



Implementation of Integrated Water Resources Management for Sana'a Basin

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A Short course with support of:



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Acronyms

NWRA	National Water Resources Authority
SB	Sana'a Basin
IWRM	Integrated Water Resources Management
BC	Basin Committee
SWSLC	Sana'a Water & Sanitation Local Corporation
LC	Local Council
WUA	Water Users Association
GARWSP	General Authority for Rural Water Supply Projects
WSLC	Water Suppliers Local Council
WC	Water Committee
WWTP	Wastewater Treatment Plant
SBWMP	Sana'a Basin Water Management Project
MAI	Ministry of Agriculture and Irrigation
NWSA	National Water & Sanitation Authority
WEC	Water & Environment Center
MWE	Ministry of Water & Environment
GS	Geological Survey
GIS	Geographical Information System
ESIA	Environmental & Social Impact Assessment
WSSP	Water Sector Support Program

1. Institutional Issues of Sana'a Basin Project

1.1. Components and Objectives of Sana'a Basin project

1.1.1. Introduction

In 2003, Yemen took over the long-term integrated water resources management (IWRM) of the Sana'a Basin (SB) on a long term basis, with urgent water problems pressing. In order to face this, fifteen years was set as a time limit to confront this crisis. This period was divided into three stages, each of which lasted five years.

The idea of establishing the Sana'a basin project:

Yemen government took an urgent action to solve the dangerous deteriorating water situation. The Sana'a basin water management project was established within the framework of a long-term water management program, funded by the International Development Authority (IDA) in three stages of 12-15 years. A steering committee was formed by a cabinet decree No.54 of 2003 under the chairmanship of the Minister of Water and Environment. Where the project works within the scope of eight directorates in Sana'a Governorate, where the main basin is located as follows:

- 1) Bani Hushaish Directorate
- 2) Hamdan
- 3) Sanhan and Bani Bahlool
- 4) Arhab and Nihm
- 5) Bani Al-Harith
- 6) Part of Khawlan Al-Tial
- 7) Part of Bani Matar
- 8) Amanat Al-Asemah

Objective of the course: raising the capacity building of water sector trainees on the implementation of IWRM for Sana'a Basin for applying the IWRM concept and indicators.

Description of the course: attendees of the short course will be able to:

- Mobilize, activate, discuss the IWRM for the Sana'a basin
- Introduce the IWRM Process
- Understand the IWRM concept and the importance of applying IWRM to manage Sana'a basin.,
- Be aware of the need for all other Yemen water basins in applying IWRM in comparison with Sana'a basin.,
- Know problems generated from the absence of applying IWRM to the Sana'a.,
- Recognize the performance indicators which reflect proper application of IWRM In Sana'a basin.,
- Understand factors affecting the proper application of IWRM for Sana'a basin.,
- Identify existing situation of the Sana'a basin and discuss other ways to overcome its related problems.

1.1.2. Sana'a Basin Project Goals

- a) Reducing the excessive depletion of groundwater in the basin through the implementation of the WDM program
- b) Supporting the infrastructure of the rural economy (especially agriculture)
- c) Strengthening groundwater recharge
- d) Extending the life of groundwater aquifer
- e) Delay the date for the need to transfer water to Sana'a Basin from the adjacent basins
- f) Increasing the efficiency of water use in agriculture
- g) Strengthening the institutional and legal framework of water management at the basin level in particular and Yemen in general

1.1.3. Components of Sana'a Basin Project

- a) Water Demand Management and Irrigation Efficiency Improvement
- b) Supply Management and recharge Improvement – Sana'a basin Dams Unit
- c) Developing institutional and social infrastructure
- d) Implementation of a media awareness campaign
- e) Environmental management plan including the following:
 - i. Check the safety of the dams by conducting periodic inspections in cooperation with the dams unit in the General Administration of Irrigation;
 - ii. Preparation and implementation of integrated pest management of grapefruit and Qat reduce the excessive use of pesticides and protection of ground water from pollution in cooperation with the General Directorate of Plant Protection;
 - iii. To combat the spread of schistosomiasis in dams lakes and water resources in cooperation with Ministry of Public Health and Population;
 - iv. Work on improving and monitoring the wastewater treatment plant for reuse in agriculture and in the irrigation of gardens and islands on the streets;
 - v. Providing fresh groundwater for drinking in coordination with the Sana'a Water and Sanitation local corporation.

1.2. Importance of IWRM for SB

Sana'a is the third largest city in the world in terms of rapid growth. The Sana'a Water and Sanitation Local Corporation (SWSLC) supplies only half of the city with its water needs. Although network connectivity is the most cost-effective model to address poverty, the local Corporation is slow in providing the network because of its high cost and limited water resources. Until 2015, the local corporation was expected to invest to increase drinking water connections from 91,000 to 150,000 (and sewerage connections from 81,000 to 120,000). After all, due to the steady increase in population, the coverage will only increase from 50% to 55%. Most of the connections will be in the southern side of the city ending at 50m Street. With the expansion of the network, the local corporation was planning to increase water production from 25 million cubic meters to 52 million cubic meters by 2015.

Prior to the intervention of the (IWRM) system in SB, water governance and institutions in the basin suffered from the following weaknesses:

- Random drilling of wells with groundwater pumping, in addition to sharp competition in pumping water between different users "Race to the bottom",
- Inadequate amounts of water pumped into urban areas for drinking,
- Lack of equality, effectiveness and sustainability of the water allocation system among users and different sectors of water,
- Demand for water is much higher than renewable quantities, and there are new needs that appear to require supply,
- The wastewater discharged from the treatment plant is estimated at about 16 million cubic meters per year, which water sector is currently considered poor and unsafe for reuse. However, farmers downstream the treatment plant use the effluent to irrigate their crops,
- Wastewater is a major water source, but at the same time dangerous to the environment, affecting the quality of groundwater aquifer and human health. The continuation of the current method has a significant negative impact on the environment and on the people health,
- The local corporation faced many problems due to the unsustainable sources (annually ten wells inter in the service while six of others are dried),
- The agriculture sector consumes the largest water in the basin by more than 80% of the extracted water while the other sectors consume less than 20% of the extracted water,
- The effects of dams depend heavily on cleaning, cleaning of the dam from sediments is essential to increase groundwater recharge from the dam,
- Fees required to get a license form for drilling wells, deepening, or maintenance of old wells is very low (YR 1000 or \$ 5),

- Some new wells were licensed, while unlicensed wells increased rapidly: 106 licensed wells between (2005-2009), while the number of unlicensed wells at the same period were 614. Existing wells are not yet registered, and there are no wells whose productivity is constantly measured.
- In 2007, the irregularities in the drilling of random wells were 141, only two cases were transferred to the court, "and until now no action has been taken",
- In spite of the conditions mentioned in the protected area decree that wells and pumping quantities should be registered within one year, registration of water rights has not yet begun in the SB,
- Groundwater is exploited in irrigation rapidly, many of them for Qat irrigation. At the same time, Sana'a is the third fastest growing city in the world (2.2 million in 2010), using 58 million cubic meters of water.

1.3. Establishment of NWRA-SB

The establishment of the branches of the NWRA is in itself the beginning of the decentralized administration, including the branch of Sana'a, the branch is considered the main authorized water management in the basin where it includes all the relevant departments of technical, legal, social and financial decision of the government to take over of the NWRA Sana'a branch is responsible for the integrated management of water resources in the basin, while the National Irrigation Program implements the irrigation development component. The Water Sector Support Program (WSSP) will finance.

Recommendations:

- Clear objectives must be defined for management at the basin level, and reflect in detailed plans the evolution of the method of participation at the level of the sub-basins, and work with beneficiaries across the three constituent bodies of the government (basin committee - local councils - water user associations),
- A small, effective planning unit requires its establishment in the General Authority for Water Resources.

Classification of sub-basin group on the basis of the following different characteristics:

- Urban,
- On his way to urbanization (city limits),
- Located on the deep reservoir,
- Green belt / Agricultural zone.
- Deep groundwater reservoir must be kept for drinking water,
- Some areas should be declared as green belt areas for agriculture and as protected area.

To create a small and effective unit for planning the IWRM at the basin level at the Sana'a branch of NWRA, supported by decision-making and modeling capabilities, define the scope and objectives of water management and prepare long-term and five-year plans and annual programs of implementation.

- Development, discussion and adoption of the three elements planning (technical, governance, and finance & implementation).

- Identify the jobs and skills required, and establish a planning department for SB.

- Prepare a method for integrated planning amongst:

- NWRA-SB,
- Local councils,
- SWSLC,
- GARWSP,
- Ministry of Agriculture and Irrigation (MAI) + National Irrigation Program (NIP).

- Socio-institutional recommendation:

Work in the manner of participation. The objectives of water resources management are proposed. The long-term plan is reviewed and a five-year plan prepared with the annual program for the current year. This plans are presented to the basin committee and WSSP.

1.4. NWRA-Sana'a Branch (NWRA-SB) As The Responsible For Applying IWRM in SB

- Institutional Measurements:

Sana'a branch was established as an office of NWRA concerned with water management in the basin of Sana'a in particular and the governorate of Sana'a in general. The Sana'a branch was divided into several departments and serve the Institutional arrangement as follows:

- Branch management,
- Water control and decision support system with tasks:
 - Preparing technical reports,
 - Preparation of objective studies,
 - Water monitoring, data collection, analysis and introduction to the public database .
- Management of licensing and user rights:
 - Monitoring the implementation of the water law with regard to drilling licenses for wells,
 - Certificate of usufruct rights for wells,
 - Licenses to practice the profession of selling water,
 - Solving water disputes.
- Monitoring and evaluation management,
- Services management.
- The role of NWRA-SB is:
 - Planning of water resources,
 - Water regulation and monitoring,
 - WDM,
 - Water quality management
- Tasks required from the branch:
 - Support basin governance at the level of the basin committee and local councils ,
 - Support the establishment and development of water user associations (community participation), gender involvement and social motivation,
 - Work in an integrated manner with the national program of irrigation and agricultural extension,
 - Work as Integrated planning, resource allocation, and demand management with the WSLCs and private providers.

1.5. Establishment of the Basin Committee (BC)

The basin committee is represented by a supreme authority headed by the Minister of Water and Environment. With broad authority power. In accordance with its decree, the Committee's functions are:

- Approval of annual water plans with quotas for each sector,
- Approval of development projects,
- Review and implement the basin management strategy.
- In accordance with the Basin Conservation Decree, it requires the following from the Committee:
 - Approval of withdrawals water,
 - Approval of projects that require significant amount of water for use,
 - Monitoring the draw down and intervene to stop over-pumping,
 - Approval of water allocation and control of the water balance.
- Some recommendations from HydroSult and JICA regarding to the basin committee:
 - Converting the committee into a basin body, in order to link the activities of governance and implementation together;
 - The committee can be developed to include representatives of all beneficiaries, and also enable the committee to make decisions on both sides of the allocation of water and the allocation of financial budgets, these are logical choices.

- A special recommendation from the conference is that the committee should be headed by the governor of Sana'a or the secretary of the capital, and not as the existing case " the Minister of Water and Environment".
- Recommendations:
 - Conducting a study to compare the experience of the basin committees and the existing basin governance.
 - Making the membership of the Sana'a basin committee more inclusive, with the participation of: water user associations, gender and civil organizations. The Commission can also include the private sector: water suppliers (vendors owners), drilling companies, direct investors in the water sector (water bottling companies and gas drinks), as well as factories with high water consumption (tourism facilities, building materials industry ... etc).
 - Making the basin committee the highest authority in the water governance hierarchy at the basin level, in conjunction with the local councils as a second line of power while the water user associations form the front line for water resources management.
 - Making the Basin Committee take over the following tasks:
 - basin plan,
 - Annual Plan of the Operational Program for the Basin (AOP) under the umbrella of WSSP, and regulation.
 - The basin committee should be headed by the governor of Sana'a and the secretary of the capital.

1.6. Involvement of Local Councils (LCs)

- Recommendations for some tasks to local councils which can be:
 - Have the right of general supervision on the WUAs (as stipulated in the local authority law), coordination with the WUAs in the preparation of plans for local management of water resources at the level of directorates,
 - Be the front-line in resolving disputes, especially in the field of preventing the random drilling of wells (as in the model of Amran),
 - Be a forum to discuss water problems, coordination and awareness raising within the Directorate,
 - In negotiating with local councils, the role of local councils in water governance is determined (so that this role is in line with the Water Law and Local Councils Law) as an intermediate level between the Basin Committee and the WUAs,
 - In cooperation with the Ministry of Local Administration, LCs and their staff are trained to form the second line in water management.

2. Legal Framework for Sana'a Basin Management

2.1. Water Law, Regulations and Decrees

- Water Law: The Water Law was issued in 2002. It included the principles of integrated management of water resources, with a focus on conservation and the involvement of beneficiaries in all its aspects. However, its executive regulations have not yet been issued until this moment. As a result, organizational measures lack judicial support and make it difficult to reach a fair trial;
- Water Law (No. 33, 2002) and its amendments (No. 41, 2006);
- Establishment of the Sana'a Branch of NWRA, in accordance with the Council of Ministers Resolution No. 58 of 2003;
- The Implementing Regulations of the Water LAW was prepared in 2006, were passed across the beneficiaries and submitted to the Cabinet for final approval at the beginning of 2009;
- Cabinet Decree (No. 343, 2002) Announced the Sana'a basin as a protected water area, and the extension of this declaration for another ten years (No. 184 of 2009);
- Prime Minister's Decree No. 148, 2000, concerning the implementation of the regulations contained in Law No. 26 concerning the protection of the environment;
- Presidential Decree No. 26, 1995, for protection of the environment;
- Updating NWSSIP 2009-2015 (NWSSIP I(2005 – 2009) was updated in 2008));
- Some policies, rules and regulations developed and awaiting the approval of the Minister of Water and Environment (the legal framework for monitoring and regulation in the water sector, 2009, Water Rights Registration System, 2009);
- Establishment of Sana'a Basin Committee, Cabinet Decision No. 263, 2002, and its amendments in 2003, No. 168, 2004, No. 54, and No. 195, 2009.

2.2. Water Law and Its Amendments

Water Law No. 33 of 2002 and its amendments issued. NWRA should propose regulations for the registration of water policies to regulate and manage water. Table (1) shows articles of water resources in Water Law.

Article No.	Its position in the Law	Content of the article
2	Definitions	Definition of water policies, water regulation, water area, depletion, water rights,
3	Objectives and principles	The aim of the law is to regulate, manage, develop and rationalize the exploitation of water resources and protect them from depletion and pollution and raise the efficiency of the transfer and distribution of their uses ... and involve users in their development, investment, protection and conservation
7	Organizing and management of water resources	To mandate the Commission to propose water strategies and policies for the management, development and regulation of water resources
12		To commission the Authority to assess the volume of demand for water and quantities that can be exploited for different sectors and take measures to ensure equitable use of available water and protect them from depletion and pollution through monitoring and evaluation and conducting studies and others

22	Control handling of water use	To mandate the Authority to prepare regulations and health requirements and to issue licenses for sold drinking water and treated and accepted tanks and networks and others
34-27	Water rights	The Authority has been charged with the registration of water use rights, the maintenance of its records and the monitoring of compliance with registration requirements and non-compliance
42	Licenses	To commission the Authority to issue licenses for the practice of drilling wells, drilling for water, distribution of water directly from wells or through drinking water networks or by filling them
46	General technical standards and specifications	Submitting the means of transport and distribution of water for drinking purposes to the system of standards and general technical specifications and other rules and procedures implementing the provisions of this article
48	Preserve water resources from depletion and rationalize their uses	To instruct the Ministry and relevant authorities to provide the necessary support and facilitation to farmers to encourage them to use modern irrigation and technologies to provide water and increase their production, and to support and encourage the participation of popular efforts to contribute to the management of water resources.
76	General and final provisions	To mandate the Commission to propose fees for the development of water resources and protection from depletion and pollution and to achieve the objectives of the law

Table(1) Articles of water resources in water law

The Commission has drafted the executive regulations for organizing, managing and developing resources, and exploitation of water, represented by:

- Draft executive regulations of the law which issued by the decree of the cabinet No. 112 of 2011.
- Draft list of water rights registration fees used and protected from depletion and pollution issued by the cabinet decree No. 135 of 2014

Part III: Water resources management and planning	Chapter 1.	Organization and management of water resources
	Chapter 2.	Controls handling of the used water
	Chapter 3.	Sectoral uses of water
Part 5: Water rights and licenses and conditions of water registration system	Chapter 1.	Water rights
	Chapter 2.	The rules and conditions of water rights registration system
Part 8. Fees	Different fees for issuing licenses of various kinds	

Table(2) Executive regulations of water law

Table (3) shows list of registration fees for water rights to be used and protected from depletion and pollution.

Article 2.	Specify different charges	Registration fees for water rights - Water user fees - Water pollution protection fees
Article 3.	Determines the items and percentage of expenditure	
articles 4-10	Provisions for collecting fees, disbursement and general provisions	Article (5) The Commission is mandated to submit a proposal for collection procedures from the non-governmental entities of the Minister. The government agencies shall be directly deducted from their account in the Ministry of Finance.

Table (3) List of registration fees for water rights to be used and protected from depletion and pollution

2.3. Development of Governance Structure

- Activating the water law;
- Delegating the responsibilities of water management to the triangle of institutional composition, which consists of: the basin committee, which represents the top of the pyramid of the water governance authority in the basin, in solidarity with the local councils, which represent the second line in power, and the water user associations, which represent the first line as resource managers ;
- Make the basin committee more comprehensive, especially in the form of representatives of user union, and enable them to allocate water and financial resources;
- If these developments are implemented, there will be an integrated governance structure that will lead to decentralization in the distribution of water management powers to the lower levels of responsibility, in line with the concept of integrated management of water resources ;
- Strengthening and integration to enable the three components of governance (basin committee, local councils, and water user associations) in the following:
 - Establishment of legalization for water quality standards,
 - Discussing environmental water requirement studies.
- It is recommended that the deep wells be limited to drinking water only, as the "protected area of agriculture" is determined in areas where water cannot be transferred to urban areas ;
- Delegating the responsibilities of water management to the triangle of institutions, which consists of: the basin committee, which represents the top of the pyramid of the water governance, authority in the basin, in solidarity with the local councils, which represent the second level in power, and the WUAs, which represent the first layer as resource managers ;
- Make the basin committee more comprehensive, especially in the form of representatives of user unions, and enable them to allocate water and financial resources;
- Activate the role of local councils in regulating the water sector;
- Enable water user associations as managers in front line of water resources;
- To make sub-basins a primary unit for water management, and to move towards gathering as institutional groups at the sub-basin or district level so that they can adopt and implement water management strategies;
- Strengthening the Sana'a branch (NWRA) to implement its functions as a planner and consultant, in partnership with users and other institutions;

- Establishment of the Sana'a branch in 2003 as an office under NWRA, concerned with water management in the Sana'a basin in particular and Sana'a governorate in general;
- Dividing the branch into several departments which serve the institutional strengthening (such as: the branch management, water monitoring and decision support department and grant a certificate of usufruct rights, and monitoring department, service department. These department would act as follows:
 - Licensing department and usufruct rights: to perform the following activities, monitoring of the implementation of the water law in terms of wells drilling licenses, awarding a certificate of usufruct rights for wells, issue permits to practice the profession of selling water, solving water disputes;
 - Water monitoring and decision support department: to perform the following activities: preparing technical reports, objective studies, water monitoring, data collection, analysis and introduction to the general database);
 - Raising the efficiency of the staff in the branch technically and knowledgeably according to the competent department;
- A work plan was prepared by JICA for the management of water resources in the Sana'a basin in the framework of IWRM, which dealt with how to achieve IWRM in the basin and developed future scenarios in 2007;
- Water modeling and future scenarios for groundwater in the basin were done by Hydrosult 2010;
- The 10-years strategy as a water resource management plan for four sub-districts (9,14,15,19) 2016.

2.4. Protected Areas and Random Drilling at Sana'a Basin

- Protection zone for Sana'a basin is established;
- The southern side of the basin must be a protected area, important for the purpose of reserving the deep groundwater reservoir for drinking;
- Control of the random drilling shall be:
 - (a) from bottom to top (through participation with WUAs and LC),
 - (b) from top to bottom, through participation and organization with drilling companies;
- Giving the WSLCs an opportunity to access water sources while taking into consideration the protection of the livelihood of rural people based on the principle of equality and environmental sustainability;
- The WSLCs and the NWRA can work together to determine the areas of public drinking water. In the places where the GARWSP is located, GARWSP should also participate in this framework;
- The WSLC, the private water suppliers and GARWSP must work together to be able to deliver;
- A plan to reserve specific areas and depths in Al-Taweelah sand stone basin for urban water supply, with the application and promotion of incentive protection standards in these areas. This means that the pumping of agriculture in these areas will be confined to sedimentary and volcanic layers.
- Implementing a socio-economic program to ensure that there is no undue damage to those currently dependent on pumping in these areas to cover their living needs and to address them if any;
- The licensing of agricultural water user associations and wells in some sensitive areas to supply water to the urban, and support them in the side of sustainable management;
- The designation of a protected area (issued by a decree of the Cabinet in 2002) is intended to grant the organizational power to NWRA-SB and the BC.
- Among the legal conditions contained in the decree are as follows:
 - (1) Legal action: not to issue any licenses to increase the agricultural area,
 - (2) Institutional action: all wells and pumping quantities must be registered within a year.
- Regulation of random drilling and drilling companies did not reduce the continuation of illegal wells;
- The method that depends on the inter-distance between the wells and the responsibility of the community to organize in their areas will be easier and will raise the burden on the NWRA;
- Establishment of an association of specialized drilling companies can be incentive to self-regulation;
- The NWRA-SB can concentrate on controlling the deep rigs that can reach and penetrate the deep sandstone;

- Stop random drilling by encouraging deep drilling rigs, to form a specialized association with the creation of agreed standards for the protection and preservation of the deep reservoir to supply drinking water for urban uses;
- The community is responsible for organizing the drilling of wells within their areas using the method based on the distance between the wells (see figures 1 and 2 of the chart for the steps to obtain a drilling license);
- Control the rigs that can reach the deep sandstone.; Work with beneficiaries through the three constituent bodies of the governance structure (BC, LCs, and WUAs);
- Strengthen the licensing system of the wells and water structures;
- Workshop for wells owners preparing them for registration and licensing;
- Tankers supplying wells registration, licensing them and install flow meters (in Sana'a city there are 150 wells);
- Continue working on monitoring to eliminate the random drilling at the legal institutions .

2.5. Licensing System of Well Drilling

- Despite the conditions stipulated in the protected decision that wells and pumping quantities should be registered within one year, registration of water rights has not yet started in the of Sana'a basin;
- Some new wells were licensed, while unlicensed wells increased rapidly: 106 licensed wells between (2005-2009), while the number of unlicensed wells reached in the same period was 614 wells. Existing wells are not yet registered, and there are no wells whose productivity is constantly measured.
- In 2007, irregularities were observed in the drilling of random wells 141. Only two cases were transferred to the court, "and until now no action has been taken."

The system of licensing wells: at the NWRA-SB, a department specialized in licenses and water rights. There is a licensing system (see Fig. (1)).

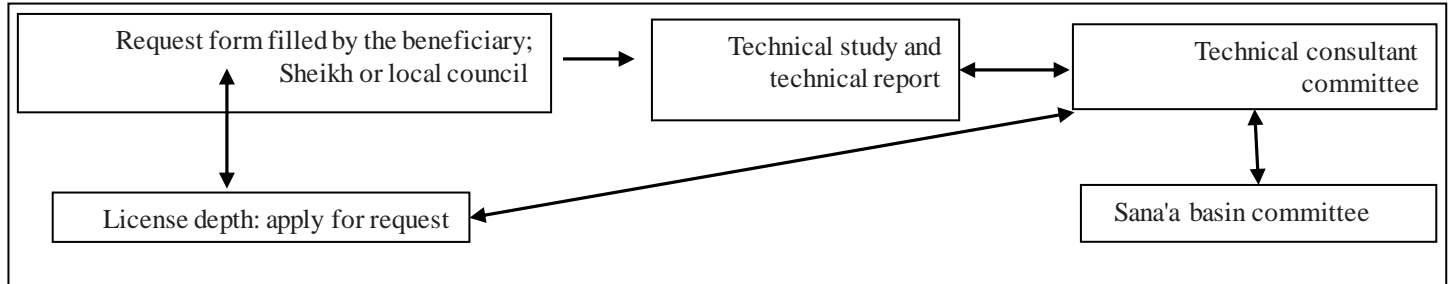


Figure (1) Legal Procedure: Licensing System in the Sana'a Basin

Beneficiaries in the Amran basin, with the technical support of GTZ, prepared the plan for managing the sources of the Amran basin, which submitted a proposal from the bottom to the top for licensing which depends mainly on:

- The minimum distance between wells is five hundred meters (or kilometers from a public well for drinking water);
- A set of procedures on the shoulders of the applicant to ensure that the rules will be respected. The procedures place simple responsibilities on the NWRA, where there are no difficult hydrographic decisions, or are subject to political pressure or moral hazard. The procedures also enable local authorities and the basin committee.
- The steps, see Fig. (1) contain:
 - The neighbors (or the authority in the case of public projects) confirm that the base of 500 meters (or kilometer in case of drinking water well) is actually located;
 - Local councils are responsible for reporting and verifying the validity of the procedures;
 - The role of the basin committee in the drilling requests is important.

Recommendation: a similar proposed application follows the method from bottom to top proposed in Amran to control random drilling, via the following:

- Local people or the local council may object, and lift the violence to the basin committee;
- The authority and the security department of the region visit the website and start the procedures;
- Violent wells may be buried (closed);
- Violated rigs are placed on the black list.

propose the formation of the so-called "Water Committee" at the level of directorates in order to overcome disputes among members of society in the following steps:

A) License Applications:

- The farmer wishing to deepen his well or dig a new well should complete the application procedures and submit it to his affiliated water user association;
- The association submits a request to the water committee in the directorate which meets, agrees or refuse, and makes its decision to the request;
- The local council is responsible for announcing and verifying the validity of the procedures;
- The local council and the security administration sign a memorandum including the water committee's decision;
- The request is then forwarded to NWRA-SB, through which it is submitted to the BC.

B) To Control Random Drilling:

- The government enables WUAs (through a decree) to play their role in controlling the random drilling;
- WUAs or any individual may object via the "Water Committee" in the directorate;
- The local council intervenes and request the security department to stop the excavator;
- The NWRA-SB shall initiate procedures at the competent court;
- The local council implements the decision of the court.

The following additional proposals also appeared:

- Checkpoints should prevent the passage of rigs without official permission;
- All rigs must be collected in one place and prevented from leaving without permission;
- To avoid moral hazard, owners of excavators must provide a guarantee;
- The Prime Minister's decree regarding the registration and numbering of the rigs must be implemented / enforced.

Action: This practical approach has been implemented by some water user associations in SB (see box).

Social action: in the directorate of Bani Al-Harith, all the heads of associations, under the supervision of the new director general of the local council, have completed a tribal agreement to prevent random drilling in the directorates. The agreement was signed by all tribal leaders and heads of WUAs, and was approved by senior leaders (Sheikhs) of the region.

- Legal recommendation: The implementation of joint work to evaluate the Amran procedure of licensing (and proposed amendments) and the control of random drilling can be carried out in a different scope as in the SB, at least within the rural areas. The legal procedure should be assessed, if the results are positive, the proposed method is submitted to the BC;
- Sana'a BC is responsible for the approval of wells drilling licenses and higher supervision of the arrangements. The costs of the drilling license fee (currently YR 1,000) must be raised at least to YR 10,000, and the amount is due to NWRA.

(1) Making the responsibility of registration and follow-up as part of the functions of the BC, supported by the branch of NWRA-SB;

(2) Working with the owners of the rigs using sticks and carrots to make them organized and specialized companies, the criteria of specialization may include, for example:

- (a) All drilling companies operating in the SB must have offices;
- (b) Each company must employ two geologists on each rig,etc.

- (3) Certain time for self-regulation must be determined, then sanctions can be imposed;
- (4) Creating system that works from top to bottom to regulates and controls the large rigs that can reach to the deep sandstone reservoir. Number of these rigs do not exceed five as well as the companies affiliated with them;
- (5) Optional control on deep rigs: The idea is to concentrate the control on the large rigs that reach the deep sandstone and penetrate it, there are currently a few rigs as follows:
 - Abu Miskah (one rig);
 - Mansour Al-Dalla'a (one rig);
 - Mabkhoot Al-Abraqi (two rigs);
 - Ali Mubarak (one rig and the other still at the sea port);
 - All companies are located in Amran .

One of the choices could be to collect all the dredges into the fenced land under the control of the basin committee (NWRA -SB and LCs). Another choice - or parallel - the rigs can be purchased if the company wants to leave the drilling job in the SB.

- (6) Review the obstacles and facilitate the process of issuing the executive regulations of the law.
- (7) Extraction of water from the Sana'a Basin should be restricted as follows:
 - The city of Sana'a as it is within SB, should be declared as a protected area for drinking water only.
 - All parks and street islands must use treated waste water.
 - All wells in the city of Sana'a, including the wells fields of SWSLC must renew their licenses annually with the payment for each cubic meter of water produced.
 - Strengthening the institutional and legal framework of water management at the basin level in particular and Yemen in general.

2.6. Legal Procedure

Fig. (2) shows mechanism for Requesting a Well Drilling Permit (Amran Model) Note: The beneficiary is required to complete the tasks shown in the boxes with the colored background.

2.7. Water rights

- Legal recommendation: - Ensure that any transfer of water between different uses is carried out on the basis of profit for all parties, with no uncompensated harm to any party.
- Conduct pilot programs to establish means to determine water rights;

➤ Discussion:

Basically, the Amran basin adopted a general decision-making approach to water rights. The plan looks at the well as a water right, and encourages the owners of wells to determine their rights. This practical approach avoids NWRA from legal, practical and moral difficulties in determining and imposing rights.

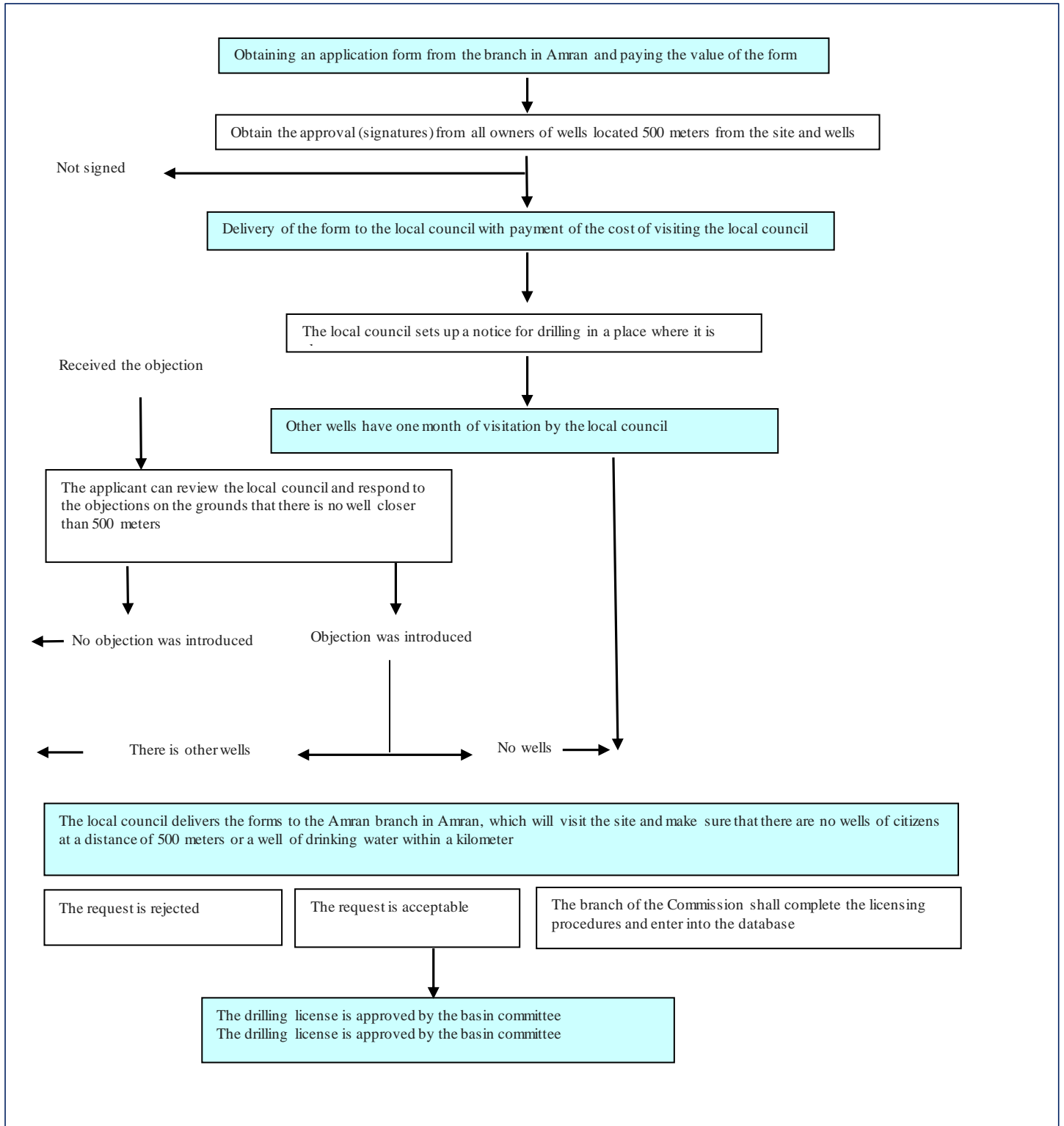


Figure (2) mechanism for Requesting a Well Drilling Permit (Amran model)

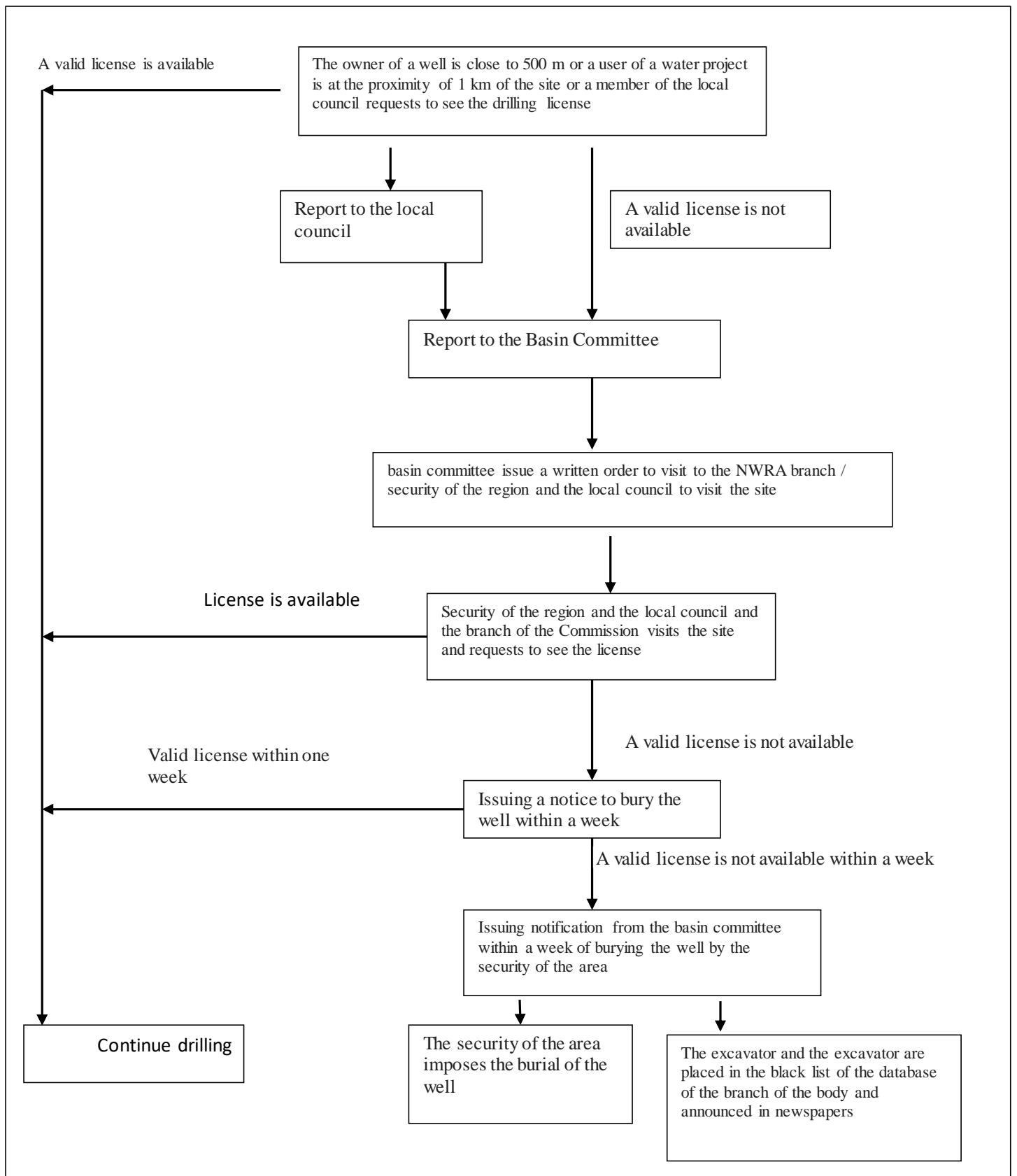


Figure (3) mechanism for Requesting a Well Drilling Permit (Amran model)

3. Policy Issues of Sana'a Basin Project

3.1. Water monitoring at sub - basin level

- Ensuring sustainable revenue from agriculture in the green zone reserved for agriculture;
- Transferring of water among different uses based on the benefit base of all parties, and compensation of damages.

3.2. Treated Wastewater

Water demand needs to be managed in a practical way on the basis of the principle of benefit to all parties. Water must be maintained for high-yield urban uses but at the same time without harming farmers' returns.

- Encouraging local manufacturers and irrigation equipment maintenance industries;
- Development of policies and visions for strong promotion of effective, unsupported irrigation through demonstration, agriculture extension, information, training of technicians;
- Stop investment in irrigation development in sub-basins where the groundwater reservoir suffers from high pressure and is expected to have a short life span;
- Stop investment in irrigation development in areas that over the medium term will be converted into urban areas or diverted to urban water supply;
- To create an integration among all elements of the structure of basin planning:
 - (a) Planning at the sub-basin level,
 - (b) Application of irrigation development (through the national irrigation program),
 - (c) Support to water user associations.
- Organizing and maintain a deep sandstone reservoir for the purpose of domestic supply;
- Addressing the water demand for urban areas, taking into consideration the equality and sustainability without harming farmers.

3.3. NWRA -SB and WSLCs Exchange Their Information with NWRA

A plan to reserve specific areas and depths in Al-Taweelah sand stone basin for urban water supply, with the application and promotion of incentive protection standards in these areas. This means that the pumping of agriculture in these areas will be confined to sedimentary and volcanic layers.

Implementing a socio-economic program to ensure that there is no undue damage to those currently dependent on pumping in these areas to cover their living needs and to address them if any.

- Encouraging private sector suppliers to form a specialized, self-regulatory organization;
- Encouraging the establishment of private supply networks, especially in the areas located within the city;
- Providing the needs of rural areas in the basin to obtain sustainable drinking water at reasonable prices, with equality between rural and urban areas;
- NWRA should plan with the WSLC and the MAI to reuse the wastewater treatment and associated regulations;
- Controlling the rigs that can reach the deep sandstone;
- Providing a system to support decision-making, monitoring and simplified modeling.

Discussing the existence and contents of IWRM-complaint water policy and developing governance structure

Classification of sub-basin group on the basis of the following different characteristics:

- Urban,
- On his way to urbanization (city limits),
- Located on the deep reservoir,
- Green belt / Agricultural zone,

- Deep groundwater reservoir must be kept for drinking water,
- Some areas should be declared as green belt areas for agriculture and as protected area.

3.4. Regarding the Aquifer

Technical recommendation: Keep the deep sandstone aquifer specific for drinking water,

3.5. With Regard to Plans and Databases

Recommendations: policy recommendation: adopt the 20-25 years, the five-year plan and yearly plan, as a general framework for planning, and create a mechanism for monitoring and evaluation in light of this policy.

Alternatives solutions are applied for water resources

Finalize and legalize water quality policy.

4. Technical Issues of Sana'a Basin Project

4.1. Water Resources Existing Conditions

The problem: groundwater is exploited in irrigation, most of it to irrigate Qat. At the same time, Sana'a city is considered globally the third largest city in terms of population growth rate (the population estimates for 2010 reached 2.2 million, using 58 million cubic meters of water).

➤ Water resources conditions and water balance

➤ Classification of sub-basins on the basis of their different characteristics (Table 4)

Sub-basin Group	Priorities and objectives
Urban	Protection of the groundwater aquifer
Urbanized (Edge of Cities)	Integration of water and sewage supply planning into urban planning Transitional planning for farmers on the basis of benefit for all
Above the deep sandstone aquifer	Protection of the deep aquifer: - Prevent deep drilling - Stimulation and regulation of revenue protection for surface aquifer users
Green belt / Agricultural area	Sustainable management of resources Increase farmers' returns environment protection.

Table(4) Classification of sub-basins into groups according to their properties

Procedures (institutional - social – technical): develop the objectives and plans for each sub-basin, based on the method of participation by water user associations and LCs. Table (5) shows the current state of each sub-basin and the expected direction.

Sub-basin No.	sub-basin name	Water balance (million cubic meters) by traditional irrigation system	What will happen if there is no change?
1	Wadi Al-Mashamini	- 0.04	Limestone aquifer, inability to supply drinking water
2	Wadi Al-Mudaini	- 2.36	Volcanic aquifer Deficiency, Continuous drawdown
3	Wadi Al-Kharid	- 1.51	Limestone aquifer, problems with water quality, lack of drinking water supply
4	Wadi Al-Maadi	0.00	Currently there is a shortage of drinking water supplies
5	Wadi Aaser	- 0.18	Limestone, sandstone, continuous drop in groundwater levels.
6	Wadi Khalaqah	- 0.77	Limestone, water shortage
7	Wadi Qasabah	- 2.57	Volcanoes, water shortage, continuous decline of water levels
8	Wadi Al-Huqah	- 13.24	Dry sandstone in 2020
9	Wadi Bani Howat	- 52.20	Water quality problem, high pressure water supply and irrigation
10	Wadi Thomah	- 0.52	Limestone, water shortage, high precipitation
11	Wadi Al-Sir	- 24.59	Dry sandstone in 2020

12	Wadi Al-Furs	- 9.49	Dry sandstone in 2020
13	Wadi Al-Iqbal	- 19.32	Dry sandstone in 2020
14	Wadi zahr Al-Khail	- 7.46	High drop in water level, transfer of water to qat irrigation
15	Wadi Hamdan	- 2.90	Dry sandstone
16	Wadi Al-Mawred	- 34.00	Dry sandstone, water quality problems, shortage of drinking water supply, high pressure on the deep sandstone aquifer
17	Wadi Sawan	- 10.26	Dry sandstone in 2020
18	Wadi Shaheq	- 3.64	Volcanic inertia, sandstone deepening, water transfer
19	Wadi Ghaiman	- 2.87	deficiency of the volcanoes, deepening into sandstone, transferring water to qat irrigation
20	Wadi Al-Malekah	- 2.83	deficiency of the volcanoes, deepening into sandstone, transferring water to qat irrigation
21	Wadi Hiziaz	- 1.57	Increase pressure on the aquifer due to drinking water supply, water transfer to qat irrigation, and to drink
22	Wadi Ahwar	- 0.40	deficiency of the volcanoes, deepening into sandstone, transferring water to qat irrigation
	total water balance	- 192.7	

Table (5) The current state of each sub-basin and the expected direction

Summary and conclusions:

- Areas under excessive water depletion are: 17,16,14,13,12,11,9,8;
- Areas that can extend the shelf life of the open sandstone aquifer to provide drinking water are: 8,11,12,17,15,16,13;
- Development of modern irrigation in the southern areas of the basin to protect the deep sandstone aquifer and its storage for drinking water use: 18,19,22,21,20,14;
- Wastewater treatment should be used for agriculture in 12,16,9,8 so as to reduce the pumping of groundwater (JICA, ???);
- Wastewater in wadi no. 16 will be used for garden irrigation and nutrition.

Recommendations:

- Implementation of a network of water balance control and cover the whole water basin including the four sub- basins;
- Hydrosult recommended the following:
 - Monitoring of 150 wells,
 - In addition to 14 runoff stations in the wadis,
 - In addition to three stations to measure the flow of wastewater, etc.
- Conduct a regular satellite survey to measure the quantities of water used in irrigation, and follow up the expansion of agricultural land (irrigated areas) and the type of crops;
- Minimizing water losses in irrigation;
- Irrigation efficiency monitoring: survey traditional water management systems farmers have access to efficient, least cost irrigation technology;
- Technical-institutional recommendations: reservation of the deep sandstone aquifer for the purpose of ensuring clean and safe water for drinking and industry.

4.2. Water Balance

Problem: the agriculture sector consumes the water in the basin by more than 80% of the extracted water, while the other sectors consume less than 20% of the extracted water.

Results: water balance in the SB showed a water gap represented by the increase in extraction compared to recharge in the Sana'a water basin (million cubic meters per year). Hydrosult also found a water balance representing 270 million cubic meters of water extracted from the aquifer with 79 million cubic meters of recharge, i.e. a deficit of 191 million cubic meter (table 6).

Component of water balance	Average
Pumping of groundwater for agriculture	212
Pumping of groundwater for domestic use	58
Total pumping	270
Recharge from rain and torrents	57
Return from irrigation	20
Return from domestic use	2
Total recharge	79
Balance = extract from groundwater stock	191

Table (6) Water balance in the basin of Sana'a

Source: Hydrosult-6 and final amended report of hydrosult

- Water modeling of the basin of Sana'a was conducted in 2010 (Hydrosult study);
- Water modeling of the four basins (19, 15, 14, 9) in 2016;
- All these studies draw the water budget and scenarios for the next ten years.

It is clear that all the sub-basins suffer from water deficit (table 7), and can be returned to the balance in the case of using the modern irrigation system. After all, the situation is rapidly deteriorating.

sub-basin no.	sub-basin name	Water balance (Mm3) Traditional/ available irrigation system	Water balance (Mm3) Modern irrigation system
1	Wadi Al-Mashamine	-0.04	0.0
2	Wadi Al-Madani	-2.36	- 0.5
3	Wadi Al-Kharid	-1.51	- 0.3
4	Wadi Al-Ma'adi	0.0	0.0
5	Wadi Sir	- 0.18	- 0.1
6	Wadi Khalkah	- 0.77	- 0.2
7	Wadi Qasabah	- 2.57	- 1.5
8	Wadi Al-Hukah	- 13.24	- 7.0
9	Wadi Bani Hwat	- 52.2	- 32.5
10	Wadi Thoomah	- 0.52	0.0
11	Wadi Al-Sir	- 24.59	- 13.6
12	Wadi Al-Furs	- 9.49	- 5.7
13	Wadi Al-Eqbal	- 19.32	- 10.7

14	Wadi Dhar Al-Ghail	- 7.46	- 0.9
15	Wadi Hamdan	- 2.90	- 2.1
16	Wadi Al-Mawrid	- 34.00	- 30.4
17	Wadi Sa'awan	- 10.26	- 5.9
18	Wadi Shaheq	- 3.64	- 0.2
19	Wadi Ghaiman	- 2.87	- 0.6
20	Wadi Al-Mulaiki	- 2.83	- 1.4
21	Wadi Heziaz	- 1.57	- 0.5
22	Wadi Ahwar	- 0.40	- 0.1
	total	- 192.7	- 114.2

Table(7) Water balance for each sub-basin

Results: Groundwater levels: Hydrosult report recorded a draw down in water levels as shown in table (8). Source: hydrosult -7

Urgent action is required if we wish to improve the situation of groundwater even partially.

Aquifer type	Average drawdown (m)	Period (since)
Alluvials aquifer	3.4	1973
Volcanics aquifer	51.2	1985
Sandstone layer aquifer	141	1993

Table (8) Draw down in groundwater level

4.3. Water Saving Technology by Modern Irrigation Systems

- Introduction of modern irrigation system;
- Calculation of water savings and installation of meters;
- Rainwater irrigation;
- Under the first component of the IWRM, the Sana'a Basin Water Management Project aims to preserve water by covering 4000 hectares by modern irrigation system supported by
 - (1) Community-based management through WUA,
 - (2) Training and extension, with arranging with the Ministry of Agriculture and Irrigation(MAI).
- Farmers' interaction with the project by water conservation was entirely positive. The baseline survey carried out by the Sana'a Basin Water Management Project (2005) showed that farmers:
 - (1) want to use water saving technology and also share the cost;
 - (2) they don't want to change their crops unless it is proven that new crops will increase their revenues;
 - (3) They don't want to sell or trade water, because they see it as limiting their access to water, as well as it can make water expensive for them.
- Improving irrigation at the sub-basin level on the basis of:
 - (1) Determine the purpose for which the supplied water will be used (e.g. for agriculture, urban water supply) and how it will be maintained for that purpose.
 - (2) Assessing the sustainability perspective of irrigated agriculture in sub-basins, with the cessation of irrigated agriculture in the sub-basin, which will become dry within 10 years, may not justify investment in modern irrigation technology.
- Reducing irrigation water use, irrigated agriculture incomes per hectare is at least maintained;
- Monitoring the irrigation systems meters in areas irrigated by modern irrigation systems;
- Protection of the surface water sources from pollution
 - (1) Preparation of the IWRM plan (JICA, 2007)
 - (2) Preparation of the water balance and a mathematical model of the basin (HYDROSULT)
 - (3) Implementation of sub-basin monitoring network.

4.4. Dams, Check Dams and Groundwater Recharge

The problem: demand for water is much higher than renewables, and new needs are emerging that require supply.

- The effect of dams depend heavily on cleaning. Cleaning of the dam from sediments is essential to increase groundwater recharge from the dam;
- Groundwater monitoring showed the effect of direct recharge from dams in hand-dug wells. The establishment of a series of retaining walls is technically the best choice for groundwater recharge compared to storage dams. Retaining walls increase groundwater recharge, reduce the negative impact of sediment, and reduce evaporation effect;
- Under the second component of the Sana'a Basin Water Management Project "Demand Management and Recharge Improvement". The objective of the component is to improve the safety of dams and recharge development, as well as the building an institutional framework for the management and safety of dams and recharge systems. (Hydrosult,).
- Check dams are a choice for groundwater recharge in some wadis such as: 18,19,22,21,20,14 for the purpose of reducing the flood flowing through Al-Mawrid valley and increasing the recharge of the sandstone aquifer and sediments of the valleys.

Before interfering with the integrated management of water sources in the basin, the problem was at first:

The Sana'a Basin Water Management Project has implemented the following activities:

- Rehabilitation and cleaning of 11 dams in the SB;
- Monitoring of groundwater in selected wells in the areas of completed dams;
- The Sana'a Basin Water Management Project established three large boreholes, completed in November 2009.
- Preliminary results after the rehabilitation showed, after the floods, that the groundwater levels in the wells located in the bottom rose directly as demonstrated in the control wells.

Recharge Facilities: The establishment of check dams starting from the highest point of the wadi seems to be a better choice than the construction of dams.

4.5. Wastewater Treatment

The wastewater discharged from the WWTP is estimated at about 16 million cubic meters per year, which is currently considered poor and unsafe for reuse. However, farmers below the treatment plant use the effluent of the plant to irrigate their crops. Therefore, wastewater is a major but important source of water, affecting the quality of aquifer water and human health. Continuing the current method has a significant negative impact on the environment and on the health of people.

- Implementation of NWRA-SB and in cooperation with the Sana'a Basin Water Management Project to implement a pilot campaign and awareness to stop the use of effluent wastewater in the irrigation of some crops consumed by humans and animals directly.
- Distinct management of wastewater treatment requires regulation and training for farmers.
- The safe use of the effluent of the new treatment plant should be regulated starting from the exit from the WWTP.
- In non-networked areas, sewage leaks into the aquifer without treatment.
- The procedure associated with increasing the connection of the sewage network and the extension of the WWTP is urgent from both the environmental and health aspects.

Effluent water quality improvement Industries and factories adopt treatment plants

- Prepare vulnerability map of the contamination of basins
- Implement program on industrial wastes treatment

4.6. Reuse of Wastewater

Wastewater is recycled and reused:

- Prepare extension programs on the safe uses of the treated waste & grey water.
- Field visits for the farmers who use the treated waste water in Bani Al-Harith.
- Conduct Waste water awareness workshops.
- Coordinate with LCs at Sana'a & governorates to reuse treated wastewater and recycle grey water.
- The safe use of the effluent of new WWTPs should begin from the beginning of the effluent point.
- Optimal management of wastewater requires training and organization of farmers.
- NWRA should plan with the WSLC and the Ministry of Agriculture and Irrigation to reuse the wastewater treatment and associated regulations.

4.7. Rainwater Harvesting

- It is proposed to start quickly with the economic assessment of the rainwater harvesting system from the roofs of houses.

- An economic feasibility study for rainwater harvesting at the household level is required. This is done with the participation of the SWSLC and Urban Housing Corporation. The economic perspective in this case is especially important in the case where there is little rain (200-300 mm).

4.8. Irrigation Development

Agricultural extension services must be on the same line with the use of modern irrigation systems to increase revenues and provide more water. The Sana'a Basin Water Management Project contracted specialists to train in the field of agricultural extension, and ten of them worked with the Sana'a Basin Water Management Project. This human investment must be maintained and utilized.

- Modern irrigation allowed farmers to use 40% less water while increasing yields by 10%.
- Modern irrigation should be reinforced in sub-basin plans - but only in economically justified places.
- Future regulatory arrangements should maintain an integrated approach to water resource management linked to irrigation development and extension.
- Sana'a Basin Water Management Project has enhanced knowledge on the irrigated agriculture side of the basin as follows:

- 1)The amount of water used in irrigation was estimated at 221 million cubic meters per year to irrigate an area of 18,953 ha (= 11,660 m³ per hectare).
- 2)Document agricultural crops.
- 3)Calculate ET by analyzing satellite imagery.
- 4)Qat is considered the main irrigated crop in the basin and covers irrigated area reached 11471 hectares (60% of the area currently irrigated). Qat, however, has a low water consumption (ET_c of 840 mm) and uses slightly less than half the amount of irrigation water consumed in the basin (47%).
- 5)The traditional irrigation efficiency was measured and calculated as low.
- 6)Transportation using pipes increases the efficiency to 60%, and modern irrigation raises it to 80-90% (drip irrigation = 90%, sprinkler irrigation = 80%). The use of both systems (transport and modern) increases efficiency to 70-75%. These results are similar to those reached in the groundwater and soil conservation project
- 7)Farmers pumped less water by 40% while their incomes improved by 10%. After all, these conclusions were built on small agricultural areas and specific crops.
- 8)Reports of the Sana'a Basin Water Management Project showed that the total annual quantities saved by modern irrigation systems installed were 18.6 million cubic meters per year from an area of 4807 hectares
- 9)The use of modern irrigation techniques enabled farmers to reduce water use by 40% and increase income by 10%.

➤ In line with what was estimated by JICA, the review of the policy paper found that if the entire irrigated area of 18,953 ha in the basin is covered by modern irrigation systems, the theoretical savings from the entire basin can be 73.2 million cubic meters per year. In light of this, agricultural uses will

decrease from 221 million cubic meters to 148 million cubic meters per year, and some sub-basins will be sustainable in current recharge quantities.

➤ Strengthening research and extension of irrigated agriculture and water management and linking it to the national program for irrigation development so that farmers receive the full transfer of technology, including tips on changing the crops to crops with less water use. The Water and Environment Center and possibly the Agricultural Research and Extension Authority may also be considered as specialized training centers for irrigation management.

➤ The development of irrigation is one of the most important investments in water conservation.

4.9. Urban Water Supply

Sana'a is the third largest city in the world in terms of rapid growth. SWSLC supplies only half of the city with its water needs. Although network connectivity is the most cost-effective model to address poverty, the SWSLC is slow to provide the network due to its high cost and limited water resources. Until 2015, the SWSLC will invest to increase drinking water connections from 91,000 to 150,000 (and sewer connections from 81,000 to 120,000). In any case, due to the rapid increase in population, the coverage will increase only from 50% to 55%. Most of the connections will be at the southern side of the city ending at 50m street. With the expansion of the network, the SWSLC plans to increase water production from 25 million cubic meters to 52 million cubic meters by 2015.

➤ The technical problem: The SWSLC faced many problems in the side of unsustainable sources (annually ten wells are enter into service, while six of others get dried).

➤ Work to coordinate with NWSA & LCs to reduce the network water loses.

➤ Prepare & implement pilot programs to expand water saving devices.

➤ Make sure of the "dry wells" closed by the SWSLC that the problem is dry aquifer and not a problem associated with the damage of the well protection pipes or the collapse of the walls of the well.

➤ Currently, the private sector covers the deficit but its cost is high and not well organized. A recent study of the water and environment center(WEC), entitled Analysis of the private sector of urban and semi-urban drinking water suppliers in Sana'a: A field survey of service providers (Dr. Balqis Zabara et al.), showed the potential of the private sector on both sides of participation and growth.

➤ Farm wells provide urban areas located on the borders of the city as well as tankers traded water.

➤ The WSLCs, the private water suppliers and GARWSP should work together to ensure that water continues to flow through the network for all the inhabitants of the basin.

➤ Focus on the important water resource areas for urban drinking water.

➤ Encourage the establishment of private supply networks, especially in the areas located within the city.

➤ To establish specific criteria for areas to be allocated for drinking water supplies.

➤ Provide the needs of rural areas in the basin to obtain sustainable drinking water at reasonable prices, with equality between rural and urban areas.

➤ Ground water levels are monitored.

➤ Work to install water flow meters for the registered & licensed wells.

4.10. Databases

1. A general database was prepared by the German BGR for the NWRA, MWE, and GS. It has included All the data (surface and groundwater monitoring, water quality, well inventory, etc.) and are linked to GIS maps and images. This is considered data base for Integrated Management.

2. A work plan was prepared by JICA for the management of water resources in SB within the framework of IWRM, which dealt with how to reach integrated management of water resources in the basin and developed future scenarios as follows:

➤ Water modeling and future scenarios for groundwater in SB were conducted by Hydrosult, 2010

➤ Ten-year strategy as a water resources management plan for four sub-basins (9,14,15,19) in 2017

➤ Technical recommendation: ensuring safe water access for domestic and industrial use, and limit the use of deep sandstone aquifer water for this purpose.

- Economic recommendation: ensuring continuous agricultural returns for the green zone specified for agriculture.
- Legal recommendation: ensuring that any transfer of water between different uses is carried out on the basis of profit for all parties, with no uncompensated harm to any party.
- Policy recommendation: adopting the 20-25 years, the five-year plan and yearly plan, as a general framework for planning, and create a mechanism for monitoring and evaluation in light of this policy.
- Establishing water laboratories in Sana'a branch;
- Conducting study on establishing water & environment laboratory;
- Evaluating available field equipment;
- Laboratory equipment reinstalling.

4.11. Planning and Studies Consultant

- Conducting meeting between IWRM experts and NWRA-SB,
- Conducting study to revise the mandate of BC,
- WUAs Assessment in SB and training needs for both,
- Regular data collection of the hydro-metrological monitoring stations,
- Surface water monitoring (day/year),
- meteorological -rainfall –stations equipment requirements,
- Data auditing & analysis,
- Studying and reviewing and evaluating water resources,
- Conducting ESIA for dams,
- Conducting ESIA for check-dams,
- Conducting well inventory,
- Conducting water quality monitoring,
- Water resource management plans prepared and implemented,
- Expanding the monitoring networks,
- Constructing pilot projects on water harvesting,
- Establishing of simplified water management model,
- Exploring new water resources,
- Produce awareness films and flashes,
- Introducing the 5yrs plan to stakeholders,
- Preparing of a guide in the best methods of water management in SB,
- Collecting of data from the groundwater level monitoring network,
- Ground water levels monitoring,
- Establishing the national monitoring network for the monitoring and exploratory wells.

Water use is improved & regulated: work to coordinate with MAI to implement programs on improving the traditional irrigation and introduce modern irrigation techniques.

Sources of water pollution map are identified: conduct pollution sources inventory and prepare management strategy for hazardous wastes(oil, industrial, medical and agricultural).

ESIA strengthened and adapted: alternatives of water use priorities are identified, conduct study to identify the needs and specify the priorities at basin level.

5. Social Issues of Sana'a Basin Project

5.1. Formation of WUAs

Water user associations are formed in a typical manner and can play a major role in the front line as water managers, in partnership with the LCs and the BCs.

Institutional arrangements for capacity building and empowerment are:

- At the national level, experiences associated with WUAs must be extracted and disseminated in addition to finding a means of self-continuity;
- Institutional measures: WUAs play a key role in the IWRM at the basin level. Farmers form the front line as a water resource managers, and the project worked tirelessly to organize them. There are 58 effective WUAs, including 1149 water users groups with 11,546 farmers. Of these, 46 associations are mainly associated with irrigation, and 13 are established for the establishment and management of recharge facilities (see table (1))

Activities	WUAs formed	WUAs closed	WUAs effective	WUAs continue
Irrigation	52	6	46	33
Recharge	13	3	12	11
Total	67	9	58	44

Table (9) WUAs formed in the first phase

- WUAs union is required to be formed at the basin level,
- The role of WUAs is as follows:
 - Participation in the implementation of the Sana'a Basin Water Management Project, which reduced the cost of the project interventions (50% reduction in the costs of modern irrigation installation);
 - Participation in the process of stopping random drilling.

WUAs are included in the water law as a tool for community participation in the regulation of water resources. Anyway, WUAs are administratively registered under the non-governmental charities act, therefore, they have a voluntary role.

5.2. Monitoring and Controlling of Groundwater

Activities could affect groundwater that can be monitored and controlled by WUAs.

Institutional recommendation: making structural elements of governance (BC, LCs, WUAs) working together.

- a. Information on IWRM shared widely with decision makers and end users;
 - b. Existence of outreach program for IWRM;
 - c. Discussing the existence of stakeholder platform;
 - d. Water management institutions generated from users.
- It is recommended that the deep wells be limited to drinking water only, as the "protected area of agriculture" is determined in areas where water cannot be transferred to urban areas.
 - Planning at the sub-basin level, as well as at the basin level in general.
 - Data should also be disaggregated at the sub-basin level, disseminated and shared with beneficiaries, and used as a tool for participatory planning at sub-basin or district levels.
 - Working in the manner of participation.
 - The objectives of water resources management are proposed.
 - The long-term plan is reviewed and a five-year plan prepared with the annual program for the current year, this plans are presented to the basin committee and WSSP.

5.3. Gender Issue

- a. Percentage increase of women in decision –making levels;
- b. Involving women through forming WUAs.

Supporting WUAs:

Recommendation for capacity building:

- Training and Providing WUAs with water monitoring, assessment equipment for water resources evaluation to start involving them with monitoring and collecting information;
- **Institutional recommendation:** central management through three organizations (SB committee, LCs and WUAs);
- Law enforcement in demand and supply management;
- Strengthen the licensing system of the wells and water structures;
- Overseas exposure visits and training for WUAs;
- Public users are aware of sustainable water management and sustainable environment;
- **Economic-financial-social recommendation:** incentive framework is identified & adjusted for water consumption in agriculture and urban area.

5.4. Control of Random Drilling

- The government enables WUAs (through a decree) to play their role in controlling the random drilling;
- WUAs or any individual may object via the "Water Committee" in the Directorate.

Social action: in the directorate of Bani Al-Harith, all the heads of associations, under the supervision of the new director general of the local council, have completed a tribal agreement to prevent random drilling in the directorates. The agreement was signed by all tribal leaders and heads of WUAs, and was approved by senior leaders (Sheikhs) of the region.

Develop the objectives and plans for each sub-basin, based on the method of participation by WUAs and LCs.

5.5. Wastewater Treatment

Implementation of NWRA-SB and in cooperation with the Sana'a Basin Water Management Project to implement a pilot campaign and awareness to stop the use of effluent wastewater in the irrigation of some crops consumed by humans and animals directly.

5.6. Plans and Databases

Social action: WUAs also worked as a counterpart to the Sana'a Basin Water Management Project in the field of Agricultural Extension and Irrigation.

Involving schools and teachers to collect primary information. This model can be tested as a tool to reduce cost in the basin. Local councils can also be encouraged to participate in the role play.

5.7. Dams, Check Dams and Groundwater Recharge

WUAs are essential for the effective operation and maintenance of dams.

Stop random drilling by encouraging deep drilling rigs, to form a specialized association with the creation of agreed standards for the protection and preservation of the deep reservoir to supply drinking water for urban uses.

Socio-legal recommendation: the licensing of agricultural water user associations and wells in some sensitive areas to supply water to the urban, and support them in the side of sustainable management.

- Support basin governance at the level of the basin committee and local councils.
- Support the establishment and development of water user associations (community participation), gender involvement and social motivation.

6. Environmental Issues of Sana'a Basin Project

- A plan to reserve specific areas and depths in Al-Taweelah sand stone basin for urban water supply, with the application and promotion of incentive protection standards in these areas. This means that the pumping of agriculture in these areas will be confined to sedimentary and volcanic layers;
- Implementing a socio-economic program to ensure that there is no undue damage to those currently dependent on pumping in these areas to cover their living needs and to address them if any;
- Establishment of legalization for water quality standards;
- Discussing environmental water requirement studies carried out;
- Public users are aware of sustainable water management and sustainable environment;
- Environmental management plan including the following:
 - 1) Check the safety of the dams by conducting periodic inspections in cooperation with the dams unit in the General Administration of Irrigation,
 - 2) Preparation and implementation of integrated pest management of grapefruit and Qat in order to reduce the excessive use of pesticides and protection of groundwater from pollution in cooperation with the General Directorate of Plant Protection,
 - 3) To combat the spread of schistosomiasis in dams lakes and water resources in cooperation with the Ministry of Public Health and Population,
 - 4) Working on improving and monitoring the wastewater treatment plant for reuse in agriculture and in the irrigation of gardens and islands on the streets
 - 5) Providing fresh groundwater for drinking in coordination with the Sana'a Water and sanitation local corporation.
- Wastewater is a major water source, but at the same time dangerous to the environment, affecting the quality of groundwater aquifer and human health. The continuation of the current method has a significant negative impact on the environment and on the people health. Therefore, wastewater is a major but important source of water, affecting the quality of aquifer water and human health. Continuing the current method has a significant negative impact on the environment and on the health of people, the procedure associated with increasing the connection of the sewage network and the extension of the WWTP is urgent from both the environmental and health aspects.

7. Economical and Financial Issues of Sana'a Basin Project

7.1. A Special Budget Allocation for IWRM

- Funding by the National (WSSP);
- Digital indicators in the documents of the National (WSSP) showed the following:
 - 1) IWRM is well supported under the WSSP;
 - 2) In total, NWRA is expected to receive US \$ 40 million for the implementation of IWRM activities within five years;
 - 3) NWRA has allocated \$ 6.8 million from the National WSSP in 2010;
 - 4) The branch of the General Authority for Water Resources in Sana'a (NWRA-SB) has allocated \$ 173,000 of the budget of the WSSP in 2010 to cover the operational costs of its programs;
 - 5) Consideration of economic value during the water allocation to users;
 - 6) Discussing the existence of IWRM – complaint in water law;
 - 7) The budget of the Sana'a branch (NWRA-SB) of (WSSP) 2010 is as Table (9) shows:

Item	*1000 (US \$)
Capacity building	87.9
Data bank (NWRIS)	27.6
Sana'a basin plan	20.0
Groundwater monitoring	5
Sana'a Basin Committee	10
Social motivation	7.5
Pilot program for water conservation equipment	5
Awareness campaign	10
Total	173.0

Table (10) The budget of the Sana'a branch (NWRA-SB) of the (WSSP)

7.2. Sources of Financing the Project

- Funding through a single integrated project (WSSP);
- Provision of water monitoring and regulation equipment for the NWRA-SB;
- The proposed fees for the licenses and services provided by NWRA represent a good aspect for provision of financial resources, but can be increased and linked to uses and benefits, for example:

The problem: the fee required to apply for a license form for well drilling, deepening, or maintenance of old wells is very low (YR 1000 or \$ 5).

 - The annual fees to be paid by the water bottling companies is fixed at YR 360,000. While it should be linked to the amount of pumping (per cubic meter);
 - Charges the SWSLC, private water suppliers, high water consumption industries, five star hotels, etc.

7.3. Basin Plan

- Decision-making regarding the basin plan and the allocation of financial resources;
- Implementation and funding, which translate the plans into reality facts on the ground;
- Elements of this structure are available - or can be readily available - in SB;
- The funding and implementation function can be based on arrangements under the (WSSP), originally established to provide funding for the implementation of basin-level plans.
- The age of the plans can be:
 - 1) A long term plan extending from 20-25 years,
 - 2) A five-year plan for a short-term program,
 - 3) Investment programs carried out annually for the completion of each year part of the five-year program.

Agreement with the Ministry of Finance and Technical Secretariat to support the water sector in the arrangements required for the annual program and how the funding and implementation programs can be integrated at the basin level among NWRA, SWSLC, and NIP,..... etc.

7.4. Incentive Framework

Economic-financial-social recommendation: Incentive framework is identified & adjusted for water consumption in agriculture and urban area. Prepare action plan for the outcomes of the economic incentives study

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