifer. Declining water tables indicate that the groundwater resources of the area are fast depleting. It also means that water abstraction costs are rising, which would make some activities, like low valued agricultural crops, uneconomical.

3.3 Conflict between urban and rural water demand

Of all the problems facing the Ta'iz region, the most serious is the competition between urban and rural water uses. As the urban and industrial water demands grew, water had to be brought in from areas farther and farther away from the city. In the Ta'iz region, these areas were typically the ones where irrigated agriculture was already placing considerable demand on local groundwater resources. Competitive abstractions by farmers and NWSA led to rapid depletion of aquifers, depriving farmers of their means of livelihood (as in the case of Southern Al-Haima, noted above) or at the very least, reducing agricultural incomes.

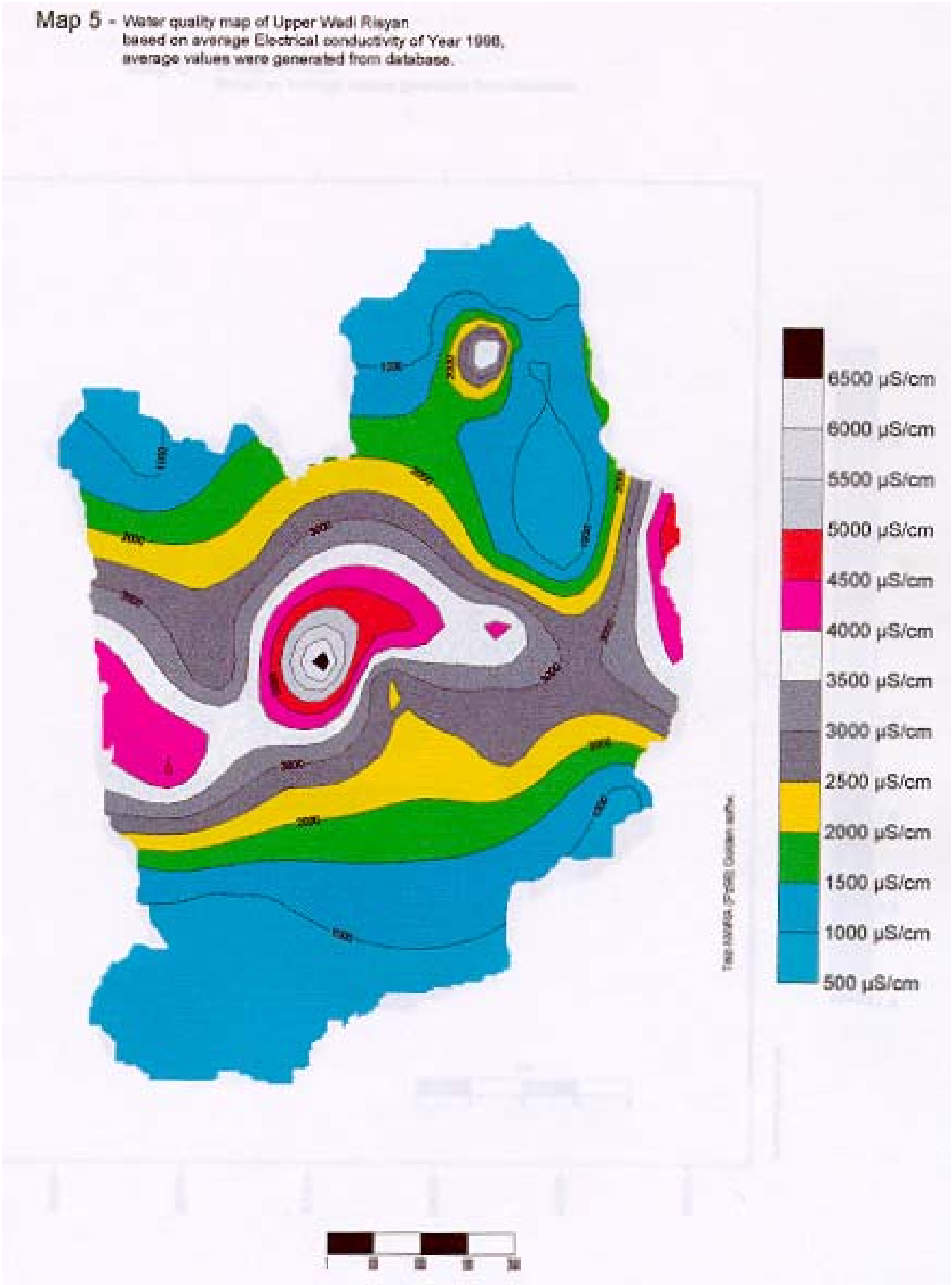
The competition for water between the rural and urban sectors has resulted in serious conflict between local communities in the countryside and the city. Initially, the farmers had agreed to allow NWSA to drill wells in Habir area, in exchange for a compensation package that consisted of certain public goods (including roads, schools, rural water supply wells, and dykes). However, as the effects of uncontrolled groundwater abstractions become more apparent to them, the farmers become increasingly reluctant to enter into such deals. In the absence of a regulatory mechanism for controlling abstractions or for linking compensation to actual losses of agricultural incomes suffered, the farmers' response was to refuse to allow exploratory drilling and well field development in their area. The recent difficulties faced during drilling in area outside the Wadi Rasyan catchment are a case in point. Unless mutually acceptable institutional arrangements can be found to govern rural-urban water transfers, future augmentation of city's water supply by developing new sources cannot be taken for granted.

3.4 Water pollution is encroaching and demands its toll

Pollution caused by untreated domestic and industrial wastewater poses a severe environmental hazard. Only about 35% of the city's population is connected to the sewerage system and the rest has to rely on cesspits, which discharge directly into the aquifer. The Sewer water collects into Burayhi lagoons situated a few kilometres to the north of the city. There is no treatment plant for treating urban wastewater. In addition, street run-off, containing oil and other hazardous materials, collects in Al-Amira dam. The EC in the dam has been measured to be in excess of 5000 μS/cm.

The problem is compounded by industrial wastewater, some of which also makes its way to Burayhi. However, many industries dump their wastewater in nearby ponds, from where it percolates into the ground and contaminates the aquifer. Industries do not recycle water and only one factory has water treatment facilities.

Map 5 - Water quality map of Upper Wadi Risyan
based on average Electrical conductivity of Year 1998,
average values were generated from database.



The untreated wastewater from urban area and the industries has taken a heavy toll of environment and health of the people living in the area. The EC values greater than 5000 have been obtained for wells located in Al-Hawban and Central zones that are adjacent to the city (See the EC contour map above). The water also contains concentration of heavy metals exceeding the WHO standards for safe drinking water. Many people in the area are suffering from water related diseases. Moreover, the farmers in the Burayhi area give the water from the lagoons to their livestock. This increases disease and mortality among the animals.
Some farmers use wastewater for irrigation from Burayhi lagoons and Al-Amira dam. Because this water is not suitable even for irrigation, land degradation occurs as a result. The crop yields start falling after first few years of use.

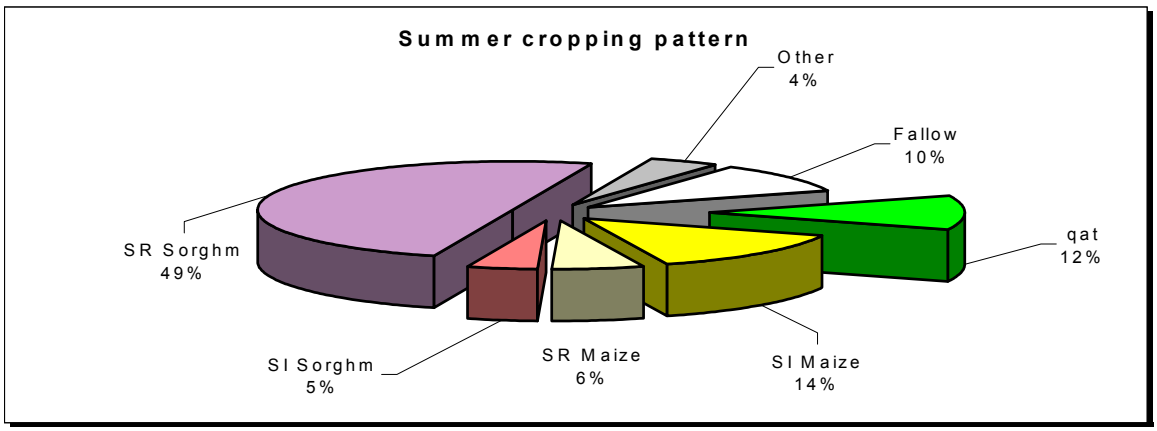
3.5 Are the scarce water resources efficiently used?

Despite acute scarcity in the Ta'iz region, water use within sectors as well as between them remains inefficient. Consider agriculture, which is the main user of groundwater in the region. Irrigation efficiencies in agriculture are low because farmers do not adopt improved irrigation methods and practices. Considerable amounts of irrigation water are lost between the field and the water source due to poorly maintained and unlined channels. Most farmers use basin irrigation instead of furrows, which further reduces the application efficiency. The water saving technologies such as drip and sprinkler systems are not found anywhere in the area.

The situation in the urban domestic and the industrial sectors is no different. According to figures released by NWSA, the unaccounted for water was more than 45% in 1997. Some of this may simply be administrative losses. But the ageing water supply infrastructure suggests that system losses are also substantial. Similarly, the industries do not recycle water. This increases their water requirements. However, like the other users, the industries also pay only the cost of abstraction and delivery of water rather than its true opportunity cost. So they have little incentive to conserve.

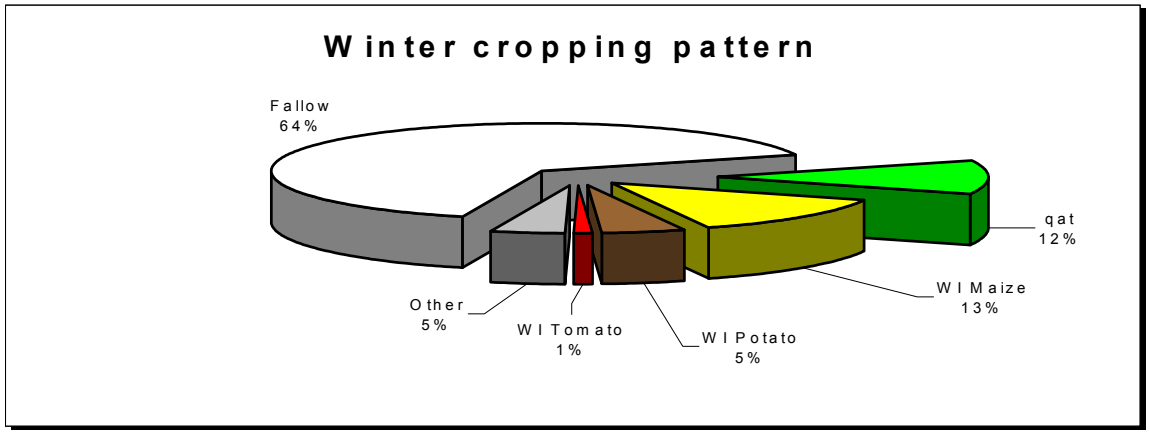
The most serious inefficiency, however, is in ***inter-sectoral water allocation***. In the Ta'iz region, low value cereal crops dominate agriculture and tie up a significant share irrigated area and hence of water resources (see cropping pattern in Figure 3 & Figure 4). In summer, cereals account for 47% of irrigated area, while this figure in 36% in the dry winter season. The productivity of agriculture as a whole, and particularly that of the cereal crops, is

Figure 3



Note: The definition of prefixes to the crop name is as follow. S= summer, I= Irrigated, R= Rainfed. Source: Agriculture & water use survey (Upper Wadi Rasyan), NWRA, April 1999.

Figure 4



Note: The definition of prefixes to the crop names is as follow. W= winter, I= Irrigated, R= Rainfed.
Source: *ibid.*

quite poor (see Table 5). This accounts for low average returns on water use in the sector. Even for cash crops such as qat grown under most favourable agro-climatic conditions (in Dhi Sufal zone), the average returns per cubic meter of water do not exceed 55 Riyals. In the Al-Haima zone, where climatic conditions require substantial quantities of irrigation for growing qat, the returns per cubic meter of water used on this crop fall to less than 25 Riyals.

Table 5 : Yields per hectare of various crops in the Ta'iz region

Crop	Unit	Overall	Dhi Sufal	Haima	Janad	Hawban	Central	Sabir	Dhabab	Shar'ab
Irrig. Papayas	Kg	6,919							6,919	6,919
Irrig. Hot Pepper	Kg	3,413				3,413	3,413			
Irrig. Coffee	Kg	799	1,320	686					799	618
Irrig. Qat	Mandil	1,414	1,966	1,333	1,792	1,412	1,414			1,165
S. Irrig. Maize	Kg	1,212	2,828	1,300	1,212	1,079	1,169		984	1,692
S. Irrig. Sorghum	Kg	1,131	1,815	1,010	1,131	1,031	817		1,131	916
S. RF Maize	Kg	1,262	1,673	783	744	1,699	528	825	1,081	1,031
S. RF Potato	Kg	7,261						7,261		
S. RF Wheat	Kg	1,164						1,164		
S. RF Barley	Kg	1,561						1,561		
S. RF Sorghum	Kg	1,095	1,475	788	1,289	1,060	997	1,320	964	1,038
S. RF Bean	Kg	587						587		
S. RF Lentils	Kg	661						661		
S. RF Adas	Kg	622						622		
W. Irrig. Maize	Kg	1,280	2,526	1,769		1,330	1,131		859	1,456
W. Irrig. Potato	Kg	14,410	14,41	14,613		11,363	14,410			
W. Irrig. Tomato	Kg	11,492	30,000	13,879		2,139				

Note: S= summer, W= winter RF = rainfed.
Source: *ibid.*

Table 6 : Returns on water use in agriculture (selected crops) in Al-Haima zone

Crop	Average returns per m^3 of irrigation water (Riyals)
Qat	23 - 17
Summer Maize	3 - 1
Summer sorghum	3 - 1
Winter Maize	13 - 7
Winter potato	37 - 25
Winter tomato	21 - 15

Note: The range of returns on water use for various crops is obtained from the estimates presented in (a) Agriculture & water use survey (Upper Wadi Rasyan), *ibid.,* and (b) Al-Haima zone policy simulation model (Draft), Abdullah Al-Shami,, Khalid Riaz, Najib Sagir, Saleh Al-Dubby. NWRA 2000.

For most other zones and crops, the returns per cubic meter of water used for irrigation are much lower. For cereal crops, these returns are even negative in some regions. Compared to this, the urban consumers are willing to pay more than 280 Riyals for a cubic meter of tanker water. The large difference in the profit derived from the use of water in the agricultural sector and the value that urban consumers place on it suggests possibilities of mutually beneficial water transfers, which would also restore efficiency. However, a satisfactory mechanism for rural-urban water transfers is long over due.

3.6 Other water-related problems

In addition to above, there are other water-related issues. The most important of these is the need for institutional reform of NWSA. The present structure of NWSA is highly centralised with little autonomy at the branch level. For instance, the Ta'iz branch cannot set its own water tariffs, or retain its revenues. This means that the Ta'iz Branch cannot charge a water tariff that reflects the cost supplying water in the region. Because it cannot retain its revenues, it has little incentive to be financially self-sustaining. Moreover, the branch is not authorised to undertake investment planning, or draw up its own training programs, hire new staff, reduce surplus staff or provide performance-based incentives to the employees. It is not surprising that there is a great room for improvement in operations of the public utility. Although it is responsible for production of water, NWSA is also a service agency. One of its important functions is to provide reliable, good quality and hassle-free water services to its clients. Unless the institutional structure of the organisation undergoes reforms that address some of the issues highlighted above, the quality of service provision will not improve. This has implications in terms of consumers' willingness to share costs and the prospects for improvements in water related infrastructure and coverage of urban water services.

The problems of inter-sector water allocations (conflicting rural and urban demands) are mentioned above. There are significant problems related to water allocations within the sectors also. In particular, there are conflicts between rural communities over the allocation of spring water. Many times these conflicts turn violent. Because there are no effective institutions to resolve or prevent them, these conflicts tend to be protracted. Government intervention usually is not sufficient to end them.

There is also latent conflict between the well owners and non-owners. Because the well owners capture a disproportionate share of the benefits of groundwater abstractions while the costs of declining water tables is shared by all, there is usually some hidden tension between the two groups. This tension does not become more apparent because the well owners are a powerful group. However, it would be unrealistic to expect that these tensions conflict would remain hidden when the water rights issues are decided. Therefore, efforts would need to be made that the water rights allocations are fair and the process used for allocating such rights is transparent for all. This would greatly reduce the chances of conflict.

Many areas in the region are vulnerable to flood damage hazard, which has become more acute in recent years due to neglected maintenance or abandonment of terraces. Because flood protection is a public good, private initiative has been somewhat lacking. Flood damages occur in sections of Ta'iz city. They are also reported in Dhi Sufal and in wadis on the flanks of Mount Saber and Mount Habashi.

Finally, there is the problem of rural water supply. This is an important issue because of the time and inconvenience involved in fetching water. The water points are usually a long distance away, sometime involving difficult terrain. The opportunity cost of time spent on this activity can be substantial in some area when viewed over the lifetime of a rural water supply project.

3.7 Conclusion: the need for co-ordinated action

In Yemen, the water problem has been, traditionally, perceived in terms of scarcity. The solution according to the conventional wisdom is to find 'more water'. However, as described above, the water problem in Ta'iz is complex and multidimensional. In addition to water scarcity, it involves a host of issues. These include poorly defined water rights, lack of appropriate incentives for conserving water resources and for protecting the environment, poorly functioning water markets, weak institutional capacities and the absence of an efficient regulatory framework for management of water resources. Water scarcity is only one of the dimensions of this problem. The discovery of new water sources would ease scarcity and provide temporary solution, as indicated by water resource development experience in Ta'iz. However, without addressing the other fundamental issues by adopting an integrated approach, a long term and sustainable solution to the problem is not possible.

Many of these issues are inter-related. For example, urban water problems cannot be adequately addressed without an appropriate mechanism for rural-urban water transfers and institutional reform of the public water supply utility. Reduction in agricultural water use would be difficult to achieve without a regulatory framework for controlling water abstractions and improving irrigation efficiencies. In view of these inter-relationships, there is a need for co-ordinated action on all issues. This would involve a number of actors, including government institutions, non-government organisations and above all, the stakeholders.

THE ADOPTED WATER RESOURCES MANAGEMENT STRATEGY

3.8 What are the objectives of managing our water resources?

As has been made clear in the previous chapter, there is an urgent need for managing our water resources. Basically, we want the scarce water to be used in the best way possible, now and in the future. This means in the first place that we have to ensure that the most vital needs – drinking water both in the city and at the countryside - are satisfied with priority. It means as well that the allocation of the remaining water should be done on the basis of sensible and generally accepted criteria. Thus, water should preferably be used for purposes that produce high economic benefit or satisfaction and each person or group in the area should be entitled to receive a fair share or profit from water. The latter implicitly will reduce conflicts regarding water, which are rather common at present. We have to care also about the future: the use of our valuable water resources should be sustainable, for our own benefit in the years to come and for that of future generations. Therefore, it is important to avoid water pollution and the depletion of groundwater resources.

3.9 Components of the strategy

An overall strategy for managing the water resources in the Ta'iz region has been developed and is outlined below. Its general features are that it attempts to strike a balance between the different and often conflicting interests regarding water, and that its implementation requires the various stakeholders to undertake co-ordinated actions in smooth co-operation. The latter may seem a difficult condition, but it is essential if we really aim for a transition from the present situation characterised by so many problems to a situation of optimum use and protection of the precious water resources. The role of NWRA is mainly that of a facilitator for initiating and co-ordinating the activities and of a 'honest broker' for negotiating deals between parties that have conflicting interests.

The water resources management strategy for the Ta'iz region consists of the following main components:

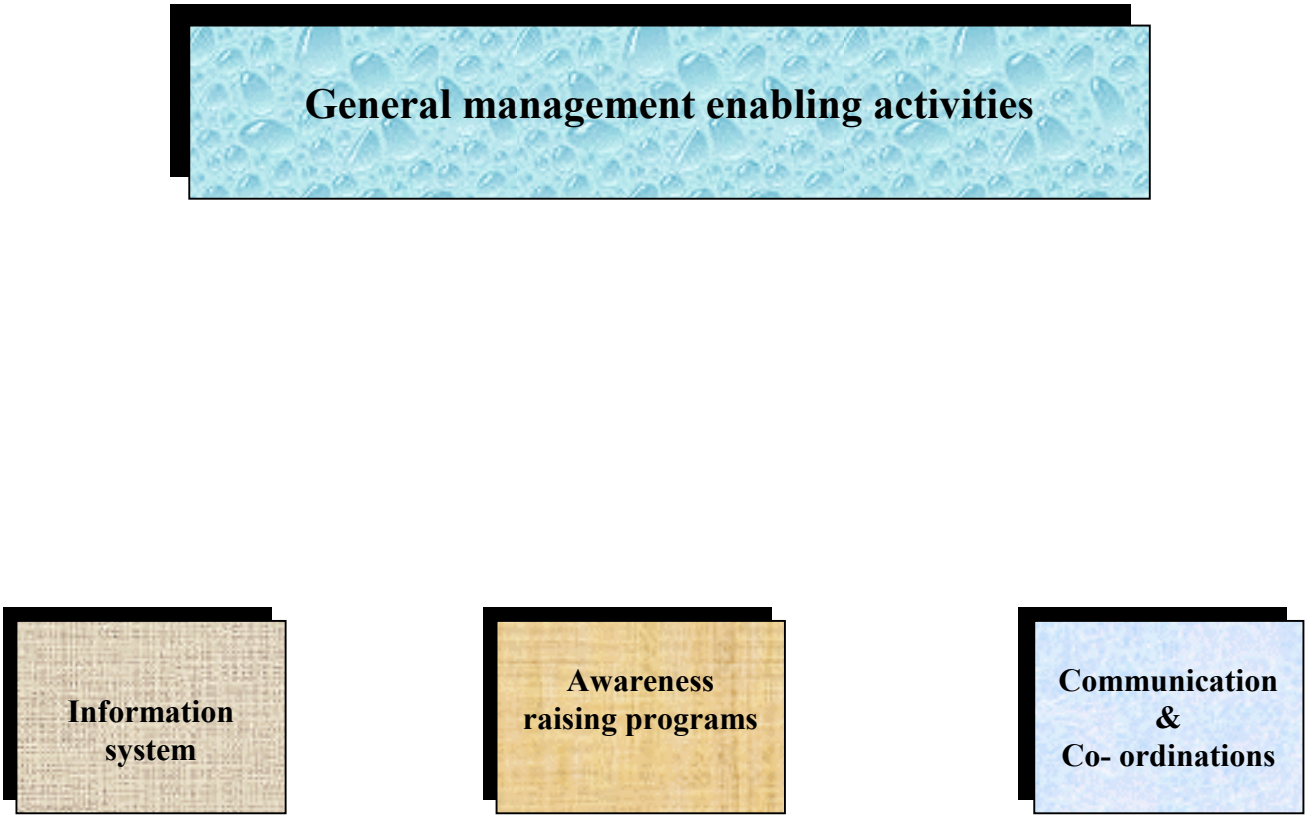
(1) General management enabling activities

This component includes activities that are not an end in itself, but that are a prerequisite for the successful implementation of the more operational components that follow below. Among these activities, the development and systematic updating of *information systems* (monitoring systems, field observations, databases, library, etc.) is fundamental, because without adequate information it is not possible to manage the water resources properly.

However, it is not sufficient if only technical personnel have access to this information and are aware of its implications. Consequently, *awareness raising programmes* based on this information need to be initiated in order to inform the general public (and the stakeholders in particular) on relevant water issues and to create in this way their understanding and their willingness to co-operate.

Finally, co-operation between institutions does not develop spontaneously. It requires significant and sustained efforts to establish and maintain *communication and co-ordination*.


Components of the strategy
General management enabling activities
Establishing regulatory frameworks for allocating water
Enhancing public water supply infrastructure & services
Combating damage from water
Sector-targeted demand management


General management enabling activities
Information system
Awareness raising programs
Communication & Co- ordinations

The target institutions not only include government institutions, but also the private sector, the urban population and the rural communities.

(2) Establishing regulatory frameworks for allocation of water

Water is in principle an 'open access' natural resource, which means that it is relatively easy for anybody to tap and exploit it. In a situation of water scarcity such as prevailing in the Ta'iz region, this situation tends to lead to competition between water users, to overexploitation of the resources and not seldom to serious conflicts. Control by restricting access to the resources then is needed in order to prevent or mitigate these problems. This can be done by means of regulatory frameworks. These frameworks require first of all the water rights to be defined and approved by a recognised institution, either centralised at the national or regional level (NWRA) or a local one (e.g. local communities united in a water users association). Next, this institution defines how much water each individual or group is allowed to abstract, when and on what conditions. It will monitor and register abstractions and, finally, it will impose sanctions in case the rules are violated.

Possible regulatory measures to control groundwater conservation

Designation of most critical areas as 'groundwater conservation and protection zones'

Well registration

Well metering

No new wells in the designated groundwater conservation and management zones.

In other zones, construction of new wells or deepening of existing wells only after obtaining licence form NWRA and following its guidelines for design and construction.

Registration of rigs operating in the area

Registration of irrigated area and ban on expanding irrigated area.

Two types of regulatory frameworks for allocation of water have to be developed in the Ta'iz area. The first type is a *regulatory framework for groundwater conservation*. The essence of such a framework is that it regulates and restricts the abstraction of groundwater in each individual zone to the extent that unacceptable interference between wells will not occur and excessive declines of groundwater are prevented. Thus it is aiming for sustainability of profitable groundwater use.

Establishing regulatory framework for allocation of water

Regulatory framework for groundwater conservation

Regulatory framework for rural–urban water transfers

The second type is a *regulatory framework for rural-urban water transfers*. It is generally agreed that larger urban centres like Ta'iz can not satisfy their basic needs for water without receiving water from outside the city boundaries. However, it matters how the necessary rural-urban transfers of water are being arranged. If they create a situation of 'winners' (urban population/ NWSA) and 'losers' (rural population), then the losing party has the perception to be deprived from a fair and equitable benefit from their zone's natural resources, which leads in most cases to conflicts. So, for the sake of justice, equity and conflict prevention, a fair deal has to be made for any rural-urban transfer of water. The regulatory framework for rural-urban water transfers is intended to be a transparent and effective tool for establishing such deals. The difference in economic value between urban water use and rural water use suggest that solutions can be found that are attractive for all parties involved ('win-win' solutions).

(3) Enhancing the public water supply infrastructure and services

The inadequate public water supply to a large portion of the region's population requires very significant efforts to bring domestic water supply services quickly to an acceptable level.

As far as the urban situation is concerned, a start has been made already with a comprehensive *programme for improving Ta'iz urban water supply*. This programme – resorting under NWSA - includes a World Bank financed exploratory drilling programme, targeting the Tawilah Sandstone and supervised by NWRA. After an initial focus on augmentation of the quantities of water abstracted, priority now has changed for the short run to rehabilitation of the distribution network (financed by KfW) and institutional reform; connection of new sources of water will follow later. It needs to be pointed out, however, that in addition to looking for new water sources, urban water supplies could also be augmented by treatment of raw (brackish) water found near the city (especially Hawban-Haougala areas). The introduction of demand management aspects (see also under 5) is certainly an important element, because water problems in the Ta'iz area can not be solved simply by expanding the technical infrastructure for water abstraction. It is also perfectly clear that exploring and planning for new NWSA well fields very likely is bound to fail unless sufficient prior attention is paid to an appropriate framework for rural-urban water transfers.

The regular *rural water supply programme* of GAREWS offers possibilities to improve domestic water supply in the rural areas. During the surveys and stakeholder participation activities it was observed that inadequate domestic water supply is considered to be a problem in several villages, mainly because of the time lost to fetch water. The actual rural water supply situation throughout the region is not accurately known; hence, for a proper planning of rural water supply activities there is a need to map this first.

Enhancing public water supply infrastructure & services

Program for improving Taiz urban water supply

Rural water supply program

Combating damage from water by means of wastewater & flood control

(4) Combating damage from water by means of waste water control and flood control

Water may be very harmful if it is polluted or if takes the form of devastating floods. In the Ta'iz region, actual pollution and pollution hazards are mainly present or originating in the urban environment. Approximately 35% of the urban population is connected to the urban sewerage system to get rid of domestic wastewater. For the protection of the local environment further *expansion of the urban sewerage system* is required. This is a component of the planned Ta'iz Water Supply and Sanitation Project. What is not yet included in this project, but needs to be undertaken urgently, is *urban domestic wastewater treatment*. Currently, the sewage from urban domestic wastewater is not properly treated, which is causing a completely polluted environment in and along the wadis downstream of the Al Burayhi lakes. However, this constitutes an environmental catastrophe and there is consensus that the polluter should be held responsible for it. Consequently, NWSA should include wastewater treatment as an inseparable companion to water supply in its programmes and priorities.

Something very similar is happening in the industrial zones. Most of the industries in the Ta'iz area produce wastewater that is severely contaminated – although it is still generally unknown which contaminants do occur and in what concentrations. Continued discharge of the untreated wastewater degrades the environment - the downstream water resources in particular – and is producing. *Industrial wastewater treatment* therefore is an important element of the integrated water resources management strategy for the Ta'iz region. *Re-use of the treated wastewater* by the same industries should be encouraged to keep contaminants confined inside a limited area and to salvage industries from claims and allegations.

To reduce the relatively high risk of flood damage in part of Ta'iz city and in several parts of Dhabab and Dhi Sufal, *flood control and protection works* should be carried out. At the one hand, they should produce some reduction of peak flows (by terracing and forestation); at the other, they should offer better protection to the impact of flowing water (protection walls; lined drainage system).

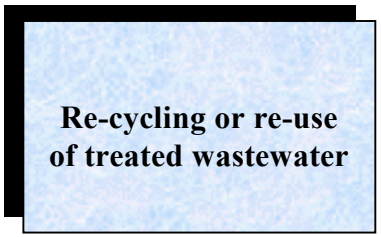
(5) Sector-targeted demand management

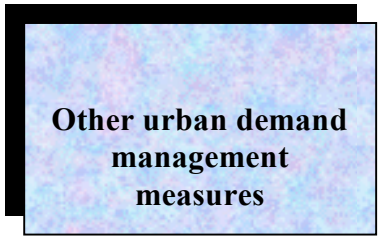
There are several options for reducing the water demands of each water-using sector (demand management). Given the technical, social and economic limits to further expanding water supply, demand management is an indispensable component of the water resources management strategy of the Ta'iz region.

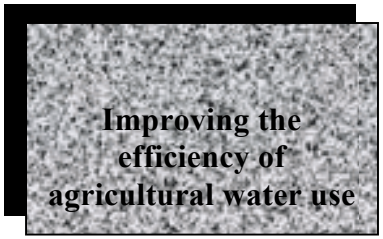
First of all, it is recommended to *recycle or re-use treated wastewater*. In the case of industrial wastewater, the same industry may use the treated water. This recycling will have the dual benefit of reducing substantially the need for water supply from external sources and at the same time isolating contaminants from the regional water systems. In the case of treated urban sewage, it is unlikely to be psychologically acceptable to recycle it for drinking water and its use for other domestic purposes would require a separate distribution network. Therefore, it seems more realistic to re-use it for irrigation purposes. A critical requirement for recycling or re-using treated wastewater for whatever purpose is that treatment should be sufficient and reliable.

Other urban demand management measures will target the per capita use of water by the urban population. Most of the options are in hands of NWSA and preferably should be incorporated in their programmes. Besides upgrading of the water distribution network (already mentioned


Sector targeted demand management


Re-cycling or re-use of treated wastewater


Other urban demand management measures


Improving the efficiency of agricultural water use


Creating non-agricultural activities

before) they include elimination of illegal connections and other unbilled clients, adjusting the tariffs to encourage economical use of water, and educating the general public on water saving practices.
Improving the efficiency of agricultural water use is another component of the water resources management strategy. The related measures are changing to more efficient irrigation techniques, lining canals and ditches, using pipes for water conveyance, allocating water to crops that yield maximum returns per cubic metre of water, land levelling, etc. Agricultural extension will help achieve these changes.

Given the fact that the current high rates of agricultural water use are not sustainable and the growth in urban water demands will reduce the future share of agriculture in total water use, *creating non-agricultural employment opportunities* is a necessity. This is the most fundamental one of all water demand management measures – its effects will become sizeable only after many years of effort.

3.10 How to ensure success?

There are many prerequisites for a successful implementation of the water resources management strategy. Only a few very important ones will be mentioned below.

Consensus, ownership and commitment
A great deal of consensus about the plan is needed among all stakeholders. Conflicts of interest are a fact of life, but stakeholders should realise that there are different ways of dealing with them. They should become convinced that opting for a plan that strikes a balance between the different interests in water is far more beneficial than maintaining a situation of uncoordinated and conflicting activities where liability for the damage inflicted on others does not exist. Consensus will have to be built on the contents of the plan. This, in turn, will lead to full ownership of the water resources management action plan and to commitment of the different actors to their respective roles. Without ownership and strong commitment the plan is bound to fail.

Maintaining a balanced and integrated view
Public or political pressures will often address a specific water-related problem. It is tempting then to focus on that particular problem and define solutions. However, these solutions may be short-sighted and ineffective if other interests and other problems are not taken into account simultaneously. For instance, exploring for water for urban water supply in a purely technical way, without paying due attention to the socio-economic and legal aspects of rural-urban water transfers may create strong opposition to transfers of water rather than creating options for augmenting urban water supplies. And the overall benefit of urban sewerage will be offset by serious environmental problems elsewhere if proper wastewater treatment is neglected. Therefore, it can not be over-emphasised that a balanced and integrated view on water should be maintained at all times. Implementation of only selective elements of the plan or improper timing of the components in relation to each other would easily lead to distorting the balance and foregoing the objectives.

Flexibility
Integrated water resources management is a new concept for the area under consideration and for all stakeholders involved. There is no experience yet on how easy or how difficult it will be to implement the various measures and to achieve the goals. Therefore, the action plan should

not be considered as a rigid blueprint, but rather be used with flexibility as a guideline for developing adequate water resources management. Implementation of the action plan has the elements of a "learning process"; the approach should be flexible enough to take immediate advantage of what is being learned. Flexibility should also be a key to co-operation: the different stakeholders should be flexible enough to make their aspirations compatible with those of others.

Planning and providing operational inputs

No action can be implemented properly if the necessary inputs are not available at the right moment in time. And because the different actions of the plan are so interdependent, it follows that inadequate input to one action may jeopardise many others. Therefore it is essential that all organisations and groups participating in the action plan make sure that at proper timing they have suitable and sufficient personnel available, as well as equipment, budgets, approvals and any other requirement to carry the jobs envisaged. Identifying and planning the inputs required for each action will be done by the participating organisations, under co-ordination of NWRA.

4. PACKAGES OF ACTIONS TO BE IMPLEMENTED

4.1 Development and operation of information systems

Purpose

Information systems are an indispensable guide to water resources management. Without them, the timely and reliable diagnosis of emerging or changing water problems is unlikely; as well as it will be impossible then to assess the impacts and adequacy of implemented measures.

Activities

These include but are not necessarily limited to the development, adjustment and operation of:

(a) Monitoring networks of rainfall, runoff, groundwater level and water quality (see annex E for details of the proposed monitoring program).

(b) Monitoring systems for periodic assessment of diversion/abstraction of water, water use, waste and wastewater production, wastewater treatment, benefits from water, etc.

(c) Databases containing the collected monitoring and related administrative data.

(d) Chemical laboratory for analysis of water samples.

The collected information will culminate in:

(e) Periodic updates of the diagnosis on water-related problems

Responsibilities

Primary responsibility for water resources management information systems rests with NWRA. Where convenient and feasible, co-operation with other institutions can be sought. Especially regarding activity (d), NWRA should try to support the enhancement of an existing laboratory, rather than establishing a new one. The owner of the existing lab (e.g. one of the universities) and principal clients (e.g. NWSA, Ministry of Health) should be approached for their contributions as well.

Financial and logistic arrangements

Besides the cost of appropriate staff, NWRA should prepare and provide a regular budget to cover transport and other field expenses, cost of equipment and spare parts, etc. For work envisaged in the annual budget, staff should be exempted from lengthy administrative requests for internal approval.

Additional remarks

Evaluation of the present information systems and data produced thus far is needed to optimise the water information system in the Ta'iz area.

4.2 Raising general awareness on water problems and solutions

Purpose

The general public – and the main stakeholders in particular – should have a good awareness and understanding of water-related problems in the region and of feasible options for solution and/or control. This will build their co-operation and commitment. Typical aspects to be covered are: presenting predicted problems and trends in the future in absence of any measures; explaining the necessity of accepting measures for the common good; pointing to imperfect water use practices; explaining the mechanisms of conflicts on water; suggesting how to save

water; mobilising support for wastewater treatment as a standard practice; explaining health consequences of using poor quality water.

Activities

All kinds of awareness raising activities have to be programmed: designing and disseminating posters and brochures; workshops; informative meetings in the field; messages at schools and mosques; radio and TV-messages; etc.

Responsibilities

Primary responsibility for awareness programmes on water resources management rests with NWRA. Where convenient and feasible, co-operation with other institutions can be sought.

Financial and logistic arrangements

Besides the cost of appropriate staff, NWRA should prepare and provide a regular budget to cover transport and other field expenses, cost of printing and copying, etc.

4.3 Communication and co-ordination

Purpose

These activities are needed to ensure good and effective co-operation between parties who have a leading or supporting role in the water resources management action plan.

Activities

The activities include: monitoring on what is being done regarding the action plan; disseminating this information among relevant stakeholders; organising meetings to discuss operational aspects of the action plan.

Responsibilities

Primary responsibility for communication and co-ordinating on water resources management rests with NWRA, which will co-ordinate its activities with the Governorates.

Financial and logistic arrangements

Besides the cost of appropriate staff and office facilities, NWRA should prepare and provide a regular budget to cover transport and other field expenses, cost of equipment and spare parts, etc.

4.4 Establishing regulatory frameworks for conserving groundwater for sustainable use

Purpose

The main purpose of the regulatory framework is to prevent groundwater overexploitation, thus ensuring a sustainable source of water and avoiding excessive interference. An additional concern may be to protect the groundwater quality against pollution or against other mechanisms of quality degradation.

Activities

Activities to establish these regulatory frameworks include the following:

- Defining zone(s) where the regulatory framework should be developed *(conservation zones)*

- Developing a communication structure between NWRA and the water stakeholders of the zone
- Establishing a local groundwater use association or any other organisation with sufficient local support (or mandate) to organise local groundwater conservation
- Discussing principles on which groundwater rights should be based
- Defining and registering groundwater rights and the period of time of their validity
- Setting a target for maximum annual groundwater abstraction in the zone, and any other targets
- Discussing and agreeing on self-imposed restrictions on groundwater abstraction (quantities abstracted, well spacing, pumping regime, etc.) and on other activities (e.g. land use) needed to reach the targets
- Monitoring compliance
- Punishing violators.

Priority zones for such frameworks are the water management zones Al Haima, Dhabab, Sharab, Dhi Sufal and Central.

Responsibilities

Main responsibility is with the local organisations to be established for this purpose. NWRA is responsible for initiating and intensive support, including involvement of NGOs for community mobilisation.

Financial and logistic arrangements

The activity will need much time of both local inhabitants and NWRA personnel before the framework is operational. Besides the cost of appropriate staff and office facilities, NWRA should prepare and provide a regular budget to cover transport and other field expenses.

Additional remarks

A legal basis for this type of framework does not yet exist. So, it should be enabled by convincing the local population of the need for it.

4.5 Establishing regulatory frameworks for rural-urban transfers of water

Purpose

The main purpose of this type of regulatory framework is to solve or prevent conflicts resulting from appropriation of rural water for urban use. The framework should enable rural water to be transferred to Ta'iz city in a way acceptable to and benefiting both the urban and the rural population.

Activities

Activities to establish these regulatory frameworks include the following:

- Defining zone(s) where the regulatory framework should be developed (with priority)
- Developing a communication structure between NWRA and the water stakeholders of the zone
- Establishing a local water use association or any other organisation with sufficient local support (or mandate) to negotiate water transfers from the zone to Ta'iz city
- Discussing principles on which groundwater rights should be based
- Defining and registering groundwater rights and the period of time of their validity
- Discussing and agreeing on conditions for transferring water to NWSA (quantities, price, terms of payment, individual or community transfers, etc.).

- Negotiation of deals between rural zones and NWSA.
- Defining rules of arbitration in case of no compliance of any partner.

Priority zones for such frameworks are the water management zones Dhabab (candidate for new transfers), and the zones where NWSA wellfields for urban water supply already exist: Al Haima and Dhi Sufal.

Responsibilities

Main responsibility is with the local organisations to be established for this purpose and – in the final stage – also with NWSA. NWRA is responsible for initiating and intensive support, including involvement of NGOs in community mobilisation.

Financial and logistic arrangements

The activity will need much time of both local inhabitants of NWSA and of NWRA personnel before the framework is operational. Besides the cost of appropriate staff and office facilities, NWRA should prepare and provide a regular budget to cover transport and other field expenses.

Additional remarks

In zones where this type of framework is developed, it should be combined with a framework for groundwater conservation, because sustainability is a prerequisite. Al Haima is an eloquent example of what may happen if sustainability is not ensured by effective control.

4.6 Improving Ta'iz urban water supply

Purpose

Improving Ta'iz urban water supply aims for achieving a reasonable standard of urban water supply services by NWSA. Although water quality currently is not satisfactory, the priority during the coming years will be matching the volumes of water supplied with the demands for urban water. At present, there is still a big gap between the urban water demands and public urban water supply.

Activities

Main activities foreseen are:

- Rehabilitation of the urban public water distribution network in Ta'iz
- Institutional reform of NWSA's Ta'iz branch in order to increase efficiency and to enable complete cost recovery
- Eliminating illegal connections and revising the tariff structure as important demand management measures (see section 4.13)
- Exploratory studies to identify possible additional sources of water
- Initiating the development of rural-urban water transfer frameworks (see section 4.5)
- Exploratory drilling, in particular in zones where permeable Tawilah Sandstones are found at reasonable depths
- Feasibility studies for additional source development for urban water
- Negotiating deals between NWSA and local communities on rural-urban water transfers (see section 4.5)
- Design and implementation of works for capturing additional sources of water for urban water supply.
- Feasibility studies (covering engineering, and financial aspects) for treating brackish water for augmenting urban water supply.

Most of these activities are included in the future Ta'iz Water Supply and Sanitation Project, Phase I or Phase II or in the ongoing preparations for the project.

Responsibilities
Main responsibility is with NWSA. NWRA is responsible for support with regard to exploring and assessing new sources for water supply. NWSA, NWRA and the local communities together are responsible for a functional framework for rural-urban water transfers.

Some of the activities have started already some time ago (exploratory studies and exploratory drilling). Rehabilitation of the network and institutional reform will take place during Phase I, whereas investments in new water supply infrastructure will become available only during the subsequent phase 2. Activities to prepare for frameworks for water transfers should start almost immediately.

Financial and logistic arrangements
Most of the activities have been planned as components of the World Bank supported Ta'iz Water Supply and Sanitation Project. World Bank financing will enable the capital-intensive activities to be carried out. This project focuses on technical aspects and on the reform of NWSA. In addition, it is important to pay sufficient attention to the rural-urban water transfer framework, without which capturing new sources of water is unlikely to be successful.

Additional remarks
- Strong evidence for the need for a rural-urban water transfer framework is given by the difficulties experienced during the exploratory drilling programme and messages received during various surveys.
- Additional sources of water are not necessarily confined to the management area (Upper Wadi Rasyan) but may lead to cross-boundary transfers, e.g. from the wadis Al Ghayl, Bani Khawlan and Warazan.
- Although not included in the Ta'iz Water Supply and Sanitation Project, control of urban wastewater should be inseparable from water supply activities. Neglecting this aspect creates a negative externality that certainly will frustrate co-operation between NWSA and the rural communities.

4.7 Rural domestic water supply

Purpose
Actions in the field of rural water supply should result in a reasonable standard of rural water supply throughout the zone, which implies good availability of drinking water for everybody within the area, without the need to spend excessive time to fetch it.

Activities
Main activities in this field are:
- Area-wide inventory and evaluation of rural water supply conditions
- Preparing annual plans for new schemes
- Preparatory field work at sites selected for new schemes
- Implementation of new schemes (usually by drilling and well completion, with pump and civil works)

Responsibilities
The main responsibility for rural water supply is with GAREWS. NWRA may co-operate in getting a good picture of the current level of rural domestic water supply and of main priorities for new schemes.

Financial and logistic arrangements
Current arrangements in GAREWS could be enhanced – and consequently the programme accelerated - if external funds would be spotted and made available. This could focus on funds from donors or projects, but it would be interesting as well to analyse to what extent contributions from beneficiaries could play a role.

Additional remarks
A good level of rural water supply will favour the willingness of the rural population to co-operate for frameworks for rural-urban transfers of water.

4.8 Upgrading urban sewerage

Purpose
Urban sewerage in Ta'iz city is limited in coverage. The aim of the urban sewerage programme is to increase the coverage of sewerage and to create in this way favourable environmental health conditions in the urbanised zone of Ta'iz.

Activities
In broad lines the work will consist of planning and design, procurement/tendering and other logistic activities, technical construction of the sewerage system, and administrative measures. As the activity is a component of the Ta'iz Water Supply and Sanitation Project, the activities will have been described in detail in the documents of that project.

Responsibilities
The activity is under responsibility of NWSA.

Upgrading the urban sewerage system is foreseen to be undertaken during phase 1 of the Ta'iz Water Supply and Sanitation Project, thus within a few years.

Financial and logistic arrangements
Upgrading the urban sewerage has been planned as a component of the World Bank supported Ta'iz Water Supply and Sanitation Project. World Bank financing will enable the capital-intensive activities to be carried out.

Additional remarks
Sewerage without adequate wastewater treatment leads to environmental and health problems at the site where wastewater is dumped and downstream of it as well. Urban domestic wastewater treatment therefore should be a natural companion to the urban sewerage programme. However, it is not included in the Ta'iz Water Supply and Sanitation Project.

4.9 Urban domestic wastewater treatment

Purpose

Urban domestic wastewater is creating at present major environmental and health problems in the zone of Al Burayhi and downstream. Furthermore, it deteriorates water and soils to such an extent that they lose their economic potentials. The purpose of urban wastewater treatment is to upgrade the water quality of the urban wastewater in order to eliminate these adverse effects.

Activities
A succession of technical activities is needed:
- Determining the type and concentration of pollutants in the untreated wastewater
- Setting water quality targets or standards for treated wastewater
- Identifying the optimal technical treatment system
- Design and costing of a treatment system
- Defining a cost recovery system for urban water treatment
- Building the treatment plant(s) and related works
- Putting the treatment plant(s) in operation

Apart from the technical activities, significant efforts are needed to build commitments and to raise the funds needed.

Responsibilities
Primary responsibility is with NWSA. It will be assisted by NWRA. The activities should start as soon as possible, as part of the damage is very difficult to remove reverse

Financial and logistic arrangements
Some initial inputs of man-power and finances will have to come from NWRA, notable for carrying out investigations and for lobbying. However, in accordance with the "polluter pays" principle, NWSA should assume responsibility as soon as possible. Possibilities to receive donor support should be explored, either within the framework of the Ta'iz Water Supply and Sanitation Project or in another context.

Additional remarks
This action clearly has an impact beyond the water resources management area. It will benefit the Lower Wadi Rasyan catchment.

4.10 Industrial wastewater treatment

Purpose
Industrial wastewater is creating at present major environmental and health problems in the industrial zones. Furthermore, it deteriorates water and soils to such an extent that they lose their economic potentials. The purpose of industrial wastewater treatment is to upgrade the water quality of the industrial wastewater in order to eliminate these adverse effects.

Activities
A succession of technical activities is needed:
- Determining the type and concentration of pollutants in the untreated wastewater
- Setting water quality targets or standards for treated wastewater
- Setting recycling targets for various types of industries
- Identifying the optimal technical treatment system
- Design and costing of a treatment system
- Defining a cost recovery system for industrial water treatment
- Building the treatment plant(s) and related works

- Putting the treatment plant(s) in operation

Apart from the technical activities, significant efforts are needed to build commitments and to allocate the funds needed.

Responsibilities

Primary responsibility is with the polluting industries. They will be assisted by NWRA. The activities should start as soon as possible, as part of the damage is very difficult to reverse.

Financial and logistic arrangements

Some initial inputs of man-power and finances will have to come from NWRA, notably for carrying out investigations and for lobbying. However, in accordance with the "polluter pays" principle, the industries should assume full responsibility as soon as possible. Possibilities to receive incentives or other types of support for encouragement should be explored.

Additional remarks

This action clearly has an impact beyond the water resources management area. It will benefit the Lower Wadi Rasyan catchment as well.

4.11 Flood hazard reduction

Purpose

Devastating floods may cause loss of lives, of environmental assets and of economic goods. Flood hazard reduction attempts to minimise the probability of occurrence of these losses.

Activities

Typical measures for reducing flood damage hazards are:

- Forestation programmes in the upper catchments of wadis where flood damage hazards are considerable.
- Rehabilitation and proper maintenance of terraces in the upper catchments of wadis where flood damage hazards are considerable.
- Providing for temporary storage of peak flow volumes at locations where they can do little harm.
- Construction of defence walls or other defence structures in wadi beds.
- Incorporating flooding risks as a criterion for land-use planning.

Activities typically follow the pattern: investigation, planning of measures for the zones concerned, design and implementation.

Responsibilities

Main responsibility for flood damage control are Ta'iz municipality (for the urban area), the different communities (for the rural area) and – probably- the Ministry of Public Works. Actions should be started as soon as possible. Some of the measures – especially forestation- will require a long time before becoming effective.

Financial and logistic arrangements

Since flood protection is a public provision, government funds should be made available for flood hazard control. Contributions by local communities and farmers organisations, however, may be very effective to get the programme underway.

- Putting the treatment plant(s) in operation

Apart from the technical activities, significant efforts are needed to build commitments and to allocate the funds needed.

Responsibilities

Primary responsibility is with the polluting industries. They will be assisted by NWRA. The activities should start as soon as possible, as part of the damage is very difficult to reverse.

Financial and logistic arrangements

Some initial inputs of man-power and finances will have to come from NWRA, notably for carrying out investigations and for lobbying. However, in accordance with the "polluter pays" principle, the industries should assume full responsibility as soon as possible. Possibilities to receive incentives or other types of support for encouragement should be explored.

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Financial and logistic arrangements

Since flood protection is a public provision, government funds should be made available for flood hazard control. Contributions by local communities and farmers organisations, however, may be very effective to get the programme underway.

Additional remarks
The most important zone where attention for flood damage control is needed includes the districts Al-Mojallia, As-Swani, Ishaq and Wadi Salah in Ta'iz city.
Rural areas affected by flood hazards are the southern part of Dhabab zone (slopes of Jabel Saber and Jabel Habashi) and certain parts of the Dhi Sufal zone (Wadi Tanif, Shuqah and Raida/Sailat Ja'ashin). Rehabilitation and maintenance of terraces is probably the most adequate measure in these rural areas.

4.12 Wastewater recycling or re-use

Purpose
Wastewater recycling and wastewater re-use may have the dual objective of increasing the efficiency of water use and implicitly ensuring that wastewater is properly treated and thus does not present a significant environmental hazard. For industrial water users there may be the additional advantage of being less dependent on water supply from external sources.

Activities
Activities still need to be defined and elaborated. In very broad terms, they may include:
- Identifying suitable combinations of wastewater producers and treated wastewater users (e.g. several industries may recycle their own treated wastewater; treated urban domestic wastewater may be suitable for irrigation of certain crops).
- Organising and evaluating pilot projects for wastewater recycling and wastewater re-use.
- In case of favourable results: promoting wastewater recycling and wastewater re-use on a large scale and providing incentives to encourage this.

Responsibilities
NWRA will try to raise interest for pilot projects and will organise them. Co-operation of other agencies, e.g. the Environmental Protection Council and the Ministry of Agriculture, and other agriculture and water institutions, will be encouraged. Pilot projects can only start after some wastewater treatment facilities are operational.

Financial and logistic arrangements
Special arrangements do not yet exist. It would be useful to create government incentives, at least for starting the pilot projects.

4.13 Other urban demand management measures

Purpose
The demand management measures have the objective to reduce the per capita net water use by the urban population, thus contributing to narrowing the gap between available water and water demands.

Activities
Activities that will tend to reduce the per capita water demands are:
- A strongly progressive water tariff
- Elimination of all illegal connections and of all privileged families that are currently exempted from paying the water bills.
- Public education on proper water economising practices at the scale of single households

Responsibilities
NWSA will be the main responsible agency. NWRA will assist by public education through its awareness programmes. The earlier a start is made the better.

Financial and logistic arrangements
Hardly any special arrangements have to be made.

4.14 Improving the efficiency of agricultural water use

Purpose
Unproductive losses of agricultural water have to be reduced to a minimum and agricultural water use with low economic return preferably should be replaced by higher-return uses.

Activities
The activities consist of water-targeted agricultural extension at the one hand, and of adopting improvements by farmers at the other. Such improvements may include:

- lining of canals and ditches
- land levelling
- replacing flooding irrigation by furrow, sprinkler or drip irrigation methods
- changing to crops with relatively low unit water use
- Encouraging a shift away from irrigated cereals; increasing the yields of rainfed cereals.
- changing to crops with relatively high economic returns per unit of water used

Responsibilities
The responsibilities for this action are shared by the Ministry of Agriculture and the farmers of the area.

Financial and logistic arrangements
Hardly any special arrangements have to be made on top of the existing ones.

4.15 Creating non-agricultural employment opportunities

Purpose
The purpose is to produce a very structural reduction of the average per capita water demand in the area, to the extent that finally sustainable rates of water use will be reached (the present rates are considered higher than sustainable rates and thus can not be continued for ever).

Activities
The action requires a wide range of activities:
Improving and diversifying education at the rural level
Identifying promising options for diversification of economic activities in the area (industries, manufacturing, services, etc.)
Government supported

Responsibilities
Responsibilities are in the first place at the level of the national government, particularly Department of Education. Activities should start as soon as possible. Effects, on the other hand, will become significant only on the longer term. Nevertheless, this may prove the most essential package of water resources management measures on the longer term.

Financial and logistic arrangements

Should be provided by the national and provincial governments.

5 A LOOK AHEAD

This action plan for water resources management in the Ta'iz region is a guidance for a process of getting the area's water resources under control. Although this process can not produce miracles, its benefits for the area will be extremely important, on the long run probably more important than the benefits of any other project or activity in the area. Water resources are a critical and linking factor in the development of any area: neglecting their proper management will create problems that will jeopardise development very seriously.

To get all the described actions in operation is not easy. It requires determination and perseverance of all people and institutions involved. It requires finances, equipment and facilities to be provided by the different institutions in adequate quantities and at the right moment in time. Above all, it requires an atmosphere of mutual trust between the different actors and the willingness to co-operate for a sustainable future, for the sake of the present inhabitants of the area, their children and all future generations.

The whole process of establishing water resources management is not a routine operation. It has several elements of trial-and-error. Therefore, one should be open-minded, observe the physical reality, be perceptive for feedback and not hesitate to modify approaches if this would seem to serve better the overall objectives. These objectives finally all boil down to a sustainable and healthy environment, where the scarce water resources are used efficiently, equitably and in good harmony, for an optimum level of welfare in the region.

During the preparation of this action plan, little attention has been paid to interactions with zones outside the Upper Wadi Rasyan catchment that was chosen as the planned water resources management area. An example of these interactions is the impact of modifying Wadi Rasyan's discharge rate or water quality on the water resources conditions in the lower part of Wadi Rasyan's catchment. Another one is the possible artificial transfer of water across catchment boundary's, such as would happen if NWSA would construct a wellfield for Ta'iz water supply in Wadi Al Ghayl, Wadi Bani Khawlan or Wadi Warazan. Confinement to this "planning area" was deliberately chosen, in order to keep the process as manageable as possible and to prevent excessive delays. Once the water resources management processes are taking shape and momentum, it is possible to widen gradually the scope and to incorporate such "cross boundary effects". In the longer run, this may lead to a larger territory to be taken as the water management area for the Ta'iz region.

The action plan is focusing strongly on decentralised actions. A number of possible actions which require decision-making at the central (national) level are not yet included, but may become incorporated in a later plan, when water legislation and other requirements are in place. These actions could include legal enforcement of regulations and measures related to general economic policy (taxes on resource use, modification of subsidies, etc.).

It is wise to evaluate systematically all activities done and experiences obtained during the implementation of this action plan. A formal evaluation report at the end of each year is recommended. In this way information will be collected that enables modifications to be formulated and implemented in due time. It will also be a valuable input to the next action plan.

Each plan has a limited validity in time: the plan period. After a number of years, autonomous developments in the area may have created new issues; results of plan implementation will have modified the area's conditions; furthermore, perceptions, attitudes and preferences of stakeholders may have changed. Then it will be time to develop a new, completely revised plan. It should be anticipated to produce a second water resources management plan for the Ta'iz region about five years after issuing the present one.

Annex A

Technical reports produced for the preparation of Ta'iz Water Resources Management Action Plan

Table A.I. Technical notes produced by NWRA

Abdulla Ali Al-Shami, 1998. Preparation of hydrogeological and hydrochemical maps for Ta'iz region using ATLAS-GIS (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-01, September 1998.

Ali Kasem As Sayagh, 1998. Industrial water requirements for Ta'iz region (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-02, September 1998.

Mahmood Sultan Taher, 1998. Domestic water demands and wastewater loads in Ta'iz region (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-03, September 1998.

Nagib M. Al-Sagir, 1998. Expansion in the irrigated areas in the Ta'iz region (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-04, September 1998.

Saleh A. Al-Dubby and Mahmood Sultan Taher, 1998. Agricultural water demand in Ta'iz region (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-05, September 1998.

Ali Kasem As Sayagh, 1998. Groundwater level measurements in theUpper Wadi Rasyan (Ta'iz) region. PPS Technical Note Series, No. TN-98-06, December 1998.

Nagib M. Al-Sagir, 1998. Estimation of groundwater recharge in the Upper Wadi Rasyan. PPS Technical Note Series, No. TN-98-07, September 1998.

Saleh A. Al-Dubby, 1998. Commandable and usable storage in the aquifer system in the Ta'iz region (Upper Wadi Rasyan). PPS Technical Note Series, No. TN-98-08, September 1998.

Nagib M. As-Sagir, 1999. Draft estimation of groundwater abstraction in the Upper Wadi Rasyan (Ta'iz) region. PPS Technical Note Series, No. TN-99-01, April 1999.

Table A.II Technical reports produced by NWRA

Joseph van Loon, 1997. Well and spring inventory Upper Wadi Rasyan, Ta'iz.

Khalid Riaz and Yussuf Al Mooji, August1998. Water resources management issues in the Ta'iz Region (Upper Wadi Rasyan). Draft report.

Khalid Riaz, January 1999. Socio-economic study of the Ta'iz region (Upper Wadi Rasyan). Draft report.

Khalid Riaz, February 1999. Water resources management strategies in the Ta'iz Region (Upper Wadi Rasyan). Draft report.

Khalid Riaz, April 1999. Agriculture and water use in the Ta'iz region (Upper Wadi Rasyan). Draft report.

Mahmood Sultan and Mohamed An-Najar, November 1998. Stakeholder participation in water resources management in Ta'iz (Upper Wadi Rasyan). Volumes 1& 2.

Bubacar Ducanse, April 1999. Monitoring activities Year 1998 in Taiz region.

Abdullah Shami, Khalid Riaz, Najib Saghir, and Saleh Ad-Dubby, April 2000. Water `resources policy simulation model for Al-Haima zone, upper Wadi Rasyan.

Table A.3. Reports commissioned by NWRA

Chris D. Handley, 1996. A baseline socio-economic study of the Ta'iz Governorate (excluding Tihama). Project YEM/010/93/A/01/01.

Jenny A.M. van der Welle, 1997. Hydrochemistry and pollution studies in the upper Wadi Rasyan catchment.

Kees Hansma and Leon Hermans, 1997. Stakeholder participation for water resources management in the Ta'iz region: the possibilities to start the process.

N.V. Mezhelovsky, Victor Rybakov, Abdulla Saleh Saif, Mohamed Emad and Ilya N. Mezhelovsky, 1997. Final report Contract NWRA/YEM/97/200-02 (Groundwater studies wadis Al Ghayl, Bani Khawlan and Warazan). Volume I: Main report. Volume II: Annexes.

Dar El-Yemen Consultants & SOAS, 1997. Hydrogeological and land-use studies in the Ta'iz region (Upper Wadi Rasyan). Vol.I: Main report. Volume II: Annexes.

Chris D. Handley, 1999. Household water use survey, Ta'iz, Yemen.

Annex-B

Organizational Structure for Plan Implementation

Organizational Structure for Plan Implementation

For implementation of the Ta'iz water resources management action plan, a three tiered organizational structure is proposed. This would consist of (a) Oversight Committee, (b) Plan Implementation Committee, and (c) Water users' organizations. The Plan Implementation Committee could form smaller sub-committees to deal with specific implementation issues.

Oversight Committee

- Governor Ta'iz
- Governor, Ibb
- Chairman, NWSA
- Head NWSA, Ta'iz Branch
- Head AREA, Ta'iz Branch
- Farmers' representatives
- Industries' representatives
- Urban water users' representatives
- Women's representatives
- Chairman, NWRA
- Head of Policy & Programming Sector NWRA
- Head of Monitoring and Implementation Sector
- Manager, NWRA, Ta'iz Branch

Plan implementation Committee

- Representatives of Governors, of Ta'iz & Ibb
- Manager, NWRA, Ta'iz Branch
- NGO representative
- Representatives of farmers organizations (sub-catchment level) 4-8
- Representative of industries
- Representatives of urban water users groups (4)
- Women's representatives
- Designated official of GAREWS, Ta'iz
- Designated official of AREA, Ta'iz
- Designated official of NWSA, Ta'iz

Water Users Organizations

- Sub-catchment farmers organizations
- Industries group
- Urban Consumers group
- Women's group

Annex C

Timeframe for Plan implementation

Timeframe for Plan implementation

1. General management enabling activities

Water Resources Management Measures	Start	End	Responsibility	Remarks
1. Development & operation of Information System				
(a) Monitoring: rainfall, run-off, groundwater level monitoring program	On-going	On-going	NWRA-Ta'iz/ NWRA-HQ	On-going
(b) Monitoring: water quality program Groundwater well Monitoring Program Industrial monitoring Program	 On-going Jul-04	 Cont. activity Cont. activity	NWRA	This includes selection of sites, decision on parameters to be monitored, frequency of monitoring, and mobilisation of personnel & equipment. Monitoring to continue on regular basis. Should include industrial wastewater monitoring component.
(c) Monitoring system: assessment of diversions/abstractions, water use, waste & wastewater production, wastewater treatment etc.	Jan-04	Mar-04	NWRA-Ta'iz	Collection of data to be a continuous periodic activity. Assessment of diversions/abstractions and wastewater loads etc. to be undertaken annually.
(d) Database: containing the collected monitoring and related administrative data	On-going	On-going	NWRA-Ta'iz/HQ	On-going
(e) Chemical laboratory for analysis of water samples Identification of labs Analysis of first batch of water samples	 Jan-04 Feb-04	 Feb-04 Mar-04	NWRA-Ta'iz	Identification of appropriate lab facilities.
(f) Periodic updates of diagnosis on water related problems	Jul-04	Sep-04 Cont. periodically	NWRA, other water sector institutions, stakeholders	Once every 3 years. To be done using information collected from monitoring system, other sources, and through consultations with the stakeholders.
I. General management enabling activities (cont…)				
2. Raising general awareness on water problems and solutions				
(a) General awareness raising activities Media campaign Urban Awareness campaign (Schools pgm, mosques pgm, community pgm)	 Jan-04 Jan-04	 Cont. Cont.	 NWRA-Ta'iz NWRA-Ta'iz	Under the Awareness program of NWRA Ta'iz branch. See TORs prepared for this purpose

Water Resources Management Measures	Start	End	Responsibility	Remarks
Rural awareness campaign (Schools pgm, mosques pgm, community pgm) Production of short film on Ta'iz WRM issues & options	Jan-04 Jul-04	Cont. Mar-05	NWRA-Ta'iz NWRA-HQ/Ta'iz Br	Includes selection of suitable firm for production of film as well as film production time
(b) Workshop in Ta'iz City to present the Action Plan	Done: Aug 2000		Governorate of Ta'iz, NWRA	With Participation from Governorate of Ibb
(c) Meetings with rural stakeholders to present the Action Plan	Done Aug-00 at Ad-Dhabab, Burayhi, Al-Haima		Governorate of Ta'iz NWRA-Ta'iz	
3. Communications and co-ordination				
(a) Establishment of Oversight Committee for monitoring implementation of plan	Dec-03	Dec-03		To be established by Ministry of Water & Environment
(b) Establishment of Plan Implementation Committee With Secretariat in office of NWRA Ta'iz Branch	Jan-04	Jan-04	NWRA, Governorate of Ta'iz, stakeholders	To be established by Decree of Governor of Ta'iz
(c) Establishment of water users' organizations Establishment of Upper W. Rasyan Basin Committee Establishment of WUAs to Federated into basin Committee	 Feb-04 May-04	 Apr-04 Oct-04	NWRA-Ta'iz, Governorate of Ta'iz/Ibb, stakeholders	Continuous periodic activity

II Establishing regulatory frameworks for allocation of water

Water Resources Management Measures	Start	End	Responsibility	Remarks
4. Establishing Regulatory framework for conserving groundwater for sustainable use				
(a) Designate conservation zones (Dhi Sufal, Al-Haima, Ad-Dhabab, and Shara'b	May-04	May-04	MW&E, NWRA-Ta'iz, Governorate of Ta'iz/Ibb	The stakeholders in the relevant zone should be made aware that their zone has been designated as conservation zone
(b) Procure services of an NGO for community organisation	Jan-04	May-o4	NWRA-Ta'iz	Donor support will be sought for funding
(c) Establish water users groups	May-04	Oct-04	NGO/NWRA-Ta'iz	
(d) Reach agreement among all stakeholder groups regarding principles on which groundwater rights will be based.	Oct-04	Mar-05	NGO/NWRA-Ta'iz,/stakeholders	

Water Resources Management Measures	Start	End	Responsibility	Remarks
Define and register groundwater rights			Governorate/Local Councils	
(e) Agree on the measures to be used for enforcing the agreements reached.	Oct-04	Mar-05	NGO/NWRA-Ta'iz, stakeholders, Governorate/local Councils,	This includes measures for control of groundwater abstractions (e.g. well registration, well spacing, restrictions on pumping, etc.)
(f) Set targets for maximum groundwater abstractions from the designated zone.	Oct-04	Mar-05	NGO/NWRA-Ta'iz, stakeholders, Governorate,	
(g) Monitoring and follow-up	Continuos Activity	Continuos Activity	NWRA-Ta'iz/ stakeholders/ Local Councils/Governorate	The information collected through monitoring should be disseminated to stakeholders for their empowerment
II. Establishing regulatory framework for allocation of water (cont…)				
5. Establishing regulatory framework for rural-urban water transfers				
(a) Designate zones from which water transfers would take place (Ad-Dhabab as pilot case)	May-04	May-04	Stakeholders, NWRA-Ta'iz, Governorate of Ta'iz/	Stakeholders involvement is necessary
(b) Procure services of an NGO for community organisation	Jan-04	May-o4	NWRA-Ta'iz	Donor support will be sought for funding
(c) Establish water users groups	May-04	Oct-04	NGO/NWRA-Ta'iz	
(d) Reach agreements with various stakeholders groups on principles for defining/registering water rights	May-04	Oct-04	NGO/NWRA, Ta'iz/TWSLC/ Local Councils	
(e) Complete the institutional arrangements for making rural-urban water transfers (including registration of water rights)	May-04	Dec-04	NGO, NWRA-Ta'iz, TWSLC, Stakeholders, Governorate of Ta'iz/Local Councils	This includes agreements on quantities of water to be transferred to Ta'iz City and the prices to be paid and received.
(f) Create necessary water conveyance infrastructure from pilot area to Ta'iz city (e.g. laying water mains from Ad-Dhabab to Ta'iz City)	May-04	Dec-04	TWSLC/Governorate of Ta'iz/donors	Govt.&/donor financing would be needed.
(f) Water transfers to commence to Ta'iz city under the agreed	Jan-05		NGO, NWRA,	

Water Resources Management Measures	Start	End	Responsibility	Remarks
rural-urban water transfers mechanism			NWSA, Stakeholders, Governorate of Ta'iz	
(g) Monitoring and Follow up	Continuous activity		NWRA, NWSA, Governorate of Ta'iz/local Councils	

III. Enhancing the public water supply infrastructure and services

Water Resources Management Measures	Start	End	Responsibility	Remarks
6. Improving Ta'iz Urban water Supply				
(a) Rehabilitation of urban public water distribution system Assessment of completed works Formulation of plans for works (incl. Mains from new sources e.g. Dhabab) Securing financing Tendering Commencement of works	On-going Dec-03 Jan-04 Jan-04 Contingent on financing availability	On-going Dec-03 Jan-04 Jun-04	 TWSLC TWSLC MW&E	Current plans call for rehabilitating only a part of the system. More donor support would be needed for rehabilitating the complete system.
(b) Institutional support to Ta'iz water & sanitation local Corporation Evaluation of experience as LC Assessment of needs Implementation	 Jan-04 Apr-04 Jun-04	 Apr-04 May-04 Contn.	NWRAHQ/ NWRA-Ta'iz TWSLC	Through UNDP funded program YEM/03/013
(c) Campaign for eliminating illegal connections Detection of illegal connections Phased program of elimination of illegal connections/metering	 Jan-04 Apr-04	 Mar-04 Apr-05	 TWSLC, Stakeholders, Governorate	To be synchronised with implementation of rural-urban water transfers framework
(d) Initiating the development of rural-urban water transfers framework (as described in subsections 4 & 5 above)			As described in subsection 4&5	
(e) Negotiating deals between City and local communities on rural-urban water transfers (see subsections 4&5 above)			As described in subsection 4&5	
(f) Revising tariff structure of urban water • Evaluation of water costs after implementation of rural-urban water transfers mechanisms	 Sep-04 Dec-04	 Nov-04 Dec-04	 TWSLC, Stakeholders TWSLC,	To be synchronised with the rural-urban water transfers framework. The tariffs will be set in accordance with the terms of agreements reached with the rural communities for transferring water

Water Resources Management Measures	Start	End	Responsibility	Remarks
• Study to assess incidence of tariff increase on various consumer classes • Implementation of new tariff structure	Jan-05	Cont. activity	Stakeholders TWSLC,	from rural areas [see point (e) above].
III. Enhancing Public Water Supply Infrastructure & Services (cont)				
Improving urban water supply (cont.) (g) Exploratory studies to identify possible additional sources of water • Assess the feasibility of developing newly discovered water sources (W.Ghayl, Hajda areas) • If feasible, plan & execute works for conveying water to Ta'iz City from new sources • Plan new exploratory drilling • Carryout drilling operations	 Jan-04 Mar-04	 Mar-04 ------	NWRA-Ta'iz/ NWRA-HQ MW&E/ TWSLC NWRA-Ta'iz NWRA-Ta'iz/TWSLC/ Local Councils	Some studies were completed by NWRA. Some more studies may be needed in the future as additional water sources would need to be identified. If development of new sources is feasible, water transfers should take place under the framework of rural-urban water transfers proposed in the Plan. Local Councils to help secure rural communities' support for drilling operations
(h) Exploratory drilling where Tawillah sandstone are found at reasonable depths	------	------		Subsumed in (g) above
(i) Feasibility studies for additional source development for urban water	------	------		Subsumed in (g) above.
(j) Feasibility study for raw (brackish) water treatment for augmenting urban water supply. • Preliminary study for assessment of brackish water resource • Study for identification & costing of brackish water treatment options • Obtaining funding for brackish water treatment facilities • Construction of treatment plant & related works	 Dec-03 Mar-04 Sep-04 Jan-05	 Jan-04 Sep-04 Dec-04 --------	 TWSLC, NWRA-Ta'iz TWSLC, NWRA-Ta'iz MW&E TWSLC	Water in Hawban-Haugala wellfields is brackish and polluted. NWSA is currently mixing it with good quality water from upstream areas but there is a limit on how much of this water can be mixed without deteriorating water quality unacceptably. Study would look at technical and economic feasibility of treating this water for augmenting city's water supply. Both the preliminary study for resources assessment and the study for identification costing of treatment options will be financed through UNDP funded project YEM/03/013
7. Rural water supply programme				
(a) Area-wide inventory and evaluation of rural water supply and sanitation conditions	Jan-04	Jun-04	GARWP	Develop a database with GIS interface
(b) Preparing annual plans for new schemes	Jul-04	Reg. Cont. activity	GARWP/Local Councils	
(c) Preparatory field work at selected for new schemes	Jul-04	Dec-04	GARWP	This should include identification appropriate technological package for both water supply &

Water Resources Management Measures	Start	End	Responsibility	Remarks
				sanitation and of willingness to pay for that package
(d) Implementation of new schemes	Jan-05	Reg. Cont. activity	GARWP	
(e) Community capacity building for scheme O&M	Jan-05	Jun-05	GARWP	Training of scheme operators and Training in Financial management
(f) Handing over of the scheme to local community	Jun-05		GARWP	
(g) Annual assessment of scheme operations under community management	Jan-06	Cont. Activity	GARWP/Local Councils	With special emphasis on ability for O&M and cost recovery
(h) Start of new RWSS planning cycle	Jan-06			

IV Combating the damage from water by means of wastewater control and flood control

Water Resources Management Measures	Start	End	Responsibility	Remarks
8. Up-grading urban sewerage				
• Assessment of completed, on-going and in-pipeline sewerage projects	Jan-04	Jan-04	TWSLC	Prepare GIS maps/database of areas served in collaboration with NWRA-Ta'iz GIS section
• Setting targets for urban sewerage coverage	Feb-04	Feb-04	TWSLC	
• Preparation of future plans for sewerage expansion	Mar-04	Jun-04	TWSLC	Inline with MDGs/in collaboration with NWSA-HQ
• Securing funding for further sewerage up-gradation	Jan-05		MW&E	
• Implementation of additional sewerage works				Implementation of additional sewerage works contingent on availability of funding
• Study to assess the feasibility of alternative low-cost sewerage technologies (ALCST) for Ta'iz City	Sep-04	Dec-04	TWSLC	Examples: condominium system
• Securing funding for ALCST pilot project	Sep-04	Dec-04	MW&E	
• Selection of pilot area in low-income neighbourhood	Sep-04	Sep-04		
• Establishing communities groups	Oct-04	Mar-05		Stakeholders participation in design and implementation of ALCST system is essential
• Implementation of ALCST pilot project	Apr-05	Jul-05		
	Jul-05			
9. Urban Domestic wastewater treatment				
(a) Study to determine the type and concentration of pollutants in untreated wastewater				To be done as part of brackish treatment water study [see sec. 6(j) above]
(b) Setting water quality targets or standards for treated wastewater	Done		NWRA	NWRA has prepared standards for wastewater. Timeframe for achieving compliance should be decided with stakeholders.
(c) Identifying the optimal technical treatment system				To be done concomitantly with 6 (j) above.
(d) Designing and costing of a treatment system	Mar-04	Sep-04	NWRA-Ta'iz, TWSLC/consultants, stakeholders	Funding would have to be committed before proceeding to this stage. Stakeholders involvement is essential at design stage.
(e) Defining a cost recovery system for urban water treatment	Oct-04	Dec-04	TWSLC/consultants, stakeholders	The stakeholders must agree to the cost recovery system
(f) Building treatment plant(s) and related works				Assuming availability of funding, the actual time needed for building the plant(s) depends on technical treatment options selected.
Securing funding for building plant		Jan-05	MW&E	
Implementing works	Jan-05		Contractor/ TWSLC	
(g) Putting treatment plant(s) in operation	???	???		Contingent upon completion of facilities
10. Industrial wastewater treatment				

Water Resources Management Measures	Start	End	Responsibility	Remarks
(a) Study to determine the type and concentration of pollutants in untreated industrial wastewater	Jan-04	Mar-04	NWRA-Ta'iz	
(b) Setting water quality targets or standards for treated wastewater	Done	Done	NWRA	These standards have to be discussed with the industries to create ownership. It may be necessary to set up intermediate targets before the standards established by NWRA are strictly enforced.
(c) Identifying optimal treatment system for industrial wastewater	Jun-04	Dec-04	NWRA-HQ/consultant, industries Stakeholders, donors	The services of a consultant should be contracted. Donor funding would be needed to implement the selected options. The final selection of treatment options for industrial wastewater should be made keeping in mind the options for treating domestic wastewater.
(d) Designing and costing of a treatment system	Jun-04	Dec-04	NWRA-HQ/consultant, industries, stakeholders, donors	Funding would have to be committed before proceeding to this stage.
(e) Defining a cost recovery system for industrial water treatment	Jun-04	Dec-04	NWRA-HQ/consultants, industries	The industries who would use the facility must agree to cost recovery arrangements.
(f) Building treatment plant(s) and related works Obtaining financing for treatment plant Commencement of works	 ----- Jan-05	 Jan-05		Time needed depends on the technical options chosen.
(g) Putting treatment plants in operation	--------			

Water Resources Management Measures	Start	End	Responsibility	Remarks
11. Flood Hazard reduction				
(a) Forestation programs in upper catchments of wadis where flood damage hazards are considerable Identify locations where forestation pgms Start forestation	 Jan-04 Jun-04	 Jun-04 Cont. reg. activity	Forestry Department, Local Councils/communities	
(b) Rehabilitation and proper maintenance of terraces in upper catchments of wadis where flood hazard are considerable • Select pilot areas for terrace rehab program • Mobilize communities in pilot area(s) • Start terrace rehab work	 Jan-04 Jun-04 Jan-05	 Jun-04 Dec-04 -----	MW&E/ Governorate of Ta'iz, local councils/ communities	Because terraces provide public benefits (reduced floods), there is justification for spending public funds for rehabilitating them. This can be coupled with poverty alleviations objectives through food for work pgms (or pub works pgms aimed at poverty alleviation). This provides an opportunity to use 'infrastructure as a water resource

Water Resources Management Measures	Start	End	Responsibility	Remarks
				management tool'. This is more important now that the other irrigation infrastructure such as dams is under the jurisdiction of Ministry of Agriculture & Irrigation.
(c) Providing temporary storage of peak flow volumes at locations where they can do little harm • Inventory of dams in the Upper Wadi Rasyan catchment • Identifying suitable locations for storing peak flows • Making plans for construction of new dams • Mobilizing financing for projects • Commencement of civil works	 Jan-04 Jun-04 Dec-04 ---- Jan-05	 Jun-04 Dec-04 Dec-04 Jan-05	MW&E/MAI/ Governorate/Local Councils/ communities	In selecting temporary storage sites, due consideration should be given to equity aspects in use of stored water
(d) Construction of defence walls and other defence structures in wadi beds • Evaluation of on-going efforts • Making future plans for Wadi protection • Commencement of civil works	 Jan-04 Mar-04 Jun-04	 Mar-04 Jun-04	Governorate of Ta'iz, local councils/ communities	
12. Wastewater recycling and reuse				
(a) Identify suitable combinations of wastewater producers and treated wastewater users	Jan-04	Jun-04	MAI, AREA, SURDP, NWSA, NWRA, EPC	
(b) Organize pilot projects for reuse and recycling; evaluate their results	Jun-04	Dec-04	MAI, AREA, SURDP, NWSA, NWRA, EPC	This activity is to be synchronised with building of the wastewater treatment systems. The treatment systems would not be constructed before 2002 (see subsections 9 & 10 above). Also donor support is needed.
(c) Encourage/promote wastewater recycling and reuse on larger scale; provide incentive.	Jan-05		MAI, AREA	Depends on evaluation of pilot project.

V. Sector-targeted demand management

Water Resources Management Measures	Start	End	Responsibility	Remarks
13. Other urban demand management measures				
(a) Strongly progressive water tariffs				To be done under 6(f)
(b) Elimination of all exemptions from paying water bills & elimination of illegal connections.				To be done under 6(c)
(c) Public education on proper water economising practices at scale of single households				To be done under 2(a)
14. Improving the efficiency of agricultural water use				
Lining of canal and ditches, land levelling, replacement of flood irrigation by drip and sprinkler irrigation systems • Design pilot program for water conservation in areas with regulatory framework for water allocation • Design interface with water rights structure • Seek financing • Implement pilot			AREA, Ministry of Agriculture and Irrigation/NWRA-Ta'iz	To be implemented in tandem with regulatory framework for water allocation (4 & 5 above)and in same areas where such frameworks are in place. The definition of groundwater rights is expected to raise the opportunity cost of water and thereby help increase investments in water conserving irrigation technologies/practices without resources to massive subsidies
Changing to crops with relatively low unit water use	As soon as possible	-------	AREA, Ministry of Agriculture and Irrigation	Continuous activity
Encouraging a shift away from irrigated cereals; increasing the yields of rainfed cereals (to ensure adequate food production).	As soon as possible	-------	AREA, Ministry of Agriculture and Irrigation	Continuous activity
Changing to crops with relatively high economic returns per unit of water used.	As soon as possible	-------	AREA, Ministry of Agriculture and Irrigation	Continuous activity
15. Creating non-agricultural employment opportunities				
Improving and diversifying education at the rural level	As soon as possible		Department of Education, and Govt. of Yemen in general	Continuous activity
Identifying promising options for diversification of economic activities in the area	As soon as possible		Governorate of Ta'iz	Continuous activity