

## CHAPTER 3 ISSUES TO BE CONSIDERED IN THE ACTION PLAN

### 3.1 GENERAL

In order to make clear the essential issues for smooth and effective implementation of water resources management for Sana'a Basin, then to formulate practicable action plan, present situation of aspects related to water resources management are considered based on the existing data and information, and summarized in each categories as mentioned in this Chapter.

### 3.2 ISSUES TO BE CONSIDERED IN THE ACTION PLAN

#### 3.2.1 HUGE AMOUNT OF WATER CONSUMPTION FOR IRRIGATION PURPOSE

Inside Sana'a Basin, annual water consumption for irrigation purpose is approximately 77% of total water consumption (209 MCM). According to Ministry of Water and Environment (2006), as a water conveyance methods used for irrigation are iron or plastic pipes having considerable amount of leakage from pipes and joints, and as an irrigation method, furrow method is mainly applied for vegetable and small basin method is mainly applied for qat, grape and other fruit trees. As for the scheme efficiency, it is very low for these surface irrigation systems and might be between 30 and 40% (according to NWSSIP, irrigation efficiency is estimated at around 35% in Yemen). Assuming that the present irrigation efficiency is improved to 70% from 40%, approximately 90 MCM, which could cover the present water consumption for domestic use, can be saved.

Improvement of the efficiency could contribute to reduce the water consumption by means of introducing improved irrigation system, change of pipes together with control system for appropriate watering for crops. Introduction of improved irrigation system has been already addressed by Sana'a Basin Water Management Project (SBWMP) at some demonstration farms; however, its progress is very slow due to a low financial, administrative and management capacity of the involved staff.

Qat is well-known as one of the intensive water consumer cash crops. Since 1970s, the area under qat expanded at faster rate due to introduction of drilling techniques and pumps, which increases the quantity of water applicable for irrigation and also due to an economical high return provided by the crop. Irrigation methods usually applied for qat plantation is small basin method and farmers irrigates their lands with much water than the necessary; they believe that as much water they give to the plant, more the plant will produce; then water consumption for qat plantation has become nearly half of water consumption for irrigation. By the view point of water resources management, it is necessary to consider qat as a plant which is consuming much water. It is also required to be very careful to deal with qat due to its social and economical influence, however, not support to improve the plantation and expansion of qat is necessary considering the actual condition of water scarcity that Sana'a Basin is facing. In addition, since some of the qat farmers have utilized dangerous pesticide which causes cancers, it is also necessary to encourage farmers to use safe and suitable pesticide.

Some other approaches should be considered simultaneously such as the control of expansion of irrigated land and introduction of less water consumption crops. Control of illegal drilling, which has been already conducted by National Water Resources Authority Sana'a Branch (Nwra-SB) has to be continued.

In addition, quantity of water abstracted or consumed for irrigation purpose was estimated by different approaches in different studies such as through inventory survey and through satellite imagery analysis which depends on unreliable coefficients and information as pump working schedule in the year by season and so, irrigation efficiency, for example and the real quantity of water abstracted or consumed is still unknown.

For these approaches, the following consideration should be taken.

- capacity development of the staff on financial, administrative and management aspects
- registration of all wells inside Sana'a Basin and installation of meter with objective of understanding the quantity of water really abstracted
- reduction of water loss by leakage
- increasing public awareness on introducing water saving irrigation system
- giving incentives such as increasing of yield of crops, saving money for pumping through the pilot project, and showing the period for cost recovery against investment (for introduction of improved irrigation system)
- control and/or prohibition of expansion of irrigated land
- securing stable income by introducing less water consuming crops by creating market for the crops (for introduction of less water consumption crops)

### **3.2.2 PHYSICAL LOSS IN URBAN WATER SUPPLY**

In 2006, domestic water for 36% of population of Sana'a City was supplied through public network system maintained by SWSLC. Since the National Water and Sanitation Authority (NWSA) was established in 1974 with taking over the responsibility for the public water supply system, network system has been developed through two phases from 1976 to 1982, then only emergency improvements were carried out in order to meet demand growth caused by rapid population growth. In 2000 SWSLC was created as a financially independent organization and took the responsibility for urban water supply and sanitation of Sana'a City. In 2002, in order to meet the demand, NWSA has provided Sana'a Water Supply and Sanitation Project including the implementation. According to SWSLC's report, Non-Revenue Water (NRW) was 38.8% in 2006 (total production is 24.1 MCM). However, loss water amount by leakage and illegal connection is not clear and great effort including technology and fund to clarify and reduce NRW is required. The amount of water to be saved with the reduction of NRW is not so large comparing that of irrigation; however, improvement of NRW to save water is required since the depletion of groundwater faced in the Basin is progressing year by year. Considering the necessity, SWSLC has already started to change pipes of the public network, with support from World Bank and a considerable decrease on NRW is expected. In addition, water connections meters with zero-reading are other factor that contributes to the increase of NRW and by the year of 2006, 11,900 connections were accounted as meters with zero-reading, what means an estimated amount of water of 2 MCM. Set of relevant tariff system also contributes to prevent overuse of produced water.

Uncovered populations by SWSLC, which is 64% of total population in Sana'a City, have obtained water from private tankers and small scale networks with higher tariff and unsecured quality. However, the consumption by private supplier has not been periodically monitored yet (It was reported that 16.1 MCM and 25.5 MCM were supplied by public and private in the year of 1997, respectively (SWSLC(2000)). Although the portion of overuse is likely to be less than that of public network system because of higher tariff, water loss from the tankers and leakage from networks might be a large portion of inefficiency of water use. Therefore, establishment

of monitoring system with private supplier's agreement is required.

For these approaches, the followings should be taken into consideration.

- rather high investment cost and period are required to reduce water loss from the network
- leakage detector and its operation technique are necessary
- monitoring the distribution network to detect illegal connections
- enforcement of regulations concerning periodical replacement or calibration of meters
- increasing of awareness of private suppliers on water resources management
- registration and monitoring of private wells installing meters with objective of understand the quantity of water abstracted, consumed by private suppliers

### **3.2.3 AVAILABILITY OF TREATED WASTEWATER**

Existing Wastewater Treatment Plant (WWTP) has operated since the year of 2000 with the designed daily maximum capacity of 55,000 m<sup>3</sup>, which covers only 29% of urban population. The treated waste water has been drained directly to an open channel in a wadi and it is not officially used for any other purposes. In deed, farmers who have farmland along the wadi, have utilized the effluent for irrigation purpose and some portion has recharged groundwater. The quantity of effluent discharged from the WWTP is almost equal to the influent quantity which accounts to 44,000 m<sup>3</sup>/day and assuming this daily drained treated water, approximately 16 MCM of treated waste water could be regarded as available water resources depending on the quality. Actually, the WWTP is working without facilities to treat the wastewater to an acceptable quality to reuse it for irrigation purpose and in addition, unfortunately, the WWTP is actually working in an overloaded condition than the designed capacity as explained in Chapter 5 of the Supporting Report and the effluent is drained to the wadi in an improperly treated condition. This improperly treated wastewater at least is in a situation not only that is unaccountable as a water resource in a water scarce region but also is a source of adverse impact for both environmental and human health. If the treated wastewater with acceptable quality for agriculture is used for irrigation purpose, saved groundwater presupposed to be used in agriculture can be transferred to domestic purpose.

Improvement of existing WWTP and construction of new WWTP have been already launched by the initiative of Sana'a Water Supply and Sanitation Local Corporation (SWSLC).

Concerning the industrial wastewater, actually, it is discharged directly to the public sewerage network without any treatment. The exact quantity of wastewater produced by industries is unknown; however, implementation of treatment facilities and reuse of treated wastewater is other approach that should be considered for decrease the quantity of groundwater abstraction.

For this approach, the followings should be taken into consideration

- reduce the water loss by evaporation and random abstraction of the treated wastewater
- farmers' acceptance for using treated wastewater for irrigation purpose and water tariff should be taken into consideration
- enforcement of regulations concerning construction of treatment facilities by industries and incentives to reuse the recycled water should be taken in consideration

### **3.2.4 DIFFERENCE OF WATER IMBALANCE AMONG SUB-BASINS**

Most of the population in Sana'a Basin relies on agriculture, the most predominant economic

activity in the area. A trend on irrigated lands is indicating farmers changing ordinary crops plantation to cash crops such as qat and grape which provides high economic return to the farmers. However these cash crops are also considered heavy water consumers where according to estimations consumes more than 91% (190 MCM/year) of total water consumed by irrigation in Sana'a Basin. Considering the higher yearly population growth rate at 5.5% observed in Sana'a City it is clear that the demand for domestic water will increase more than the production and also the demand of water for agriculture is expected to increase despite to the depletion of potential of groundwater.

Given priority for domestic water supply for urban and rural population is one of the main objectives of National Water Strategy. From the view points of the priority given to domestic water and basic human needs, transferring water from the irrigation purpose to the domestic purpose seems to be a favorable option.

Allocation of water resources is set considering two policies, 1) Priority of allocation of water is given to the domestic purpose and 2) Clean and safe water shall be utilized for domestic purpose as much as possible. Based on these policies, three options for allocation of water are presented, which are 1) irrigation use and watering for roadside trees to domestic use in urban area, 2) irrigation use to domestic use in rural area and 3) irrigation use in rural area to domestic use in urban area. Simultaneously, potential of water resources in the regional level (e.g. sub basin level) shall be taken into consideration. In order to take this approach, other approaches such as improvement of irrigation water use efficiency and reuse of treated wastewater for irrigation purpose are shall be conducted simultaneously.

As for effective implementation of water resources management for Sana'a Basin, comprehension of actual situation of water resources such as water level fluctuation, distribution of water quality, volume of recharge to groundwater, run-off, distribution of aquifers with hydrogeological characteristics, evapotranspiration and so on is fundamental activity. Considering this necessity, NWRA-SB has started these activities as a part of the SBWMP funded by World Bank since 2004 and has accumulated fruitful data and information as well as experience.

Following consideration shall be taken for smooth implementation.

- demand for domestic and irrigation use in the rural area shall be satisfied
- increasing of public awareness shall be carried out
- incentives or regulation will be necessary
- NWRA-SB as the regulatory body for water resources management, shall give instructions and advices to executing individual and organization of water development and NWRA-SB is required to take into consideration plans and situation of water development activities of all other organizations such as water consumption, demand, and water quality
- all organizations concerned to water development are required to submit information to NWRA-SB

### **3.2.5 INSTITUTIONAL DEVELOPMENT**

#### **(1) Finalization of the Executive Regulation to the Water Law of 2002, and Development of Decrees for Water Protection Zone of Sana'a Basin**

Although the Water Law of 2002 is a first step of significance towards the State's IWRM, some of "legislative" shortcomings in its basic provisions are the risk to decline its legal effect and validity of the Law itself. These shortcomings include particularly lack of provisions to

introduce demand control measures such as groundwater abstraction metering, and water charge levying. These provisions originally stipulated in the Draft Water Law were amended and deleted in the parliament approval on the Law, while second attempt to rectify and include these had also been denied again in the parliament approval of the amendment Law for the Water Law of 2007 (Republican Decree No. (41) of 2007 regarding the Adjustment of the Water Law No (33) of 2002). At present, the Final Draft of Executive Regulation of the Water Law of 2002 is submitted to and approved by the Cabinet, which is also subject to the parliament approval. The Draft Executive Regulation, which may include these regulations to introduce groundwater abstraction metering and groundwater charge levying, however, becomes highly confidential due to its political and social sensitivity, of which availability is also limited. Moreover, parliament approval on the Regulation without amendment on these regulations seems to be pessimistic, due observation on the recent decision made by the parliament on the Adjustment of the Water Law of 2002, in 2007.

Another negative decision may have to lead to the efforts to develop the other bylaw for the “protected zone”, in particular for Sana’a Basin. The challenges and obstacles that are confronting water sector in Sana’a Basin in particular represent the highest percentage of loss and spoilage of such water which is not less than 40%. The irrigation, utilizing groundwater, is regarded as the most contributing factor to the future water crisis in the Basin. The agriculture sector in the country consumes not less than 93% of the available water resources. In Sana’a Basin, in particular, due to difficulties to develop other water sources, higher dependence on groundwater for irrigation is remarkable. The production of water-consuming cash crop, especially qat, increases further water demand in Sana’a Basin, which indeed requires more than half of the extracted groundwater. Moreover, commonly prevailed methods of irrigation customary and traditionally practiced in Sana’a Basin with less efficiency in water use increase the burden on water aquifers, in which practice not less than 40% of extracted water is lost. Thus, in the area like Sana’a Basin where considerable groundwater demand for water-consuming crop, over-consumption, and excessive loss of extracted water is remarkably observed, such measures to control demand and encourage an introduction of modern irrigation methods with high water efficiency shall be considered desirable. Groundwater metering and groundwater charge levying shall be the most indispensable prescription to address the issues of over-consumption for water-demanding cash crop and excessive water loss typical in Sana’a Basin.

Considering time factors to increase social acceptance, thus, the bylaws for the “protection zones” of Sana’a Basin should have the objective of gradually and over time limiting abstraction to the annual natural recharge as a priority. They should include; 1) a ban on well drilling for agricultural and irrigation use, 2) licensing of all wells, irrespective of depth, 3) mandatory water abstraction metering, and 4) a provision that may allow over time levying water charges for agricultural and irrigation use. The development of the bylaw for protected zone of Sana’a Basin could be a key prerequisite for the effectiveness of Action Plan of NWRA-SB.

## **(2) Advocacy of Water Resource Management for Public and Political Leaders**

The measures taken in the Action Plan to address such water crisis may necessitates undertakings to increase public awareness and gradually establish public consensus for water resource management, which would duly changes political attitude and further increase political willingness towards it. Thus, current efforts for public awareness campaign shall be further concentrated. All citizens in particular the water users, stakeholders, and public at large shall be informed of the seriousness of the water crisis in a first places. The awareness campaign shall be also extended to the authorities, corporations, and companies involved in the water

development sector whether they are at central or local, and governmental or private for compliance of the relevant laws and regulations.

Moreover, a package of public awareness campaign shall be developed and implemented suitable for the country's unique socio-culture of "tribalism". Inheritance of their tribal land of prosperity to the next generation over the generation shall be one of the most important concerns for them so as to water on and under the ground which is regarded as servitude to the land in their custom. The lost opportunity cost in the land productivity incurred to the next generations, when the barren land due to overexploitation of groundwater by them is inherited, shall be fully recognized. Also, education and information network for tribal authorities may be established. As far as possible, inter-tribal coordination system for the conciliation of their interests shall be identified and utilized to ease the current competitions of over-development and over-abstraction of groundwater.

Provision of reliable information on the water crisis to the political entities shall be also significant. Along with the awareness campaign for the public in general, the "right" political decisions based on reliable evidence on the water crisis in future shall increase public support with "vote".

Those approaches for awareness and consensus building targeting for public, tribal communities, and political entities shall be taken in the Action Plan.

### **(3) Distinctive Definition of Water Usufruct**

There are traditionally and customarily dominating legislative sources governing water resources management, such as Sharia'h, 'urf, and the Civil Code, that define that land ownership gives the owner the full right and control over natural resources above and beneath (thus, surface and ground water) its surface. The deliberations and discussions for the Water Law of 2002 and its amendment Law in parliament also indicates that most of the parliament members insist on the conservative approach of the Civil Code regarding groundwater ownership and protection of the landlords from any interference by the State.

The Water Law of 2002 clearly defines that water is public property that is subject to the State's administration and registration. Hence, only water use right (usufruct) may accrue to individuals and entities based on the provision of the Water Law or on permit and licensing issued by the State. This legal status of water defined in the Water Law shall be convinced to the public; otherwise the Water Law loses its effect in execution and enforcement, overwhelmed by other predominating legislations. Parliament approval could be prerequisite for the effectiveness of the Action Plan, on the Executive Regulation of the Water Law of 2002 and such legal provisions to determine the Water Law as sole legal mean to regulate the water use right (usufruct) instead of other predominating legislations.

### **(4) Respect on Traditional and Tribal System**

One of significant principles in institutional and administrative framework employed in the Water Law of 2000 is to delegate authorities in management of water resources and enforcement of regulations to decentralized local institutions and communities, in which self-regulating mechanism for water resource management is enforced. Thus, improved participation of local institutions and communities in all the process of water resource management in decision making, execution and regulation and monitoring, becomes the most important determinant for the success of self-regulating mechanism for water management.

Local institutions, not as formal but rather significant in their socio-culture, should include “tribes” or “tribal system”, which can not be ignored and, in fact, can be regarded as the most governing institution particularly in highland area of the country including areas of Sana’a Basin. Decentralized framework of local institution and administration introduced by the Water Law and other relevant laws and bylaws, however, seems to lack effective mechanism to enhance active participation of “tribes” and “tribal system” in decision making and execution for improved water resource management.

Thus, channels and network to connect tribes and tribal system shall be identified and developed as it is possible. “Tribal system” herein refers to interrelationship among tribes, and it can be defined as the forum for groups of tribes to conciliate their interests, dispute, and conflict. Development of such mechanism to facilitate and institutionalize their participation shall be considered in the preparation of Action Plan of Sana’a Basin Office of NWRA under the Study. In this line, involvement of tribal authorities in Basin Commission could be also considered. As it may be further discussed in the Chapter 7 of “Current Organizational Structure” of Supporting Report, Sana’a Basin Committee has been established in accordance to the Water Law and relevant Decrees, of which function has two-folded characteristics that one served as decision making body for the Basin water management, while one functioned as regulatory body. An active participation of tribal authorities in such decision making and regulation, if supports granted, could be a backstopping institutional support for enhancement of self-regulating mechanism in water resource management.

It shall be also emphasized that, the stakeholders involved in decision making process for the water resource management either at central, local, and community level, shall take account of and apply where possible the traditionally and generally accepted principles and considerations. Thus, tribal rules and customs developed over generation require respect, and can be often a sound and practical basis for cooperation between water users and resolution of conflicts in water management.

#### **(5) Improvement in Decentralized Framework of Local Administration and Institution**

The decentralized framework of local institution and administration delineated both in the Water Law of 2002 and the Local Authority Law of 2000, with their related by-laws and decrees was reviewed in Chapter 6 of Supporting Report. It is also confirmed that the institutional and administrative framework introduced in Sana’a Basin in accordance with Water Law and related decree is consistent with the one determined in the Local Authority Law. The Local Authority Law indeed shares an extensive parts for the provisions in relation to water resource management determining functional roles of local councils at governorate and district level, local organs of line-ministries, community and community-based organizations, as well as means and procedure in its planning, execution, and regulation and monitoring. However, the current institutional structure developed in Sana’a in accordance to the Water Law of 2002 seems to make less use of local institutions, particularly Governorate Local Council and District in execution, enforcement, and regulation and monitoring of the Water Law and program relating improved water resource management.

Apart from the institutional and administrative capacity of the sector, one of the major constrains to promote IWRM in Sana’a Basin, in fact, all in the country according to the applicable law and regulations is vacuum of organizational capacity of relevant regulatory authority, NWRA and its Branch Offices, to prepare local (basin) management plan through comprehensive study, execute program relating resource management, regulate and monitor the

undertakings on resource development, and enforce applied duties and penalties. Those required undertakings are all related to “decentralized” and “local” institutions, of which functional responsibilities is defined and allocated to local authorities (i.e. Local Councils at district and governorate level) in collaboration with local organ of line-ministry (i.e. Sana’a Branch Office of NWRA) clearly under the Local Authority Law of 2000 and its Executive Procedures and Regulations. Thus, there are significant opportunities to improve decentralized framework of local institution and administration in Sana’a Basin, through full utilization of local capacity in Local Councils and institutionalization of those local institution of opportunity in the Basin management.

### **3.2.6 ORGANIZATIONAL DEVELOPMENT**

As it is observed in Chapter 6 and Chapter 7 of Supporting Report, IWRM in the country could be successful only if basin-level management is properly and effectively carried out by the relevant local authorities and user communities. Indeed, administrative and institutional framework as well as organizational structure set forth for IWRM in the Water Law and governmental decrees put great emphasis on delegation of power in water management to the lowest appropriate levels. In decentralized organizational framework determined for the State’s IWRM and the basin-level water resource management in Sana’a Basin, the following organizations take leading roles and responsibilities, NWRA-SB and Local Council as local authorities, SBC as stakeholders’ platform for decision making in the basin management, as well as WUA as user community organization. In this section, the key capacity of these organizations to execute tasks and duties defined the sector policy and strategies are analyzed, and issues to be considered in organizational development plan under the Action Plan to be prepared under the Study are described.

#### **(1) NWRA Sana’a Branch (NWRA-SB)**

##### **1) Organizational Structure**

NWRA-SB has two major departments - Department of Studies and Information, and; Department of Licensing and Public Awareness. However, as it is observed above, organizational bylaws that determines tasks and duties of NWRA-SB has not finalized yet. Without finalization of organizational bylaws, further development of job-descriptions for each department/section and organizational charts defining interrelationship among departments/sections can not be possible at present. In the absence of defined organizational bylaws/job-description and chart, factors the most important for organizational operation and management, such as mutual understandings, decision making process, system for giving and monitoring orders, and interdepartmental coordination/cooperation, are being hampered. Thus, there are strong needs to finalize their organizational bylaws and job-description based on tasks and duties allocated for them.

##### **2) Human Resources**

Staff capacity of NWRA-SB was assessed as low by a number of past studies, which suggest that technical capacity is still a major issue. IWRM calls for basin-level water management, which requires coordinated actions from various sub-sectors. NWRA-SB was set up for this coordination, but is only a few years old since its establishment in 2002. In fact, most of current staff of NWRA-SB, as well as of headquarters, was transferred from various ministries and authorities involved in another sector development, so that most of current staff had not been equipped with their expertise in the water resource management.



Among 20 government staff in NWRA-SB, there are no Master or Ph.D degree holders. During 2006, training courses has been conducted for NWRA Headquarters and its seven Branch Offices including Sana'a. Total of 69 staff received training in basic skills such as English language and computer programs, 49 in technical fields, 18 in administrative and financial fields, and 4 in the MSc. program abroad. Training was also provided to the members of water basin committees locally and abroad. However, training opportunities are limited to its Branch Offices, including NWRA-SB. Under the training course provided in 2006, a few staff from NWRA-SB has received training in water supply, water quality, remote sensing and report writing. To enhance the authority's technical capacity to carry out its mandates, the following areas were identified as priority; groundwater modeling, legal framework, regulation and enforcement, user participation in the basin management. These areas are critical to equip NWRA-SB to be a relevant and responsible local authority for Sana'a Basin water resource management.

Moreover, lack of sufficiently qualified staff is serious problem in NWRA-SB. It is reported that 50% of NWRA-SB staff, or 20 staff out of 40 staff in total, is still under contract basis for the particular assignments under donor-funded project/program. Thus, relatively qualified staff of current tends to be contracted and employed by donor funded project/program, while it is often said and may be true that other qualified staff in NWRA-SB is looking for employment in the private sector. There seems to be necessity to review staff remembrance/salary and to introduce an improved incentive mechanism through pay rises and promotion based on performance-based staff evaluation system.

### **3) Financial Management**

IWRM requires coordination with other sub-sector not only in strategies and activities but also in investment plan. There are several sub-sector national authorities in water sector, such as for urban water supply and sewerage, rural water supply, irrigation/agricultural development, and environmental protection. In such circumstances, MWE formulated the National Water Sector Strategies and Investment Program (NWSSIP 2005-2009) in 2005, through series of consultative meetings and consensus buildings with stakeholders. NWSSIP is indeed regarded as sole and prime national investment program for improvement of the water sector as a whole, which enables IWRM in a coordinated and strategic manner with all related sub-sectors.

NWRA is the main executive authority to undertake the planned water resource management activities set forth in NWSSIP, so that budget is requested to the government in accordance with financial requirement determined in the investment program in NWSSIP. However, the requested funds planned for 2006 investment budget in NWSSIP, is much more than the actually approved budget, while real expenditures of NWRA in 2006 were about 60% of the planned investment budget for water resource management set in NWSSIP for 2006. However, approved funds were only about 67% of the requested investment budget. Real expenditure of NWRA in 2006 was around 89% of approved investment budget. This simply implies both the government and NWRA could not meet the requirement in investment and planned activities determined in NWSSIP.

### **4) Regulation and Monitoring**

Regulation and monitoring is one of the most significant tasks and duties to be provided by NWRA-SB for its basin-level water resource management. NWRA-SB has made a beginning in well registration. Up-to-date, NWRA has inventoried about 65,000 wells in Sana'a, Taiz, Sa'da, Hadramout, Rada'a, Amran, Ibb, Abyan and the Southern Tihama,

while in 2006 about additional 14,600 wells were inventoried in Southern Tihama (11,500), Ibb (1,000) and Abyan (2,099). This figure represents about 22% of the total wells and about 16% of the total estimated wells (93,000) in the country.

NWRA-SB has prepared well registration formats, which were approved by the NWRA Chairman. In implementation, NWRA-SB approved 43 out of 132 license requests for the use of groundwater by various users. Cases of violation of rules such as unlicensed drilling by drilling contractors were referred to the prosecutor. These field activities are a good start. However, the progress is very slow with only 43 well registered and licensed among a considerable number of wells in the Sana'a Basin. Furthermore, scaling-up of registration and licensing seems to be rather challenging, when reviewing capacity of NWRA-SB in execution and enforcement of the regulation on the ground without having adequate staff (only 20 government staff in total is available for NWSA-SB as a whole) and budget for the field monitoring. Thus, there is a significant need to develop mechanism on field monitoring network, in collaboration with other local authorities. Local Councils as other local authorities that are also responsible for supervision and enforcement of rules and regulations in the basin-level water resource management shall be fully utilized to establish such local monitoring network.

## **(2) Local Councils**

Local Councils are also relatively new organization with its establishment has been facilitated since issuance of Local Authority Law in 2000. Local Councils exists at governorate and district levels, of which tasks and duties in basin-level water resource management are supervision and enforcement of rules and regulations as it is observed in detail in the previous sections. Local Councils both at governorate and district levels composes of distinctive two entities; one is directive body of which director at governorate is appointed by prime minister while one at district is appointed by governorate director, and the other one is executive organ that execute local administration and development that composes of local administrative staff. Although the executive organs for water resource management in Local Councils located in Sana'a Basin are not developed yet, and NWRA-SB seems to neglect the possibilities to cooperate with these local executive organs particularly for establishment of local monitoring network, it shall be further utilized and incorporated in the local organizational framework for the basin-level water resource management.

## **(3) Sana'a Basin Commission (SBC)**

Since SBC had established, it meets fairly regularly at about 6 times in a year, and based on the advice with donor and expatriate experts, it appears that substantive decision are made and are considered from a multi-sectorial basis. This is very positive.

However, the capacity for institutional arrangement to improve water management is insufficient and fragmented. Public institutions often lack authority over tribal structures and the strong autonomy of local water users. Experiences show that enforcement can only be successful on a participatory basis, through a system of self-regulation. The project would couple regulation with a participatory water resource management approach and a public information and awareness program.

Thus, means create and maintain channels to involve traditional leaders and tribal institution in decision making, enforcement of self-regulating water management mechanism, e.g. involvement of them in SBC.

Furthermore, in order to strengthen regulatory and monitoring system, relevant supporting organizations such as the Ministry of Interior, Ministry of Local Administration, and Ministry of Justice to enforce water regulations, seems to be involved in SBC for its purpose.

#### **(4) Water User Association (WUA)**

Irrigation accounts for 90% of groundwater withdrawals in the country. Groundwater depletion, especially in the Sana'a Basin, has reached a stage where migration of the whole valley's population is no more a remote debate. Thus, on-farm water savings to reduce non-beneficial water losses and thus to reduce pumping form a central pieces of the national water strategy set forth in the Water Law and decree that defines Sana'a Basin as one of the "protected area". To be successful, it needs collective effort and working closely with farmers through Water User Association (WUA) and Water User Group (WUG).

Currently, under the project component of "Demand Management and Irrigation Improvement" implemented by Sana'a Basin Water Management Project, traditional open channel flood irrigation is being replaced by modern irrigation technologies such as pipes with drip and bubbler. As a pre-condition to participate and benefit from the project investment in which a considerable portion of cost for introduction of improved technology is subsidized by NWRA-SB, farmer covering 6-12 ha with a few families, are required to form a WUA. The number of WUGs in each WUA varies, depending on location and vicinity of the wells, but is at times arbitrary. WUA collects farmer contribution to capital investment, organize farmer awareness activities, and acts as liaison between the Project and individual farmer or WUGs. The establishment of WUA forms an important part of this project component. Together with WUA formulation, demonstration farm (often 1-2 ha) has been selected for each WUA and received investment in modern irrigation infrastructure.

Establishment of demonstration farms is of vital significance. The significance of the demonstration farms stems from the fact that they are the major source and means for convincing the farmers to adopt improved irrigation systems. Farmers have to be confident with the soundness and profitability of the technology in a visible manner. The more practical an explanation is (actual demonstration), the more farmers will adopt the new improved technology.

The benefit from these on-farm investment have so far been obvious, as water saving reached over 50%, and it could be higher per the huge reduction in pumping time; reduction of diesel consumption due to reduced needs for pumping, better products and production.

However, this activities are highly delayed, and has had a negative impact on farmers' acceptance of the new irrigation technologies (MWE, SBWMP, 2006). Accompanied with this, farmer's awareness raising appears also inadequate. Some are hesitated in contribution to capital investment or in joining WUA (in some area, only 10 out of 40 WUGs joined WUA).

At present (July, 2007), 48 WUAs has been established with 530 WUGs formed and 4,440 farmers involved. It can be said that this is good progress since the project component started in 2004. However, poor progress is observed in installing and converting improved irrigation system with only 211 ha installed, or less than 5% of the project target. The relatively higher number of WUAs and WUGs formed against smaller area converted with improved irrigation technologies calls for good quality implementation in social mobilization, cohesion and training of WUAs and WUGs.

The key issue over longer term, herein, is the improved awareness of WUAs and WUGs. It is

they that are going to handle the bulk of the regulation of water usage by the group and by each farmer through adoption of improved technologies with irrigation efficiency. If this is done, and farmers simply use the water saved for higher application levels or expand irrigated area, the entire point of this component - water saving - is lost. Thus, the quality of WUAs/WUGs is a key need, and is more fundamentally important than the project's achievement in terms of the number of WUGs and number of hectares. In essence, it is more important to develop successful program than to achieve targets that are not replicable or of demonstration value because they have not succeeded. In the assessment for the WUAs and WUGs that have already been formed, their quality, in terms of social mobilization and training is not yet sufficient.

Accompanied with this, there is limited training for WUAs/WUGs in agronomic practices that will result in water waving. Beneficiaries should be acquainted with appropriate cropping patters in order to adopt to growing less water consuming crops. Training programs for the staff should emphasize efficient water use through proper knowledge of crop water requirements, irrigation scheduling and water saving, leading ultimately to increased productivity. Thus, farmers' extension services should focus on the aspects of operation and maintenance of improved irrigation equipment and agronomic practices. Also, they should be convinces not to expand to more crop area as a result of water saving through the modern irrigation systems. Additionally, the tripartite agreement between farmers, the community organization and the NWRA-SB should be endorsed, and especially, the role of WUAs should be fully activated as referred above.

### **3.2.7 CONTAMINATION OF LIMITED GROUNDWATER RESOURCES**

#### **(1) Contamination in Urban Area**

In urban area, 29% of population, which is equal to 560,259 inhabitants, was covered by public sewage network in the year of 2006 according to SWSLC's report. Effluent from wastewater treatment plant has been drained directly to an open channel in the wadi since the year of 2000 and the farmers have used the drained water for irrigation purpose. And as mentioned above, WWTP is working in an overloaded treatment capacity condition and the quality of treated water is not satisfied even for the irrigation purpose. Therefore, in 2007 NWRA-SB has started to raise awareness of these farmers not to use of the drained water to avoid health risk. In addition, the drained water not consumed for irrigation purpose has infiltrated into ground and might contaminate groundwater. Indeed, quality of groundwater in downstream of the treatment plant has become worse as a reported case of Al-Masham Dam located around 12 km downstream of the WWTP where the treated wastewater is collected. Actually, improvement of existing WWTP by construction of new plant downstream of wadi was planned by SWSLC.

Population not covered by the public sewage network depend on the cesspits and problems reported are that under heavy rain, the rain water flows into the cesspits and finally overflow with the content flows to outside. In the other hand, pollution of groundwater by infiltration is also reported. Depletion of groundwater quality by infiltration of sewage became visible as a high concentration of nitrate (NO<sub>3</sub>) and concentration two to three times higher than the World Health Organization (WHO) permissible limit for drinking water which is 50 mg/l were found in the older central part of Sana'a City. Several hundred private wells affected by the contamination by sewage were reported and a very important point what should be remembered is that the public well fields are located closer to the city. Since the SWSLC and Sana'a Municipality have been aware of necessity of treatment of sewage, they allocated budget from Arab Fund and national budget to deal with this situation.

Other factor pointed out is the pollution caused by insufficient waste disposal in the petrol stations, car service shops and the medical units like hospital, laboratory and clinic and even industries since these establishments are not equipped with any wastewater treatment facilities and discharge of wastewater is presumably uncontrolled, unregulated and unmonitored. Groundwater contamination caused by these individual factors has not been clarified, therefore, comprehensive groundwater quality survey and implementation of regulations concerning construction of treatment facilities on these establishments is required without late.

Once water resources are polluted, it is not easy to remediate it to the original state, then, it will result in a decrease in available safe water resources. In addition, if the polluted water is consumed for drinking, irrigation and other purposes, it will cause health problem for human beings and animals, deterioration of farmland with lowering the yield of agricultural crops and adverse impact for environment.

## **(2) Contamination in Rural Area**

In order to grow crops as much as possible, unfortunately, the farmers have overused not only water resources but also chemical fertilizer and pesticides and contamination of groundwater is observed along the wadis where agriculture activity is conducted. The Government of Yemen has sanctioned the prohibition on use of some pesticides and fertilizers which can cause not only adverse impact to the nature but also to the human live. However, since agriculture is considered the main economic activity in the Basin and farmers in intent to protect their assets and incomes are using fertilizer and pesticides in an uncontrolled and unregulated manner without are aware about the risks caused by these chemicals. Fertilizers and pesticide might be one of the sources of groundwater pollution; however storage and disposal of livestock waste on land is also other pollution source effect widely the groundwater quality.

Approaches to increase the awareness of farmers concerning the risks caused by over use of pesticides and fertilizers and also utilization of illegal chemicals is needed. They should be aware that that they are not exposing only the water resources in danger but also the life of consumers and the most important thing, their and their own families life.

Considering the situation, the Integrated Pest Management Plan for Grapes and Qat has been already launched by SBWMP in cooperation with the General Department for Plant Protection.

## **(3) Concentration of Fluoride**

It was reported that the effects by high concentration of fluoride such as dental fluorosis and skeletal fluorosis were also observed inside Sana'a Basin. Totally 202 samples were analyzed in the previous studies. The concentration of fluoride in 28 of 202 wells (14%) exceeds the maximum permissible limit, that is, 1.5 mg/l and these are observed in the southeastern, western and north part of the Basin. 67 wells (33%) are in concentration of fluoride between 0.5 and 1.5 mg/l. The causes of contamination is unknown such as if it originates from natural source or originates from infiltration of contaminated water and so on and only information available is that most of samples analyzed are located in an area of distribution of volcanic rocks. However it is only a rough figure concerning contamination by fluoride and since the people who live in the high fluoride concentration area, have limited choice of water source for drinking purpose, the measures should be taken by the governmental body.

For these approaches, the followings should be taken into consideration

- improvement of sewage network system shall be considered in order to meet the increasing population in the urban area in conformity with city development plans

- enforcement of regulation for construction of wastewater treatment facilities for industries, petrol stations, car service shops, medical units and so
- increasing awareness of farmers through education of effective farming technique
- enforcement of regulation for use of internationally prohibited pesticides and fertilizers, and increasing awareness of farmers for the health and environmental dangers on utilization of such pesticides and fertilizers

### **3.2.8 NECESSITY OF CONSIDERATION OF EFFECTIVE RECHARGE**

The precipitation inside Sana'a Basin, which varies from 200 mm/year in the northeastern area to 350 mm/year in the southwestern area, is low; therefore, States and farmers have made an effort to utilize these precious water resources as much as possible by the water harvesting methods and surface structures. These methods and structures have also contributed to recharge the groundwater. However, the dependence on the water harvesting systems has been decreased because of the expansion of farmland and the use of groundwater resources. As for the surface structures, discussions have been made to optimize the effectiveness of the structures from the view point of integrated water resources management. Therefore, appropriate action for improvement of recharge groundwater should be considered.

#### **(1) Water Harvesting and Maintenance of Terrace**

Traditional water harvesting methods have been used in the country for a long time so as to obtain water for domestic, animals and irrigation purposes, and contributed to recharge groundwater simultaneously. However, since agricultural activities have expanded with increase of consumption of groundwater, dependence on traditional water harvesting methods have been decreased. Then terraces in mountainous region were sometimes abandoned without maintenance. Considering the scarcity of water in the basin, such kinds of traditional methods shall be utilized as much as possible.

#### **(2) Consideration of Construction and Rehabilitation of Recharge and Subsurface Dam**

In general, dam has function of recharge to groundwater, indeed, recovery of water level of shallow wells was observed inside Sana'a basin. However, NWSSIP points out that in spite of the tremendous efforts in dam construction in the country, dams that have been built have not stopped the continuously declining levels of groundwater or recovered the depleting aquifers in many basins. Then, it concludes that dams' policy should be accompanied by measures and actions to control and rationalize water demand.

For these approaches, the followings should be taken into consideration

- increasing of awareness of farmers on necessity of water harvesting
- availability of mountainous area for terraces
- measures and actions to control and rationalize water demand
- analysis of cost and benefit
- possible adverse impact on social and environmental aspects and necessary mitigation should be made on the basis of the result of comprehensive study

**REFERENCES**

Ministry of Water and Environment (2006) Baseline Survey for Future Impact Evaluation, Sana'a Basin Water Management Project, MWE, 107p